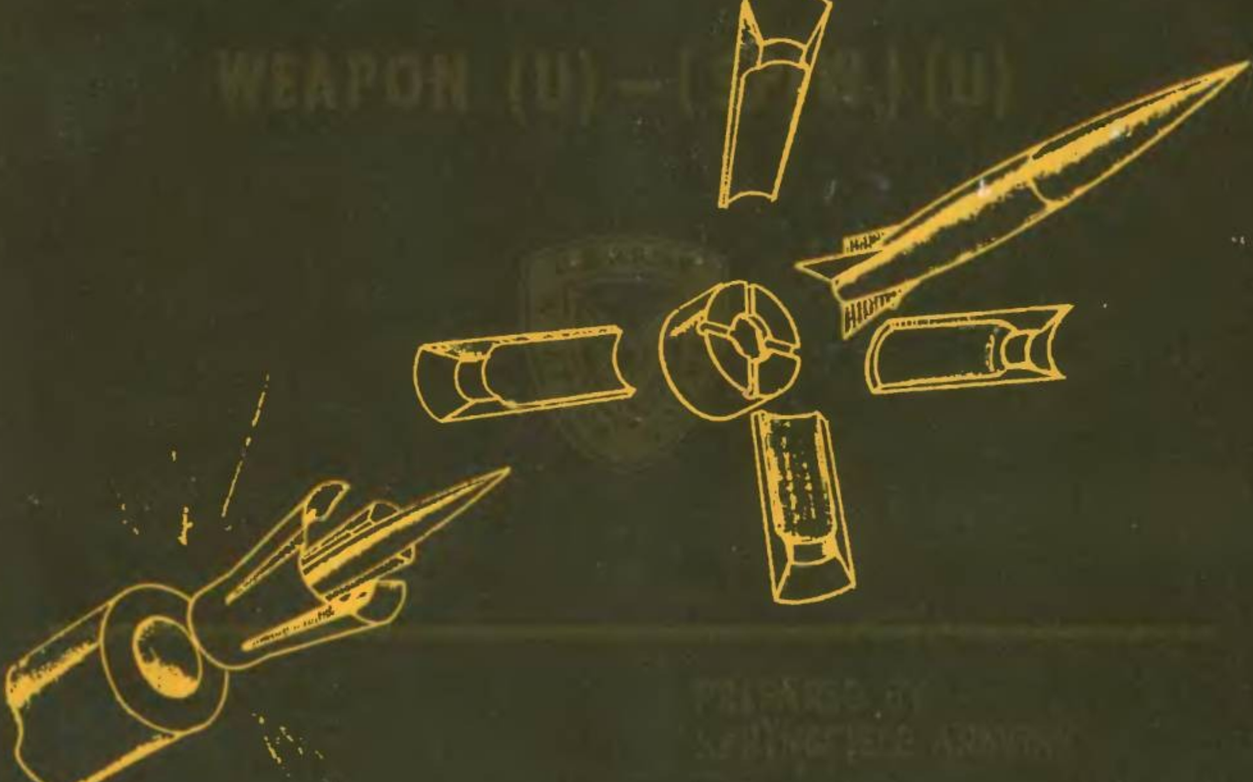
Modern US Military Small Arms Series — Volume Two

The SPIW
The Deadliest Weapon that Never Was

by R. Blake Stevens
and Edward C. Ezell



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Frontispiece

One of ten AAI SPIW prototypes produced and fielded for the first generation SPIW competition in 1964. Shown here in point fire configuration only, undergoing phase I firing trials at Fort Benning during the summer of 1964. The first generation AAI SPIW featured a 60-round drum magazine and fired the 5.6×53mm XM110 single-flechette cartridge (muzzle velocity 4,820 fps) at a recorded three-round burst rate of 2,400 rpm, and weighed just over 5 lbs fully loaded. This competition was to have resulted in a "Standard A" replacement for the M1 rifle by June of 1965. The AAI weapon came the closest of any in the 1964 competition to being considered for adoption. U.S. Army photo.

Prologue

What Was the SPIW?

SPIW is an acronym standing for Special Purpose Individual Weapon, a radically new, omni-purpose infantry arm which was initially conceived as an offshoot of Project SALVO (1952-1960).

SPIW was to be a hand-held weapon holding sixty rounds of "point target" ammunition (deliverable in the form of controlled bursts of tiny, lethal darts or "flechettes"), plus three 40mm "area target" grenades in a piggyback launcher, *all* in a package weighing less than a loaded .30 caliber M1 rifle.

The SPIW concept had been created as a direct attempt to address *actual combat needs*. These had first stood revealed in the early fifties as a result of important advances in weapons trials technology, wherein innovative new methods of automatic data-capturing had been applied amid trials conditions approaching the gruelling reality of combat. Under these circumstances, SPIW promised dramatic increases over the performance of the Army's existing small arms, both in point-target hit and kill probability, plus devastating area-fire potential. Irresistibly, these life-saving features touched a responsive chord in everyone, combat veteran and neophyte alike. Mounting evidence in favor of the feasibility and effectiveness of the SPIW came from numerous individually focussed studies into various single aspects of the SPIW program.

In actual manufacture, however, the enthusiastic all-things-to-all-people SPIW specifications translated into extreme weapon complexity and high multiple-ammunition capacity within ultra-light weight. These characteristics were soon found to be inextricably interdependent, not to say mutually exclusive, yet were stubbornly insisted upon by the Army. Not surprisingly, developmental weapon and ammunition prototypes, fielded for trials, were found to be dismayingly and fundamentally problem-plagued; capable *at their best* of achieving only very limited results.

As the program progressed into the sixties despite these deep-rooted problems, there was an increasing political need for SPIW to figure meaningfully against other weapons such as the M14 and M16. In order that the SPIW might participate, in theory at least, against its vastly more fully-developed conventional rivals, first- and second-generation SPIW performance *at its best* was projected and extended, using computer models of actual combat scenarios. The results of these biased studies, which pitted the SPIW's theoretical best against *actual* simulated-combat data from competing conventional weapons, showed the SPIW as being clearly superior to the best existing weapons in the world. The heavily slanted nature of these comparative standings led to the fatal temptation to confuse potentiality with reality. Sad to say, as an actual, combat-ready weapon system, the flechette-firing SPIW has never completely fulfilled its computer predictions: to this day its fame still rests only on the enhanced sum of its proven parts.

The SPIW program was certainly one of the very few times in history that the US Army backed a "pig in a poke". Today's adamant DoD policy, stated most succinctly in the Air Force dictum "it must fly before we buy" is a direct outcome of this most embarrassing and expensive blunder, the full extent of which may be appreciated in that the collapse of the SPIW program is arguably the chief underlying reason why we're all playing with M16s today. Type classification as "Standard A" was confidently predicted for the SPIW as early as June of 1965: this was two years after the cancellation of M14 rifle procurement, and just in time for America's massive military buildup in Vietnam.

Aside from such "low-risk, follow-on" parallel developments as Project GLAD, (which resulted in the M203 grenade launcher for the M16 rifle), and in spite of the fact that roughly six times the developmental money spent on the entire M14 rifle program was committed to SPIW, its fantastic potentials have never been satisfactorily realized to this day. Indeed, many of the advanced studies which were undertaken, especially during the latter part of the program, created technological breakthroughs which have yet to yield their full potential.

Interestingly, the SPIW program has never been explicitly cancelled, thereby never becoming a candidate for an official restrospective biography. In fact, testing and evaluation of flechette ammunition continues today on a limited scale. Only recently declassified, some of the key documents relating to the SPIW program make extremely informative reading from a number of different viewpoints. Certainly the Army's decade of apparent indecision and annoying flaccidity in the M14-M16 debate leaps into focus when this "missing ingredient" is added: how confidently the officials at Army Weapons Command awaited the dramatic entrance of their secret "ace-in-the-hole"!

The vast SPIW data-base examined in this study is strong testimony to the dedicated work of the American defense community, military and industry alike, which pushed back the very frontiers of knowledge in almost every single aspect of traditional gun and cartridge design in their quest for the SPIW.

It is hoped that this book will illustrate how worthwhile it was for the US Army to attempt to perfect and field the SPIW, and just how close they came to achieving their goal.

Introduction

The Seeds of the Reduced Combat Range Concept

The British bolt action No. 4 rifle seems as far removed as one could imagine from explorations into ultra-velocity, fin-stabilized projectiles and gun mechanisms which function on the thin edge of known metallurgical technology. Yet World War II was largely fought and won with bolt action rifles such as the No. 4 Enfield, and a good part of the impetus behind the SPIW actually had its roots in the capitulation of the exhausted *Wehrmacht* in 1945. Here began the close examination of the world's first *Sturmgewehrs* or "storm rifles": every one of Germany's former foes took some home to study.

By 1946, a British Infantry Combat Weapons program was well under way, featuring among other arms in the future soldier's arsenal a selective-fire, eight-pound *Personal Weapon*, or *Light Auto Rifle*, whose practical, accurate range was determinedly set at a realistic 150 yards on automatic fire and 300 yards on single shot. By the following year, the Russians had perfected the arm which still ranks today as the world's most popular assault rifle, the 7.62x39mm AK-47 *(Avtomat Kalashnikov)*.

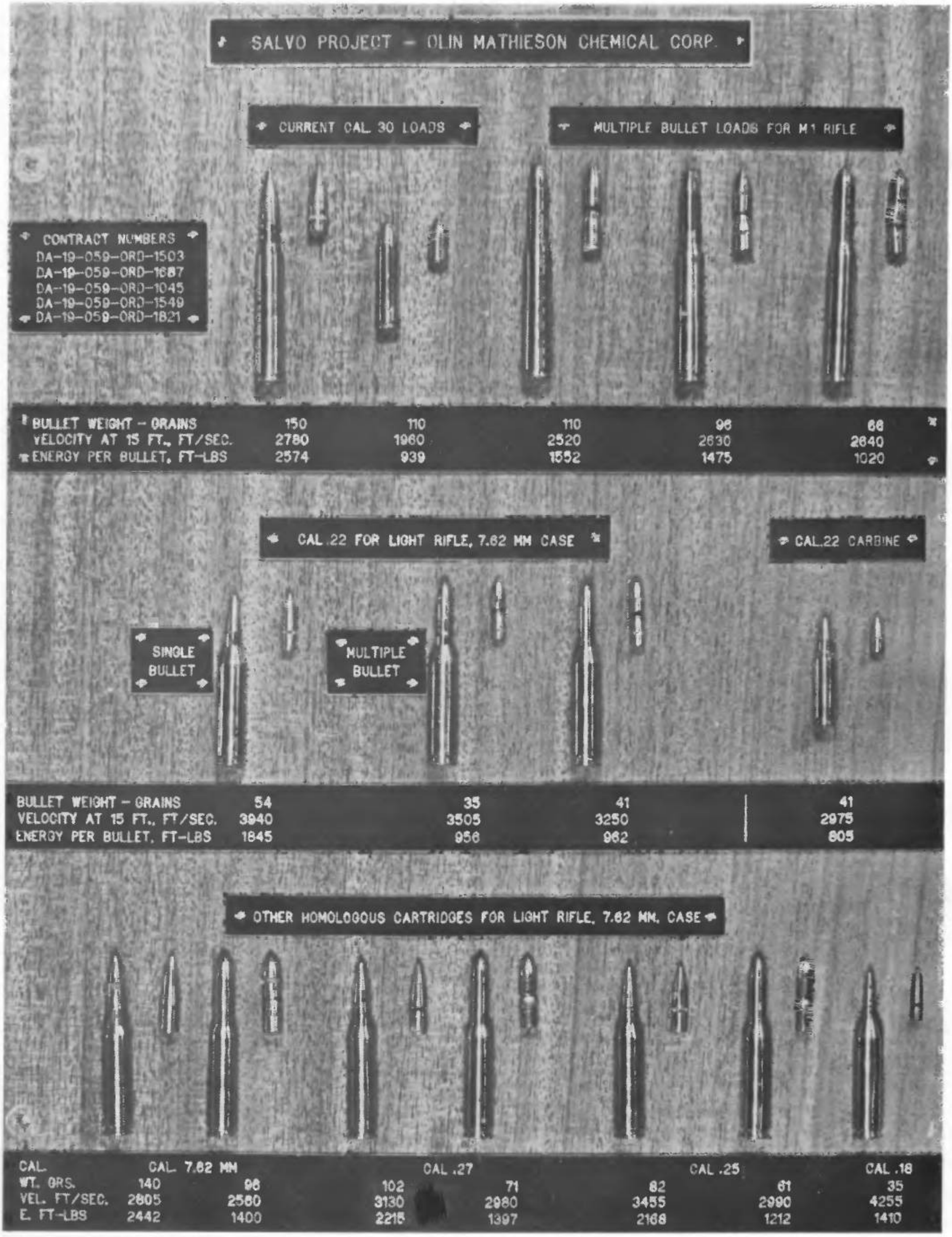
In America, on the other hand, the postwar mood was one of proud, prosperous elation. The American soldier had proven himself victorious in all-out, worldwide combat. America alone possessed the atomic bomb, and was, for the time at least, invincible. True to the adage "nothing succeeds like success", both the M1 rifle and the powerful .30 M2 cartridge were deeply and fondly ingrained in every fiber of America's military establishment.

The British first arrived in post-war Washington for standardization talks with their counterparts in US Army Ordnance Research and Development (R&D), just in time to divert the autocratic and dictatorial head of that department, Col. René R. Studler, from the enjoyment of his very own pat on the back: a retrospective describing the new arms, ammunition and accoutrements which had been championed by the Ordnance Department during the war. This impressive two-volume tome had just been published by the Colonel's Ordnance Research and Development Service in January, 1946. Colonel Studler soon discovered that there was little time to sit on his well-earned laurels, however, as events in the new "atomic age" were happening thick and fast. Quite aside from the meddlesome British, whose well-reasoned challenge to the Colonel's own carefully-hedged, middle-of-the-road "lightweight" .30 caliber cartridge program caused him more anxious moments that he cared to admit, there were new threats within America's defense establishment itself to his position as sole arbiter of US small arms Ordnance R&D.

The newly-independent US Air Force, for example, no longer just another Army dependency, was acquisitively riding a wave of popularity which extended all the way to the White House after having so decisively ended the war against Japan with its devastating atomic strikes on Hiroshima and Nagasaki. The atomic-age Air Force doctrine of "massive retaliation" was swiftly scooping all the glamor, prestige and funding away from Col. Studler's carefully planned Ordnance projects. The Air Force had even created the ultra-prestigious RAND Corporation, the arch-"think-tank", and had enlisted its aid in planning future strategy.

Not to be outdone, in September, 1948 the Army General Staff created the civilian Operations Research Office (ORO), whose initial mandate was to supply the Army with scientific advice about the conduct of nuclear war. Dr. Ellis A. Johnson, a geophysicist and previously the assistant to the director of the wartime Office of Scientific Research and Development, (OSRD), was appointed the first director of ORO, with temporary headquarters at Fort Leslie J. McNair, in Washington, D.C.

This interesting postwar period of small arms development and trial among the western Allies led to three variously successful embodiments; the FAL, the M14 and the EM-2. These weapons and their cartridges have already been documented and described in other Collector Grade books.



1. A very interesting cartridge board from Olin's Winchester/Western Division (headstamps WRA or WCC) of standard (Simplex) plus special Duplex- and Triplex-bulleted cartridges made up in support of three important American research programs: Aberdeen's small caliber, high velocity (SCHV) program, the 1952 Hall Study, and Project SALVO. Contract dates 1950-1957.

Chapter One

From Korea to SALVO

As the western Allies loudly argued the various pros and cons of their new 7mm or caliber .30 weapons, based on (or in stubborn opposition to) mid-1940s German developments, a parallel series of astounding and unprecedented new American research projects was just beginning. Although no one could have known it at the time, these two complementary studies were destined to have a most profound effect: they were to change the shape and nature of the combat rifle the world over.

One such study was ordered in the name of the Chief of Ordnance by Col. Studler himself, perhaps partly as "insurance" against a possible future wave of popularity for the medium-range concepts the British were espousing, and also to keep abreast of the distrusted civilians at ORO. On November 28, 1950, he requested the Ballistics Research Laboratories (BRL), an Ordnance Corps agency quartered at Aberdeen Proving Grounds, to prepare an in-depth report on the whole subject of the effectiveness of the infantry combat rifle.

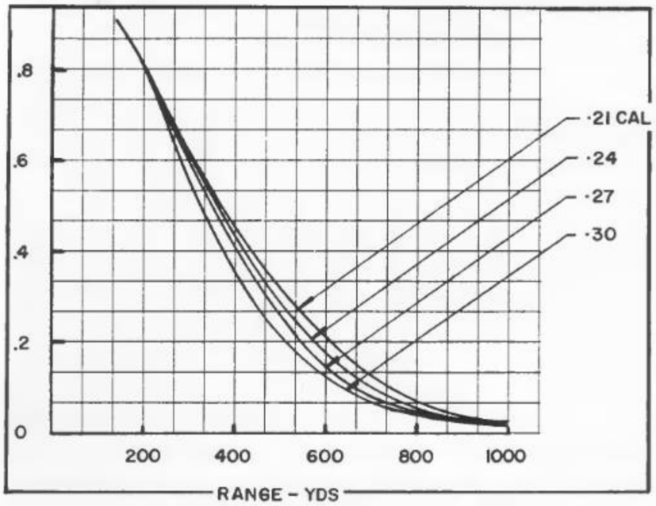
In the meantime, the sudden outbreak of the Korean war meant that the US Army was again scrambling for innovative, up-to-date solutions to a host of military problems, while also ensuring an adequate supply of standard weapons and equipment for its combat-bound troops. Well aware of the ponderously self-protected rationale of its own technical services, the General Staff decided to extend the mandate of the Operations Research Office (ORO), which by this time had settled into expanded quarters at Johns Hopkins University in Chevy Chase, Maryland. ORO was asked to study a whole range of such non-nuclear problems as improved artillery, better anti-aircraft defenses and more effective counter-armor operations. Dr. Johnson accordingly created an Infantry division within ORO, under Mr. Norman A. Hitchman.

One of the first official tasks given the new division was Project ALCLAD, wherein it was hoped that ORO's "less restricted" methodology would give the Army some new insights into the development of improved body armor. In beginning this study, Mr. Hitchman reasoned that fundamental to the creation of a better defense, (the armor), was a thorough study of that which threatened to penetrate the defense (bullets and shell fragments). It was soon discovered that comparatively little data was on record concerning the real nature of the wounding process itself — at first glance truly as sad and gruesome a topic as anyone could ever imagine, and yet one of incalculable importance to the future *saving* of friendly lives in combat. Bio-mathematical analyses of over three million casualty reports from both World Wars were fed laboriously into the ORO computers, and merged with on-the-spot data gathered by over a hundred ORO staffers actually in Korea. From this research came the second of the two profoundly important studies discussed below.

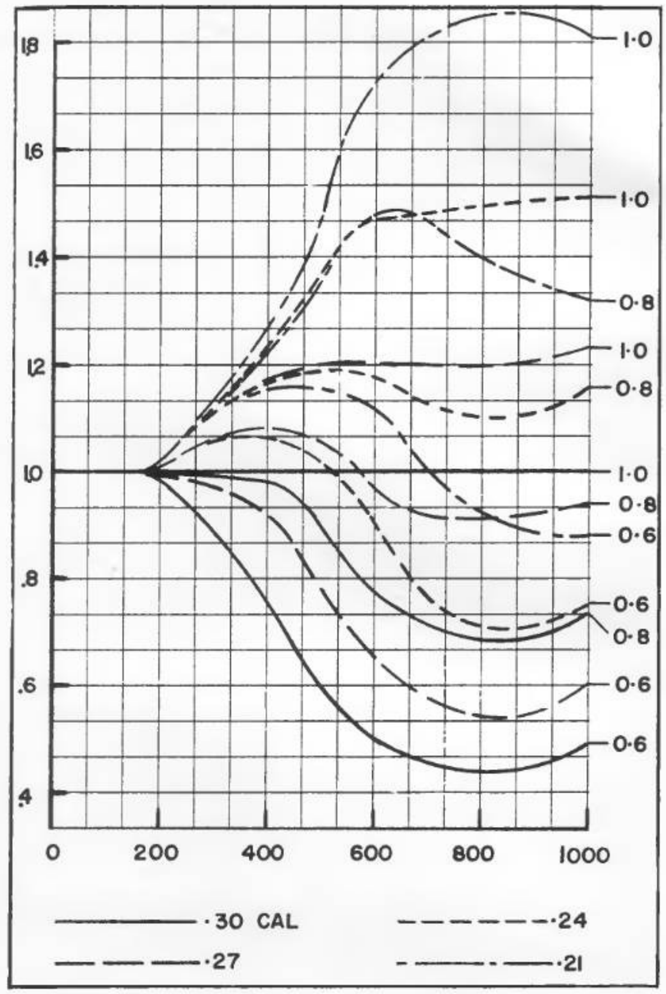
As if to confirm Col. Studler's suspicions, the final ORO report contained important new findings which challenged every one of the Army's deeply ingrained traditions of firepower, marksmanship and the combat rifle.

The Hall Study

The Ballistic Research Laboratories (BRL) had been formed at Aberdeen Proving Grounds in 1938, with an ongoing mandate to conduct basic ballistic research for the Army. The official reason behind the ground-breaking BRL study into combat rifle effectiveness, ordered by Col. Studler in 1950, was to address the unsettling fact that, despite the Army's doctrinal insistence on accurate, long-range, carefully aimed rifle fire, an estimated 50,000 rounds of ammunition had been expended per enemy casualty during World War II.



2. From the Hall Study report: a correlation of hit probability versus range for several experimental cartridges compared with the issue .30M2. Target size: 3.5'×1'; Allowed range estimation error: ±20%; Allowed windage error: ±3 mph; Aiming and ballistic error: ±0.6 mils.



3. Essentially the same information as shown in figure 2 above, but dramatically "reoriented" to reflect relative hit probability, assuming a hit probability of 1.0 for each round fired of the full-charge issue .30M2. The figures down the right side of the chart indicate the three powder charge weights tested: full charge (1.0); 8/10-charge (0.8); and 6/10- charge (0.6). The Hall Study was history's first serious look at how a small, fast bullet stacked up against the issue .30 caliber: the final report stated "When the . . . weight of gun and ammunition is held constant at fifteen pounds, the overall expected number of kills for the caliber .21 rifle is approximately 2½ times that of the present standard cal. 30 rifle."

The results of the study by Mr. Donald L. Hall were released in BRL Memorandum Report No. 593, dated March 1952, entitled *An Effectiveness Study of the Infantry Rifle.*

The Hall study was the first real, authenticating publicity for the fledgling small caliber, high velocity (SCHV) concept, a new and cooperative research effort involving Aberdeen's Development and Proof Services (D&PS) and the Ballistic Research Laboratories (BRL). The SCHV proponents sought to win favor for the idea that bullets of around .22 caliber (or even smaller) could produce lethality results equal to or better than the issue .30 M2 projectile, if their velocity could be kept high enough. The advantages in saved weight and reduced recoil alone made the idea seem well worth investigating.

Mr. Hall blended the initial SCHV results with his own theoretical studies, to produce history's first serious espousal of the small caliber concept:

> *The theoretical consideration of a family of rifles indicates that smaller caliber rifles than the .30 have a greater single-shot kill probability than the cal.30 M1. This is obtained by increasing the muzzle velocity and thereby obtaining a flatter trajectory, so that the adverse effect of range estimation errors is reduced. When the combined weight of gun and ammunition is held constant at fifteen pounds, the overall expected number of kills for the cal.21 rifle is approximately 2½ times that of the present standard cal.30 rifle. If the number of rounds is fixed at 96, the total load carried by a soldier with a cal.21 rifle and ammunition with $^{6}/_{10}$ the charge in the M2 cartridge will be 3.6 lbs less than that carried by a soldier with a cal.30 M1 rifle. This is a 25% reduction in load.*
>
> *Furthermore, if it were necessary for a soldier with the M1 to carry the rounds required for the same expected number of kills at 500 yards as a soldier with 15 lbs of cal.21 $^{6}/_{10}$ charge rifle and ammunition, it would be necessary for him to carry 10 lbs more ammunition, or a total load of 25 lbs.*

The Hitchman Report

The second important study mentioned above complemented but greatly expanded on the Hall study. It was presented by the head of ORO's Infantry Division, Norman A. Hitchman, on June 19, 1952. Originally classified SECRET, ORO's Technical Memorandum ORO-T-160 was entitled *Operational Requirements for an Infantry Hand Weapon.* Its broad purpose was stated rhetorically in the report's abstract:

> *Of what should a rifle be capable in battle today? Since there is a limit as to how accurately a rifleman fires, can one increase hits by giving him a rifle with new operational characteristics? ORO's Project BALANCE studied this by taking data on how often, and by how much, riflemen missed targets (as well as the distribution of hits) at different ranges, . . on the ranges of engagement in battle, . . and on the physiological wound effects of shots with different ballistic characteristics . . .*

The Hitchman report began where the Hall study had left off, taking as its gospel that "it is desirable to increase in both *number and rate* the hits which may be inflicted on the enemy by aimed small arms in the hands of the infantry".

Some of the reasons for ORO's unpopularity among the Army's own technical agencies were not long in surfacing: certainly there was proof in abundance that ORO's methods were as Colonel Studler's later successor, Dr. Fred Carten, termed it, "remarkably innovative". To "get a handle on" such complex issues as the "man-weapon system", ORO went right back to basics:

> *It has been found, from an examination of many campaigns from the [ancient Greek] battle of Marathon [490 B.C.] to Korea, that battles are no more bloody now, despite vastly "improved" weapons, than they were in the days of the short sword: the casualties incurred per number of men engaged per unit of time remains about constant. In fact, it may well be that the sword is much more lethal than conventional weapons . . . Most advances in weapons either increase the distance over which a blow can be delivered (improved launcher) or increase the lethal radius . . of effect (improved missile), or both. Since logistics costs have markedly increased since the early wars, war itself has become vastly more costly in terms of the cost-effect ratio, yet little if any more effective in terms of personnel casualties per unit [of] time or . . effort.*

ORO summed up these opening remarks by stressing that the "severity of weapons as measured by their lethality has not changed, at least in the past century."

The vast amount of preparatory work done by ORO, in its previously mentioned analyses of casualty reports from earlier wars, allowed Mr. Hitchman to speak with unsettling authority on just how well the rifle was found to perform its defined task:

> *. . rifle fire and its effects were deficient in some important military respects . . . in combat, hits from bullets are incurred by the body at random: . . the same as for fragment missiles which . . are not 'aimed' . . . Exposure was the chief factor . . . aimed or directed fire does not influence the manner in which hits are sustained . . . [Despite] evidence of prodigious rifle fire ammunition expenditure per hit, . . the comparison of hits from bullets with those of fragments shows that the rifle bullet is not actually better directed towards vulnerable parts of the body.*

There was stubborn Army opposition, especially among Ordnance officials, to this ORO attempt to quantify certain parameters as they *truly existed*, as opposed to how they had traditionally been perceived, regarding the infantry rifle and its effectiveness in combat.

If time and degree of exposure really *were* the chief casualty-makers, what then of marksmanship and Army's devotion to long-range shooting? In its study of combat casualty reports, ORO lamented that, for the most part, very little had ever been recorded to link bullet hits as a function of *range*. Statistics from the World War II Bougainville campaign *had* included range data, however; almost all rifle hits recorded in that survey had occurred at less than 75 yards. Subsequent studies by a team from the Surgeon-General's office in Korea had found the mean range from a sample of 109 hits to be just over 100 yards.

Out of all the combined British and American research available, 80% of effective rifle and LMG fire had been reported at ranges under 200 yards, with a full 90% under 300 yards. This substantiated the Hall study, wherein hit probability from small arms fire at ranges exceeding 300 yards rapidly descended into the "negligible".

ORO's unpopularity in Ordnance circles rose to new heights as field testing revealed the poor full-auto effectiveness of the Army's proud new developmental cal.30 T47 and T44 selective-fire rifles: in repeated firings of controlled, five-round bursts at Type E silhouette targets mounted on 6-by-6-foot screens, ORO reported that "never did more than one round hit the target *or screen* [at 100 yards] from any of the bursts . . . To obtain more than one strike on the . . screen, the range had to be closed to 50 yards". Even at this short range, it was noted that the ". . target in front of the screen was not hit more than once from any burst". Since it was hard to miss a man-sized target at such short range with a single shot from the M1, "the effectiveness of automatic fire . . was of no interest".

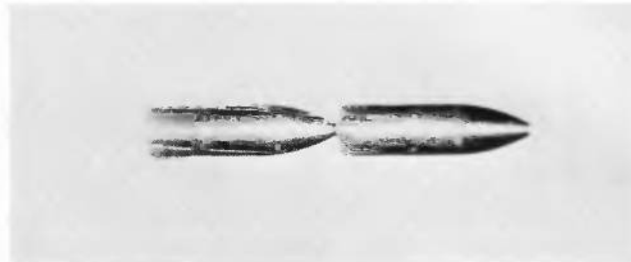
Unsettlingly, ORO summed up that "the emphasis and impetus currently being placed by the US and other NATO countries on the development of fully-automatic hand weapons should be questioned on the basis of actual military requirements for the automatic feature".

A correlation of weather, time-of-day and terrain data further substantiated that "the basic infantry weapon is actually used, on the average, at shorter ranges than commonly believed." Thus, ORO concluded, the existing combat rifle, with a maximum range capability of 3,500 yards, was "overdesigned" and overpowerful, as 90% of all observations were made at much shorter ranges.

The problem, therefore, lay not with the *rifle*, but with the *man*. Mr. Hitchman noted:

> *it is interesting . . . that at all common ranges,* weapon errors *are without significance in the man-weapons system . . . the dispersion of the weapon could be more than double without materially affecting the probability of hitting the target . . . weapons-design standards which seek perfection by making the rifle more accurate (approach zero dispersion) . . are not supported by this analysis as genuine military requirements.* Errors in aiming *have been found to be the greatest single factor contributing to the lack of effectiveness of the man-rifle system . . . [in combat] men who are graded . . as expert riflemen do not perform satisfactorily at common battle ranges.*

ORO's dramatic dissection of the Army's rifle problem had, typically, gone far deeper into an analysis of every aspect of the man-weapon system that many were prepared to accept. The Hitchman report's suggested solution to low combat effectiveness was to compensate *intentionally* for the soldier's inherent aiming errors by developing a new type of automatic arm capable of projecting missiles either in a burst or *salvo*:



4. An historic photo showing the successful launching of two projectiles from a single cartridge case, which proved the feasibility of ORO's nested-multiple-bullet "salvo" concept. "Round no.5", fired on October 20, 1953, clearly shows both 140.2-grain projectiles 10" from the muzzle (of a modified BAR) and proceeding downrange in an orderly fashion, propelled by 40 grains of IMR 4895 powder.

> *. . either a simultaneous [salvo], or a high cyclic rate burst, with the number of rounds per burst automatically set rather than dependent upon trigger release. In the . . (single-barrel burst) design, controlled nutation [nutate: to nod or droop] of the rifle muzzle would provide the desired shot dispersion or pattern; in the . . (salvo), the scatter would be obtained and controlled by multiple barrels, a mother-daughter type of projectile, or projection of missiles in the manner of a shotgun."*

For its posited salvo weapon, ORO had already narrowed down such variables as caliber size and the size of the burst, both in number-of-rounds-fired and in optimum target spread. Referring again to the earlier Hall study and other pioneering small-caliber work then in progress under Ordnance Corps direction at Aberdeen Proving Grounds, ORO noted that "quite apart from the idealized

5. The rationale behind Project SALVO: ORO's concept of intentional *dispersion to minimize aiming error and improve hit probability, as dramatized by Springfield Armory.*

concept of a salvo weapon, sufficient evidence is at hand to be quite certain that a light, high-velocity, small caliber rifle could be designed for military use . . . a .21 cal. missile of . . about 3,500 feet per second [muzzle] velocity creates equal or greater damage than the standard .30 cal. missile at ranges up to 800 yards."

Encouragingly, ORO was in favor of the Ordnance Corps' parallel development of the SCHV concept for other reasons as well: ORO's research indicated four or five rounds as the optimum burst size, and Aberdeen's 60-grain, homologous .220 cal. missile "suggested the possibility of obtaining logistic equivalence (that is, equivalence in weight of weapon and ammunition carried) between a four-round salvo [of .220 rounds] and present single-shot [M1] rifle fire."

Mr. Hitchman summed up: "a cyclic or salvo-type hand weapon would materially increase the effectiveness of aimed fire among the infantry . . . it appears that the best design (for the greatest practical gains) is one using the four-round salvo with 20-in. spacing among rounds at 300 yards range." The relative hit effectiveness of such a four-round salvo was found to be more than double that of the M1. In other words, this "would raise the performance of common marksmen using the salvo weapon to the level of expert riflemen using the M1."

The Fantastic World of Project SALVO

6. The old in the service of the new: two modified Winchester falling-block rifles in tandem form a rudimentary multi-barrel SALVO test weapon in an early contracted study.
Winchester/Western Research Department, New Haven, Ct.

With the publication of the Hall and Hitchman studies, the lid, which Col. Studler had tried so long to keep firmly in place, was off Pandora's box forever. Traditional US Army attitudes and loyalties towards its most basic combat weapon were deeply held, however, and not easily changed. Indeed, long-term Ordnance projects, while always susceptible to the vagaries of funding and popularity, proved very difficult if not impossible to turn around in mid-stream.

Consider the unfortunate state of affairs in Col. Studler's vaunted "lightweight" rifle program, wherein his original favorite, the T25, had evolved briefly into the T47 only to be ignominiously terminated in favor of what was basically nothing more than a "product-improved" M1 Garand. This arm, the selective-fire, 20-shot T44, had been in its initial stages of development at Springfield Armory when the Hall study and the Hitchman report were released in 1952. The controversial ORO/BRL results stood in direct opposition to nearly every single feature the Army had approved in the T44. Nevertheless, the luckless M14 rifle, the final embodiment of the T44, was to be adamantly adopted as the standard US service rifle after five more years of snail's-paced refinement. During this time the privately-developed .223-caliber ArmaLite AR-15 had appeared, a direct result of ORO/BRL research and the resulting SALVO studies. Ultimately, it was to render both the M14 and the 7.62 NATO cartridge obsolete.

Fig_1_

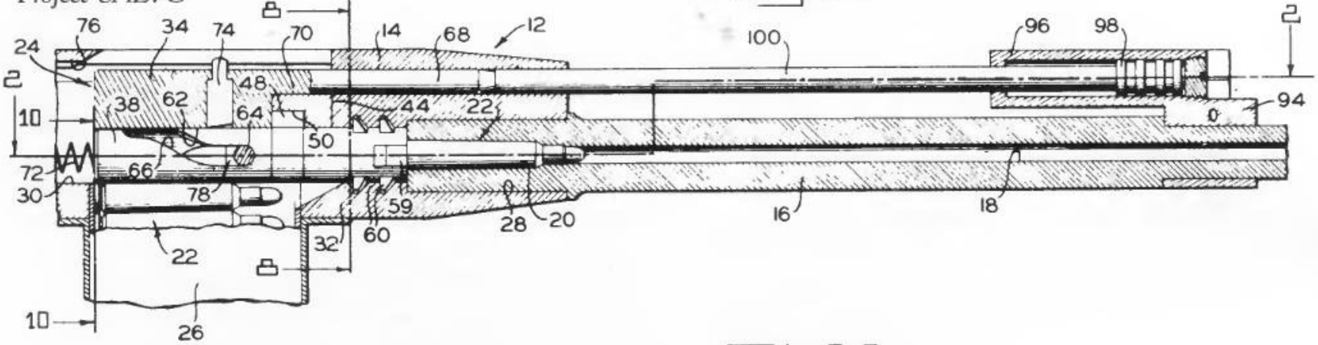
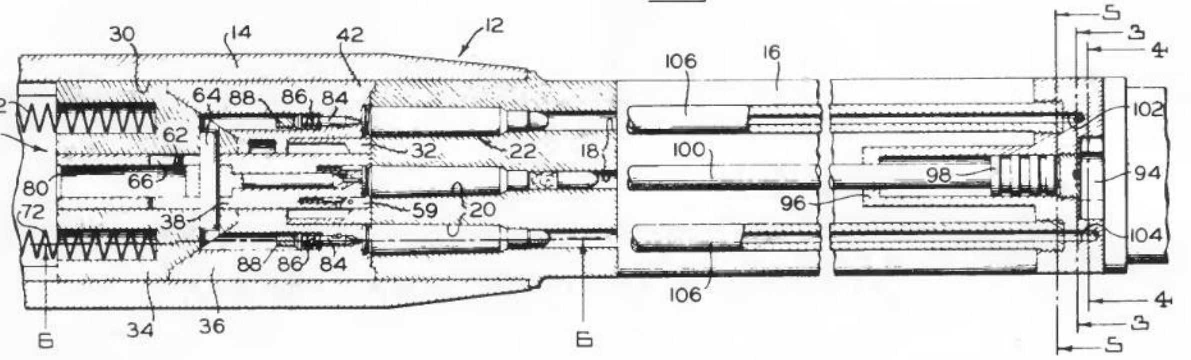


Fig_2_



7. *Patent drawings of a Springfield Armory 3-barrel SALVO weapon, designed by Robert F. Magardo and Donald C. Dadmun. This ingenious weapon was to fire a near-simultaneous, three-round burst. Trigger pressure fired the center barrel, whereupon a gas piston activated the firing pin of barrel no. 2 (Patent fig. 6), which in turn similarly fired the third barrel. The gas piston from barrel no. 3 activated the turning bolt to extract and eject all three fired cases, and reload all three barrels from the triple magazine (Patent fig. 10).*
US Patent Office.

Fig_6_

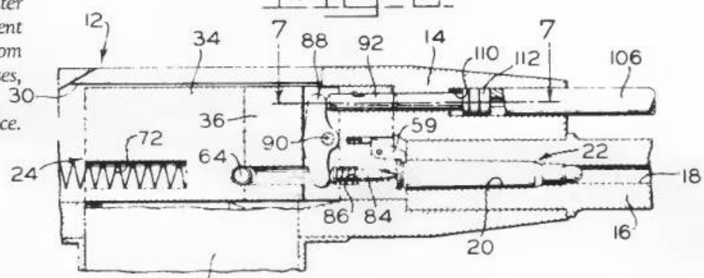


Fig_9_

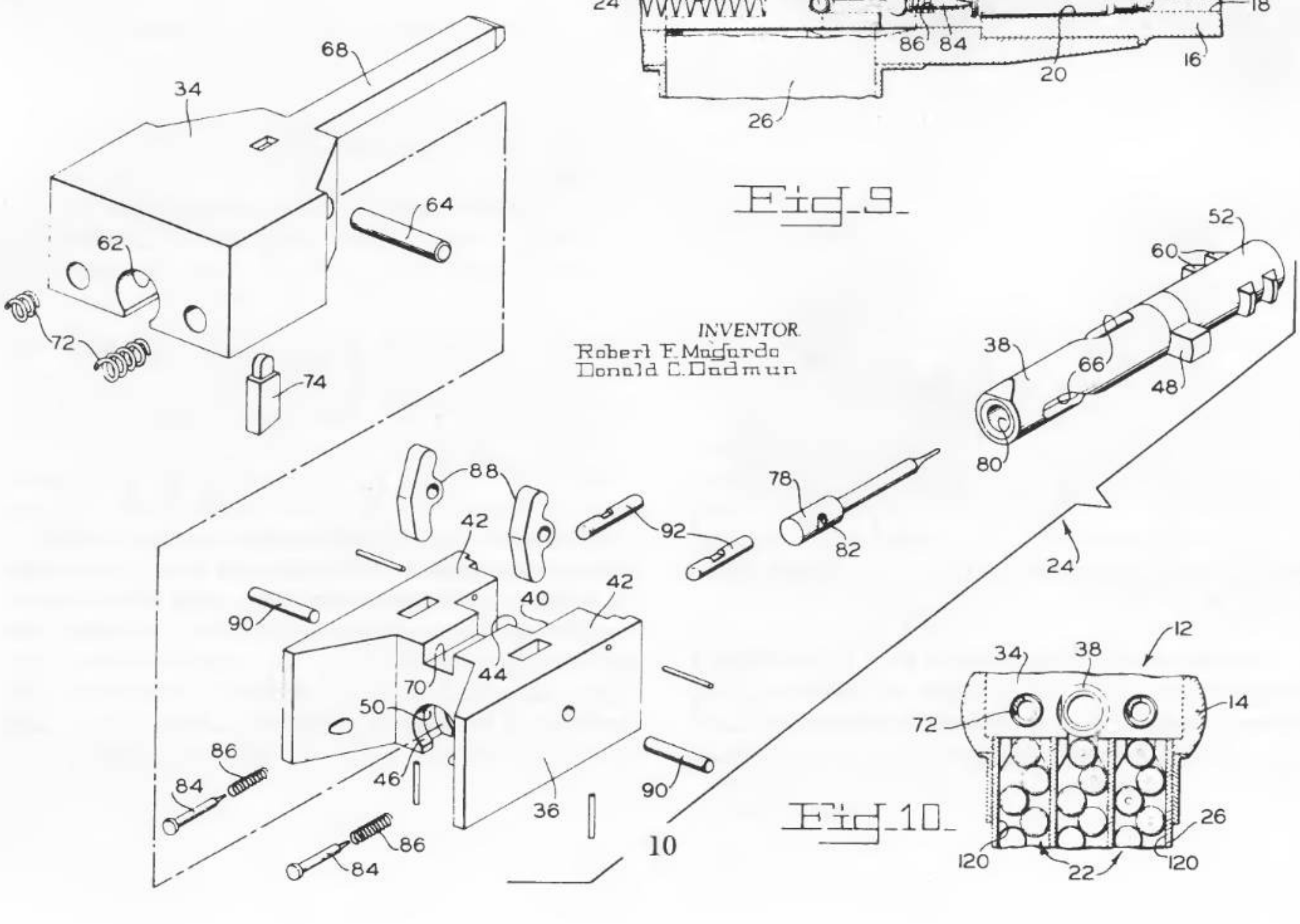
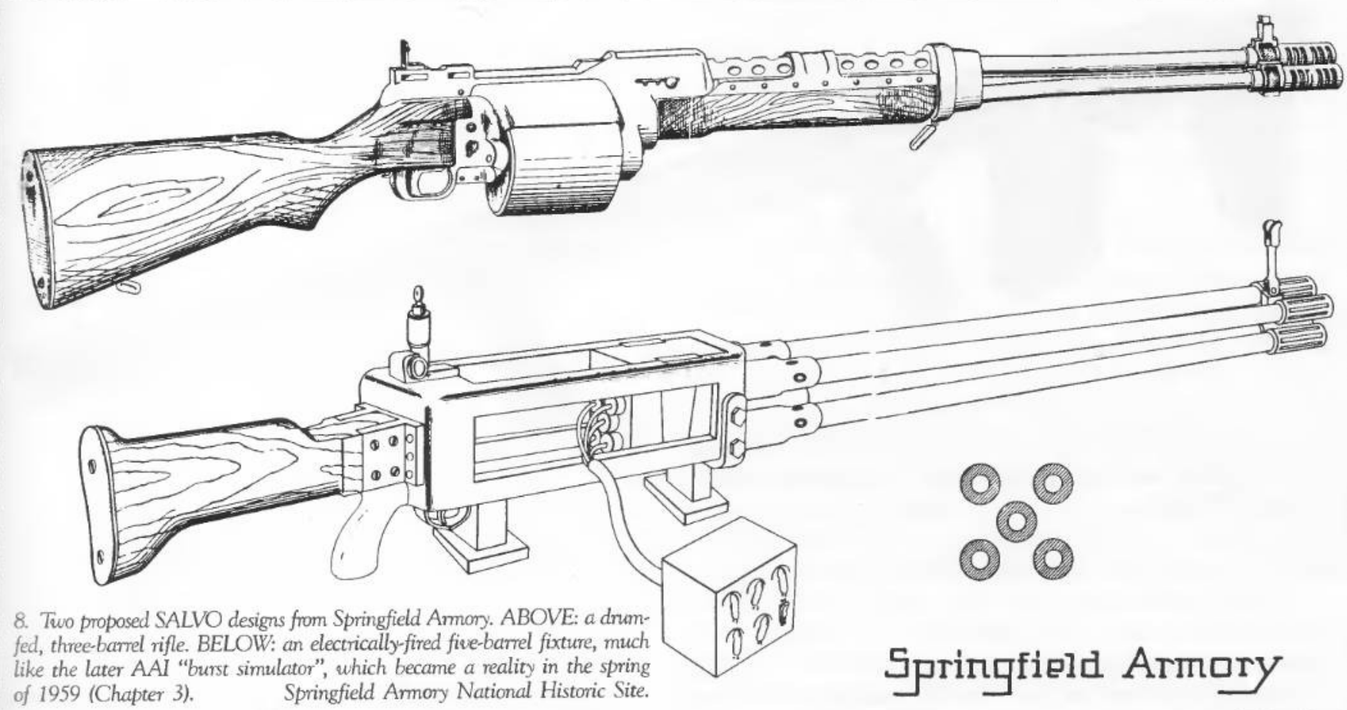


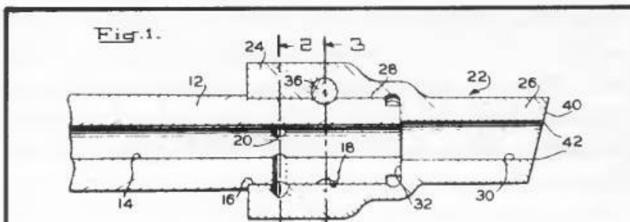
Fig_10_



8. Two proposed SALVO designs from Springfield Armory. ABOVE: a drum-fed, three-barrel rifle. BELOW: an electrically-fired five-barrel fixture, much like the later AAI "burst simulator", which became a reality in the spring of 1959 (Chapter 3). Springfield Armory National Historic Site.

The initiation of the multi-agency SALVO Project in November of 1952 was the main immediate reaction to the Hall and Hitchman studies. This organized and concerted effort pursued a number of recommendations which Hall and Hitchman had made in the name of increased combat efficiency. The SALVO Steering Committee was chaired by a representative of OCO, thereby supposedly assuring that at least nominal control of the whole project remained with the Office, Chief of Ordnance. However, the pilot feasibility studies were supplied by the Operations Research Office: Dr. Carten soon found that it required every tactic he had learned at the feet of his now-retired mentor to keep a determined leash on the enthusiastic ORO theoreticians.

Rivalries intensified almost immediately as the various agencies began to identify very strongly with the rationales of their individual SALVO sub-projects. ORO, for example, aside from considering itself the initiator and thus the only true arbiter of the whole project, became initially a strong and vociferous proponent of the nested-multiple-bullet, single-barrel salvo weapon concept. Over the period of the SALVO study, ORO designed and tested Duplex and Triplex loadings in several US developmental cartridges. Indeed, a version of the ORO Duplex loading of the 7.62mm NATO cartridge was subsequently adopted: ORO later termed the green-tipped M198 Duplex round, with considerable justification, a "low-cost, low-risk, high-payoff innovation". Curiously, the M198 cartridge was never made in significant numbers, nor was it ever issued in any but token quantities.



9. Another SALVO idea, from the designer of the T25 rifle, Earle M. Harvey. This gas-operated muzzle device rotated a few degrees with each fired shot, intentionally deflecting the bullets in different directions due to its slightly off-square front end. US Patent Office.

10. A wooden mock-up of another three-barreled Springfield SALVO rifle, featuring a bullpup butt and breech remarkably akin to John Garand's last rifle design for the Armory, the ill-fated T31 (discussed in Volume I US Rifle M14, *p.107).*

Springfield Armory and Olin (Winchester) drew up plans for several complex and unwieldy prototypes of two- and three-barreled salvo weapons, designed to fire near-simultaneous bursts of small caliber projectiles. Valuable research into the nature of burst fire was gleaned from each of these studies, but as a design for a combat shoulder rifle, the sheer and dismaying forward imbalance of their weighty multiple barrels proved utterly impracticable.

On another tack, the Office of Naval Research had initiated a contract in 1952 with Aircraft Armaments Inc., of Cockeysville, Maryland, to supply for test a quantity of 12-gauge shotgun shells, each loaded with 32 small nested steel "flechettes", or arrows. Impressive preliminary tests showed that these tiny, 8-grain flechettes were capable of penetrating nearly six inches of wood at 100 yards.

The SALVO I Field Experiment

Nineteen-fifty-six was an eventful year indeed for US Army Ordnance developments. The ArmaLite AR-10 rifle had been introduced to the Infantry Board and other officers, and many thought it an admirable attempt to create a truly modern and controllable light auto rifle firing the 7.62mm NATO cartridge. Later in that year, the AR-10 was rather reluctantly tested and then summarily dismissed at Springfield Armory. ArmaLite complained loudly that they had been given short shrift, thus adding more fuel to the growing "lightweight rifle" controversy. The latest developmental model of the T44, the nine-pound T44E4, was meanwhile still nearly a full year away from adoption as the M14.

This then was the backdrop for what became known as the "SALVO I Field Experiment". Within this framework of innovative combat simulation, three different SALVO concepts were tested during June and July of 1956, alongside the M1 rifle firing the standard M2 AP cartridge as control. The first SALVO project tested concerned ORO's original "long-necked" Duplex and Triplex loadings of the .30 M2 round, fired semi-automatically from modified M1s. Next came two products of the small caliber, high-velocity (SCHV) research being conducted by Aberdeen's BRL and D&PS agencies: a modified M2 Carbine firing a 41-grain, .22 caliber bullet, and a modified, selective-fire T48 (the American-made FAL rifle) firing a 68-grain, .22 bullet from a necked-down NATO case. Finally, a Remington model 11-48 shotgun had been made up with a suitably strengthened barrel, for testing the 32-flechette AAI shotshell.

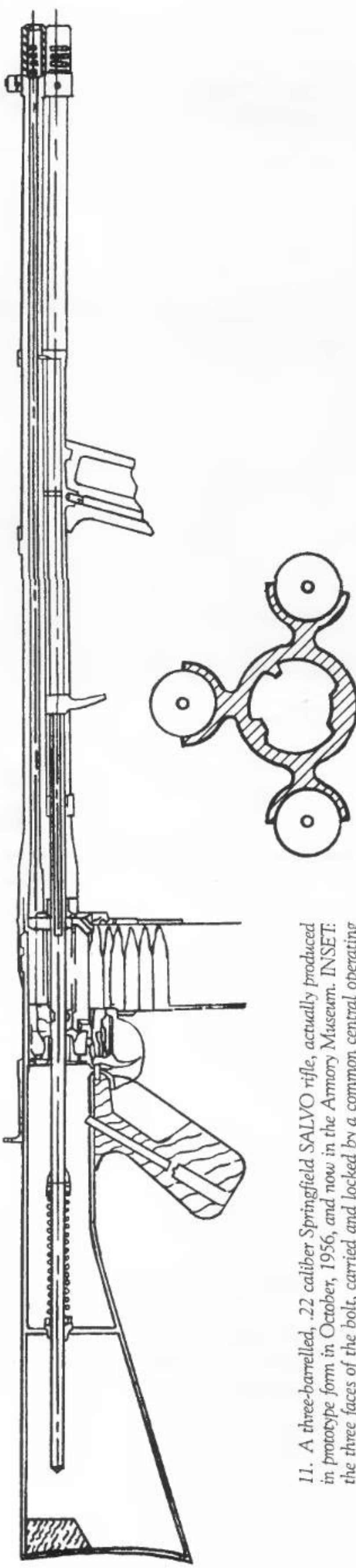
General conclusions made after the trial were that typical combat aiming errors were in fact even greater than had previously been allowed for. Automatic fire was again proven inferior to aimed single shots on point-fire targets.

The results were somewhat disappointing for Aberdeen's SCHV concept, as the .22 test barrels tended to "walk" badly when heated by rapid burst fire, rendering the weapons extremely inaccurate and thus denying BRL's high theoretical hit probability forecasts any conclusive, practical proof.

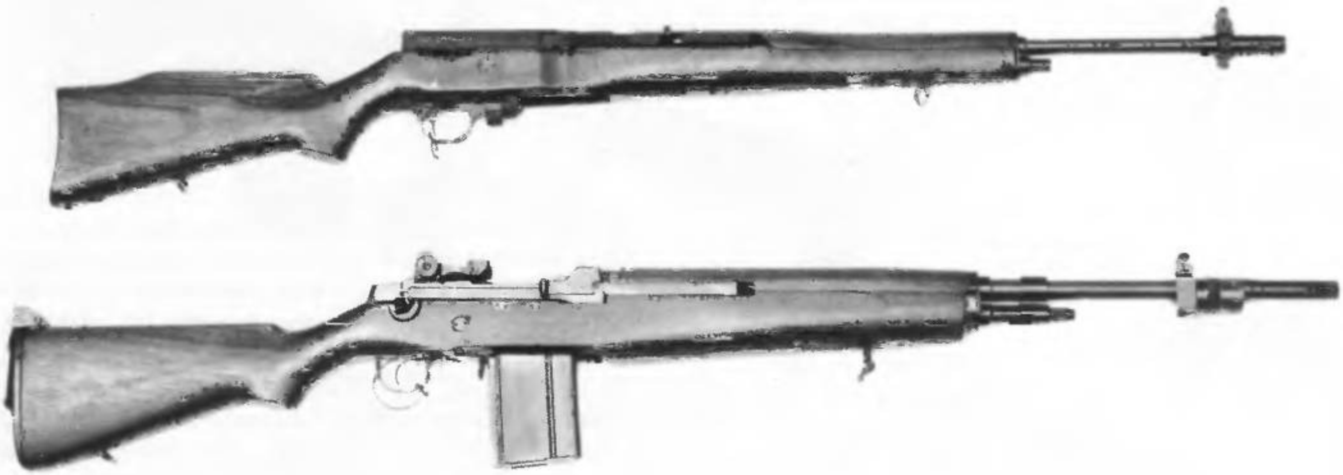
Regarding ORO's "long-necked" Duplex and Triplex .30 M2 loadings, the results were extremely encouraging. These further studies substantiated the Hitchman report's findings that bullets fired in a simultaneous salvo are *independently* potentially lethal, and therefore for each shot fired a *sum of lethal probabilities* existed, which increased the statistical kill probability dramatically over that of single-bullet firings. Indeed, ORO reported in the SALVO I results that .30 Duplex cartridges showed a 65% increase in kill probability over standard (Simplex) rounds. The Triplex loading produced double the hit rate of single bullets; further tests might even prove them superior to the Duplex loads. Meanwhile, the shotgun-launched clusters of flechettes were found to have a distinctive value in the short-range area-fire role, especially in darkness.

From April to September of 1957, Mr. Lawrence F. Moore of Aberdeen's Development and Proof Services (D&PS) further examined the material from SALVO I to obtain measured data on velocity, penetration and accuracy. In his final report, *A Test of SALVO Rifle Material*, Mr. Moore noted that the multiple-flechette shotshells gave an instrumental velocity at seven feet from the muzzle of an average 1,258 fps. In a dispersion trial however, only fifty-two percent impacted into a 30-inch circle at 40 yards.

Both SALVO I and the Aberdeen studies thus indicated a lack of control over the dispersion of multiple flechettes. On the other hand, Mr. Moore reported that, even when launched in a cluster from the relatively low-pressure shotshell, the .087-inch diameter flechettes would often pass cleanly through one side of an M1 helmet and liner at 300 yards, and would sometimes even make a hole in both at 500 yards!



11. A three-barrelled, .22 caliber Springfield SALVO rifle, actually produced in prototype form in October, 1956, and now in the Armory Museum. INSET: the three faces of the bolt, carried and locked by a common central operating rod and rotary locking ring. Springfield Armory National Historic Site.



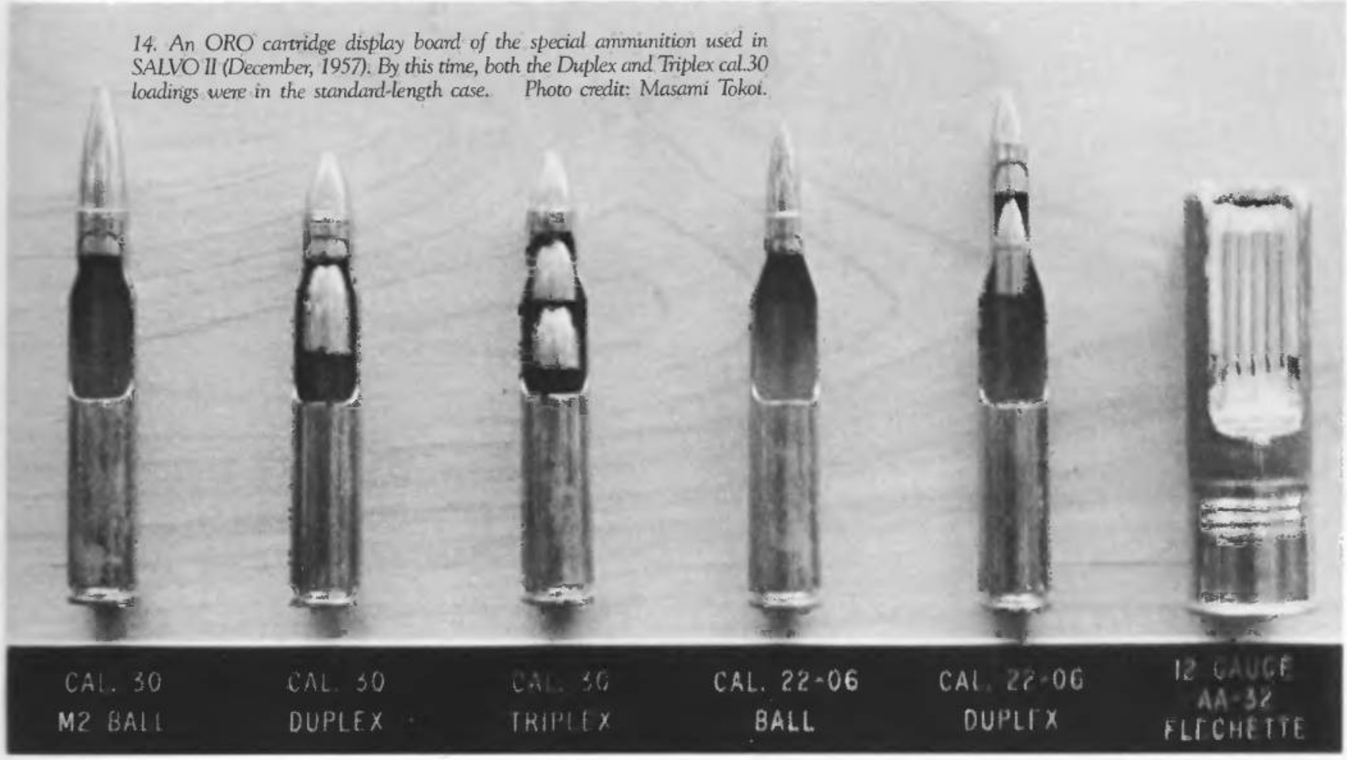
12. Two contenders from Col. Studler's "lightweight rifle" program, circa 1952. ABOVE: an unserialled Harvey T25E1, chambered for the 7.62×49mm FA T1E1. BELOW: the 14.5-lb. T44E5, ser. no. 1369; the heavy-barrel version of the T44; caliber 7.62×51mm. The "T" series of rifles is fully discussed in US Rifle M14.

QAD (Ord) Pattern Room, Enfield Lock, Middlesex, England.

Cartridge					
Type	**Muzzle Velocity (fps)**	**Bullet Weight (grains)**	**Total Weight (grains)**	**Weapon**	**Method of Fire**
Standard M2 AP, cal .30	**2,760**	**163**	**414**	**M1 rifle**	**semiautomatic**
Duplex, cal .30	**2,630**	**96**	**449**	**modified M1 rifle**	**semiautomatic**
Triplex, cal .30	**2,630**	**61**	**439**	**modified M1 rifle**	**semiautomatic**
Carbine, cal .22 (modified M1 case)	**3,125**	**41**	**135**	**modified M2 carbine**	**automatic and semiautomatic**
Sierra, cal .22 (modified NATO case)	**3,400**	**68**	**280**	**modified T48 rifle**	**automatic and semiautomatic**
Flechette - 32	**1,400**	**13**	**720**	**Remington shotgun, 12-gauge, Model 11-48**	**semiautomatic**

13. A table showing details of the special ammunition used in the SALVO I Field Experiment at Fort Benning, June-July, 1956. (The Duplex and Triplex caliber .30 rounds listed are the original "long-necked" versions, as shown in the top row of figure 1).

US Army TIR 27.1.1.1 (Interim Report) October, 1964.



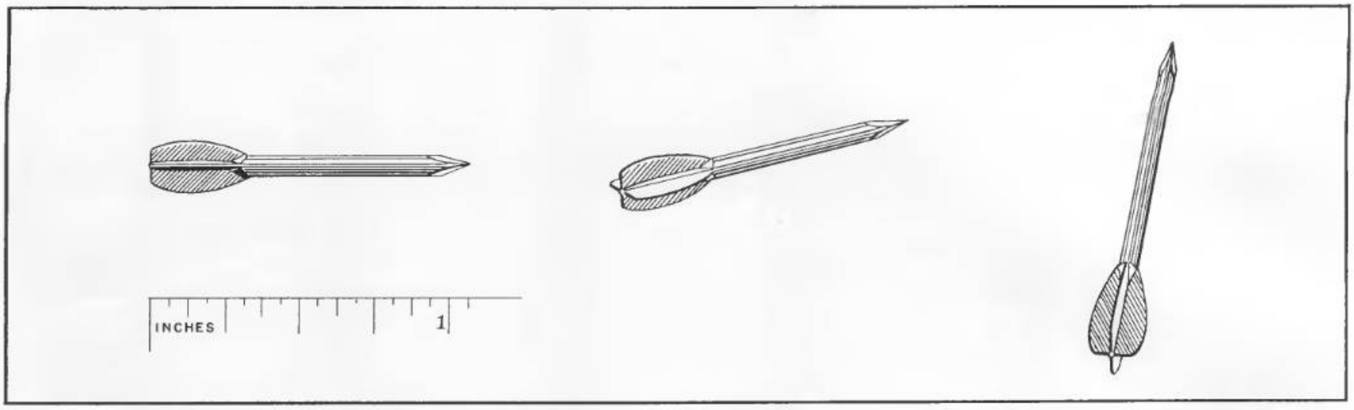
14. An ORO cartridge display board of the special ammunition used in SALVO II (December, 1957). By this time, both the Duplex and Triplex cal.30 loadings were in the standard-length case. Photo credit: Masami Tokoi.

Cartridge					
Type	**Muzzle Velocity (fps)**	**Bullet Weight (grains)**	**Total Weight (grains)**	**Weapon**	**Method of Fire**
Standard M2 ball, cal .30	2,810	150	391	M1 rifle	semiautomatic
Duplex, cal .30	2,645* 2,502**	96	439	M1 rifle	semiautomatic
Triplex, cal .30	2,913* 2,754** 2,251***	61	427	modified M1 rifle	semiautomatic
Ball, cal .30/.22	3,350	62	326	modified M1 rifle	semiautomatic
Duplex, cal .22-06	2,975*; 2,897**	50	351	modified M1 rifle	semiautomatic
Flechette - 32	1,350	13	729	modified Remington shotgun, 12-gauge, Model 11-48	semiautomatic

* first bullet
** second bullet
*** third bullet

15. Characteristics of the special ammunition used in SALVO II. Compare with figure 13. US Army TIR 27.1.1.1 (Interim Report) October 1964.

Once More With Feeling — SALVO II

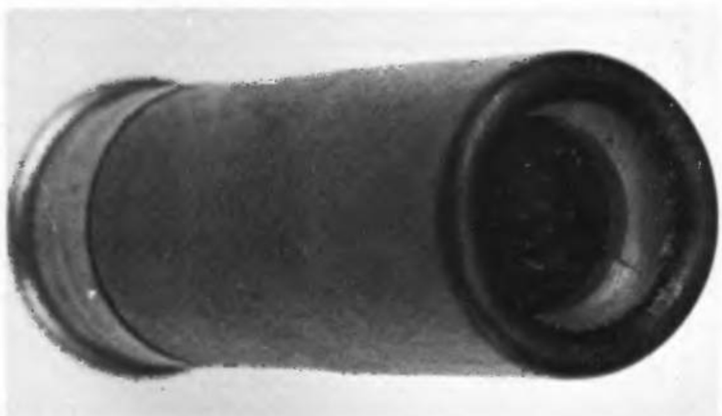


16. Three views of the AAI 8-grain flechette, as featured in the 32- flechette shotshell in SALVO II. In a 1957 test of SALVO material at Aberdeen Proving Ground, it was found that even when fired from the relatively low-pressure shotshell, these .087"-diameter flechettes would often perforate one side of a helmet and liner at 300 yards, and sometimes even puncture one side of both at 500 yards!

Both the Continental Army Command (CONARC) and its test agency, the Army Infantry Board, were headquartered at Fort Benning, and Infantry Board officers had enthusiastically observed the SALVO I trials. Improvements made as a result of the SALVO I field test led to a further series of trials at Fort Benning in December, 1957. Dubbed naturally SALVO II, they sought to gather more meaningful data on measured hit probabilities. The end result was the first-ever true comparison of ammunition effectiveness under conditions realistically simulating actual combat. ORO found that the accuracy of aimed fire changed when variances in range, target exposure time, and degree of marksmanship skill were introduced. These fluctuations were painstakingly added to the basic equation, with the aid of the innovative ORO measuring techniques already in place for the hit probability studies.

In sum, SALVO II confirmed to the ORO analysts that target exposure time and the actual area presented by the target were the determining hit-probability factors. Target movement and degree of incoming enemy fire were the variables next in importance. On the ammunition side, the usefulness of ORO's new standard-length-case Duplex concept was further borne out, and it was at this point that ORO recommended a 7.62x51mm version be perfected and adopted as standard for combat use. In the face of the Army's hallowed marksmanship tradition, ORO stated flatly that accuracy requirements for any new shoulder rifle should be based on an intentional, built-in aiming error of three mils.

To the SALVO teams, there was now no question as to the effectiveness of multiple projectiles being delivered with each trigger pull. As noted, ORO had devised the Duplex bullet in the 7.62mm NATO case as the *most expedient* method of adopting this controlled dispersion theory. Soon, however, ORO switched allegiance to even more exciting and dramatic advances in hit probability, by marrying BRL's concept of high velocity and consequent flat trajectory to the almost imperceptibly low recoil impulse of a lightweight, *single* flechette. ORO recommended that by following this path, a controlled-dispersion burst weapon could become a reality for every American combat soldier. This new weapon would be devastatingly lethal, regardless of his individual marksmanship abilities.

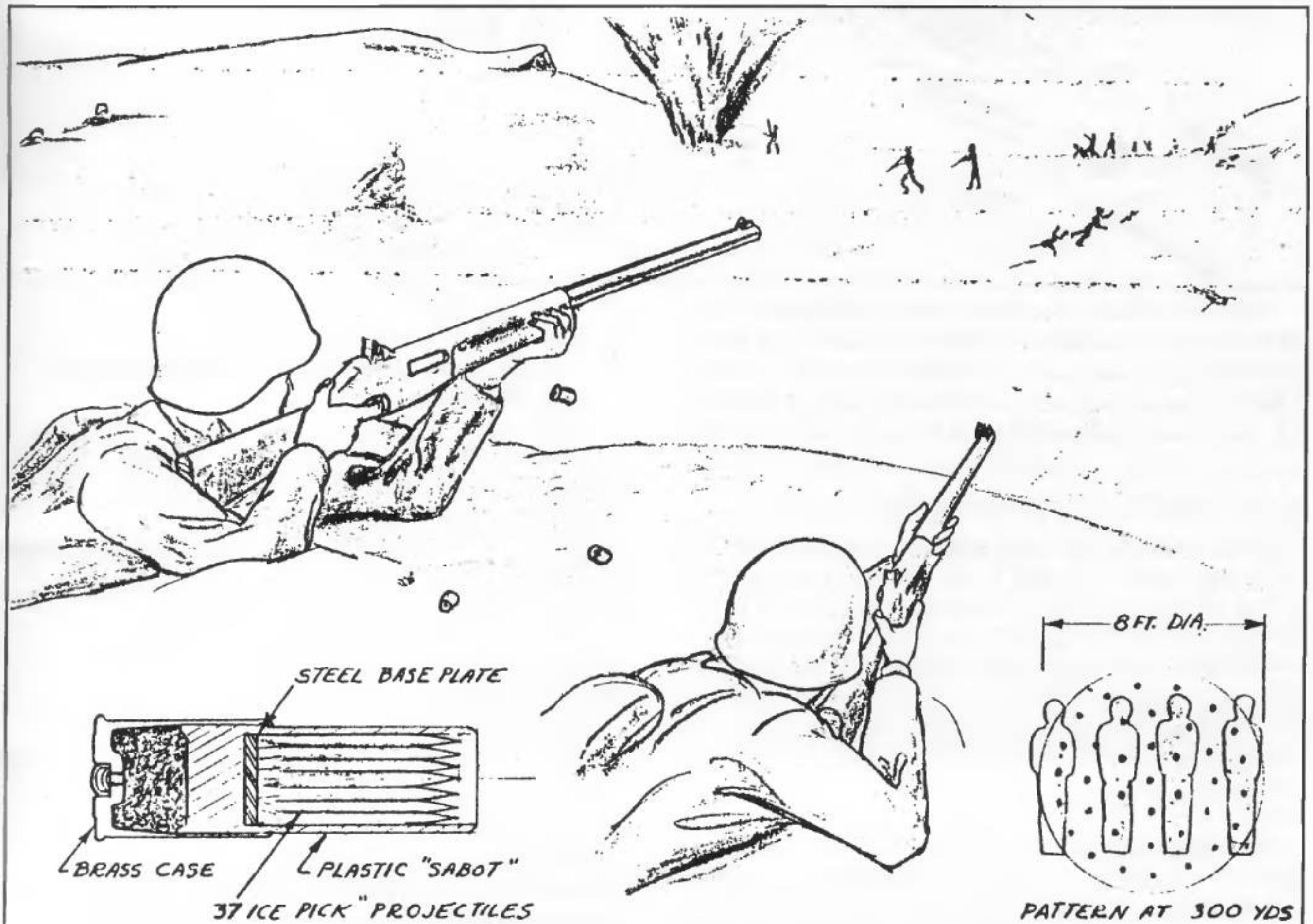


17. A look at the business end of the AAI 32-flechette shotshell. SALVO II found this loading to have considerable merit in the area-fire role, especially in darkness, although as a point-fire load its dispersion characteristics and therefore its range limitations were disappointing.

Chapter Two

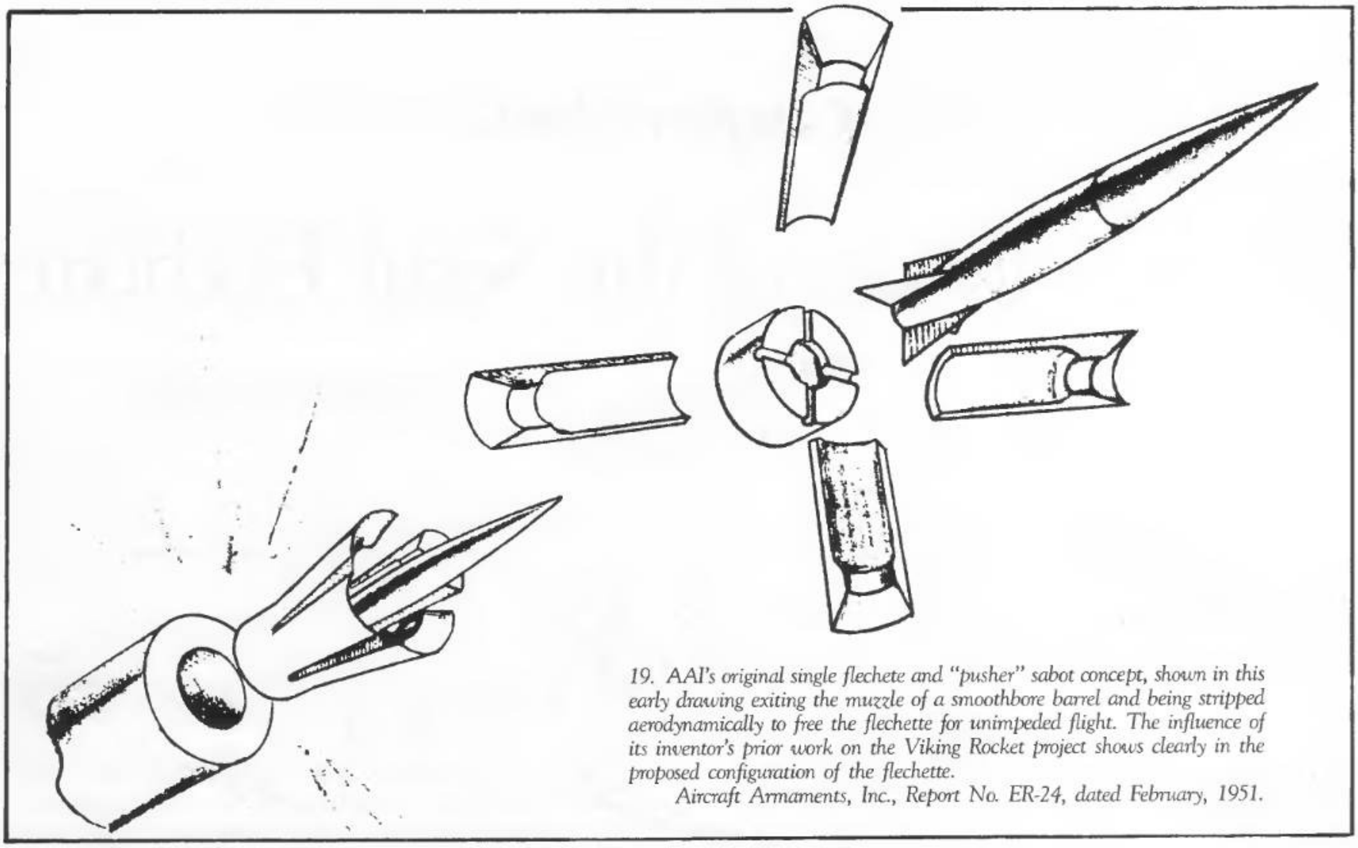
The Evolution of the Serial Flechette

The Concept



18. Aircraft Armaments Inc.'s fledgling idea for a devastating new Infantry weapon, circa 1951. At that time it was proposed that each shot would fire 37 of AAI's "ice pick projectiles", which it was hoped would produce a lethal pattern at 300 yards. With ORO's research and the results of the SALVO program pointing the way, AAI soon abandoned the shotshell approach in favor of the phenomenal improvements in hit probability and lethality offered by a high-speed burst of lightweight, single flechettes.

Aircraft Armaments, Inc., Report No. ER-24, dated February, 1951.



19. AAI's original single flechette and "pusher" sabot concept, shown in this early drawing exiting the muzzle of a smoothbore barrel and being stripped aerodynamically to free the flechette for unimpeded flight. The influence of its inventor's prior work on the Viking Rocket project shows clearly in the proposed configuration of the flechette.
Aircraft Armaments, Inc., Report No. ER-24, dated February, 1951.

Mr. Irwin R. Barr, one of the seven founders in 1950 of Aircraft Armaments Inc., is by all accounts the father and leading proponent of the flechette concept. Initially Chief Ordnance Engineer (and now President) of the firm, Mr. Barr introduced the flechette idea in an unofficial biography of the times which he later wrote, entitled *History of Fin Stabilized Ammunition*, as follows:

> *The idea of fin stabilized projectiles really dates back to the arrows of ancient times. The use of this type of projectile in modern history has been limited to occasional use in World Wars I and II. The French in World War I used them in the form of long steel arrows dropped from aircraft and coined the name "flechette", or little arrow. In World War II, the Germans used both multiple and single arrow projectiles as cannon ammunition .*

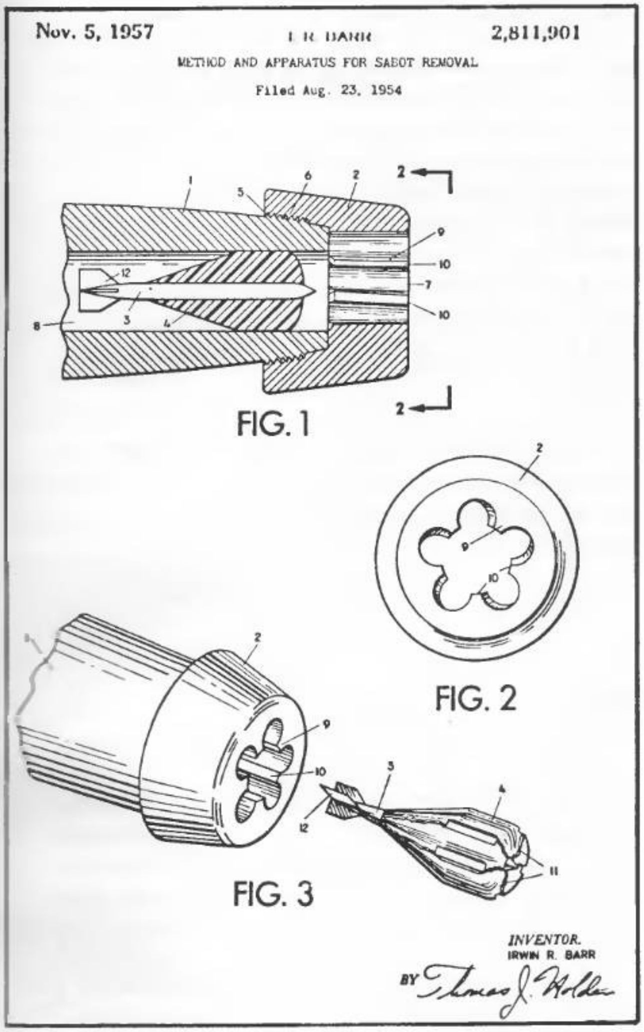
Mr. Barr had already seen his ideas become reality to an initial degree in the US Naval Research contract for the 32-flechette shotshell of 1952, but felt that the concept had even more to offer. As Mr. Barr himself said, in a later article subtitled "[SPIW] Developer Details History", published in *The Rifle Magazine* of July-August, 1969:

> *The large dispersion of these [shotshell] projectiles and the resulting short range limitations . . caused us to feel that another radically opposite approach was required to achieve the high 'Salvo' hit capability of a rifle at long ranges by using a short burst of serial-fired flechettes.*

Mr. Barr had left a ten-year career in weapons, rocket and guided missile design at the Glenn L. Martin Company to join the group which formed Aircraft Armaments. His last job at Martin had been as a group engineer in charge of design of the Viking Rocket. As he reports in his historical biography, "Wind tunnel tests of the long finned shape of the Viking Rocket had established drag coefficients and stability criteria at high mach numbers that were not available before . . . [the] idea of applying this principle to small arms ammunition was formulated from this data."

For several years after the time of the shotshell contract, Aircraft Armaments continued to experiment with the single flechette idea without any outside assistance or funding, gambling that the flechette's innate advantages of minimal recoil, high penetrating power and light weight would ultimately not go unnoticed. As Mr. Barr recalls in his biography,

> *Several model projectiles were made from hardened steel sewing needles with fins silver-soldered to the back. These were fired from a .22 caliber rifle using a pusher-type sabot. They had stable flight characteristics but were not very accurate.*



20. Original Patent drawings, filed in August of 1954, of the "puller" sabot and stripper idea, which allowed for a much more compact cartridge than that possible with a "pusher" sabot situated behind the flechette. The concept was that the "puller" sabot (Patent fig. 1, no. 4) would grip the body of the flechette by friction and constriction alone, like the "chuck" in a drill, and be separated at the muzzle by being slit and spun by the angled ribs (Patent figs. 2 and 3, nos. 9 and 10) in the stripper. *US Patent Office.*

Whereas a standard bullet is *spin*-stabilized, the spin being imparted by rifling in the gun barrel, the flechette is *fin*-stabilized by means of its own feather-like fins, which are of a greater diameter than the body of the flechette itself. Rifling was found to be unnecessary, and the AAI flechette as it evolved was designed to be fired from a smoothbore barrel, with a bore size necessarily slightly larger than the diameter of the fins.

Two initial considerations when firing single flechettes were to guide the reduced diameter of the body of the arrow-like flechette on its short and speedy trip to the muzzle, and also to provide an adequate gas seal around it. Enter the sabot; a sort of segmented, bore-sized plug which would either sit behind the flechette and *push* it, or grip the body of the flechette firmly and *pull* it down the bore. Mr Barr's *History* records the important early evolution of the sabot:

> *All previous work by AAI on single projectiles utilized a pusher type of sabot. However, this configuration would make a cartridge too long to be satisfactory as the propellant had to be packed behind the long, thin, needle projectile and sabot.*
>
> *Arrow rounds for large caliber cannon had been built by the Germans during World War II using a sabot located at the center of the projectile. This transmitted the gas propelling force from the sabot to the projectile by means of threads. The metal sabot itself was split into four pieces and retained by the barrel, separating at the muzzle. The use of threads left much to be desired, as it increased the projectile drag and limited the pulling force . . . The basic [AAI] idea . . required a new concept. The projectile must be pulled by the sabot which would surround the forward part of the projectile . . . The new concept allowed this to be done without any threads, and thereby permitted the use of a light metal or plastic sabot. This invention of the puller sabot consisted of using the gas that propels the round to push inward on the sabot of constrictable material and so generating a friction force to transmit the pull of the sabot to the projectile. By utilizing materials with a sufficiently high coefficient of friction and some elasticity, the sabot would then act like a multiple-jaw chuck holding the projectile as a chuck does a drill, the holding force being generated by the inward push of the chamber pressure. A preliminary search of available literature revealed no evidence that this method had ever been used.*

Experiments were carried out with numerous designs and materials for the elusive puller sabot before the right combination was discovered and the "chuck" concept vindicated. During early trials in March, 1954, several rounds were fired from an ordinary .22 rifle using sabots machined from fiberglass rods. It was noted that sometimes the sabot would work perfectly while still in the bore, pulling the projectile without blowing off, but would not fracture and fall away from the flechette at the muzzle as it was supposed to. The solution was to add a short extension to the muzzle of the smoothbore barrel, resembling a machinist's threading die. The original half-inch-long prototype featured four inner projections similar to large angle rifling, set at a five-degree twist. Known as the "stripper", this scored and imparted a violent spin or twist to the sabot as it left the muzzle. The resulting shock and centrifugal force ensured that the segments flew apart and did not cling to the flechette to degrade its accuracy and velocity. Aircraft Armaments Inc. applied for patents on the basic concepts of its single flechette, puller sabot and muzzle stripper designs in July of 1954.

The key to any successful lethality comparison between the single flechette and the standard rifle bullet was velocity. The Hall study and other SCHV research had proven that a 50-grain, .22 caliber bullet could be just as deadly if not more so than the much heavier .30 caliber, if its velocity was kept high enough. For the 50-grain .22 bullet, this translated into a muzzle velocity of around 3,500 fps. The flechette that Mr. Barr's company was developing weighed only one-fifth of that: 10 grains. This of course was the secret of its remarkably low recoil signature, but it meant that the velocity would have to be correspondingly higher still.

Unlike a solid-core bullet, the flechette-sabot combination was only temporary; it was crucial that the sabot segments uniformly fall away at the muzzle to allow the flechette to travel down-range unimpeded. On the other hand, it was perhaps even *more* crucial that the assembly *not* separate *until* out of the barrel, at the risk of leaving part of one or the other as a potentially hazardous obstruction in the bore. The design of such a device, to say nothing of its successful and economical mass manufacture, was a challenge indeed, yet this is what the flechette concept entailed. In order to exploit the advantages so tantalyzingly offered by burst fire from a virtually recoil-free rifle, AAI had first to prove to the skeptics that a saboted flechette could withstand the awesome stresses of initial high-velocity launch, while ensuring a complete seal for the high-pressure gases behind it, and yet separate reliably once out of the bore.

As it turned out, nearly every facet of modern gun and cartridge technology was stretched beyond its known frontiers in the ensuing struggle to make the serial flechette concept work.

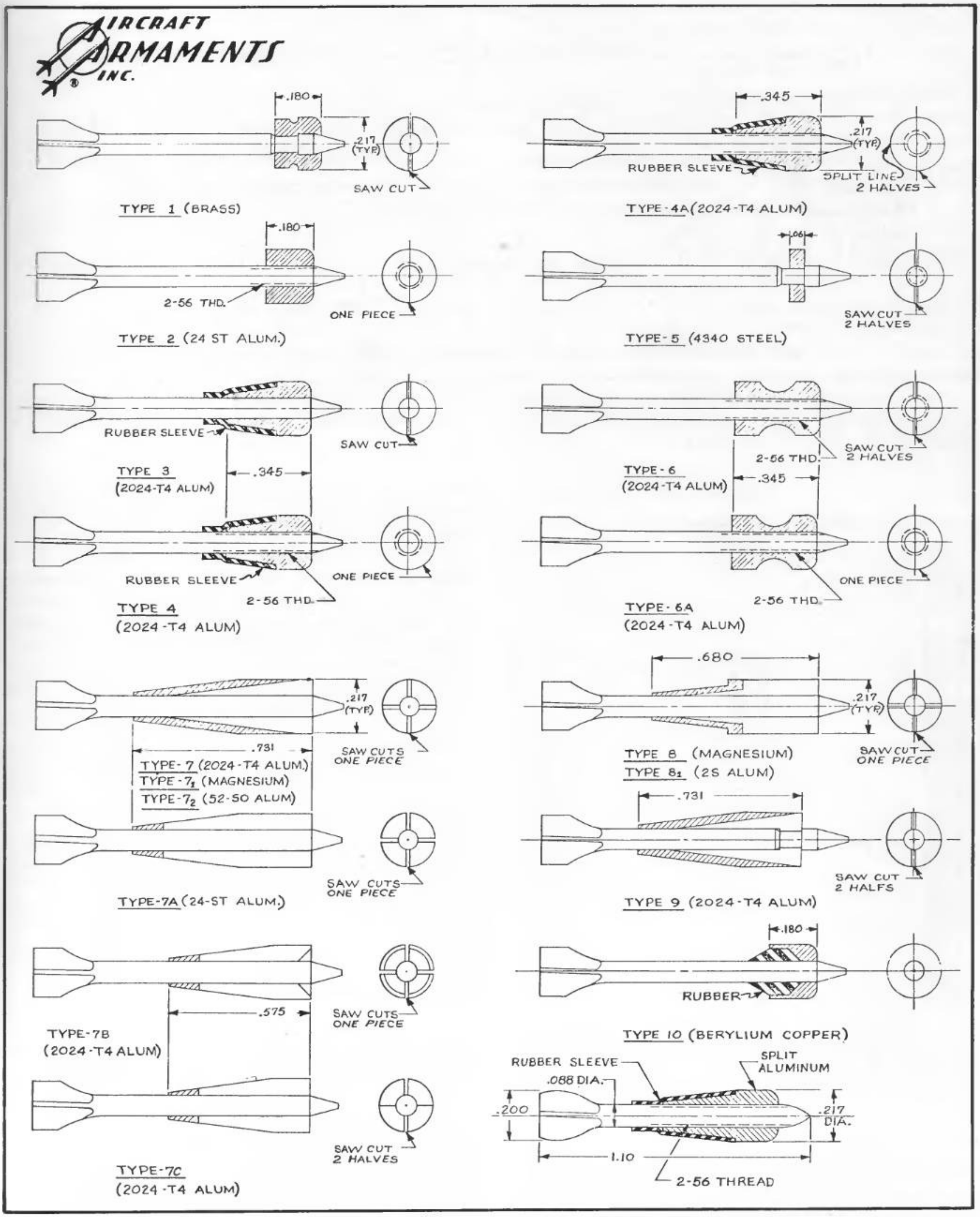
The Launch

Mr. Barr's faith in the flechette won Aircraft Armaments Inc. an Army development contract in 1956, the purpose of which was to "establish the feasibility of launching a fin stabilized projectile at an approximate velocity of 4,000 feet per second." Work commenced on the contracted study on May 9th, just one month before SALVO I began at Fort Benning. Mr. Barr's *Final Report, Small Arms Cartridge,* dated March, 1957, charts the whole interesting and complex procedure which led the AAI engineers from the basic concepts of flechette-and-sabot through a number of design refinements until, in the triumphant words of the report:

> *Feasibility of launching techniques has definitely been established during the current study. Various projectiles and sabot configurations have been successfully launched at muzzle velocities of approximately 4,000 feet per second. Down-range accuracies of the individual projectiles have been satisfactory in many of the configurations.*
>
> *The caliber .30 projectile weighs 150 grains. If comparable striking power can be obtained with ammunition weighing only one-seventh the present weight, and thus imposing only one-fifth of the present recoil force, a much lighter weapon can be produced with provisions for correspondingly greater ammunition capacity.*
>
> *From preliminary data, it appears that in normal usage a fin stabilized projectile weighing between 12 and 21 grains, striking in excess of 2,500 feet per second, will cause incapacitation in the same order as the caliber .30 M2 military projectile.*

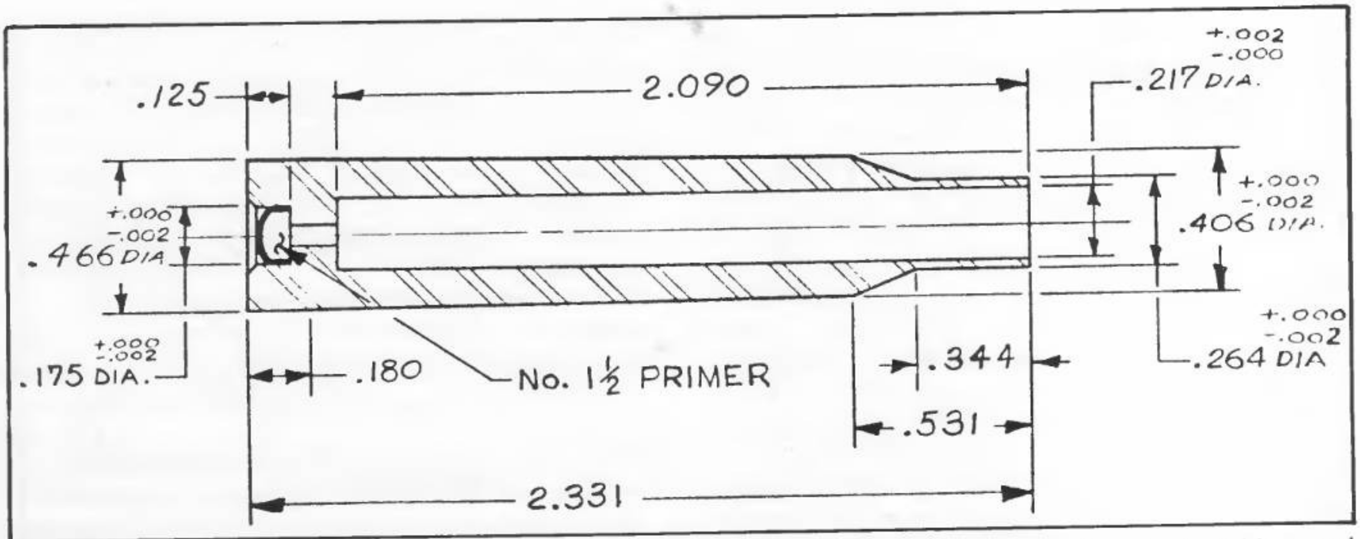
All the recorded 354 firings in the nine-month study were from a smoothbore .22 caliber Mann barrel. This heavy, single-shot fixed apparatus was fitted to a standard .30 caliber bolt action breech assembly and firing mechanism, with built-in provisions for measuring chamber pressure and other necessary data. The cartridge case used was of an extremely ingenious design, resembling a standard 7.62 NATO case on the outside, but only bored out internally to approximate the much smaller powder chamber dimensions contemplated in the final ammunition.

Mr. Barr's idea of a puller sabot gripping the flechette by pressure alone and thus acting as a "chuck" was proving problematical. The puller sabots were by this point being made of variously shaped segments of aluminum, brass or steel, and yet it was still found that the sabot's grip on the flechette had to be assured by mating it either with a threaded section on the flechette, or, alternatively, with a reduced-diameter portion of the flechette body. This in turn was proving unsatisfactory, for as velocity neared the desired 4,000 fps, the tensile stresses on the flechette approached 200,000 psi, and any thrust shoulder or thread undercut would fail, resulting in the flechette being literally pulled in half.

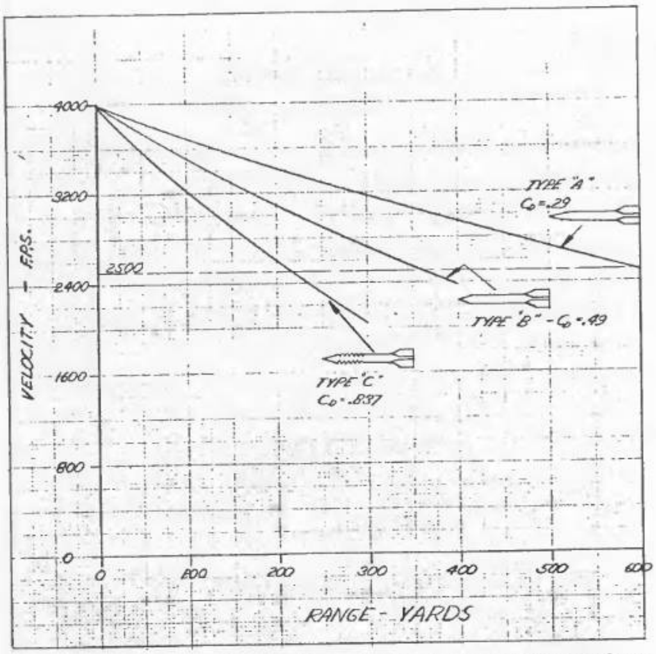


21. The "chuck" concept proved much more difficult to realize than AAI had anticipated, and numerous trial-and-error methods and materials were experimented with in the attempt. In order to ensure an adequate grip, and thereby a successful launch, most of these early experiments required actual threads or thrust shoulders on the flechette body, although this introduced a whole new series of worries and problems.

Aircraft Armaments Inc., Report No. ER-1026, dated March 5, 1957.



22. The special AAI cartridge case, fabricated in June of 1956 to support the 354 Mann-barrel firings recorded during the initial Army flechette development contract. The outside dimensions were those of the 7.62×51mm case, while the inside approximated the much smaller case volume of the proposed single-flechette cartridge. *Aircraft Armaments Inc.*

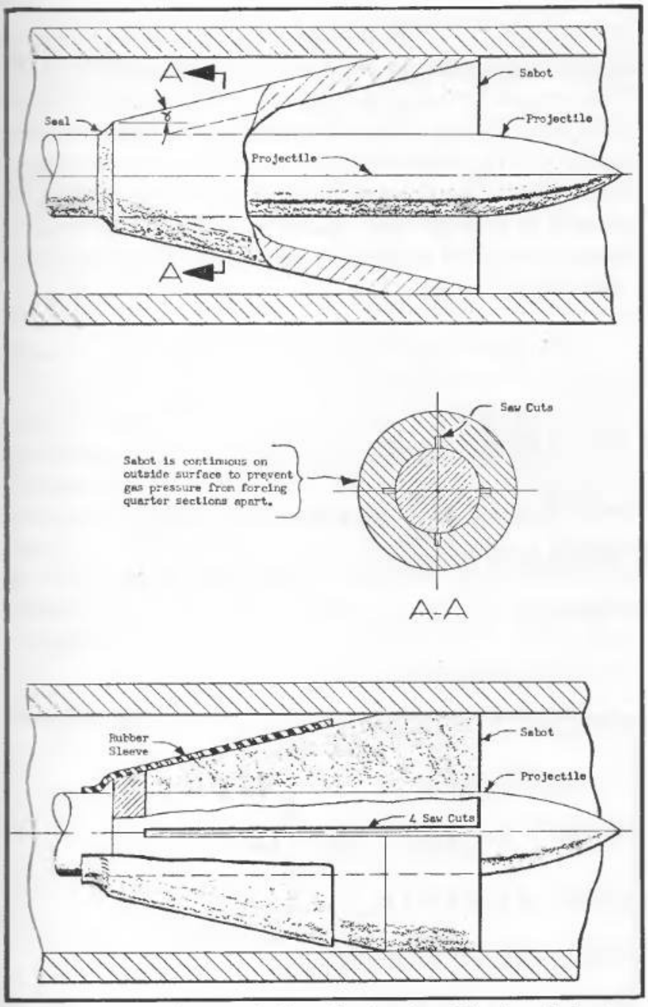


23. A chart of comparative remaining velocities for three different flechette configurations studied by AAI during the initial Army flechette development contract in 1956. Type "A" had the lowest coefficient of friction due to its smooth body and ogive nose configuration, and consequently gave the best results, still travelling at 2,500 fps at 600 yards. The velocity of Type "B", with a smooth body but semi-blunt nose, was 100 fps less at only 400 yards. Type "C" did the worst, with nearly three times the coefficient of friction as type "A" due to its threaded body and semi-blunt nose. *Aircraft Armaments Inc.*

Further trial-and-error established quite distinct limits for a number of features of the flechette's design. For example, .088-inch seemed to be the minimum diameter which would withstand the tensile stresses of the high-velocity launch, and since that was the diameter of the flechette body itself, the decision was taken to persist with the design of a sabot which would transmit force to the smooth circumference of the projectile by friction alone. Regarding the front end of the projectile, an ogive nose configuration gave better remaining-velocity results than a semi-blunt one. Too much projectile weight would result in the sabot being pulled right off the flechette while still accelerating down the bore. The metal sabot segments had moreover to be very meticulously fashioned in order to form an effective gas seal.

Further problems arose just as a new one-piece design of aluminum sabot, carefully slit for nearly its full length into quarters and then sheathed from the rear with a thin rubber skin or sleeve, performed satisfactorily both as a gas seal and in gripping the flechette and not losing it while still in the barrel. Once free of the muzzle, however, the rubber-sleeved sabot stubbornly refused to break apart, and travelled determinedly down range as an integral part of the projectile. Experiments with variations in slit length and sabot thicknesses continued to give erratic results and unreliable separations throughout the waning months of 1956.

Finally, a fresh look was taken at one of the basic premises of the whole program. The initial objective had been to launch a fin-stabilized projectile at about 4,000 fps, from the shortest possible cartridge case. (The length of the case was of prime concern, as it affected ammunition weight and consequently the length, weight and action time of the resulting weapon.) However, the shortest possible case meant the use of small-grained, rapid-burning powder, which required comparatively little case volume. The chronic sabot failures were finally traced to the nearly instantaneous high breech pressures generated by this type of powder.



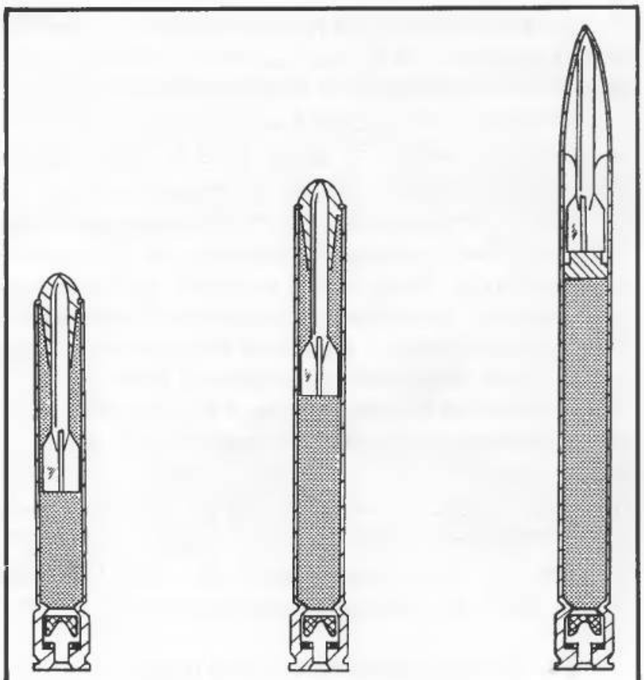
24. The "chuck" effect was finally realized in this rubber-sleeved aluminum puller sabot design of 1956, but further problems were experienced once the assembly left the bore, as separation proved unreliable.

Aircraft Armaments Inc.

Further experiments late in 1956 led to a second option: the use of slower-burning Olin ball powder WC660H in a somewhat longer case. This satisfied the muzzle velocity requirement, but produced a slower rise in breech pressure, allowing the re-introduction of the more reliable threaded sabots-and-projectiles. These now launched and separated properly, and gave satisfactory accuracy results at 100 yards.

After sorting through all the various design tradeoffs of tensile strength versus reliability, accuracy, velocity and lethality, a flechette weighing 10 grains was settled upon as the basis for all further experimentation. Within this projectile weight limit, the 1957 AAI report presented results of investigations into three different cartridge case lengths, using three different configurations of flechette-and-sabot. Repeated, successful launches of all three types had been achieved at muzzle velocities of 4,000 fps or greater. There were, however, advantages and problems inherent in each design.

Type "A", for example, was the final product to date of the "shortest possible case" branch of the study, which necessitated the use of the notoriously fast-burning, small-grained powder. As indicated, the flechette in this case could not be threaded or undercut, at the risk of its failing due to the very high tensile stresses of the launch. The one-piece, friction-fit sabot was carefully slit for nearly its full length into four, so that at the instant of firing a combination squeezing and pulling action drove it and the flechette down the barrel as a single unit. At the muzzle, the stripper spun the sabot so that it broke into four segments at its internal slits. The short-cased Type "A" round was the best logistical choice, only two inches long overall, and at 62.5 grains the lightest, thus permitting more ammunition to be carried within a given load-and-space limit. The segmented, friction sabot was its weak link; it had to be made to extremely close tolerances in order to form an effective gas seal and yet separate reliably at the muzzle.



25. An actual size drawing of the three types of flechette rounds presented by AAI in their March, 1957 final report on the initial Army flechette development contract. Their characteristics are as follows:

	Type "A" (left) (shortest possible case)	*Type "B" (center) (threaded flechette)*	*Type "C" (right) ("Pusher" sabot)*
Overall length (in.)	2.0	2.5	3.3
Overall weight (gr.)	62.5	75.0	99.5
Projectile wt.	10.0	10.0	10.0
Sabot wt.	7.5	7.5	12.0
Powder wt.	10.0	15.5	15.5
Case wt.	35.0	42.0	62.0

Aircraft Armaments Inc., redrawn by Thomas B. Dugelby

Type "B" was a half-inch longer and weighed 12½ grains more, but the extra case length permitted the use of larger-grained, slower-burning powder. As mentioned, this allowed a return to the threaded flechette and matching, two-piece sabot, which did not have to rely on a perfect friction fit. This sabot separated more reliably at the muzzle, by simple air pressure. The threaded flechette section was thinner and weaker, however, and therefore still prone to structural failures at peak velocities.

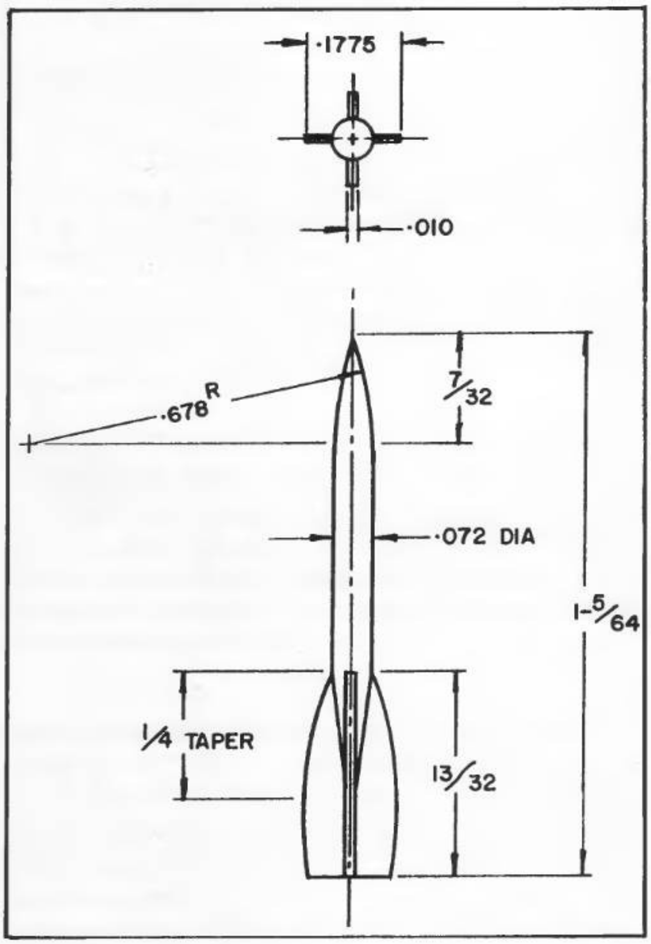
The Type "C" round at 3.3. inches overall was nearly twice as long as Type "A", and at 99.5 grains over half again as heavy. It featured a four-segment sabot to guide and stabilize the flechette, plus a "pusher"-type base plate as its gas seal. At the muzzle, air pressure separated the sabot segments, and the base plug simply fell away due to its poor aerodynamic characteristics. Type "C" was plainly the least desirable of the three designs, but also the most pragmatically reliable. It was included mainly as "insurance" should the inherent problems of both the others prove insurmountable in actual mass manufacture.

Mr. Barr's 1957 report went on frankly to say that the main thrust of the AAI study so far had been simply to prove that it was possible to launch a flechette-and-sabot combination at the required velocities without failure to either. In a number of areas, the AAI team had just scratched the surface: further investigations would be necessary to improve both the performance and reduce the cost of the projectiles. For example, Mr. Barr recommended further study on the optimum projectile nose configuration, "to establish the design which will produce the least velocity loss . . consistent with good accuracy." Other topics singled out as needful of more study included optimum flechette fin span, for better stabilization with no increase in drag, and a complete look at the sabot: lighter materials such as plastic or magnesium would reduce its weight, thereby reducing the amount of propellant required and subsequently the total round length, and also the down-range distance the sabot fragments would travel as a potential hazard to friendly troops.

The last point stressed for all components of the flechette cartridge was the need to reduce their *cost:* such complexities as threads and grooves added greatly to the cost-per-projectile, which was already considerably higher than that of a conventional cartridge.

Even while pointing out the flechette's deficiencies, Mr. Barr confidently declared his company ready to undertake further developmental contracts. The results to date were certainly encouraging: AAI reported that, when successfully launched at the required velocities, the 10-grain projectiles tested had "lethality equivalent to the caliber .30 M2 bullet up to ranges of 600 yards." This invited further comparisons which married happily with the findings ORO had tabled. AAI stated: "the weight of the sabot-projectile round as now developed is 75 grains. The standard .M2 ball cartridge weighs 396 grains. On a weight basis, therefore, it would seem reasonable to compare a 5-round burst of darts to a single caliber .30 round."

(Mr. Barr's frank discussion of the two salient problem areas of the flechette's cost and accuracy now seems sadly ironic and painfully prophetic, for here is the father of the flechette himself, even at this early date, pinpointing the troublespots that would ultimately lead to the reluctant abandonment of the concept as a whole. In the final analysis there was never to be such a thing as a "cost-effective" single-flechette round, and yet such was its allure that the Army was to spend thirty-four million dollars over a twenty-year period, trying to perfect the flechette and its weapons.)



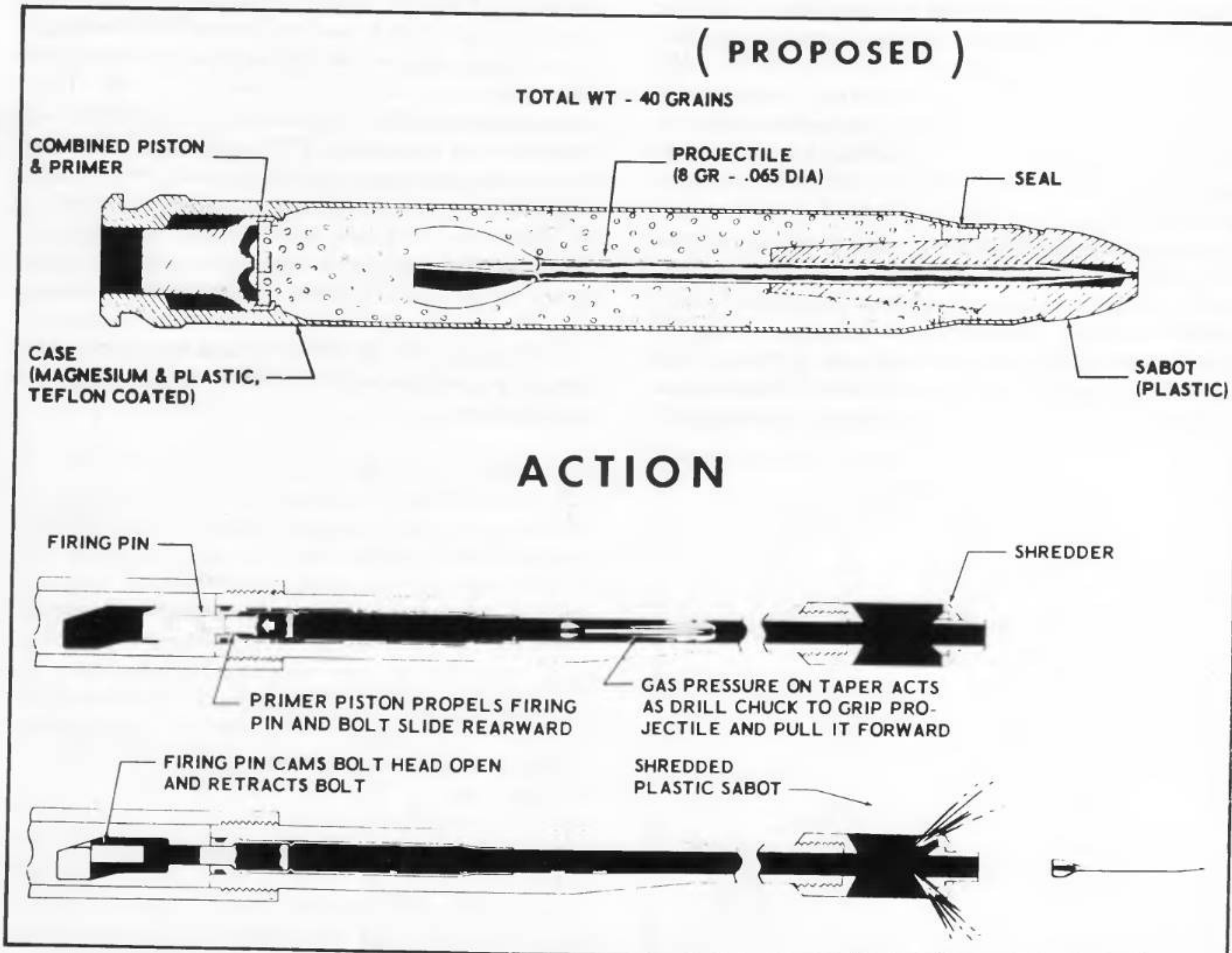
26. Flechette FL-17C-8, as loaded by the thousands into the devastating "Beehive" antipersonnel artillery canister. Weight: 8.2 grains; center of gravity .542" from nose. From a Ballistic Research Laboratories (BRL), report dated April, 1958, redrawn by Thomas B. Dugelby.

Meanwhile, Aberdeen's Ballistic Research Labs had been doing some further studies with the smaller 8-grain flechette, such as had been used in the earlier AAI shotshell. Massed, or at least very determined, "human wave" enemy infantry assaults in Korea had left a very strong impression indeed on all who had seen and survived them. The Army had awarded a contract to International Harvester Co. of Evansville, Indiana, in conjunction with Picatinny Arsenal, Watertown Arsenal and BRL, to further the development of a flechette-firing "canister" cartridge; sort of a giant version of the AAI flechette shotshell. In what became known as the "Beehive", several thousand projectiles, either balls or darts, were tightly packed in an artillery-type projectile. When fired, the "Beehive" produced a devastating, relatively short-range antipersonnel effect. Numerous flechette designs were evaluated for flight stability, range-velocity characteristics, quantity and ease of loading, economy of fabrication, and effect of manufacturing deviations on flight performance. One such interesting BRL report was entitled *Retardation and Velocity Histories of an 8-Grain Flechette,* from April of 1958. Drag and velocity characteristics were plotted from actual firings of an 8-grain flechette known as the FL-17C-8. In the canister loading, the flechettes were nested as compactly as possible, with many being packed tail first. A series of experimental firings of single flechettes, loaded backwards into their sabots, revealed that at an instrumental velocity of around 2,000 fps, each flechette would right itself to nose-first flight after several tumbles, each of about 12.5 feet in length, and would then require an additional 40 feet of travel to stabilize into relatively yaw-free flight. Watertown Arsenal later released its *Terminal Ballistic Study of Flechettes,* in December of 1958, to summarize its studies of penetration characteristics of various designs of the 8-grain flechettes into lightweight armor materials such as found in armored vests, helmets and personnel carriers. No advantage was found in making the canister-flechette either lighter or heavier than the 8-grain FL-17 design.

Thus, gradually, the flechette data-base assumed impressive proportions, and in so doing, the program gained momentum.

* * *

The AAI Multipiece Piston Primer



27. In an early presentation to the Army, AAI had conceptualized the piston-primed single flechette cartridge and its method of weapon actuation by means of firing pin movement in this fashion. By the end of the initial development contract in 1957, the somewhat sketchy ideas illustrated here for the primer, case material, flechette weight and stripper had all been superseded (see figure 28).
Aircraft Armaments Inc.

Aircraft Armaments Inc. responded to two further Ordnance R&D contracts in 1959 with a finalized first version of its ".22 caliber, Single Flechette Ammunition". An interesting and integral feature of the slim, belted cartridge case design which AAI presented was its unique multipiece piston primer assembly.

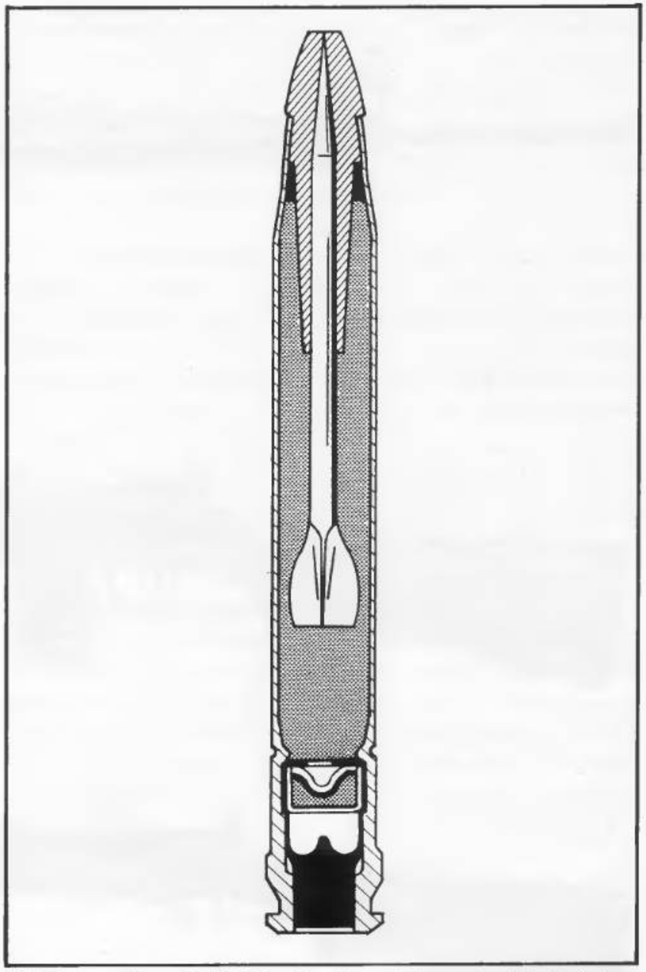
In choosing the primer-actuation system, it appeared that AAI was following in the footsteps of some very great designers, notably John Garand, whose personal first choice of a rifle design for Springfield Armory back in the 'twenties had been primer-actuated. Yet the AAI *piston primer* differed importantly from the designs of Garand and others, which had been built around standard military cartridges with normal primers. Each and every example of the special AAI piston primer actually contained the front half of its own firing pin.

In assembly, the piston primer was inserted down through the neck of the case and held securely against forward movement by means of a crimp, which showed as four distinctive dimples in the outside circumference

of the case. It was intentionally positioned slightly forward inside the primer pocket, and was designed to be fired by a blow from the weapon's flat-faced firing pin. This would collapse the whole piston forward, whereupon the internal, frontal point of the piston itself detonated the priming compound, thus igniting the powder charge. The resulting pressure inside the case not only pushed the saboted flechette down the bore, but at a certain point forced the collapsed piston backwards a short distance, cushioned by the spring-loaded, flat-faced firing pin. When the piston protruded about two millimeters (.080") beyond the base of the case, primer movement was halted by the flared front section of the primer body contacting the inner base of the cartridge case. The heavy-bodied firing pin continued to the rear, transmitting the energy needed through a camming action to rotate and unlock the bolt and thus begin the action cycle of the weapon. Under the terms of the flechette ammunition development contract, the patent application for the multi-piece piston primer was assigned to the US Government.

The puller sabot itself was now made from four small blocks of lightweight magnesium alloy, first painstakingly glued together and then turned to shape as a single piece, in order to assure positive gas-sealing.

The AAI engineers concentrated on their final goal: the launching of mechanically-regulated, ultra-fast bursts of high velocity, low-recoil single flechette projectiles from an as-yet unperfected weapon system, whose every component was to be as light as possible. Every feature of their new round bore evidence of this singleminded pursuit. The remarkable slimness of the case itself translated into a compact yet high-capacity magazine, plus the shortest possible time necessary to position the next round for feeding. The round's extra-light case walls and sabot also cut down the weight of a full magazine considerably. The piston primer concept was possibly the hardest trade-off to justify, as it added an admitted and unavoidable extra degree of complexity and cost to each and every cartridge.



28. Cutaway view of AAI's .22 caliber "Arrow" piston-primed single flechette cartridge, as tested by the Infantry Board. Drawing date 18 January, 1960. Overall length: 2-5/16"; overall weight: 86 grains. The 10-grain, .072"diameter flechette, with its gas seal and magnesium-alloy "puller" sabot, was exactly 1½" long. US Army Infantry Board, redrawn by Thomas B. Dugelby.

On the plus side, however, it allowed the fastest possible action cycle time, and most importantly did away completely with the weight, cost and potential fouling problems of the tube, block, piston and spring of a conventional gas system.

A Short Historical Update

All of this of course did not go on in a vacuum; indeed the events which by this time surrounded our story were so remarkably fraught with acrimony that probably even without the flechette program's strictly "secret" security classification, it would have generated little interest. By the beginning of 1959, the .22- versus the .30-caliber debate had reached a positively feverish pitch. Both the Army Infantry Board and Aberdeen's D&PS had the year before held comparative trials of three contending small-caliber rifles: the .223cal. Armalite AR-15; Winchester's short-lived M1 Carbine-like "Lightweight Military Rifle" in caliber .224; and an even shorter-lived Springfield light rifle design, chambered for another similarly named but non-interchangeable .224 cartridge.

29. By 1958, Aberdeen's small caliber, high velocity (SCHV) research had led to the development of these three contending .22 caliber rifles (to be discussed in detail in Volume III of this series). The space-age AR-15 in particular proved extremely popular with the Infantry Board, among others, and there ensued some high-profile bickering which brought increased criticism of the Ordnance Corps' troubled .30 caliber M14 rifle procurement program. This did much to polarize the Army into factions, and enhanced in the eyes of many the concept of a burst-firing single flechette weapon. ABOVE: the revolutionary ArmaLite AR-15 rifle, serial no. 2, in caliber .222 Remington Special (later known as .223 Remington). Note the cocking handle inside the carrying handle, like the earlier NATO-caliber ArmaLite AR-10. CENTER: the Winchester "Light Weight Military Rifle", caliber .224 Winchester. BELOW: Springfield Armory's caliber .224 "Springfield Infantry Rifle", produced under contract 19-058-2098/ORD-58 and fielded briefly for Infantry Board trial. The Springfield .224 cartridge was later marketed commercially as the .222 Remington Magnum.

The Infantry Board was initially quite enthusiastic about the AR-15, recommending in its September, 1958 report that a few deficiencies be corrected and that the modified AR-15 be summarily adopted as their ideal follow-on to the aging M1 Garand. Aberdeen, an Ordnance Corps agency, demurred. There, the small calibers were deemed inferior to the 7.62mm with regard to penetration and brush-bucking, while the AR-15's high line of sight was seen as objectionable in that it exposed too much of the firer's position. Much was made of the fact that the small bore of the AR-15, if filled with water with a cartridge in the chamber, would retain the water by capillary action even if the barrel was tipped down, and would burst dramatically if subsequently fired. Propaganda, in the form of pin-sharp glossies of a burst AR-15 barrel, photographed following a very thorough Aberdeen rain test, was grimly circulated by the OCO.

These developments themselves took place in waters already muddied by the Ordnance Corps' beleaguered M14 procurement program, which was by this time under way at Springfield Armory with an initial order for over

fifteen thousand rifles. CONARC's new Commanding General, Bruce C. Clark, tried manfully to defuze the rapidly materializing confrontation with the Office, Chief of Ordnance by appointing a board of officers, under CONARC's Deputy Commanding General Herbert B. Powell, to examine the whole rifle program. The Powell Board, as it became known, wrestled with the knotty issues of the day in a four-month study, only to fudge a little by recommending the purchase of a non-decisive 750 AR-15 rifles for "extended trial". Dr. Carten and his associates in the OCO, staunch M14 supporters to a man, immediately objected: America's NATO obligations if nothing else stood in the way of any cognizance of weapons in .223 caliber, and there was the potentially much more serious problem of water retention in the tiny bore. In a move worthy of Machiavelli, the OCO suggested that further lightweight rifle development be shifted to a new, slightly larger, "optimum" caliber, .258-inch. This round did not as yet exist, Dr. Carten confided, but Ordnance calculations indicated that it would be of sufficient size to solve the barrel water-retention problem.

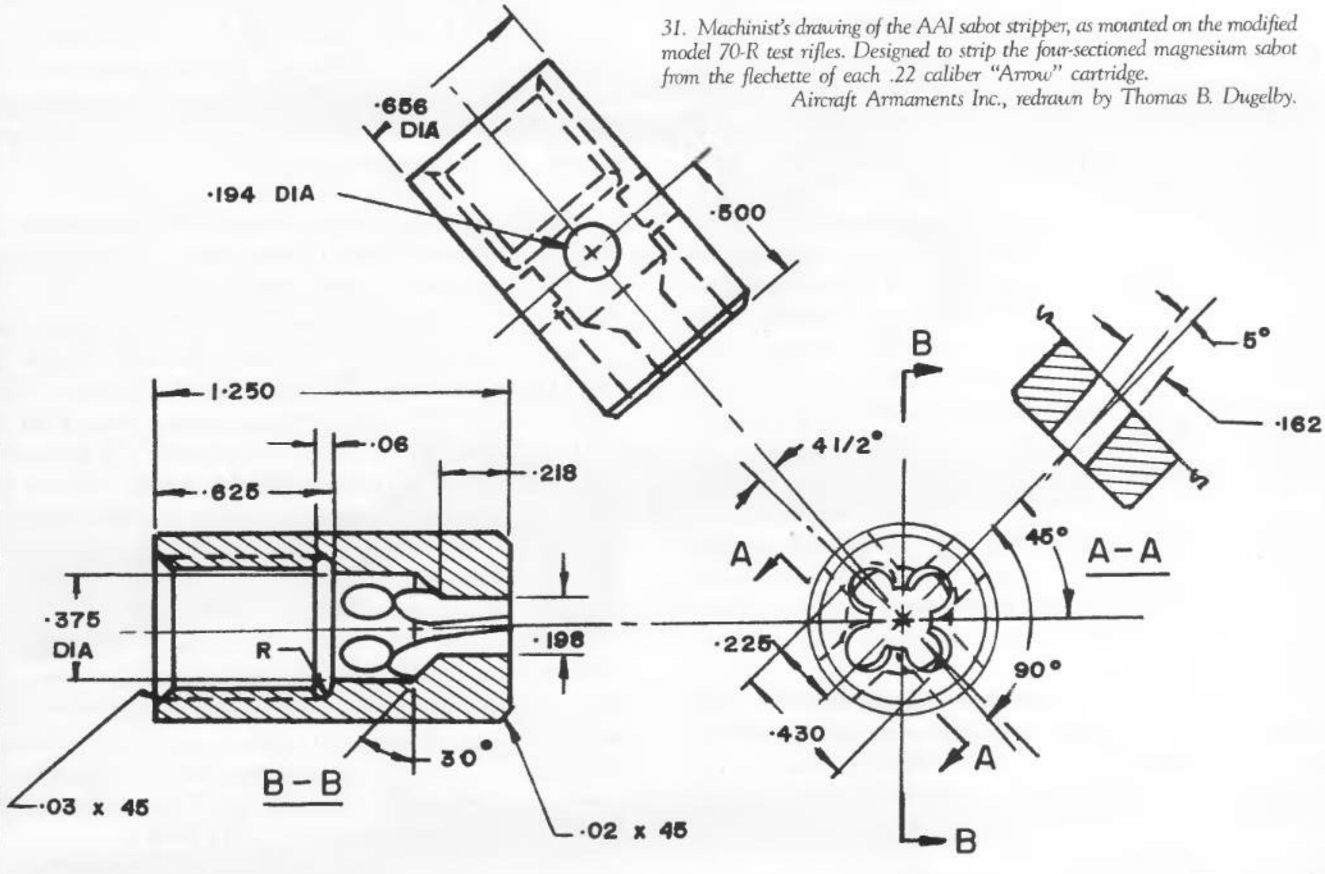
The result of this masterstroke was to render the availability of lightweight rifles and ammunition in .223 caliber as nought, relegating the AR-15 itself right back to the drawing-board. By this logic, the M14 literally stood alone as the only available choice. The Powell Board duly passed to the Chief of Staff of the Army for his final approval its recommendations that the M14 be retained in the automatic rifle role, and that for the future, development of an AR-15-type weapon be expedited in caliber .258. Not for nothing did Dr. Carten subsequently become known as "the father of the M14".

It remained only for the Chief of Staff of the Army to concur: in February, 1959 General Maxwell Taylor vetoed any further purchases of the AR-15 in favor of continued procurement of the NATO-caliber M14, and approved a development proposal for the new cal.258 (6.35mm) in the ongoing Ordnance R&D program. By February 17th, the first civilian M14 procurement contract was in place at the Olin Mathieson Chemical Corporation's Winchester-Western division, where 35,000 M14 rifles were to be fabricated at $69.75 apiece.

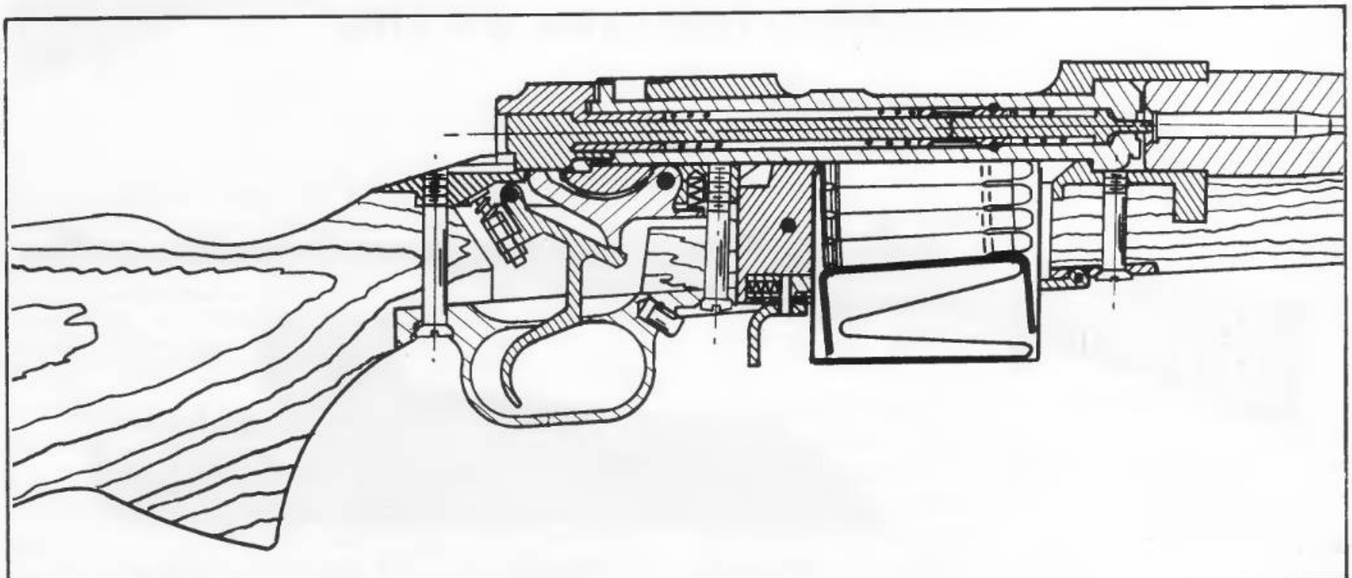
One other Ordnance recommendation had been enthusiastically endorsed before the Powell Board, and it too carried all the way through into General Taylor's 1959 pronouncement. It paved the way for the development of a completely new light, flat-shooting weapon which would truly qualify as the successor to the M14. It would fire patterned bursts of the ten-grain flechettes developed by Aircraft Armaments Inc., and would be called the All-Purpose Hand-Held Weapon, (APHHW).

Smoothbore, Bolt-Action Test Rifles

30. One of the ten Winchester model 70-R bolt-action rifles, modified in 1959 for initial trials of AAI's .22 caliber "Arrow" single flechette ammunition. Note the four-round, single-row box magazine. INSET: A closeup view of the sabot stripper, mounted on the muzzle end of the smoothbore barrel.



31. Machinist's drawing of the AAI sabot stripper, as mounted on the modified model 70-R test rifles. Designed to strip the four-sectioned magnesium sabot from the flechette of each .22 caliber "Arrow" cartridge.
Aircraft Armaments Inc., redrawn by Thomas B. Dugelby.



32. Cutaway view of the action of the modified, smoothbore Winchester model 70-R bolt-action test rifles. Note the four-round box magazine, and the buffer mechanism around the special flat-faced, two-piece firing pin. These rifles were used in the 1959-1960 Infantry Board and Arctic Test Board trials of AAI's .22 caliber "Arrow" single flechette cartridges.
Aircraft Armaments Inc., redrawn by Thomas B. Dugelby.

In December of 1959, Aircraft Armaments Inc. published the results of a further Ordnance contract, under which they had modified ten Winchester model 70-R .270-caliber bolt-action rifles to fire the new .22 caliber Single Flechette ammunition. In the introduction to its *Final Report — Research and Development Activities on Flechette Ammunition Test Rifles*, AAI stated: "Since the ammunition development program was in urgent need of a shoulder fired test rifle, and because the time required to design and build automatic weapons was considerable, it was decided to make single shot bolt action test rifles."

With the aid of Springfield Armory, new 27" smoothbore .22 caliber barrels had been fabricated and threaded at the muzzle to take the AAI design of sabot stripper. New four-round, single-row box magazines had been fitted, and the bolts were modified to include a new firing pin, extractor, ejector way and silicone buffer, the latter necessary to absorb the presently useless excess energy of the primer piston; energy which would one day become the heart of AAI's planned automatic flechette rifle.

Once proofed at AAI, the ten modified rifles were delivered to Springfield Armory, and were subsequently used to conduct initial flechette ammunition firing trials there and at Fort Benning, Aberdeen, and Frankford Arsenal. AAI was by this time understandably champing at the bit to begin the real job ahead: the construction of an automatic weapon specifically built from the ground up to fire the new flechette ammunition. AAI had recommended that several different models be developed for initial evaluation tests, and were already at work on a firing model of their own.

The Infantry Board Tests the "Cartridge, .22 Caliber, Arrow"

With the M14 finally locked securely into a production program (however rocky *that* road was to be), and the ArmaLite proponents temporarily stunned into disarray by General Taylor's adamant veto of the AR-15, the spotlight slowly swung onto the flechette cartridge and the concept of the All-Purpose Hand-Held Weapon.

With the future at stake, the AAI engineers crossed their fingers and held their breath as developmental "lots 6A, 7, 8 and 9" of the single flechette cartridge they now dubbed the "AAI Arrow", were examined and fired in a crucial 1960 Army Infantry Board trial. The Board proceeded to conduct the actual shooting trials using AAI's modified Winchester 70 bolt action rifles. Fired alongside the "Arrow" were two versions of the new .258 (6.35mm) round; the Winchester 6.35mm "Short" in a 1.880" case, and Frankford Arsenal's 6.35mm "Long" (caselength 2.080"). The early, long-bulleted M59 ball version of the 7.62mm NATO cartridge served as control.

Excerpts from the very informative Infantry Board report of these firings, dated March 18, 1960, are reprinted below. (The report's original security classification of "Secret" took until December 10, 1971 to become downgraded all the way to "Approved for Public Release; Distribution Unlimited"):

United States Army Infantry Board
Fort Benning, Georgia
Report of Project Nr. 2876

Evaluation of Single Flechette

Purpose

To determine whether the single flechette has sufficient military value under temperate weather conditions to warrant further development.

Description of Material

Cartridge, .22 Caliber, Arrow, Lots 6A, 7, 8, and 9 . . contains a 10-grain, arrow-shaped steel projectile (called a flechette) that has a length of 1½ inches and a body diameter of .072 inches . . . [The primer-actuated] type of gun mechanism was not furnished for this evaluation. [When the weapon is fired], the sabot with flechette is pushed from the cartridge case into the bore . . The flechette is then pulled through

the bore by the magnesioum, four-section sabot which grips the forward half of the flechette . . At the muzzle the sabot-flechette assembly is given a high rate of counter-clockwise spin by a rifled section known as the stripper . . . The stripper has four teeth similar to the lands in a standard barrel. These . . teeth have a 5-degree counter-clockwise cant which imparts the spin to the sabot . . . The centrifugal force thus created . . causes the four quarter sections of the sabot to separate from the flechette, leaving a "clean" projectile. The muzzle velocity of the flechette is 4,600 fps. The rifles used to fire the test ammunition . . were bolt-action Winchester Model 70s, modified and rebarreled to accept the .22 caliber single flechette round.

Background

The single flechette is a prototype round developed for Frankford Arsenal by Aircraft Armaments Inc., to meet a requirement to replace standard small arms ammunition. It is to be at least equal . . in accuracy and penetration while possessing a greater casualty-producing capability and having less weight . . . Single flechette ammunition was furnished this Board for test in November 1959 and testing was completed on 14 December 1959. On 23 December this Board, in a preliminary report to USCONARC . . concluded that single flechette ammunition has the potential for fulfilling the requirements of the direct-fire ammunition for the All-Purpose Hand-Held Weapon. This item has not been proposed for Tripartite Standardization.

Physical Characteristics [of Cartridges Tested]

	Overall Weight (Grains)	Overall Length (Inches)	Case Diameter (Inches)
Flechette	86	2.31	.296
6.35mm Short	229.2	2.28	.418
635mm Long	237.6	2.48	.418
7.62mm NATO	376	2.79	.471

During handling it was found that the forward half of the cartridge case was so soft that it was easily bent by hand. Representatives of Aircraft Armaments recommended that each round be chambered by hand since the case would be bent by mechanical chambering.

Accuracy Test Results

*Average mean radius (MR) and maximum spread (MS) (inches) for groups fired from a bench rest.**

Range	.22 CAL** FLECHETTE		6.35mm SHORT		6.35mm LONG		7.62mm NATO	
(Meters)	MR	MS	MR	MS	MR	MS	MR	MS
100	4.28	10.44	—	—	—	—	—	—
200***	7.72	20.24	—	—	—	—	—	—
300	8.64	23.40	5.04	16.68	4.80	15.00	5.88	19.20
400****	18.84	54.36	6.84	20.40	6.24	19.32	7.92	27.60

Notes:

* *An undetermined number of all flechette rounds fired were erratic and did not hit the target. In all accuracy firing at least 8 out of each 10 rounds were hits; therefore, the MR and MS shown for the flechette are for the best 8 out of 10 rounds in each 10 round group.*

** *Due to the lightness of recoil when the flechette cartridge was fired, the rifle was quickly and easily realigned on the target.*

*** *Due to a loss in accuracy, the stripper on rifle No. 8 was replaced after a total of 173 rounds.*

**** *Due to a loss in accuracy, the strippers on all flechette rifles were replaced prior to firing at 400 meters.*

Analysis

An undetermined number of all test rounds fired was erratic in flight.

Accuracy of semiautomatic fire, as represented by the best 80 per cent of all rounds fired, is not as good as that of the 7.62mm Ball . .

Accuracy is adversely affected as the stripper wears out.

During the conduct of the accuracy test it was noticed that the longer a weapon was fired the less accurate it seemed to be. An analysis of the probable causes led to the belief that as the weapon heated it lost some of its accuracy . . . Although the [test] results . . are not conclusive, there is reasonable cause to believe that accuracy is adversely affected as the temperature of the weapon increases.

The trajectory is such that no sight change would be required to hit a man-sized target between 0 and 400 meters.

Wind has no noticeable effect upon the trajectory of the flechette between 0 and 400 meters.

Muzzle flash with the test ammunition-weapon combination is excessive.

Penetration Test Results

Number of pine boards perforated by the test and control ammunition is shown below:

Range (Meters)	Type Ammunition	Average No. of Pine Boards Perforated
400	.22 Caliber Flechette	7.6
	6.35mm Short	10.2
	6.35mm Long	10.4 *
	7.62mm NATO	11.3 (+)**

Notes:

* *A total of 11 rounds instead of 10 was fired with this type ammunition.*

** *One round perforated the last board; therefore, the exact average cannot be computed.*

Test and control ammunition perforated both sides of the steel helmet (w/liners) and body armor 100 per cent of the time at 400 meters.

Sabot dispersion and Penetration Analysis

Although no criterion has been established as to an acceptable cone of dispersion, it appears that present tactical concepts would not permit [the] large danger zone forward of the gun. [12'x12' witness panel was not large enough at 35 feet to intercept all sabot particles; one particle was found sticking into a board at 45 feet.]

Discussion

Representatives from Frankford Arsenal and Aircraft Armaments have familiarized this Board with the concept of the rifle in which this test ammunition will ultimately be used. The following aspects of this rifle system were taken into consideration by the Board in arriving at the conclusions and recommendations:

a. The proposed rifle would weigh approximately 3.5 pounds. This weight, when coupled with the light weight of the flechette ammunition, would permit the user to carry a much larger ammunition supply than at present.

b. The proposed rifle would incorporate design features to reduce or eliminate the tendency of present weapons when fired automatically to ride off the target.

c. The proposed rifle would have a cyclic rate of approximately 2,000 rounds per minute and a controlled burst (1 to 5 rounds) trigger mechanism. These controlled bursts of automatic fire theoretically would increase hit probability, thus offsetting the reduced single round accuracy of the test ammunition.

Deficiencies and Suggested Modifications

The deficiencies listed below are those that remain uncorrected at the completion of this project. They are listed in two categories: major deficiencies and minor deficiencies. The former are those deficiencies which must be corrected to make the item suitable for Army use. The latter are those deficiencies, the correction or elimination of which will increase the efficiency or desirability of the item but which need not be corrected to make the item suitable for Army use.

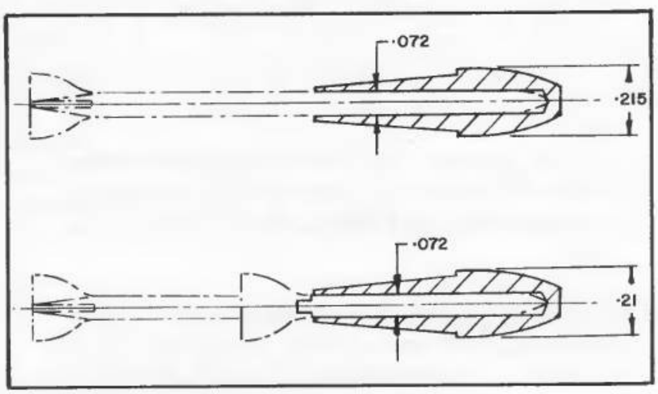
Major Deficiency	Results	Suggested Modification
1. *Cartridge case lacks rigidity and hardness.*	*Case would bend under normal usage.*	*Harden case.*
2. *Accuracy of semiautomatic fire is not satisfactory.*	*Does not meet military characteristics.*	*Correct.*
3. *Weapon appears to lose accuracy as it heats.*	*Adversely affects accuracy of the weapon.*	*Correct.*
4. *Danger zone for sabot particles is excessive.*	*Is distracting and dangerous to friendly soldiers.*	*Reduce in size or eliminate danger zone of sabot particles.*
5. *Life of stripper is too short.*	*Would require frequent replacement of stripper.*	*Increase stripper life.*
Minor Deficiency	**Results**	**Suggested Modification**
6. *Muzzle flash is excessive.*	*Would reveal firer's position.*	*Correct.*
7. *Does not penetrate 6" of sand.*	*Reduces the ammunitions' effectiveness against targest protected by earthworks.*	*Improve.*

Conclusions

The United States Army Infantry Board concludes that:

a. The single flechette has sufficient military value under temperate weather conditions to warrant further development.

b. The single flechette has more potential than either 6.35mm simplex or 7.62mm NATO ammunition for meeting the proposed direct fire ammunition requirements of the All-Purpose Hand-Held Weapon.



33. Having perfected the "puller" sabot, AAI continued experimenting. Here is a March, 1959 proposal for an 11-grain, tungsten carbide armor piercing flechette load (below), compared with the standard 10-grain steel flechette. Aircraft Armaments Inc., redrawn by Thomas B. Dugelby.

Recommendations

It is recommended that development be continued and directed toward, but not limited to, the correction of deficiencies listed above, and that the improved ammunition be submitted to this Board for further tests.

(signed)

HENRY B. KUNZIG
Colonel, Infantry
President

Although the Infantry Board had registered an ominous objection to the poor quality and single-round accuracy of the "Arrow", they approved wholeheartedly of the *potential* of the concept: with the final burst-fire weapon projected at a mere three-and-a-half pounds, and with *no* sight adjustments necessary from 0 to 400 yards, it was clear to the jubilant AAI designers that the Infantry Board was indeed willing to overlook a few as-yet unresolved details and give the enthusiastic go-ahead to the proposed new APHHW.

The "Cartridge, 5.6mm, XM110"

The Fort Benning Infantry Board trial represented only *temperate* phase of the official flechette test project; next in line was the Arctic phase, to be conducted by the Army's Arctic Test Board at Fort Greely, Alaska, in conjunction with that body's ongoing evaluation of various developmental cartridges under Arctic conditions. Their *Evaluation of Single Flechette and 6.35mm Simplex and Duplex Ammunition* report was dated May 7, 1960. By that time, the first-generation AAI flechette cartridge's short-lived proprietary designation had been superseded: the "Arrow" was now officially the "Cartridge, 5.6mm, XM110"; a heartening advancement indeed for the AAI design team.

The Arctic Test Board reported that they had received a thousand rounds of the newly-named XM110 single-flechette ammunition, and four thousand rounds each of Winchester's "Short" 6.35mm Simplex (the FAT116E1 cartridge), plus a Duplex version in the same 1.880" case-length (called the FAT115), along with several lots of 7.62mm M59 and M80 ball, and Winchester .224.

Excerpts from the Arctic Test Board's report are of interest, and are reprinted below:

US ARMY ARCTIC TEST BOARD
Fort Greely, Alaska

Evaluation of Single Flechette and 6.35mm Simplex and Duplex Ammunition

Description of Materiel

The single flechette is .22 in caliber and is of the discarding sabot type. The flechette weighs 10 grains and has a muzzle velocity of . . 4,600 fps.

The 6.35 Simplex bullet weighs 70 grains and has a muzzle velocity of . . 3,300 fps.

The 6.35 Duplex round contains two bullets weighing 53 grains each. Muzzle velocity of the lead bullet is . . 2,600 fps and of the trail bullet , 2,450 fps.

Background

The US Army has experimented for a number of years with projectiles of various calibers, velocities and configurations in an effort to improve the effectiveness of combat rifle fire. Principal approaches have been Duplex and Simplex bullets for standard calibers; small caliber high velocity bullets; and flechettes launched singly or in multiples.

Prior to conduct of any test, test ammunition was cold-soaked at an exposed storage site for 72 hours. Ambient temperature during this period ranged from 19 degrees F to -37 degrees F.

Weapons provided to fire the 5.6mm and 6.35mm cartridges were modified commercial sporting rifles and were not evaluated as hardware items.

Summary of Test Results

[In the accuracy test], two [expert] riflemen fired three 10-round [benchrest] groups of each type test ammunition at a vertical target 20 feet by 20 feet at ranges of 300 and 500 yards.

Accuracy Test Results

TYPE AMMO	300 Yards				500 Yards			
	MV	MH	MS	MR	MV	MH	MS	MR
Single Flechette	22.70	32.37	36.12	10.96	45.62	47.04	61.09	17.49
6.35mm Simplex	11.91	11.91	14.33	4.64	25.25	24.00	30.41	9.52
6.35mm Duplex — Lead Bullet	19.70	23.70	27.29	7.69	63.25	28.95	65.91	19.32
*Trail Bullet	43.66	51.04	59.00	21.74	84.04	95.75	102.75	40.97
7.62mm M59	13.33	14.44	18.34	5.63	19.54	19.70	24.58	7.40
7.62mm M80	12.01	8.01	12.29	3.88	13.87	12.70	17.87	5.84
Cal. 22 [Springfield Armory design]**								

* Center of impact of the trail bullet was 16.14" low and 2.32" right from center of impact of lead bullet at 300 yards, and 37.99" low and 5.00" right at 500 yards.

** Data not available.

During conduct of this test several flechette cartridges were bent while loading the round in the chamber. The cartridge case was made of very soft material and was easily bent.

Twenty two rounds of single flechette failed to fire after three attempts.

Seven rounds of single flechette showed evidence of improper assembly in that sabot parts were not seated equally.

Silicone buffers in the bolt . . provided to fire single flechette ammunition lasted an average of fifteen rounds before misfires occurred.

Fourteen large muzzle flashes approximately 12" in diameter occurred while firing the single flechette. All other flechette rounds fired produced greater muzzle flash than the . . 7.62mmm, M59 or M80.

During initial firing by test personnel, six flechette rounds failed to hit a 16' x 16' target at 300 and 500 yards.

Due to the flat trajectory of the single flechette, it was unnecessary to make elevation adjustments on the sight when firing at 300 and 500 yards.

[In the penetration test], five rounds of each type test ammunition were fired into six inches of solid ice at 300 yards range . . [With the] single flechette, all rounds completely perforated; one round lodged in one-inch witness panel in rear of target.

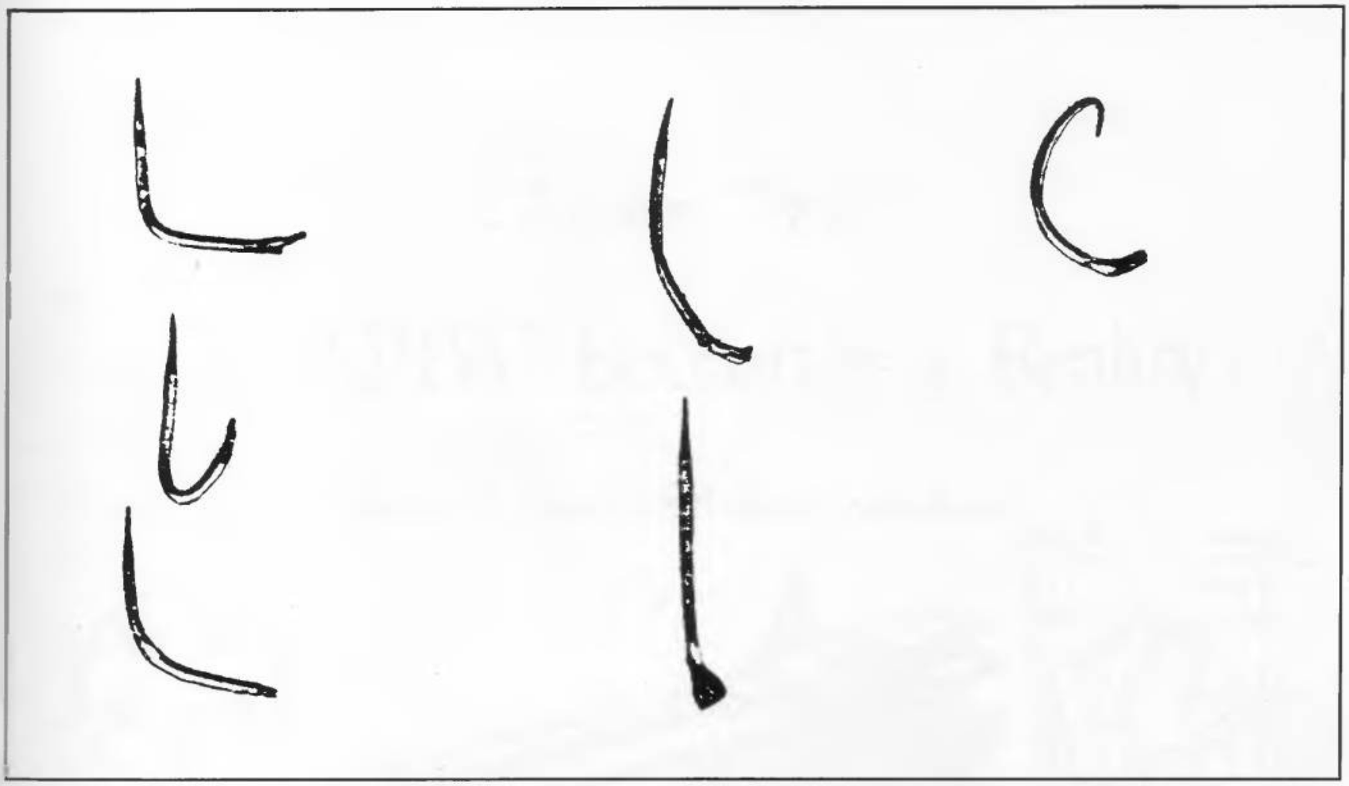
Three rounds of single flechette were fired into eight inches of solid ice at 500 yards range. All flechettes perforated the target . . all flechettes recovered from penetration targets were badly deformed . . .

Discussion

Single Flechette — Assuming that the design of this type ammunition could be refined to provide a higher degree of point target accuracy, many advantages could be gained by adoption of this type of round. Uppermost of these is the capability of providing the individual soldier with a small, extremely light weight weapon with effectiveness generally equal to the 7.62mm caliber. This type ammunition will also permit the individual soldier to carry a considerably greater number of rounds within the same weight and bulk as now required for 7.62mm ammunition.

6.35mm Simplex — This type ammunition performed similarly to the current standard Cartridge, Ball, 7.62mm, M59 in areas where comparatively tested. A weapon of lesser weight and the same general effectiveness as the M14 rifle could conceivably be developed to fire this cartridge. A greater number of rounds of this type ammunition could be carried by the individual soldier within the same weight and bulk as 7.62mm ammunition.

6.35mm Duplex — No real military advantage could be gained by adoption of this cartridge due to lack of accuracy and penetration capability.



34. *Single flechettes fired from XM110 cartridges by the Army Arctic Test Board, at Fort Greely, Alaska. LEFT: recovered from pine panels. CENTER: recovered from "old, dry, hard, wind-crusted snow." RIGHT: recovered from six inches of solid ice. Shown actual size.*

Conclusions

> *The Cartridge, 5.6mm XM110 (Single Flechette) and the Cartridge, 6.35mm, Ball, FAT, 116E1 (Simplex) have sufficient military value to warrant further development for Army use under arctic winter conditions.*
>
> *The Cartridge, 5.6mm, XM110 (Single Flechette) shows more promise for Army use under arctic winter conditions than the Cartridge, 6.35mm, Ball, FAT, 116E1.*
>
> *The Cartridge, 6.35mm, Ball, FAT, 115 (Duplex) does not have sufficient military value to warrant further development for Army use under arctic winter conditions.*
>
> *[signed]*
>
> *DURED E. TOWNSEND*
> *Colonel, Infantry*
> *President*

Again, the XM110 flechette's single round accuracy had been criticized, even though the avowed purpose of the APHHW program was to provide the combat soldier with the means to fire a controlled *burst* of darts, *intentionally* spread around the point of aim. A perfected weapon capable of firing the flechettes in bursts simply did not as yet exist, however, and in its absence there was little the Army could do except continue to record the accuracy results of each single shot, which were often inexplicably erratic.

Some obvious "bugs" had been quickly spotted in the Winchester test rifles: the sabot strippers and the temporary silicone bolt-buffers had both proven disappointingly short-lived. But, the overall consensus was favorable: if ammunition quality could be assured, both Army test agencies were excited about the extreme light weight and the astounding flat-shooting nature of the promised flechette weapon. The APHHW was definitely worthy of further development.

Chapter Three

The SPIW Becomes a Reality

The AAI Five-Barrel Burst Simulator

35. One of two five-barrel flechette "burst simulators", designed and constructed by AAI in 1960. Since no automatic flechette-firing weapons had as yet been produced for trial, the Army was still recording only single shot accuracy scores, which were most embarrassing. With the electrically-fired burst simulators, a series of five rounds could be fired in a serial time frame, just as from an automatic weapon. INSET at left: the barrel brace, which could be adjusted for optimum burst spread. INSET at right: rear view of the simulator's hinged breech mechanism.

Thus far, the XM110 flechette cartridge had shown itself capable of realiable, single-shot launch. As mentioned, no automatic flechette-firing weapon as yet officially existed, and based on the rather limited amount of spoon-fed evidence in hand, the Army was still not ready to fund such a venture. Aircraft Armaments Inc. very much wanted to move on into the "serial flechette" area of the study: it was after all the mode for which the XM110 flechette cartridge had been designed in the first place, and if satisfactory patterned bursts *could* be demonstrated, the embarrassing single-shot scores would be superseded and forgotten. To this end, and working alone, AAI developed a demonstration model of a flechette-firing "burst simulator". This they submitted to Springfield Armory in the spring of 1959, as an unsolicited proposal for the advancement of the APHHW.

Basically five fixed, single-shot smoothbore barrels bolted together in a circular, Gatling gun-type array, this ingenious device was designed to *simulate* the firing of a five-round burst in a precisely controlled serial time frame, just as from an automatic weapon. Springfield approved the design that July, and granted AAI a formal development contract, number DA-36-034-ORD-18RD, to proceed with the detailed design and the manufacture of two finalized versions. The associated firing circuitry fed electric triggering impulses, spaced about 20 milliseconds apart, to each of five identical firing mechanisms housed in a standing breech. Each of these in its turn drove a flat-faced firing pin forward, against the piston primer of the XM110 round chambered in front of it. After firing, the still-unharnessed rearward thrust of the piston primers was absorbed by buffers made of rubber and metal washers.

Using barrels supplied by Springfield, AAI completed and proofed the first of the two burst simulators in February, 1960. After some minor adjustments and improvements to the electrical contact points, gun number one functioned satisfactorily, giving instrumental readings of an average muzzle velocity of 4,400 fps, at a "burst rate" of 2,300 rpm. It was shipped to BRL at Aberdeen for Ordnance tests. Gun number two was then finished up and sent to Springfield three months later. Both simulators were mounted on government-furnished M2 machinegun tripods, and carried their portable battery packs in regular Army ammunition cans.

The new year, 1961, brought more jubilation into the AAI camp, as the BRL trials confirmed what ORO had been saying all along. BRL had fired and recorded a number of three-and five-round bursts of XM110 flechettes, at ranges from 50 to 300 meters. They reported that the AAI burst simulator yielded from 10% to an astounding 270% more hits per trigger pull than corresponding full-auto bursts from the 7.62mm M14 rifle. At ranges of 100 to 300 meters, the AAI flechette produced about three times as many "casualties" as the M14 on semiautomatic fire. BRL concluded that, on the basis of effectiveness per round of ammunition fired, a 3.5-pound weapon firing the XM110 flechette at 2,300 rpm would be about *seven times* as effective as the 8.5-pound M14.

All of a sudden, it seemed that the tide abruptly turned: the flechette was respectable, the flechette was interesting, the flechette was *in*!

Simulated mass-production studies of the flechette-and-sabot "package" had meanwhile concentrated on the perfection of the "chuck" effect of the puller sabot; the right combination of compression and grip had at last been found in standard fiberglass-reinforced plastic rod stock, the same type used in the manufacture of fishing-rods. Every sabot was carefully hand-slit and pushed onto a flechette, which had been meticulously degreased and sprinkled with talcum powder for maximum "grip", and then sleeved at the rear with a rubber obturator to ensure reliable launching and separation. The flechette-and-sabot "package" was then carefully inserted into the primed and charged case, crimped, and finally sealed with a coating of green Teflon. With the aid of these newly available quantities of XM110 test ammunition and the AAI burst-fire simulators, BRL and the Combat Research Development Laboratory (CRDL) at Edgewood Arsenal carefully began to roll back the various frontiers of knowledge concerning the serial flechette.

* * *

The study which tipped the scales most dramatically in favor of the APHHW as a *weapon* was titled the *Optimum Composition of the Rifle Squad and Platoon*. This was an important field experiment carried out by the Army's Combat Development Experimentation Center, (CDEC), from May 6 to June 16, 1961 at their Hunter Liggett Military Reservation in Fort Ord, California. CDEC was a no-nonsense agency of the Army Field Forces, with a mission to evaluate new tactical concepts in actual combat situations. In the CDEC rifle squad trial, a variety of existing weapons were issued out in various combinations and strengths within the trials teams. These were deployed and studied for target effectiveness in combat situations, in comparison with one another. This information was merged with target array data produced by the AAI flechette burst simulators. The flechette targets were by far the most impressive; so much so that at the conclusion of the trial CDEC recommended that "All personnel of the [optimum] squad be armed with the all-purpose hand-held weapon (APHHW) except machine gunners who carry side arms".

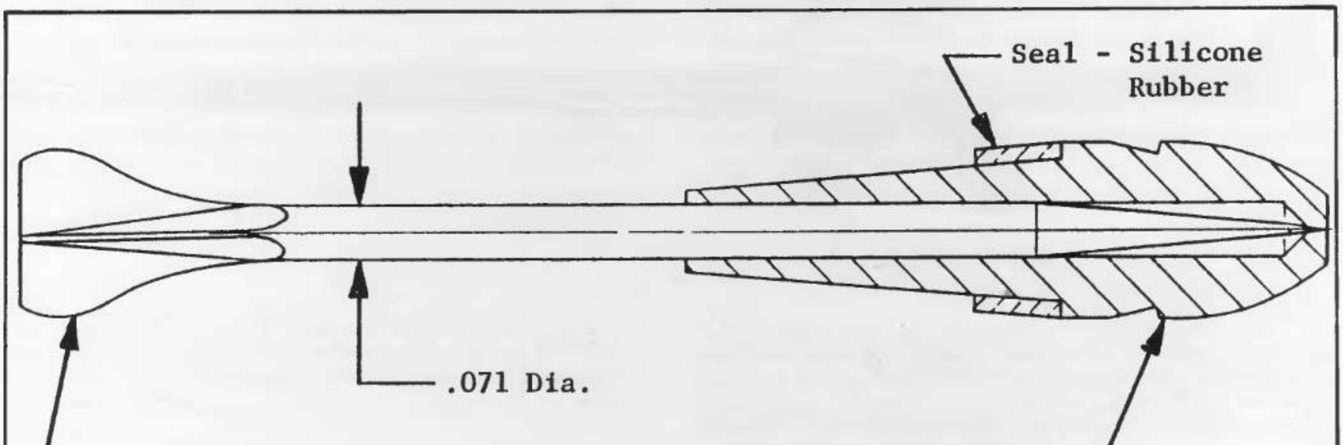
It certainly cannot be said that AAI lacked faith in the serial flechette concept. By the time of the CDEC trial, and well ahead of any firm contract, firing models of AAI's first true flechette-firing automatic weapons already existed. These were of extremely lightweight construction, due in part to the superthin, jacketed smoothbore "pencil" barrels and the absence of any burst control mechanism. To fire a burst, the operator simply inserted a magazine loaded with the requisite number of rounds and pulled the trigger! These early rifles were largely responsible for the tremendous boost given to the flechette program by the overwhelmingly positive response from CDEC and the other Army test agencies.

36. Three examples of AAI's first auto-fire flechette rifles, produced by AAI without any government aid or funding. Extremely lightweight construction with remarkably thin jacketed "pencil" barrels and no burst-fire counter mechanism. To fire a burst, the operator simply inserted the required number of rounds into the magazine, and pulled the trigger! These early rifles turned the tide in favor of the flechette and the "All-Purpose Hand-Held Weapon" (APHHW) concept in such important trials as the 1961 Army Combat Development Experimentation Center's Optimum Composition of the Rifle Squad and Platoon. *Aircraft Armaments Inc.*

37. A burst-fire test of the early "pencil" barrel AAI serial flechette rifle. Aircraft Armaments Inc. photo, dated February, 1962.

The real clincher finally came in the form of official Ordnance Corps sanction of a parallel Defense Department flechette weapon-and-ammunition development program. Under broadly-based and open-ended terms, Springfield Armory was tasked to come up with an alternative proposal for a flechette-firing weapon, and Frankford Arsenal was ordered to develop the best possible competitor to the piston-primed XM110 cartridge. One important area of communality was stipulated from the outset: AAI's flechettes and rubber-obturated, fiberglass "puller" sabots were deemed satisfactory, and were to be loaded as an AAI-supplied "package" into both the XM110 and the new Frankford/Springfield round. At this time, determined to develop a plan that would mass-produce loaded flechette cartridges at an economical unit cost, the Army allocated $777,000 towards an advanced production engineering (APE) program for both rounds.

38. And then there were two: a comparison of the first generation of flechette cartridges. LEFT: AAI's dimple-case XM110, 2-5/16" overall, beside the Springfield/Frankford XM144, 1-15/16" overall. CENTER: a cutaway view of the XM144, showing the AAI flechette-and-sabot "package". RIGHT: three flechettes: a practice "blunt", a hand-ground 10-grain compound-point anti-personnel, and for comparison the 8-grain shotshell flechette. All actual size. Recollections are that the cost of these relatively small test quantities of early flechette cartridges ran to around $3.50 per round.



39. An AAI drawing of the perfected flechette-and-sabot "package", as loaded into all the competing flechette cartridges; the XM110, the XM144 and the H&R "Triple-bore Tround".

The Fateful Inclusion of Area-Fire Capability

Thus, less than a year after H&R's burst-bolt-and-receiver debacle had further staggered the already teetering M14 rifle procurement program, there existed a new, shorter, conventionally-primed version of the single flechette cartridge, called the XM144. Design studies for two types of flechette-firing shoulder rifles were begun during this period at Springfield, plus a gas-operated "Universal" light machine gun , all chambered for the XM144 cartridge.

By January of 1962, a set of formal military specifications for a flechette firing weapon had been prepared and submitted to the Office, Chief of Ordnance for approval. The specifications superseded the short-lived APHHW nomenclature with a new name for the project: The Special Purpose Individual Weapon; the SPIW. In these specifications one important main addition was made to the original burst-fire flechette weapon concept: the new SPIW was to combine the *point-fire* characteristics of the flechette-firing APHHW with the *area-fire* potential of a weapon like the recently introduced M79 grenade launcher.

40. A view of the failed breech of M14 rifle serial no. 73293, produced by the Harrington & Richardson Arms Co. as part of H&R's initial April, 1959 contract for 35,000 M14 rifles. A number of H&R's early M14s "disintegrated" when fired, due to a mixup in the steel used for fabricating the receivers. This fiasco, discussed in US Rifle M14, *created a further serious setback in the Army's already beleaguered M14 procurement program.* *US Army photo.*

The single-shot, break-open M79 launcher had been declared "Standard A" in December, 1960. It fired the highly effective 40mm area-target cartridge, originally loaded with the M406 HE grenade. Both weapon and cartridge had been the result of another, very successful late-fifties ORO study, codenamed project NIBLICK. (Originally, a niblick was the golf club with the highest "loft"; today, it would fall between a nine-iron and a sand wedge. In any case the name was certainly apt in describing the flight of the M79's projectile). A whole range of versatile anti-personnel loadings was developed for the M79, which deservedly became quite a popular combat tool.

The 40mm cartridge case itself represents a very interesting and noteworthy triumph of American design and production techniques. It is constructed in an unusual reverse-draw process, akin to peeling a banana, but with the aluminum "skin" remaining in one piece. The bottom tip of the "banana peel" thus ends up as a small, hollow chamber *inside* the base of the case. This chamber is therefore sealed on the inside, but open at its new "end" in the base of the case. Here it is shaped to receive the primer. Before being charged with powder and primed, however, the interior of the chamber is intentionally "weakened". This weakening operation is performed so meticulously that when the cartridge is fired, the chamber will reliably contain the explosion until the pressure inside it reaches a certain closely-defined point. When this happens, the chamber perforates and the *high-pressure* gases rush out into the comparatively much larger area of the hollow, empty case itself, where they quickly produce a relatively *low-pressure* push, launching the projectile out of the rifled bore of the M79. The resulting round is expensive to make, but has proven very effective. In combat it has saved many "friendly" lives by providing for the first time a practical and astonishingly accurate 400-meter area-fire capability for the individual soldier.

The main advantage of this "high-low" pressure system from a weapons design standpoint was that the shell casing was virtually *self-contained* when fired, requiring remarkably little in the way of barrel-and-breech support. (This ingenious principle soon proved extremely adaptable, not to say invaluable, in the various SPIW grenade launcher developments described later in the book. Here if anywhere the Army's enthusiasm knew no bounds: the requirement for *single-shot* launchers was superseded even before the SPIW development plan was finalized. In the sudden rush to build *semi-automatic* area fire into the SPIW, weight and complexity became dismayingly major issues indeed.)

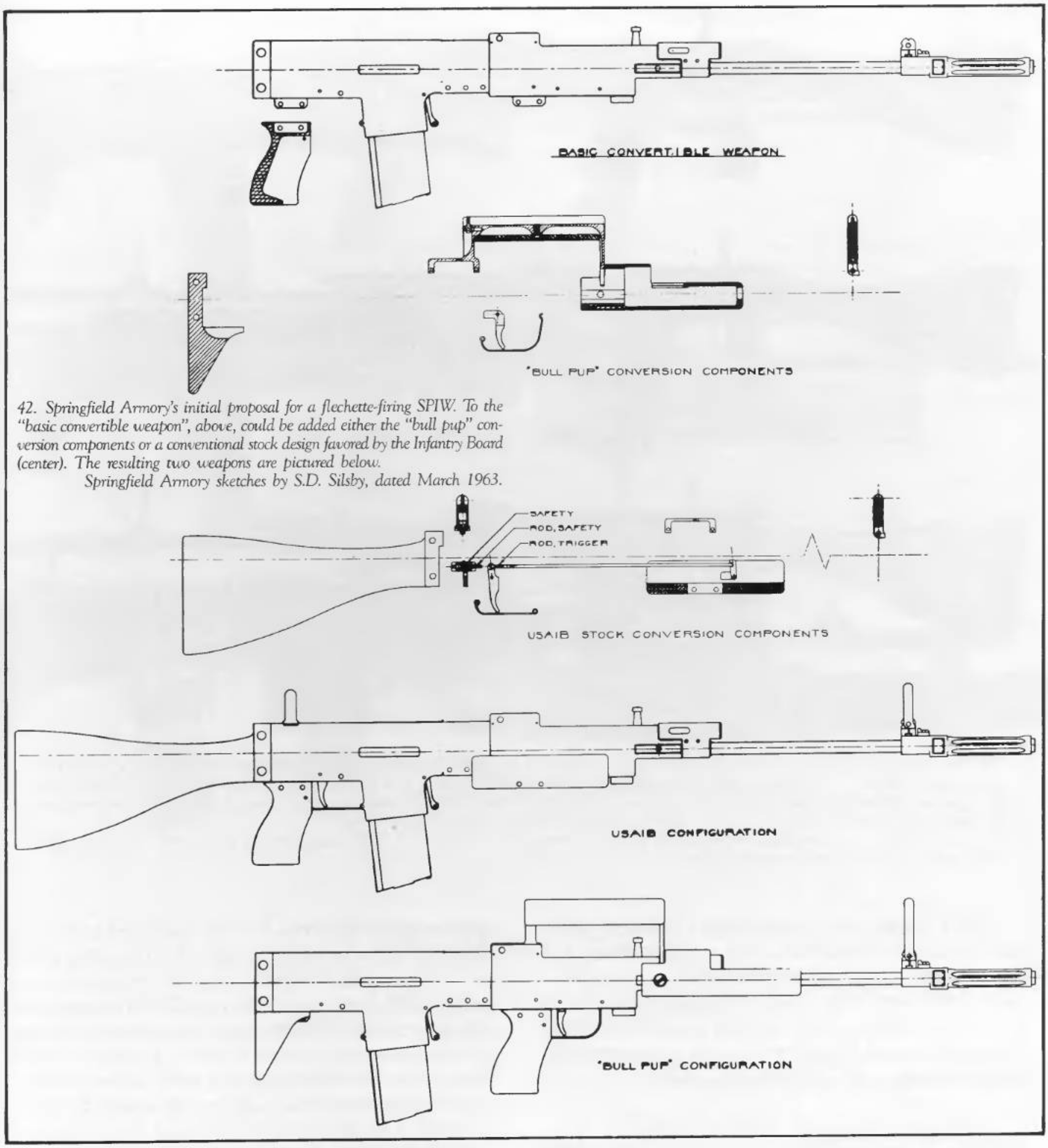
On March 22, 1962, the Office, Chief of Ordnance approved the detailed forecast for the development of the SPIW. This bulky document spelled out every characteristic which the SPIW was to have, along with a carefully thought-out series of steps which were to be followed during its creation, acceptance testing and final adoption. The objective was to "provide the individual soldier with a weapon system possessing the capability to engage point and area targets to a range of 400 meters". The forecast ended by confidently predicting that the SPIW would be type classified "Standard A" by June of 1966. Ironically, this casting-in-concrete of the plan to make the SPIW was one of the last functions ever performed by the Ordnance Corps.

41. The popular and versatile M79 break-open grenade launcher, designed by Springfield Armory, shown here being loaded with the M433 dual-purpose 40mm grenade cartridge as developed by the Army Munitions Command at Picatinny Arsenal. The M433 could penetrate up to two inches of armor plate, and was designed to break up enemy fortifications of logs, earth or sandbags. US Army photo.

The Army Cleans House

On July 1st, 1962, President Kennedy's Secretary of Defense, Robert McNamara, authorized the creation of a brand-new, gigantic Defense Department agency named the Army Materiel Command (AMC). The newly organized chain of command within AMC reflected the recommendations of several studies which had been carried out over the preceding decade, all of which pointed to the need for widespread reorganization within the Army. By a dramatic stroke of the pen, the Ordnance Corps plus the Chemical, Quartermaster, Transportation and Signal Corps ceased to exist, and were melted down into the one new Command. In choosing AMC's first Commanding General, Secretary McNamara passed over the senior Chief of Ordnance in favor of an officer with a career hitherto in Transportation Management, General Frank S. Besson. The Ordnance function was reconstituted into a new "Commodity Command" subordinate to AMC, and headquartered hundreds of miles away from the Pentagon and the traditional New England arsenal system, at Rock Island Arsenal in Illinois. Originally titled the US Army Ordnance Weapons Command, the new agency was renamed the US Army Weapons Command (AWC; later called WECOM) on August 1.

To many, here was retribution at last for every real and perceived Ordnance snafu that had gone before; proof of the acute displeasure which surrounded the Ordnance Corps' much-maligned M14 rifle procurement program



42. Springfield Armory's initial proposal for a flechette-firing SPIW. To the "basic convertible weapon", above, could be added either the "bull pup" conversion components or a conventional stock design favored by the Infantry Board (center). The resulting two weapons are pictured below.
Springfield Armory sketches by S.D. Silsby, dated March 1963.

and its stubborn but ultimately futile stonewall against the AR-15. (The latter had already been purchased in limited numbers by this time). Scant months later all M14 rifle production was abruptly halted, and contracts with the three hapless civilian M14 producers were brusquely abrogated. At Springfield Armory, all further development of the hardy but exceedingly untimely M14 was resolutely wound down. The countdown to the adoption of the SPIW was allowed to proceed as directed in the Ordnance-approved plan, but henceforth under the direction of AMC's Army Weapons Command and its test agencies.

43. Three views of the conventional version of Springfield's "convertible" SPIW. ABOVE: mock-up of the point target weapon only. CENTER: point target weapon, fitted with single-shot grenade launcher. BELOW: point target weapon with semi-automatic launcher.
Springfield Armory photos, dated May-June, 1963.

To Dr. Carten and the few other Ordnance people who relocated to Rock Island, the secret five years and the nearly two million dollars already spent on the development of a flechette-firing "wonder rifle" suddenly appeared in a determined new light: only by carrying the SPIW to completion could they save any shred of the previously proud reputation of US Army Ordnance.

During this violent political upheaval within the Army, there was at least agreement on one topic: all the tests by all the agencies over the preceding two years had concurred that the SPIW concept was technically feasible, and that the approach to its development as mapped out in the Ordnance-approved plan was logistically sound. One of the few notes of warning concerned the flechette ammunition; although it was pointed out that only relatively small test quantities had been produced to date, the unit cost was so far still very high. An interesting report by the Comptroller General's office, commissioned much later in 1970 to examine the whole SPIW program, had this to say about the early cost of flechette ammunition:

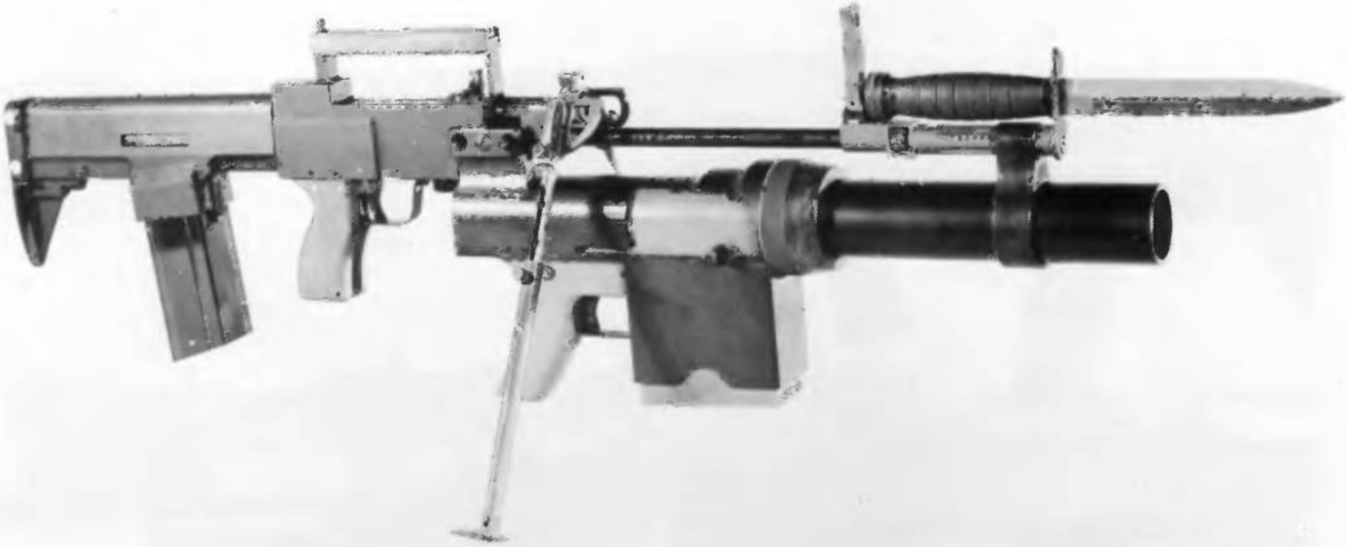
> *. . there was some question as to the ultimate unit cost of combat quantities. Because of the large quantities of small arms ammunition used in combat in a small arms system, the per unit cost of ammunition is critical in determining whether or not the small arms system is economically feasible. Thus tooling studies for mass production techniques and manufacture of large ammunition quantities were required to establish reasonably predictable and low enough units costs.*

44. The Springfield "convertible" SPIW in bullpup configuration. ABOVE: mock-up of the point target weapon only. CENTER: point target weapon fitted with a 3-round, pump-forward grenade launcher, designed by Robert F. Magardo (see figure 47, below). BELOW: point target weapon with an improved version of the semi-automatic launcher.
Springfield Armory photos, dated May-June, 1963.

The SPIW is Born

Meanwhile, forty-six private-sector companies had participated in an October, 1962 meeting arranged by Army Weapons Command to familiarize industry with what was required in the new weapon, and to solicit design proposals. Heartened by this response, the Army confidently accelerated the SPIW's adoption date by a full year, to June of 1965.

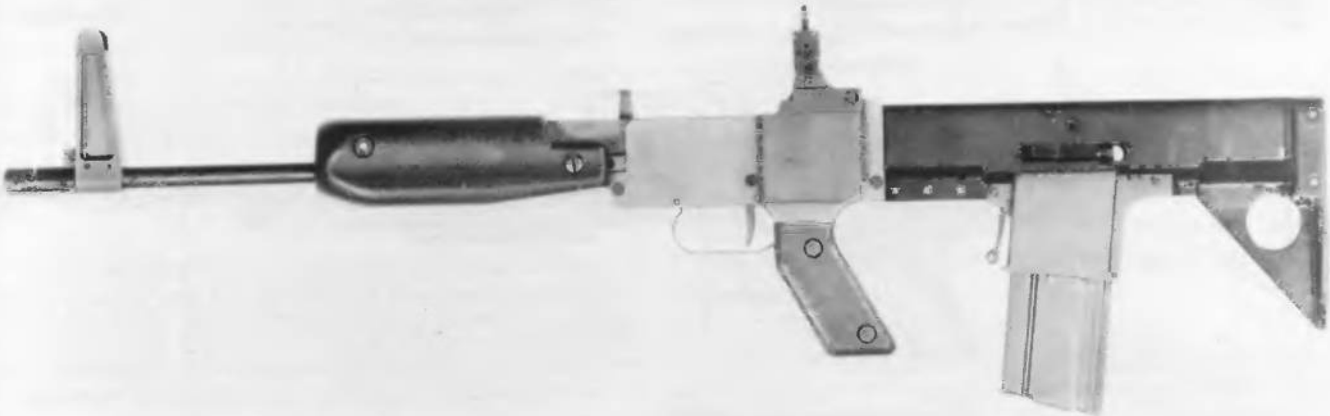
By December 1962, ten formal written SPIW development proposals had been received from industry. Each posited a completely different design, but all ten promised an on-time and reliable hand-held point-and area-target weapon which would meet the specifications. These proposals were carefully evaluated in a two-month study. AWC had already decided to encourage differences in approach to the actual SPIW design, and concluded that four competitors would be sufficient to produce a viable "best" design. Accordingly, in February, 1963, contracts were awarded to two still-smarting former M14 rifle producers, the Harrington & Richardson Arms Co., and Olin's Winchester/Western Division. The third and fourth designs which were chosen already had head starts, as mentioned previously, at both the soon-to-be-renamed AAI Corporation (formerly Aircraft Armaments Inc.), and at Springfield Armory.



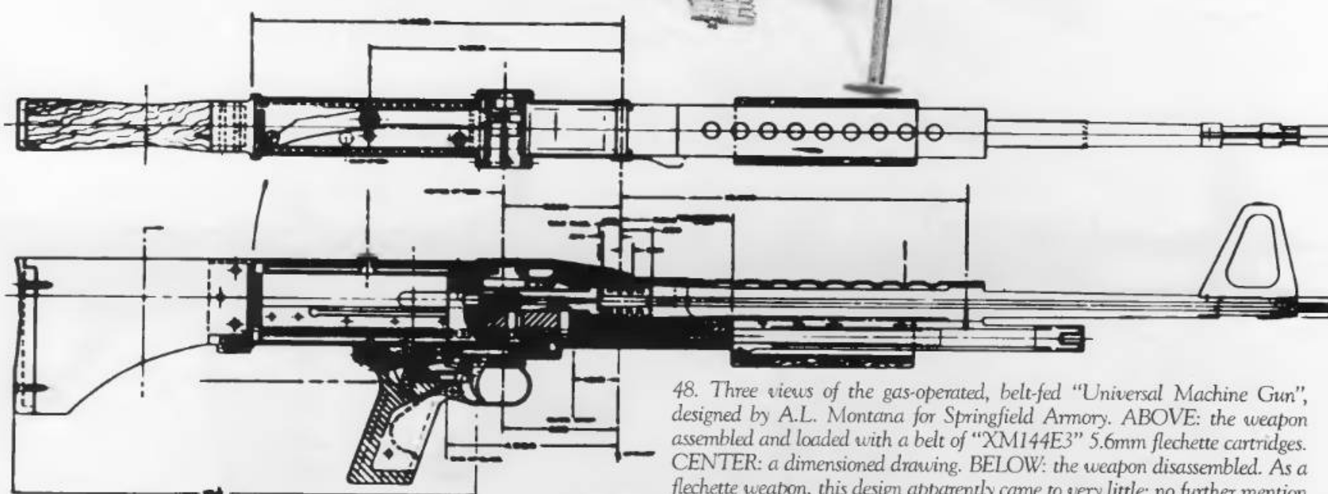
45. Mock-ups of both versions of Springfield's original SPIW, complete with ancillaries. ABOVE: bullpup point target weapon with semi-automatic launcher, bipod and (M4) bayonet knife. BELOW: conventional point target weapon with manual launcher and accessories. The bewildering complexity of these early weapons brings home designer Richard Colby's later comment: "the SPIW was the first of the programs to be doomed from the start by ridiculous specifications." *Springfield Armory photos, dated May-June, 1963.*

Army Weapons Command solemnly forecasted that the development, testing and subsequent set-up to manufacture the four SPIW designs and the necessary cartridges would cost over twenty-one million 1963 dollars, not including the one-point-nine million already spent by the Ordnance Corps. AWC retained responsibility for overall technical control and staff supervision for the entire weapon system, and would co-ordinate progress status reporting to headquarters, AMC. The three civilian contractors, plus Springfield Armory, were already hard at work on the four different weapon designs. Turning to the old line Ordnance agencies for support, the Army charged Springfield with the conduct of parallel supporting investigations into such matters as water-in-the-bore and barrel-and-stripper life and erosion. Frankford Arsenal was made responsible for overseeing the development and production of both AAI's piston-primed XM110 cartridge and Frankford's own new conventionally-primed XM144 flechette round. Picatinny Arsenal was given overall responsibility for area-target munitions. When the prototype weapons were ready, engineering design testing would be performed by Aberdeen's Test and Evaluation Command (D&PS) and the Ballistic Research Laboratories (BRL), plus the Human Engineering and Materials Research Laboratories. Here the four SPIWs would be compared, and the most promising weapon system would be selected for refinement and final service trials. Meanwhile, contracts let mainly to private industry would provide the goodly quantities of flechette ammunition for the firing trials, developing as a by-product the much-needed mass production "know-how" to ensure an economical flechette round.

46. Springfield Armory's "SPIW Concept No. 2", serial no. 1, point fire weapon only. *Springfield Armory photo, dated August, 1962.*



47. Springfield designer Robert F. Magardo, demonstrating his manually operated three-shot "pump-forward" grenade launcher, mounted on the Springfield SPIW "Concept No. 2", shown above. *Springfield Armory photo.*



48. Three views of the gas-operated, belt-fed "Universal Machine Gun", designed by A.L. Montana for Springfield Armory. ABOVE: the weapon assembled and loaded with a belt of "XM144E3" 5.6mm flechette cartridges. CENTER: a dimensioned drawing. BELOW: the weapon disassembled. As a flechette weapon, this design apparently came to very little: no further mention of it has been found. Springfield Armory NHS

Weapons Command's statement on the subject of the combat role the SPIW would fill, once perfected and adopted, reveals just how heavily the Army was gambling on the success of the SPIW program:

The weapon will provide the basic arm for riflemen in Infantry units and the individual arm for most other personnel in the Army. It will provide every member of the Infantry squad with the capability of projecting both point and area type ammunitions in offensive and defensive operations. Initial issue of this system will be to Special Forces and to Rifle Squad Grenadiers. Issue of the system to other [troops] will be determined at a later date.

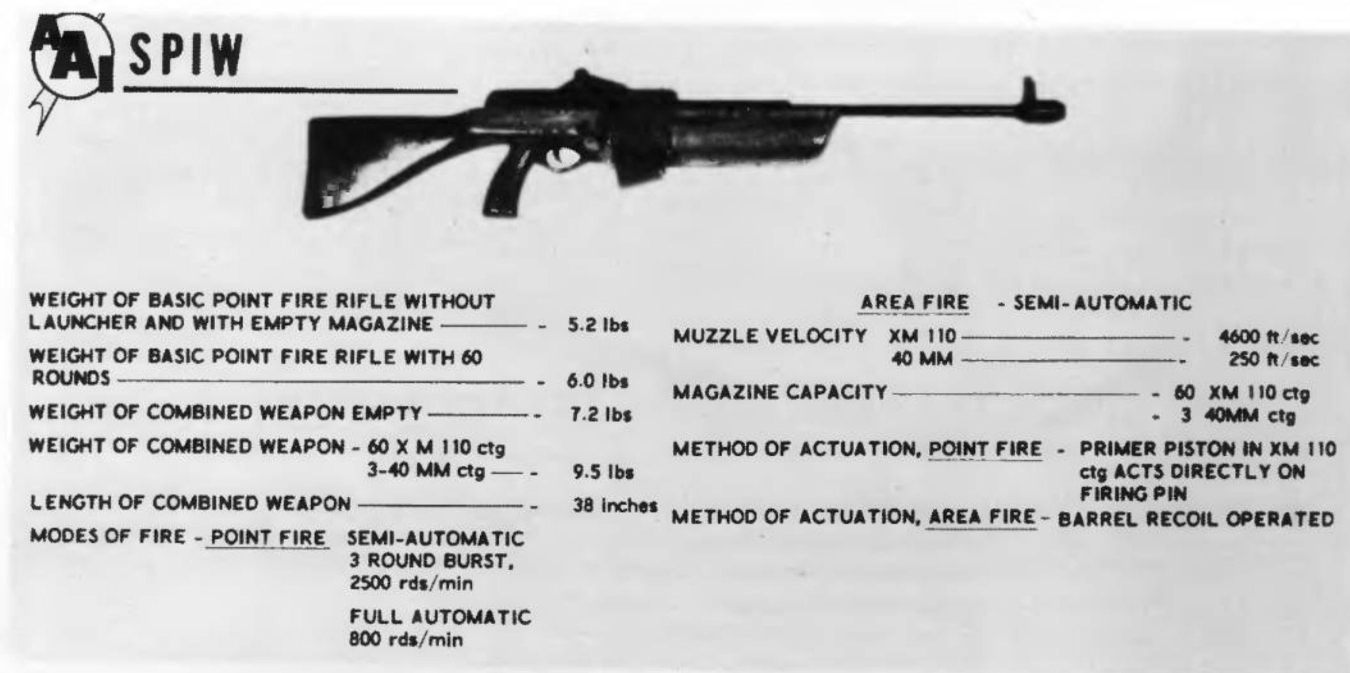
AWC's Two-Phase Technical Development Plan

The final, complete Technical Development Plan (TDP) for the SPIW program was released by AWC in January of 1964. The TDP confirmed that the program had indeed been "reoriented and accelerated to accomplish type classification by the 4th quarter of Fiscal 1965" (June 30, 1965). Phase I of the plan was as noted already under way: each of the four contractors had agreed to supply ten prototypes for initial trials by February, 1964.

As for the flechette cartridges, there were again, intentionally, several types for initial evaluation, notably AAI's multipiece piston-primed XM110, and the as-yet unjudged Springfield/Frankford XM144. AWC noted that the ammunition contracts with industry had resulted in "a higher unit cost than anticipated". Further component design improvements and tooling studies were expected to yield significant mass production economies. The feasibility of a tracer flechette had been established, and small test quantities were expected to be ready in time for trial during the phase I weapon systems evaluations of March-April, 1964.

Avco Corporation's Ordnance Division was meanwhile under long-term contract to investigate the possibility of reducing the diameter of the 40mm area-target round. (The advantage most sought-after here was a reduction in the size and weight of future launcher mechanisms).

The entire Ordnance community eagerly awaited the phase I engineering design trials of the four first-generation SPIW designs, confident that at least *one* of them would qualify as the forerunner of a whole new arsenal of prestigious and combat-effective American Infantry weapons.



49. A wood mock-up of AAI's initial prototype designed early in 1964 in response to the specifications contained in the Army's SPIW Technical Data Package. *Courtesy AAI Corporation.*

50. ABOVE: right side view of AAI's initial SPIW firing model, point fire configuration only. Caliber 5.6×53mm XM110. Note the square-section muzzle device. BELOW: left side view, weapon fitted with an early single-shot grenade launcher. Note the grenade sights. *AAI Corporation.*

51. Right side view of AAI's initial SPIW prototype, fitted with the early single-shot grenade launcher and bayonet. Throughout the entire SPIW program, AAI consistently tested and improved its own weapons without waiting for the Army: by the time of the official first generation trials in the summer of 1964, this weapon and launcher had both been superseded. *AAI Corporation.*

Chapter Four

The First-Generation SPIW

What the "SPIW Must Do"

AWC's carefully prepared SPIW data package, the TDP, officially defined the SPIW to the four phase I competitors as follows:

[Characteristics of the] Weapon, Hand-Held

The hand-held weapon shall consist of a point target shoulder fired rifle and a detachable launcher for the area fire grenade.

The weapon shall:

Be of the simplest possible design and most durable construction compatible with desired function, intended employment and economical mass production.

Be of a minimum length . . and in no case greater than 40 inches overall.

Be of minimum weight . . the loaded weight including a minimum of three (3) area type rounds and sixty (60) point type cartridges excluding other accessories shall not exceed ten pounds. Weight distribution will be such as to . . insure [maximum] pointing and handling characteristics.

Be equipped with easily identifiable, conveniently located, positive safety(s).

Have a minimum number of operating controls . . capable of being operated . . under extremes of weather.

Be relatively comfortable to carry . .

Be incapable of reversed assembly . .

Be capable of accepting:

— a light sling for carrying which is adjustable and detachable.

— a lightweight, folding detachable type bipod, sufficiently rigid to support the weapon in fire roles. The bipod must be readily detachable and be capable of attachment to that portion of the weapon which most improves stability and least compromises accuracy.

— a bayonet-knife which will provide . . a weapon for use in close combat . . No additional weight or strength will be built into the weapon to fulfill primarily the bayonet-fighting capability.

Be capable of shoulder firing without undue discomfort from recoil or blast.

Be provided with those integral safety features that are necessary to prevent accidental firing and dangerous malfunctions.

Have an ejection pattern (if there are cartridge cases to be ejected) which will not interfere with adjacent firers or the firer's ability to aim and fire accurately from any position.

[Produce] no hazard from ejected particles to personnel . .

Have simple and durable integral sights . . [with] positive settings . . it is desirable that the sight shall require only one range setting or index for firing from zero to 400 meters with 550 meters desirable.

A flash suppressor, if necessary, is acceptable. The reduction of smoke is more important that the reduction of blast.

The feed system shall include . . provision for maximum ammunition capacity . . but in no case less than 60 rounds . . [plus] . . an ammunition storage container, . . economically disposable . . [or] . . readily loaded to . . capacity in one operation . .

The [point target] weapon shall be capable of delivering selectively semi-automatic or controlled burst automatic or full automatic fire. A positive, . . manually-controlled means which is functionally tamper-proof, shall be provided to render the automatic fire and the controlled burst group mechanism inoperative without impairing the semi-automatic functioning . .

The launcher for the area target grenade shall be of minimum bulk . . and weight . . . be attachable to and separable from the point target rifle but not at the option of the individual to whom it is issued . . [and] be semi-automatic in operation. [It] shall provide for the storage and feeding of at least three (3) rounds of the munition selected. [It shall] have a simple and durable sighting system . . effectively and comfortably usable in all normal positions of fire. Adjustments for windage and range are to be provided . . ."

Under the heading "Long Range Objectives", the SPIW TDP proclaimed the intention of AWC to "explore and exploit" the following:

— caliber reduction studies for the 40mm family, to include study of smokelessness and flashlessness

— liquid propellants

— solid propellants, including combustible cases

— multiple-barrel systems

— various SCHV projectiles, of "conventional and novel configurations"

The TDP had intentionally left such items as the actual system of weapon operation to the ingenuity of the individual designer. On reading over the vast number of general parameters, however, one can begin to understand the enormity of the gulf which historically has separated weapons designers from those who think up the specifications. Those searching for the SPIW project's Achilles' heel need look no further: the mutually-exclusive requirements of great complexity within stringent weight and size limits effectively locked each competing contractor into an arcane series of trade-offs and compromises, virtually ensuring the ultimate failure of the program right from the outset. Indeed, Springfield's SPIW designer later commented that the SPIW was "the first of the programs to be doomed from the start by ridiculous specifications".

There was in fact a vast gulf separating the fanciful SPIW requirements from the realities of designing and producing successful combat hardware, but it was to take a further two very expensive years to bring this message home to AWC.

Difficulties notwithstanding, firing models of each of the four competitors' first-generation SPIWs *were* duly delivered for examination and trial in March of 1964, only one month behind schedule. Three of the four were subjected to a variety of tests throughout the summer. The fourth design never even made it to the firing trials; it was rejected almost immediately as being far too heavy, and unsafe.

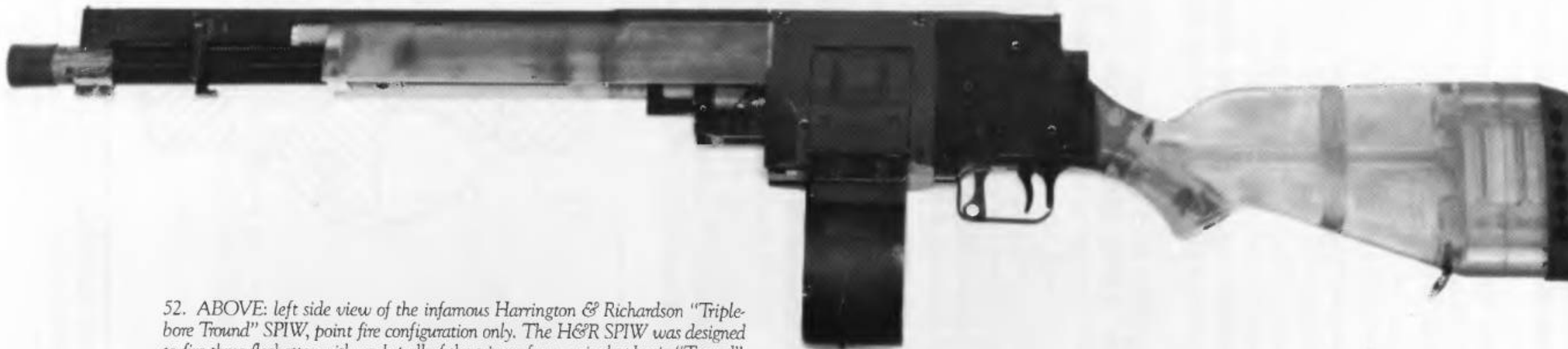
The Harrington & Richardson "Triple-Bore Tround" SPIW

Harrington & Richardson has had a curiously constant history of government production contracts for military small arms, despite the fact that the H&R product has often left a good deal to be desired. Their Korean-era M1 Garands, for example, and their later M14s (of which they were by far the major contractor), are universally considered to be among the poorest examples of these arms in existence.

The SPIW design which H&R proffered did nothing to improve the company's low reputation. Quite the reverse: the H&R SPIW earned the dubious distinction of being the only contender of the four to be rejected out of hand as "dangerous to shoot". It was built around an exceedingly ill-conceived refinement of the revolving "open chamber" principle, which had previously been unsuccessfully offered on the commercial market in pistol form by its inventor, Mr. David A. Dardick. Working for H&R on the initial phases of that firm's SPIW project, Mr. Dardick adapted the special triangular plastic cartridges his pistol had utilized, called "Trounds", to contain *three* of the standardized AAI flechette-and-sabot projectiles, grouped around a central primer and powder charge. The result was called the "5.6x57mm triple-bore Tround."

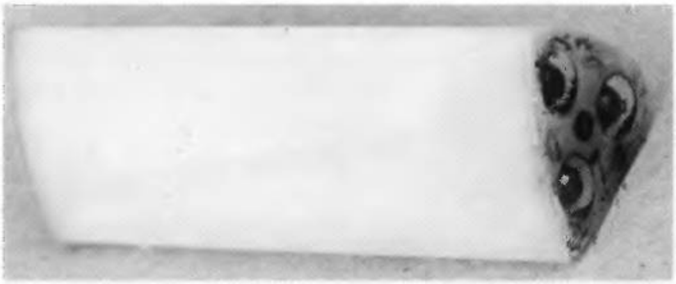
In the Dardick/H&R SPIW, the only reciprocating part was a top-mounted gas piston, which cammed a revolving cylinder 120° (a third of a turn) with each fired shot. The three open-sided chambers in the cylinder thus successively picked up the leading round of a belt of the taped-together Trounds from a box magazine suspended below the standing breech, positioned it for firing, and then released the spent case, still in its plastic belt, down the other side of the weapon. When the chamber containing a live Tround was in the firing position, all three of its flechettes were automatically lined up with a triangular cluster of three smooth bores which had been drilled in the weapon's ponderously front-heavy, square-section steel barrel. Each single shot was thus intended to fire three flechettes simultanously.

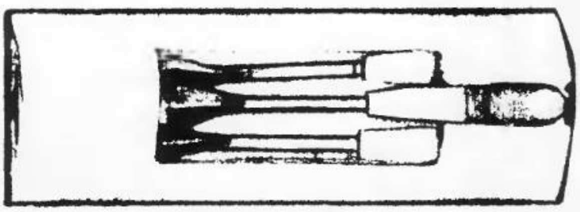
As can be seen from the accompanying diagrams of the open chamber concept, the body of each plastic Tround itself plays a much more crucial part in containing the forces of the explosion than does a conventional cartridge case, completely supported in a normal chamber. Initial function firings of the H&R SPIW had produced excess bulging and splitting in the Trounds due to variations of only a few thousanths of an inch in the plastic feed tape which surrounded each Tround.

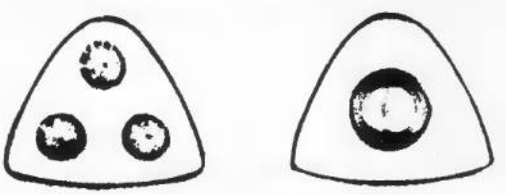


52. ABOVE: *left side view of the infamous Harrington & Richardson "Triple-bore Tround" SPIW, point fire configuration only. The H&R SPIW was designed to fire three flechettes with each pull of the trigger from a single plastic "Tround". Note the distinctive clear-plastic stock and the 20-Tround (60-flechette) drum magazine.* *Photo courtesy TRW Systems Group.*

BELOW: *right side view of the H&R SPIW, showing the weapon fitted with H&R's plastic-cylindered, manually operated three-round grenade launcher, sling, and modified M2 bipod. This unwieldly package weighed in at 23.9 lbs., against the Army's specified maximum weight of 10 lbs. fully loaded. The H&R SPIW was immediately pronounced "unsafe to shoot" by officers at Aberdeen conducting the initial proof-of-contract-performance examinations, and the program was abandoned with no further testing being attempted.* *Photo credit: Masami Tokoi.*







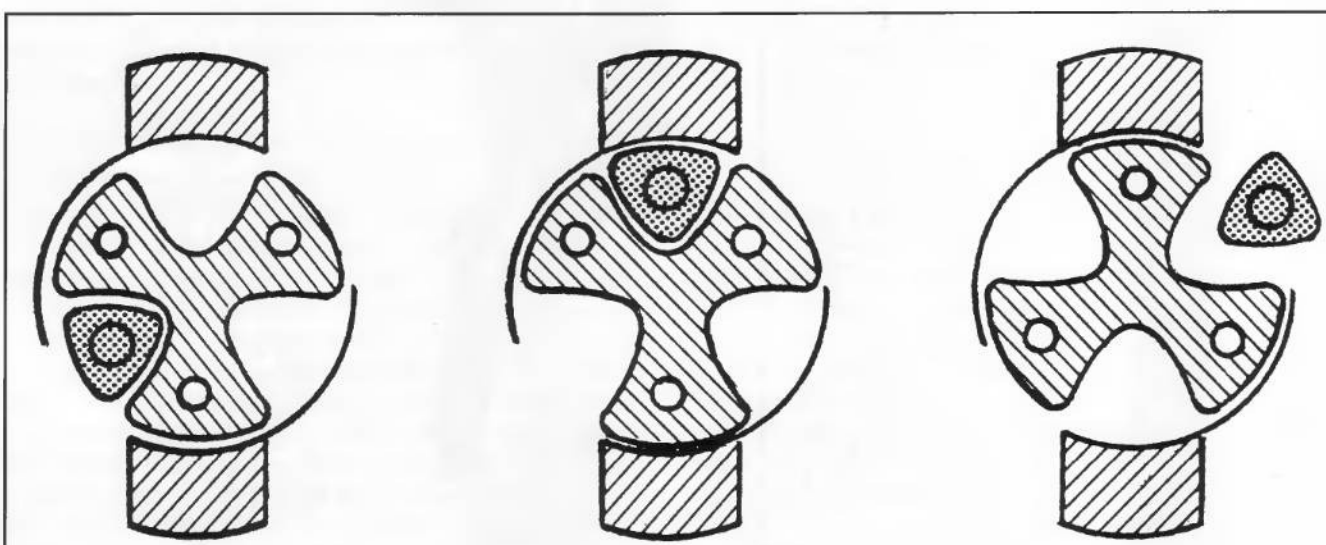
53. The H&R plastic 5.6×57mm "triple-bore Tround" cartridge, loaded with three standard AAI flechette-and-sabot "packages". The diagrams are from the Army's interim SPIW TIR 27.1.1.1 of October, 1964.

Another immediate and fundamental problem concerned the three-shots-at-once theory. The three "barrels" were in fact one common space: every time the H&R was fired, gas leakage *began* as soon as the flechettes left their Tround. The first flechette exiting the muzzle triggered a further, dramatic drop in pressure. At best, this reduced the muzzle velocity, and consequently the range and accuracy, of the other two flechettes. At worst, the pressure drop just might leave one or both of the remaining flechettes stuck in their respective bores, waiting to act as a serious obstruction when the next shot was fired.

The H&R area-target device, on the other hand, was apparently not a bad idea at all. It was later described as:

> *a three-chambered plastic cylinder shaped like a three-leaf clover. Its firing spring was cocked by a short-stroke manual pumping action of the forearm stock. Each stroke brought a chamber of the cylinder into firing position. Fresh cartridges were inserted through the rear, . . automatically pushing out the fired case through the front. The launcher system was directly connected to the trigger system of the rifle through an adjustable linkage.*

In any event, the whole H&R SPIW package weighed in loaded at a ludicrous 23.9 pounds: the specification, it will be remembered, read a maximum of ten. Examining officers at Aberdeen's Development and Proof Services, conducting the initial evaluation of contractual performance, promptly turned thumbs down on any further testing of any part of the H&R SPIW design, summing it up



54. A diagramatic rear view of the lateral-feed, "open chamber" principle as used in the H&R "Triple-bore Tround" SPIW. LEFT: picking up a Tround from the drum magazine below the receiver (plastic tape "belt" not shown). CENTER: clockwise rotation of the cylinder positions the Tround's three flechettes for firing, supporting the Tround as much as possible, although splitting of the Trounds was reported in initial functioning trials, due to variations of only a few thousanths of an inch in the thickness of the plastic tape "belt". RIGHT: the spent Tround is released, (still in its plastic tape "belt"), down the right side of the weapon. *Drawings by Thomas B. Dugelby.*

in their *Final Report of Engineering Design Test (D&PS Phase) of Special Purpose Individual Weapon (SPIW)* as follows:

The [H&R] version of the SPIW rifle . . is designed around the open chamber principle which accommodates a triangular plastic cartridge case to contain the forces of the explosion. These cartridge cases are moved to firing station by a gas-operated cylinder which has three evenly spaced triangular notches cut into it. The triangular cartridges, referred to as Trounds, are fed by a belt which lays them in the cylinder notches to eliminate the reciprocating action required to insert and extract . . in conventional mechanisms. The rifle controls dispersion by a simultaneous launch of three projectiles (all in one plastic case [Tround] with one powder charge) through three separate barrels . . in a single housing. The rifle can be fired selectively semi-automatically (three projectiles per trigger pull) or automatically with an expected rate of 400 to 500 Trounds per minute (1,200 to 1,500 projectiles per minute). The cartridge belt consists of a plastic tape which is molded to the plastic cartridge cases. The 20-Tround belt is stored in a disposable container positioned forward of the trigger guard. Rifle no. 7 was examined only. No other tests were conducted with the [H&R] SPIW system."

* * *

The test officers at D&PS went on to conduct "a variety of adverse-condition tests, a muzzle flash test and an engineering examination" on the three remaining SPIW candidates, between June 2 and July 27, 1964, plus an evaluation of the first XM144 tracer flechette cartridges:

The objectives . . were to obtain performance and other data necessary to the comparative evaluations of four competing SPIW concepts, essential for the evaluation of contractual performance and to the continued development of the selected concept.

A further objective was to evaluate the degree of implementation of the SPIW concept into a feasible system.

The test plan was divided into a number of phases with a responsible agency appointed for each phase.

This document reports the D&PS phase of the engineer design test.

Ten each of the competing weapons systems . . were developed to meet the SPIW requirements . . . Rifle, 5.56mm, AR-15, no.013058 and rifle, 7.62mm M14, no.1166879 [Olin (Winchester)] were used for comparison purposes in the engineering examination and the flash test.

Test Ammunition, XM110

The cartridge, 5.56mm, XM110 . . is fired in the [AAI] rifle. This cartridge has a plastic sabot which pulls a 10.2-grain flechette out of the barrel of the rifle and the flechette, as it leaves the muzzle, is expected to have a velocity of approximately 4,700 fps. This cartridge has a primer-piston [which] is driven rearward upon initiation and activates the mechanism of the rifle. Lot WCC-6034 was used in this test.

Test Ammunition, XM144

The cartridge, 5.56mm, XM144 . . is fired in the [Springfield Armory and Winchester] rifles. This cartridge has a plastic sabot to pull a 10.2-grain flechette (identical to the flechette used with the XM110 cartridge) out of the barrels of these rifles, and the flechettes, as they leave the muzzle of these rifles, are expected to have a velocity of 4,700 fps. Conventional cartridge case and primer characterize the XM144. Lot WCC-6110 was used in the test.

Test Ammunition, Tracer

An experimental tracer round . . is currently being developed for evaluation during this design test. Lot no. 228 was used.

The Olin (Winchester) "Soft Recoil" SPIW

Aberdeen reported receiving Winchester prototypes nos. 1, 2, and 9 for their phase I D&PS test. As noted, the Winchester design also fired the conventionally-primed Springfield XM144 5.6x44mm flechette cartridge, developed for the Armory's SPIW program by Frankford Arsenal. Recorded muzzle velocity from the Winchester's 20-inch, non-chromed smoothbore barrel was 4,585 fps. The weapon weighed twelve-and-a-half pounds fully loaded. It was built around the "soft recoil principle", wherein the barrel and breech mechanism recoil to the rear within a housing as each round of the controlled burst is fired, thus reducing recoil felt by the firer until the recoiling parts hit the rear end of the receiver housing at the end of the burst. The mechanism itself consisted of a conventional, three-lug rotating bolt, activated by a short-stroke gas tappet above. The rate of fire was around 700 rpm for both full-auto and burst modes of fire. The rifle fired from the closed-bolt position on semi-auto, but the open-bolt position when set for full-automatic or burst fire. Aberdeen reported that the Winchester SPIW was "designed to achieve dispersion control through the soft recoil and the low mounting of the barrel to bring it on line with the shoulder without use of a straight stock and high sights."

A feature of the Winchester SPIW's sighting system which found favor was a rib extending along the top of the barrel housing from the rear aperture to the front sight blade. It enabled the firer to line up the sights and the target quickly. A detachable bipod was mounted at the extreme front of the stock and could be folded back on the top of the stock, along the sides of the sighting rib. The rifle was fed from a 60-round, detachable plastic drum magazine, mounted just forward of the trigger guard.

Winchester's area target device, which mounted quite far out on the front of the weapon, was "a three-shot recoil-operated launcher . . [firing] the standard 40mm cartridge. It functions with a forward recoiling barrel and a fixed breechblock which allows the empty cartridge case to be ejected downward to reduce mechanism length. The extra cartridges are located in two storage pods mounted in either side of the chamber of the launcher."

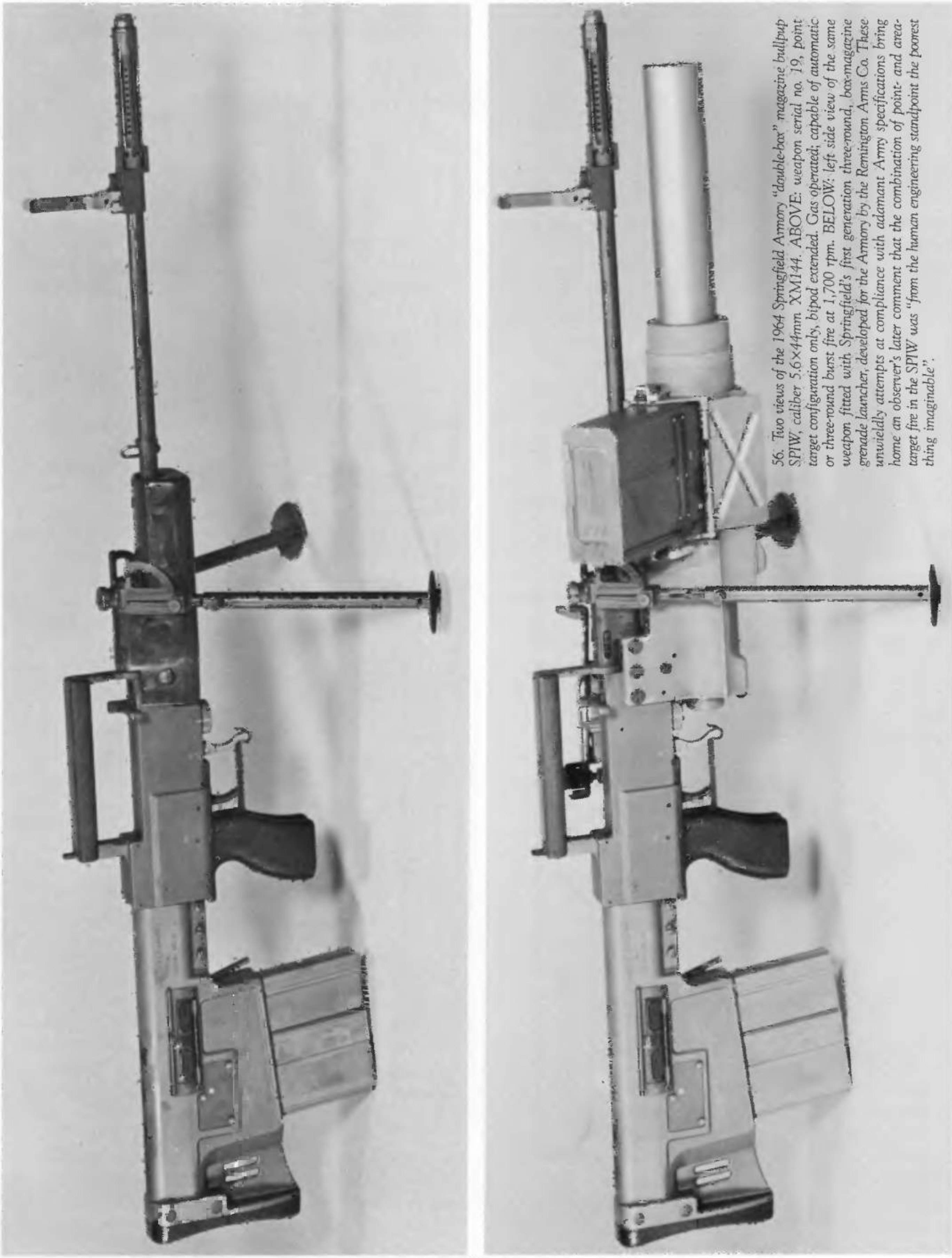
The grenade cartridges were loaded from the rear, and fed into the firing position from alternate sides. The sight for the blow-forward launcher was on the left side of the rifle. The same trigger was used to fire both rifle and launcher, but to fire the launcher an "area-fire connector button", located on the top of the rifle just to the rear of the safety, had to be depressed and held down while the trigger was pulled. If the button was not depressed, the trigger linkage to the launcher was blocked, and would not fire it.

This innovative blow-forward grenade launcher was the only feature of Winchester design to survive the phase I selection process. The point fire portion of the weapon was judged unsatisfactory due to the extreme high sliding contact areas and additional bulk and complication of the "soft recoil" components, and also because of other reliability problems. Indeed, it was discovered that the very advantages claimed for the "soft recoil" concept were difficult if not impossible to obtain when teamed with the Winchester's low rate of fire: a recoil housing many times longer than that provided would have been necessary in order that a three-shot burst could be fired at 700 rpm before the recoiling parts abutted the rear of their housing and transmitted the recoil impulse to the shooter. Test officers further reported that field stripping was difficult due to the numerous small parts and high spring forces: the unusually large mass of the recoiling components required a very strong operating spring. This made normal corrective action difficult when a malfunction did occur. During the adverse-condition trials, mud and sand quickly clogged the Winchester's recoiling barrel-and-breech system, rendering the point-target portion of the weapon useless. The Olin (Winchester) SPIW was consequently abandoned, but the blow-forward launcher was developed further under contract for the Springfield SPIW team, in favor of the Armory's own initial design.

If the first two candidates mentioned above were quick disappointments, it appears in a very paradoxical fashion that the remaining two were not. Indeed, it is ironic in the extreme to consider that the phase I weapons fielded by AAI and especially Springfield were prototype designs, which sprang in their complexity virtually from nowhere in terms of predecessors, and yet in some ways their performance was never surpassed or even matched in the following six, expensive years.

55. The first generation Winchester "Soft Recoil" SPIW, which was found unsatisfactory in the trials due to complexity and high spring forces. ABOVE: left side view of the complete weapon system, featuring Winchester's innovative, three-round "blow-forward" grenade launcher. Shown with sling and (modified BAR) bipod, folded. [This is a recent picture, taken some years after the trials, and the weapon has in the meantime been stripped of its trigger]. Plastic stock, caliber 5.6×44mm XM144. Photo credit: Masami Tokoi.

BELOW: right side view, with sling, bipod extended and bayonet fitted. The position of the ejection port directly above the drum magazine serves well to illustrate the remarkably low center-line of the bore. Note the rifle's sighting rib, one of the few features which found favor with the Fort Benning test crews. Winchester/Western Research Department, New Haven Ct.



56. Two views of the 1964 Springfield Armory "double-box" magazine bullpup SPIW, caliber 5.6×44mm XM144. ABOVE: weapon serial no. 19, point target configuration only, bipod extended. Gas operated; capable of automatic or three-round burst fire at 1,700 rpm. BELOW: left side view of the same weapon fitted with Springfield's first generation three-round, box-magazine grenade launcher, developed for the Armory by the Remington Arms Co. These unwieldly attempts at compliance with adamant Army specifications bring home an observer's later comment that the combination of point- and area-target fire in the SPIW was "from the human engineering standpoint the poorest thing imaginable".

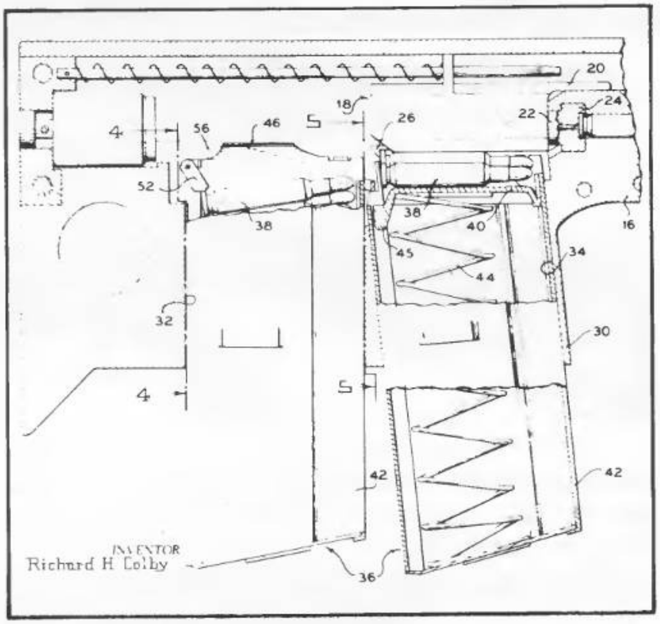
The Springfield Armory Bullpup SPIW

As part of its initial 1963 "exploratory development", Springfield has designed at least two SPIW models capable of being assembled in both conventional and bullpup configurations. Largely due to the point target magazine actually fielded for first-generation trials, the bullpup version was retained.

Aberdeen described the 1964 Springfield bullpup SPIW as " . . a conventional gas operated system which fires the XM144 cartridge . . . main portions of the mechanism are housed in the butt stock." The rifle fired from a 60-round double-box magazine and was gas operated (gas impingement), with a front-locking, rotary bolt. A selector knob permitted setting the rifle to fire automatically or in controlled, three-round bursts, both at 1,700 rpm; or semi-automatically. All modes of fire were from the closed-bolt position. A flash suppressor/muzzle compensator, containing a rifled insert for stripping sabots, was mounted on the front end of the 26" smoothbore barrel. A bipod, mounted on the gas cylinder, could be folded along the barrel when not in use. The 38-inch Springfield SPIW weighed 14.1 pounds fully loaded.

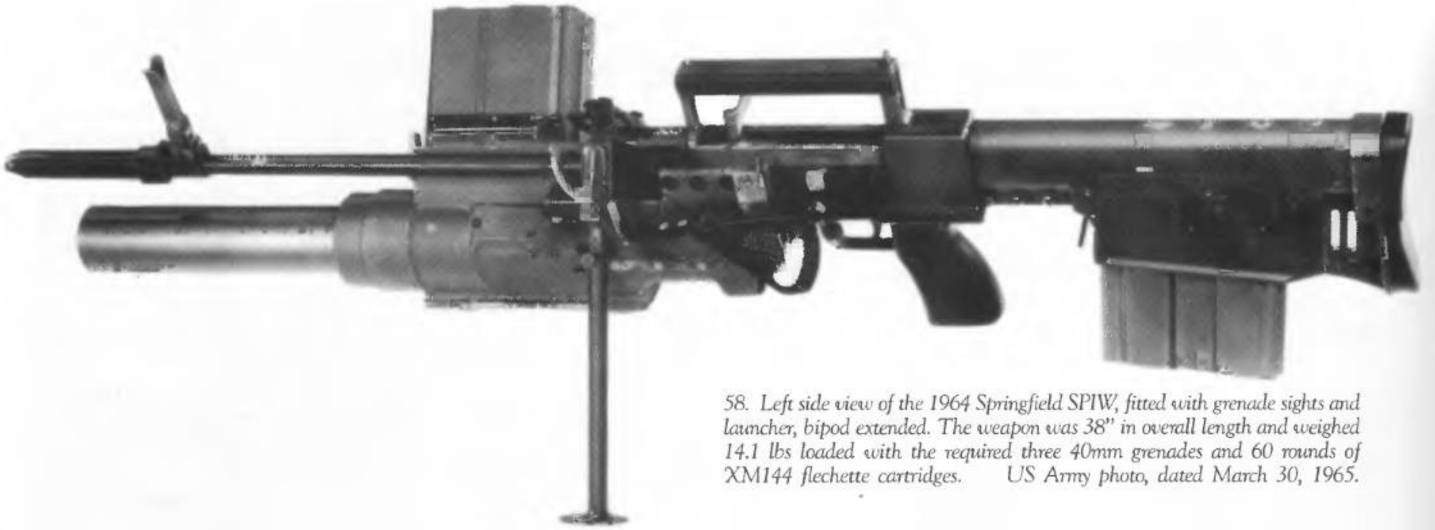
The Armory grenade launcher fastened under the rifle barrel and operated on the short-recoil system with limited blowback assist. It fired the standard 40mm grenade, semi-automatically from a three-round box magazine, by means of a separate trigger integral with the launcher. As mentioned, the Springfield team subsequently abandoned this launcher in favor of continued development of the blow-forward Winchester design.

The Springfield "point target" magazine serves very well to illustrate the ingenuity of design born of sheer desperation which was to become the rule rather than the exception during the SPIW program, simply in an attempt to stay even with the requirements! Springfield's solution to the 60-round capacity specification combined two thirty-round, double-column stacks one behind the other. (It was here that the bullpup concept came to the rescue, providing the least-awkward place to mount such a box-like device!). In firing, the reciprocating bolt stripped rounds off the leading stack until it was empty and the follower appeared. This freed a device which had been depressing the rear stack of cartridges, allowing them to rise into the path of the bolt. The rear magazine had no feed lips as such: the bolt first slid the top round from the rear magazine forward onto the follower of the empty front one, and then fed it up into the chamber.



57. A drawing from Richard H. Colby's US Patent concerning his double or tandem 60-round box magazine design for the first generation Springfield SPIW. In firing, rounds were stripped off the leading stack until it was empty and the follower appeared, whereupon a pawl freed the rounds in the rear stack to rise into the path of the bolt. The bolt then pushed rounds from the rear stack onto the front follower, and then up into the chamber. This was just one of many incredibly ingenious designs made necessary by the rigorous SPIW specifications. *US Patent Office.*

The designer in charge of development of the 1964 Springfield bullpup SPIW was Mr. Richard Colby. He had not chosen the unique double magazine design frivolously. Feeding sixty rounds of even the small, lightweight XM144 flechette cartridges from a *single* double-column stack had proven to be an impossible task: *no* magazine spring that could be reloaded by hand would provide enough "lift" fast enough to have the next round of a full magazine ready for feeding during 1,700 rpm burst fire. This is not to mention the fact that calculations for such a magazine revealed that it would be so long and unwieldy as to make shooting from the prone position impossible.



58. Left side view of the 1964 Springfield SPIW, fitted with grenade sights and launcher, bipod extended. The weapon was 38" in overall length and weighed 14.1 lbs loaded with the required three 40mm grenades and 60 rounds of XM144 flechette cartridges. US Army photo, dated March 30, 1965.

Both Winchester and, as we shall see, AAI answered the first-generation 60-round point target capacity requirement by using drum-type magazines, but in so doing both firms encountered many new and serious frictional forces inherent in a rotary feed system. These led to chronic feeding problems and consequent unreliability, which in Olin's case contributed to the demise of the whole Winchester SPIW program. It is noteworthy that the point target ammunition capacity specification was eventually relaxed to a more realistic fifty rounds, but not until the perfection of the sixty-round magazine had eluded a further two years' expensive development.

The AAI Corporation Primer-Actuated SPIW

The examining officers at the initial Aberdeen D&PS trials described the AAI entry as follows:

> *The [AAI] SPIW rifle is gas operated. The mechanism is designed to exploit a recent piston primer concept in ammunition (XM110 cartridge). In this system, the primer ignites the propellant and it, as a piston, is moved to the rear by the force of the propellant gases. This power, acting through the piston, drives the firing pin to the rear, so as to unlock and open the bolt, thereby eliminating the requirement for a conventional gas system. The [AAI] rifle was expected to achieve cyclic rates as high as 2,300 to 2,500 rpm. With this high cyclic rate, together with a muzzle compensator, it was hoped that controlled dispersion could be realized. The rifle is intended to be fired selectively semiautomatically, in controlled bursts of three sequential rounds (cyclic rate of 2,300 to 2,500 rpm), or automatically (predicted cyclic rate, 600 to 700 rpm). The rifle is fed from a 60-round plastic drum-type magazine . . positioned just forward of the trigger guard. Rifles nos. 2, 4, and 7 were tested.*
>
> *The [AAI) launcher, mounted beneath the barrel, . . was to be a 3-shot, blowback-operated launcher featuring a sliding type breech and firing standard 40mm, M79 grenade launcher ammunition. This breech was to reduce the mechanism length through elimination of a reciprocating bolt. However, the launchers delivered for test employed a manual lever action mode of fire and were not blowback operated. The extra 40mm cartridges are stored in a tubular magazine arranged in tandem behind the breech. The . . launcher is fired by a separate trigger integral to the launcher."*

The 1964 AAI SPIW was 39.9 inches long overall, and weighed eleven pounds unloaded, or 13.3 pounds fully loaded with the required sixty XM110 flechettes and three 40mm grenades. Muzzle velocity from the AAI's 18-inch barrel-and-stripper was 4,820 fps, with an actual measured cyclic rate of 2,400 rpm on three-round burst fire. The rifle fired from a closed bolt in all modes of fire. Fire selection was made by moving a rate selector to "3" for high-rate burst, "A" for full automatic (600-700 rpm) and "1" for semi-auto.

59. ABOVE: two views of a third- or fourth-iteration prototype of AAI's 1964 primer-actuated SPIW, point target configuration only. Caliber 5.6×53mm XM110. The round-section muzzle device was soon superseded, as was the fragile wood surround protecting the 60-round drum magazine. BELOW: one step closer to the AAI SPIW as fielded for first generation trials. Note the metal magazine well, and the distinctive square-section muzzle device. The safety is ON in both pictures. AAI Corporation

The AAI semi-auto, blowback grenade launcher, which Aberdeen describes above but did not test, was perfected in time to feature in the first-generation firing trials, and was later described as

> *. . fastened beneath the barrel of the rifle. It was 16.5" long, weighed 6.5 lbs. fully loaded, and had a 6" barrel. One M406 cartridge was positioned in the chamber and the other two in a tubular magazine immediately to the rear of the operating mechanism; the magazine was similar to the kind used in automatic-loading shotguns. The spring-loaded side closures were opened by the pressure of a new cartridge being loaded into position. The [area fire] sights were of the simple aperture-and-blade type, and they folded along the [left] side of the weapon. Settings were provided in 25-meter increments from 50 to 400 meters. Adjustments for zeroing and windage were provided.*

60. Photographed just before the trials in March of 1964, here are nine of the ten contracted AAI SPIWs, proudly lined up and ready for inspection. AAI's rapid progress from initial mock-up through the prototype stages to these actual fielded first generation weapons can be traced in figures 49, 50, 51 and 59. The AAI SPIWs came the closest of any to achieving overall success in the 1964 competition.
AAI Corporation.

The First Generation SPIW at a Glance

	H&R	WINCHESTER	SA	AAI
Cartridge designation	Tround	XM144	XM144	XM110
Caliber/case length mm	5.6×57	5.6×44	5.6×44	5.6×53
Muzzle velocity fps	4325	4585	4585	4820
weapon length inches	40	40.1	38	39.9
weapon weight pounds (loaded)*	23.9	12.5	14.1	13.3
barrel length inches	20.5	20.0	26	18
operation	gas revolving cylinder	gas short stroke tappet	gas impingement	primer actuated
mag type	belt	drum	double box	drum
capacity	20 Trounds	60	60	60
rate-auto	400-500 Trounds (1,200-1,500 flechettes)	700	1,700	600-700
rate-burst		700	1,700	2,300-2,400
bolt-semi auto	—	closed	closed	closed
bolt-full auto	—	open	closed	closed
launcher type	revolver	blow-forward	short-recoil	blowback

*sixty rounds point target and three 40mm grenades.

61. Two AAI first generation 40mm grenade launchers. ABOVE: the 3-shot, sliding-breech, blowback-operated launcher, in prototype form only. As the Aberdeen test officers noted, this device was not perfected in time for the 1964 tests and was not actually fielded. Here it is shown for demonstration purposes only, mounted on the rifle with the early round muzzle device shown in figure 59 (above). AWC photo.
BELOW: the 3-shot, manually-operated, lever-action launcher as actually delivered for trial, shown mounted on a first generation AAI SPIW. The two extra cartridges were stored in the tube behind the launcher. AAI Corporation.

Phase I Results

The results of the phase I Aberdeen D&PS examinations and that summer's firing trials, which had taken place at Fort Benning from April to the middle of August, led to a curious mixed reaction. Army Weapons Command remained solidly behind the SPIW as a concept, and the SPIW designers themselves had long since recognized and accepted most of the erratic, not to say startling, behavior of their brainchildren as necessary "trade-offs" in the desperate attempt to meet the weight, size, rate-of-fire and velocity specifications. Nevertheless, a bewildering array of problems in almost every conceivable area of the endeavor was documented by the test teams.

By November of 1964, when the results were all in, one thing was certain: the carefully-planned scenario leading to adoption of a successful SPIW by the following June was out the window completely. Even "phase II" of the initial TDP, which had confidently envisaged a short period of full-scale engineering development for the successful phase I candidate followed by its limited manufacture for final troop trials, was itself now out of the question.

In the face of this major setback, the basic Army attitude to the SPIW remained one of deep commitment. In the view of many, the SPIW represented an exciting "leapfrog" into the future. Deputy Defense Secretary Cyrus Vance had summed up the importance and the clout of the SPIW program before an investigating Senate Armed Forces Preparedness Subcommittee in December, 1963, by which time ten each of the four first-generation SPIW prototypes had been well on their way to the phase I trials. The Subcommittee had questioned the judgment of terminating the M14 program the previous January before any new rifle procurement plan was securely in place. The Senators were also curious about the famous, all-we'll-ever-need "one-time buy" of 116,695 M16 and 84,350 XM16E1 rifles which the Army had just completed. In reply, Secretary Vance had glowingly described the SPIW in all its potential glory, and outlined the well-under-way two-phase plan for its adoption: once SPIW was perfected and fielded, all would be well, he said, and the wisdom of the temporizing nature of the Army's recent actions would be revealed. Secretary Vance concluded: "Termination of production of the M14 prior to the availability of SPIW involved certain risks which, after consideration by the Army, are deemed acceptable."

Around the time of the phase I selection trials, the Deputy Chief of Staff for Logistics (DCSLOG) had further stated the Army's position on the SPIW:

> *For the past several years, we have fought off any solution [to the rifle problem] which would commit the Army to another interim weapon which would hinder the development of a greatly improved individual weapon in the 1965-1970 time frame . . . if one of the current weapons [M14; M16] were procured in [this] time frame, the Army Staff prefers the M14.*

The first generation prototypes of Secretary Vance's "greatly improved weapon" had meanwhile been put through their paces at Aberdeen and Fort Benning, and the dismaying number and nature of their shortcomings were now a matter of record. The final results of the initial Aberdeen D&PS examination , for example, while written as positively and politely as possible, heralded the bad news:

> *. . A limited sampling of the systems indicated that the Springfield Armory SPIW design was the most reliable and exhibited the smallest dispersion during the adverse condition testing; however, the [AAI] SPIW design was lighter in weight, had fewer parts, was the most durable, and incorporated many desirable design features. The extreme temperature test indicated that this system . . was incompatible with high-and low-temperature environments although the results pointed to an ammunition deficiency. The XM144 tracer ammunition provided neither acceptable dispersion nor suitable tracing characteristics when fired in a special test fixture.*

Regarding the summer's simulated mass production runs of XM110 and XM144 cartridges, the news was worse: in brief, *no* economical way had been devised to fabricate a satisfactory flechette round in quantity. On the contrary, the contractors complained that *every component* required extraordinary care in manufacture and assembly, in order to ensure a reliable round. This meant a great deal of costly and difficult-to-inspect hand-work on each cartridge. The flechettes themselves, for example, in order to be lethal or even fly straight, required extremely close tolerances in fin formation, nose grinding and shaft straightness. Once sharpened, they could not again be touched with the bare hand, for fear of leaving oil or grease on the polished shaft, the minutest quantity of which might cause the sabot to slip off when the round was fired. (An expensive and much-heralded attempt to institute contracted mass flechette manufacture on "nail-making machinery" was subsequently proven a dismal failure).

Once the cartridges were successfully (if expensively) manufactured and actually fired, the Fort Benning test crews reported further problems of great magnitude.

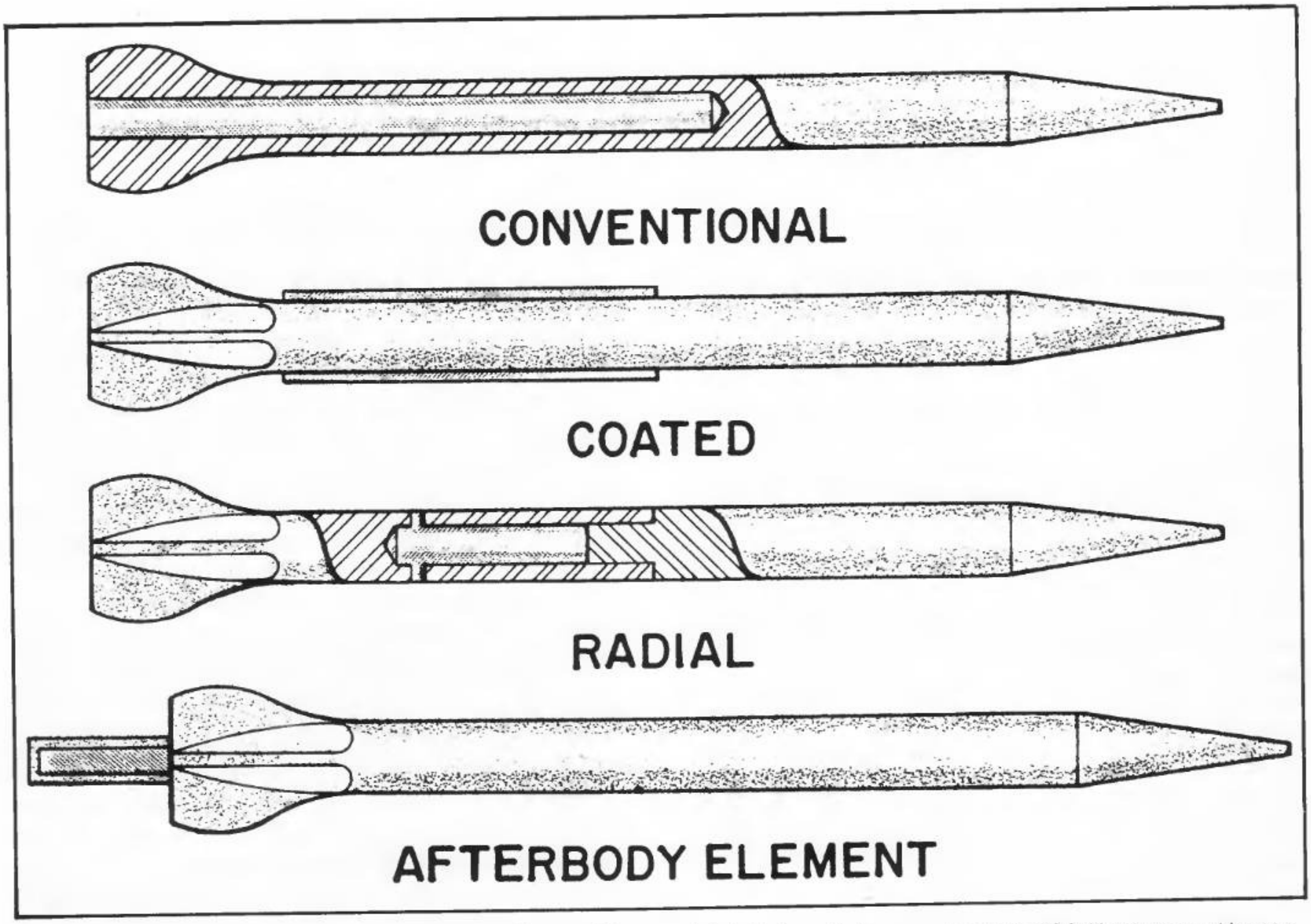
Velocities of over 4,000 fps were inherently part and parcel of the whole "serial flechette" concept, in order to achieve the stated lethality requirements. It appeared that the designers of both the XM110 and XM144 had borrowed from the original 1957 AAI report on cartridge case construction: Type "A", as previously described, had been the result of the "shortest possible case" branch of the study. This typefied the Springfield/Aberdeen XM144, which was less than two inches long overall. Sure enough, Springfield's first-generation SPIW suffered all the same problems that AAI had documented for its 1957 Type "A" round, including high breech pressure and rapid overheating. AAI, on the other hand, in order to avoid the violent peak pressures and consequent sabot slippages they had experienced with the 1957 Type "A", had opted in the XM110 for a round most like Type "B"; slightly longer and therefore capable of using a slower-burning powder. This kept the *breech* pressure within limits, but created extremely high *exit* pressures (over 20,000 psi). This resulted in a truly resplendent amount of flash and blast. More problems arose when trying to extract the fired case while the pressure inside it was still very high, necessitated in turn by the extremely high rate of burst fire [2,300-2,400 rpm] which the AAI SPIW featured.

AAI was the only first-generation contender to feature fast and slow rates of fire, and soon found that incidents of parts breakages and malfunctions occurred at an abnormally high rate when firing in the burst mode. As if this wasn't enough, the summer's firing trials at Fort Benning had revealed that the flechette as a combat projectile had less brush-penetrating ability than required, possessed virtually no ricochet capacity, and could easily be deformed or deflected in flight by even a heavy drop of rain.

The results of limited firings of the initial lots of tracer flechettes were poor, with many reports of fail-to-trace and at best a weak and/or short trace. On examination, it seemed to many that the thin, tiny body of the 10-grain flechette simply could not hold or carry enough tracing compound to ensure a strong, reliable trace. Springfield found that their water-in-the-bore research indicated even more problems in .22 cal. smoothbore barrels than with the M16: in all, the irony could not have been lost on the ex-Ordnance types who remembered their vociferous opposition to the AR-15.

In general, reported user dissatisfaction with the two "finalist" SPIW designs as *weapons* was lumped into three basic categories: poor reliability, poor durability, and excessive weight. The physical feeding of the extremely thin-walled and delicate flechette rounds at the required high rates of fire led to too many jams and stoppages; AAI in particular had a lot of trouble here, in conjunction with friction in their 60-round drum. Under adverse conditions this circular friction slowed down the feeding mechanism just enough so that, particularly in the high-speed burst mode, the next round was only half-presented for chambering, if at all. In this event, the bolt either slammed closed on an empty chamber or misfed the frail, plastic-tipped cartridge, bending it severely and jamming the action.

62. A compact, short-barreled sub-machine gun version of the 1964 AAI SPIW, shown with stock folded. Caliber 5.6×53mm XM110. One of several "spin-off" ideas which were constantly being tried out by AAI in addition to their government contract work. AAI Corporation.



63. Four proposed tracer flechette concepts, explored around the time of the first generation SPIW trials. From the top: trace compound inserted inside the body of a bored-out flechette; a standard flechette coated externally with trace compound; a two-piece flechette body designed to trace "radially" from an interior reservoir; and a standard flechette lengthened by the addition of an "afterbody element" of trace compound. The XM144 tracer ammunition actually supplied for the trials featured a variation of the "conventional" bored-out flechette (top), although in the words of the trials report this loading provided "neither acceptable dispersion nor suitable tracing characteristics" when fired in a special test fixture.

As for "system durability", the exasperated designers grew weary of trying to explain to adamant AWC test officers that every conceivable ounce had been shaved from these complex weapons in an attempt to meet the ten-pound-loaded weight requirement. It simply couldn't be done if the resulting weapon had to be robust enough to open C-ration crates and withstand bayonet charges as well. (As it turned out, it couldn't be done at *all*: no SPIW *ever* came within the ten-pound-loaded, point- and area-fire weight limit).

As the program continued, this official weight requirement was ignored as much as possible, with weights for the two "halves" of the SPIW system henceforth discussed separately.

Chapter Five

The Second Generation SPIW

With the phase I SPIW results in hand, the kindest interpretation which could be mustered was that there was still no single approach working well enough to stand alone.

No one appears to have done much of anything about SPIW for the next few months. AWC itself did little except to abort, by simple default, the rest of the first generation plan. The one glowing exception to the general mood of shocked paralysis was at AAI, where confidence and exhilaration did much to carry the whole program over the difficult winter following the 1964 tests. Indeed, many of the SPIW's initially startling idiosyncrasies, which had been abruptly "user discovered" in the first generation trials, were already the subject of much AAI research. The AAI engineers felt strongly that effective remedies were not only feasible, but just a matter of a little more time and R&D money. This attitude was at length adopted by AWC.

First, it was decided that since the initial development stage was obviously not yet completed, both the Springfield *and* AAI designs were worthy of continued funding. The Army's stated rationale for carrying both concepts further was that "following multiple concepts . . might cost a good deal less in resources and time than following a single approach if the approach eventually proved to be wrong." Thus, in a move which coincided with the March, 1965 deployment of American troops into the combat zones of South Vietnam, AWC approved a re-orchestrated, 35-month, two-phase SPIW development plan. Under the new plan, AAI and Springfield were both to develop and fabricate ten complete "second generation" weapon systems. The two contenders would again meet in competition and one would be chosen as the most promising for further development. The new phase II was to be in essence a re-staging of its stillborn counterpart from 1964: one hundred examples of the winning design would be fabricated, after some last engineering refinements, and fielded in troop trials which when successfully completed would give way directly to final adoption. There was one difference: "Standard A" status for the successful second-generation SPIW was rescheduled for March of 1968, a postponement of almost three full years. Actual manufacture was now seen in a "nineteen-seventies" time frame.

Another interesting difference in the new plan was that the Army had turned thumbs down on any further development of the EM-2-like bullpup concept, which Springfield had emulated in 1964, or even a rifle with a separate FAL-type pistol grip, like the early AAI models. From now on, all SPIWs submitted were to feature what AWC considered to be the increased "pointability" of conventional rifles, like the M14, or, to give it its due, the 1964 Winchester SPIW.

In accordance with AWC's stated plan to involve private industry in the eventual manufacture of the SPIW, new contracts were awarded to a number of companies, notably AAI Corporation: in addition to remodelling their SPIW along more conventional lines, AAI was to set up a simulated mass-production assembly line to produce 130,000 rounds of its new improved piston primed cartridge, described below. Production contracts for AAI's second-generation cartridge case, and for new one-piece piston primers, were first let at this time to the Canadian government ammunition facility Dominion Arsenals in Quebec (headstamp DA 65).

This busy program at AAI contrasted sharply with the mood at Springfield, where following the 1964 trials the Armory engineers had received virtually no feedback regarding their first generation design. In fact, as later recalled by Mr. Colby, the Armory was "completely inactive" on the SPIW project until the spring of 1965, when orders arrived giving them exactly one year to transform their 1964 bullpup into ten firing models of a second generation "conventional" rifle. Reasons for this brusque treatment were not long in surfacing: in a further reorganization

disguised as "cost-cutting", Defense Secretary McNamara had already announced the termination of Springfield Armory as an official agency, to be effective by April of 1968.

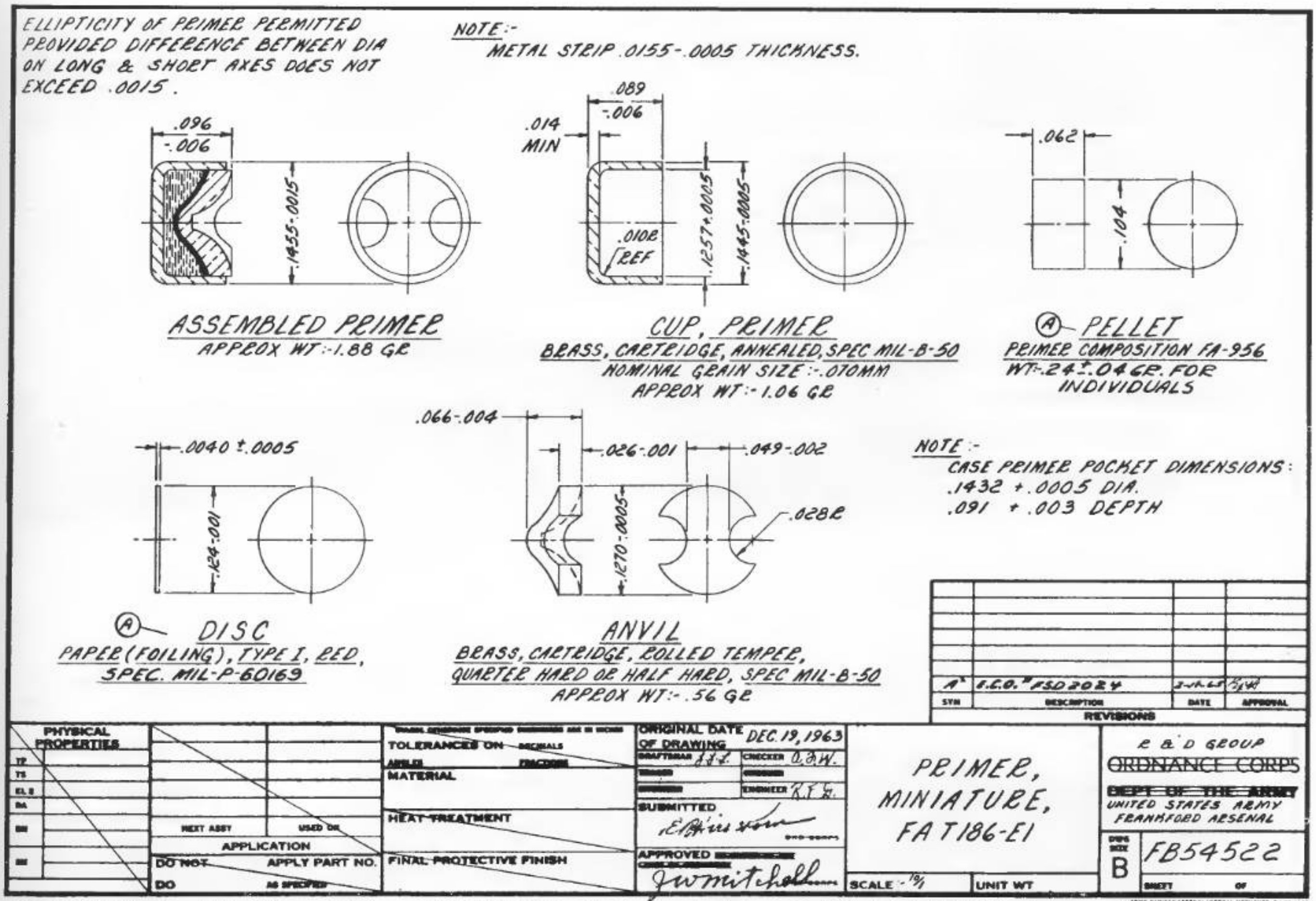
AWC held a formal "in-process review" of the whole SPIW program on February 28, 1966: according to the second generation plan, both new weapon systems were now due for testing. Neither competitor was ready; in fact both disclosed that some aspects of their new weapons had not as yet even been *designed*, let alone manufactured. AWC backed off, allowing each competitor a further ninety days "for the resolution of current problems and improvement of functional reliability."

Improvements in Flechette Cartridges

64. A contemporary American military small arms cartridge compendium. From left: the first generation 5.6×44mm XM144 beside the fatter second generation Springfield/Frankford XM216; AAI's dimpled, first generation 5.6×53mm XM110 compared with its second generation 5.6×57mm XM645, plus a cutaway view of the XM645 showing AAI's new one-piece piston primer; the 5.56×45mm (.223 caliber) M16 rifle cartridge and its "micro-bulleted" offshoot the 4.32×45mm (.17 caliber) cartridge for the serial bullet rifle (SBR); the 7.62×51mm NATO; and the 40mm grenade. All shown actual size. By this time flechette ammunition production costs had been sliced almost exactly in half from the $3.50 per round maximum mentioned earlier, but every flechette cartridge was still many times more expensive than any conventionally primed, bulleted rival.

Springfield in particular had experienced difficulty meeting the velocity requirement with their XM144 cartridge; in fact the unofficial word is that they never quite did. Be that as it may, *both* contenders redesigned their cartridge cases for more powder capacity before entering the second generation competition. Thus, Springfield's XM144 was presently superseded by a completely new round, the somewhat fatter XM216. AAI's XM110 had already left its dimples behind, to become the slightly longer XM645. Both were loaded with AAI's still-standard flechette-and-sabot package for the upcoming second generation trials.

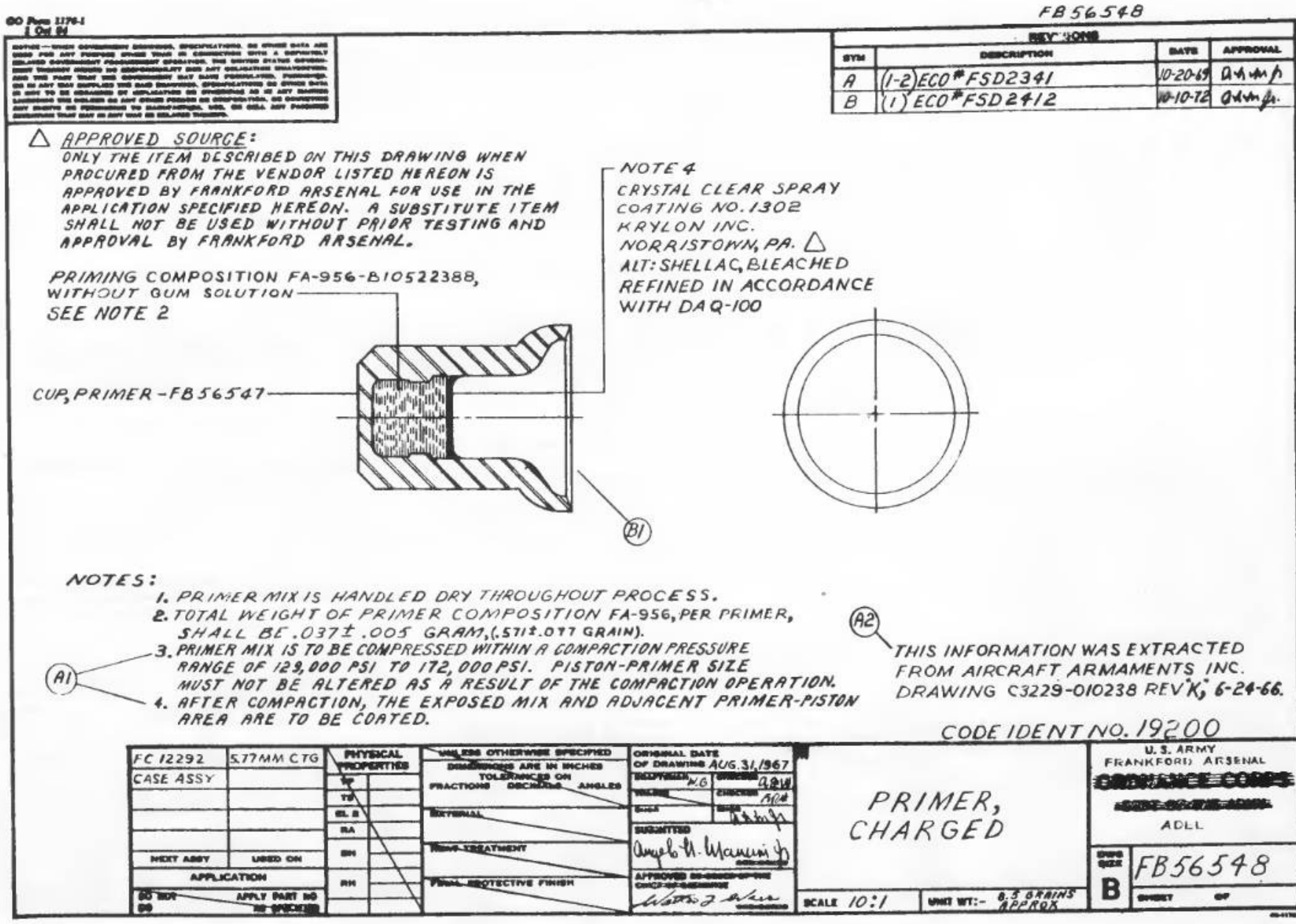
AAI had in the meantime also developed an ingenious one-piece piston primer to replace the more complex and prohibitively expensive first-generation multipiece design.

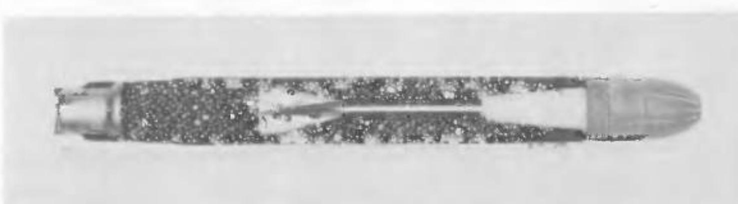


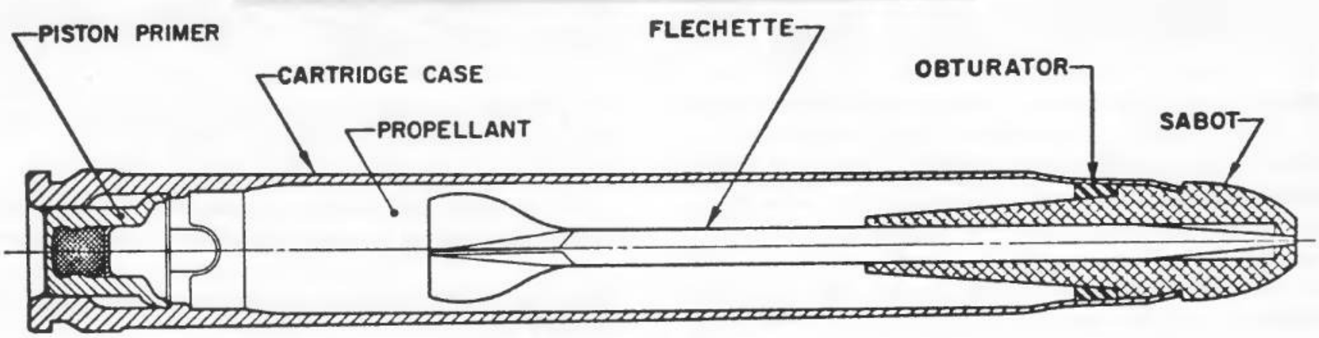
65. Official drawing of the "Primer, Miniature, FA T186E1". Frankford Arsenal had originally proposed a standard small rifle primer in its first flechette case design for the Springfield SPIW program, which had resulted in a very narrow base rim. Circumventing this potention weakness had necessitated the development in 1963 of the FA T186E1 miniature primer shown here, which was used throughout the whole of the Arsenal's SPIW program in the production versions of both the first generation XM144 and the second generation XM216 rounds. Frankford Arsenal Report No. R-2060, dated November, 1972.

Indeed, back in 1964 the Aberdeen D&PS officers had noted that by the time of their examination, the bolts of AAI rifles nos. 4 and 7 had already been modified to fire the new primers. The AAI one-piece piston primer was yet another remarkable product of the SPIW program, in that it was designed to function without an anvil. In other primers, whether Boxer, Bloehm or Berdan, it is the action of crushing the priming compound against the anvil which causes ignition. No such anvil was present in the new AAI design, as can be seen in figure 66. Interestingly enough, no one was really sure just how the AAI anvilless primer worked; some thought the priming pellet, which contained about three times more primer mix than usual, slid a bit when the piston was pushed in, thereby striking itself alight like a kitchen match. Others felt that the restricting front collar acted like an anvil. Still others pointed to the roughened, or finely threaded, internal sides of the primer cup itself, positing that the specially-compounded priming pellet set itself alight as contact here was abruptly broken by the firing pin blow.

Both contractors finally completed their ten second generation weapon systems, submitting them to AWC in August, 1966. Both were, as ordered, conventional rifles, gas-operated and air cooled, with front locking, rotating bolts.





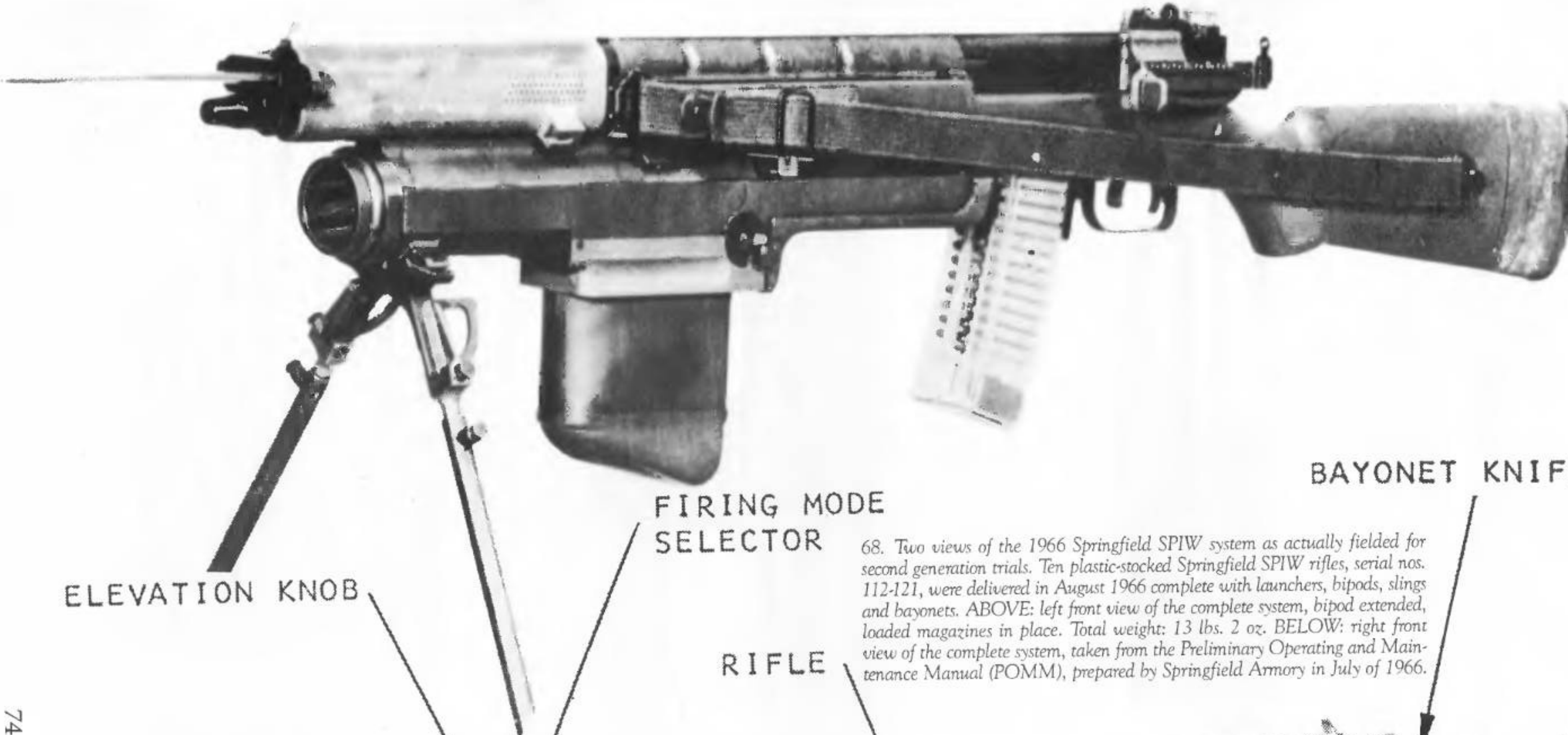


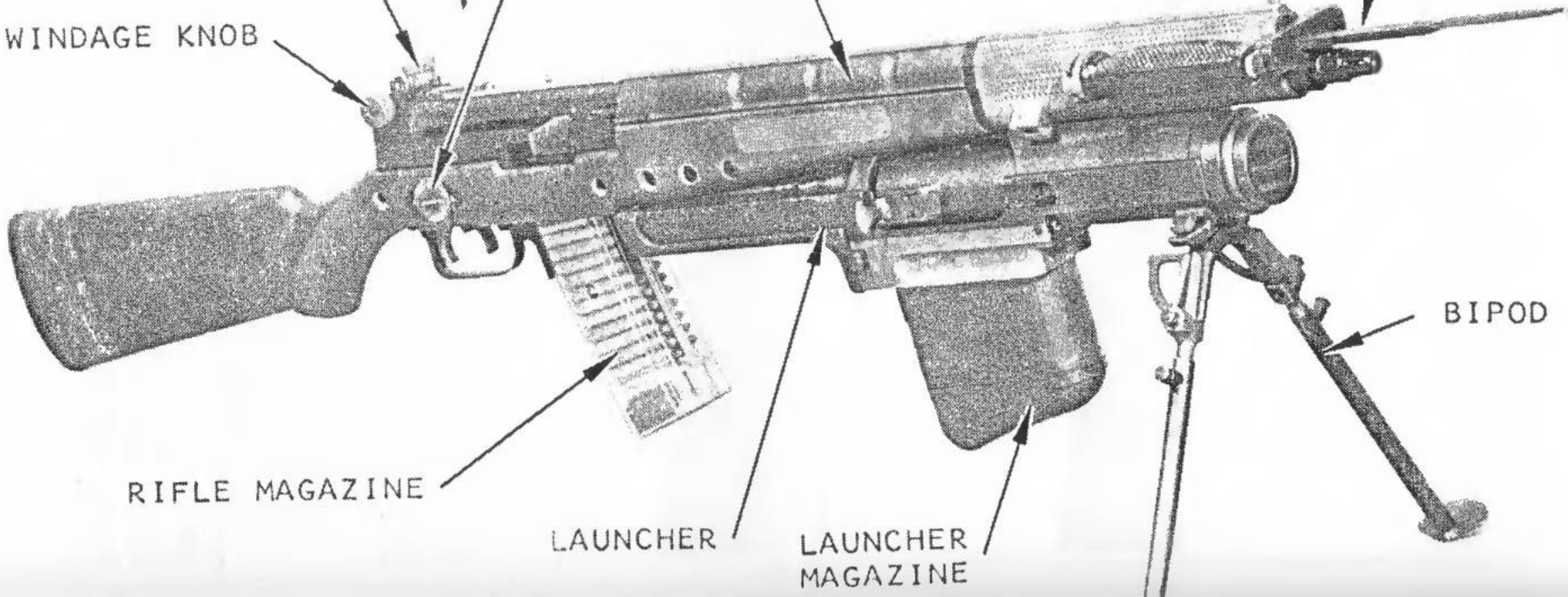
66. *The AAI one-piece anvilless piston primer, shown (above) in an official drawing from Frankford Arsenal's November, 1972 report entitled* Investigation of the Piston Primer For Use in the XM645 Cartridge, *and (below) as it was assembled into the XM645.*

The Last SPIW From Springfield Armory

67. *Two views of wood-stocked prototypes of the last SPIW from Springfield Armory. ABOVE: rifle with early rear sight, marked "Springfield Armory/SPIW Rifle Serial No. 102", chambered for the second generation XM216 cartridge. Lexan (polycarbonate plastic) side-by-side double- 30-round-stack magazine. The rifle is shown fitted with an early, low-mounted model of the Armory's blow-forward grenade launcher.*
US Army photo, dated December 21, 1965.
BELOW: rifle with late rear sight as fielded. Note the improved grenade launcher, mounted much closer to the forestock of the rifle, and fitted with a mock-up of the three-round magazine. *US Army photo, dated December 12, 1965.*

The 1966 Springfield SPIW was exactly 40" long and was chambered for Frankford's new, fatter XM216 cartridge. The prototype, now in the Armory museum's basement, featured a conventional stock made of walnut, although the ten examples which were actually submitted for trial had plastic stocks. While AWC's ten-pound weight requirement had not yet officially been relaxed, weights were being politely quoted separately for point-and area-target weapons and presumably added up later; the Springfield system still weighed 13 lbs 2 oz. fully loaded. The new rifle featured two rates of fire; 2,000 rpm on 3-round-burst and 600 rpm for full automatic.

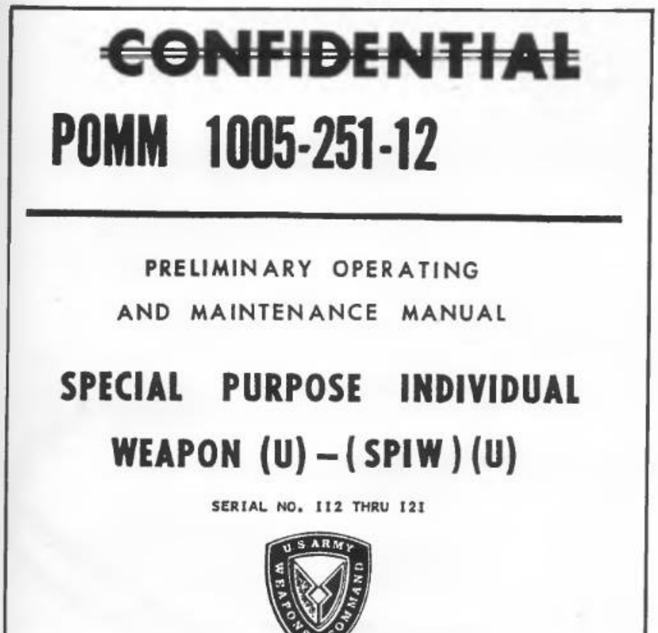




68. Two views of the 1966 Springfield SPIW system as actually fielded for second generation trials. Ten plastic-stocked Springfield SPIW rifles, serial nos. 112-121, were delivered in August 1966 complete with launchers, bipods, slings and bayonets. ABOVE: left front view of the complete system, bipod extended, loaded magazines in place. Total weight: 13 lbs. 2 oz. BELOW: right front view of the complete system, taken from the Preliminary Operating and Maintenance Manual (POMM), prepared by Springfield Armory in July of 1966.

The 60-round point target ammunition capacity specification was still in effect, and due to the conventional nature of the new rifle the longish, front-and-rear double magazine of 1964 had been redesigned. It was now made of clear Lexan plastic and, in a further burst of desperate ingenuity, featured two thirty-round stacks *side-by-side*. Springfield's *Preliminary Operating and Maintenance Manual* (POMM 1005-251-12) for their 1966 SPIW described the functioning of this novel magazine as follows:

> *The left cartridge stack is depressed by the stack release mechanism when the magazine is seated in the magazine well, while the right stack remains elevated in stripping position. When the last round is stripped from the right stack, its spring actuated follower raises the cartridge retainer actuator into the path of the operating rod. After the operating rod moves rearward after [the chambered] round is fired, it cams the actuator and retainer to [the] left side, releasing the left cartridge stack to stripping position.*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POMM 1005-251-12

PRELIMINARY OPERATING
AND MAINTENANCE MANUAL

SPECIAL PURPOSE INDIVIDUAL
WEAPON (U) – (SPIW) (U)

SERIAL NO. 112 THRU 121

U S ARMY WEAPONS COMMAND

DA PROJECT NO. 1X542703D345

PREPARED BY	MANUFACTURED BY
SPRINGFIELD ARMORY	SPRINGFIELD ARMORY
SPRINGFIELD, MASS. 01101	SPRINGFIELD, MASS. 01101

JULY 1966

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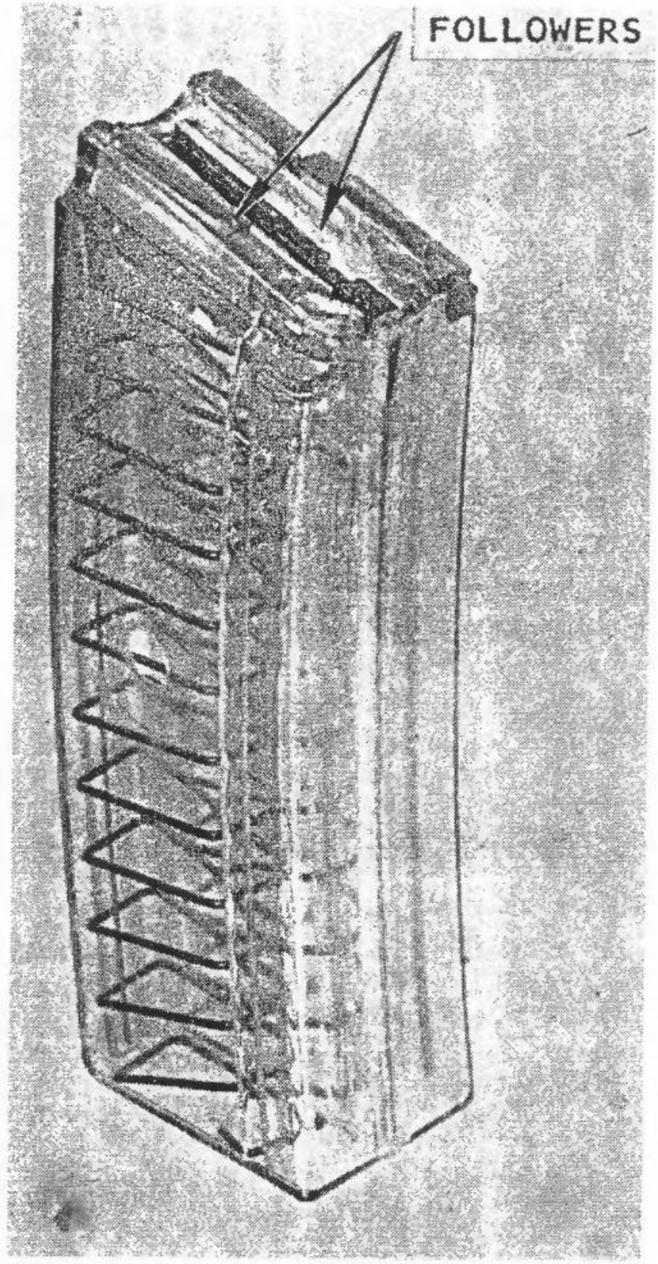
69. The title page of the Preliminary Operating and Maintenance Manual (POMM) for the second generation Springfield SPIW as it appeared in July of 1966, showing its original security classification.

Courtesy Col. George M. Chinn.



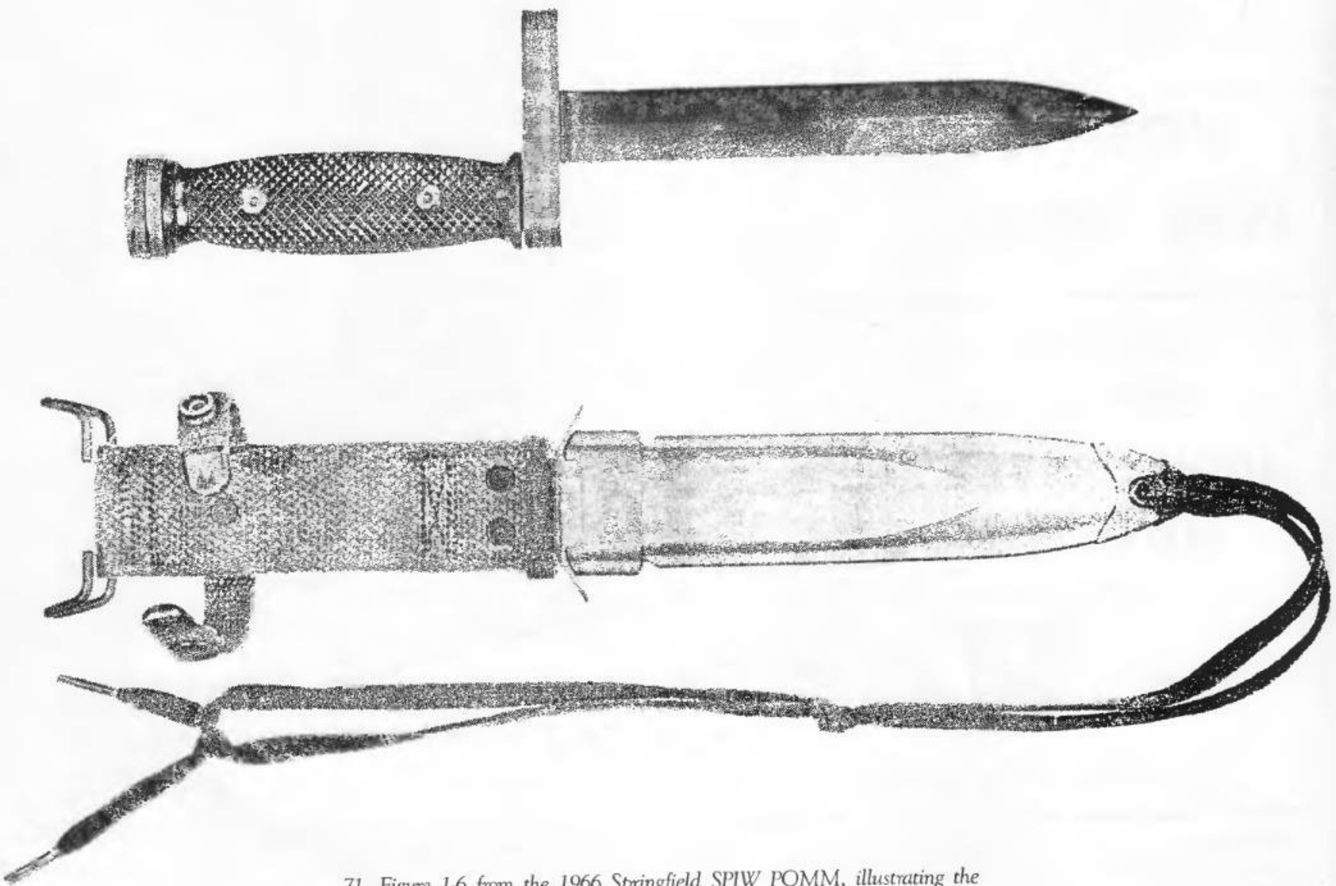
70. Figure 3-3 from the 1966 Springfield SPIW POMM, showing the two followers in the double-stack, see-through Lexan magazine. The action of transferring the feed from one stack to the other is described in the text.

As mentioned, it had been arranged that Winchester would continue development of their blow-forward grenade launcher, on a contract basis. For the 1966 trials, this basic mechanism had hastily been combined with a modified version of the Armory's original 3-round box magazine. This plastic magazine was described as "expendable", but "disposable" would have been a more accurate term, for it was designed to be used only once. Due to the launcher's blow-forward action, the magazine was without

feed lips, and was supplied *pre-loaded* with its three grenade cartridges secured by a strip of tape. The idea was that once a fresh magazine was clipped into place below the launcher's standing breech, an external tab on the restricting tape would be given a sharp tug, thus snapping the tape and releasing the rounds upwards against the tension of the magazine spring. As noted, the launcher functioned by cycling the spring-loaded barrel *forward* on firing, due largely to the friction of the 40mm grenade passing through it. As soon as the fired case was clear of the forward-moving barrel it was ejected, and the next round popped up into the chamberway. The fresh round was securely sheathed and the launcher recocked as the barrel returned to battery.

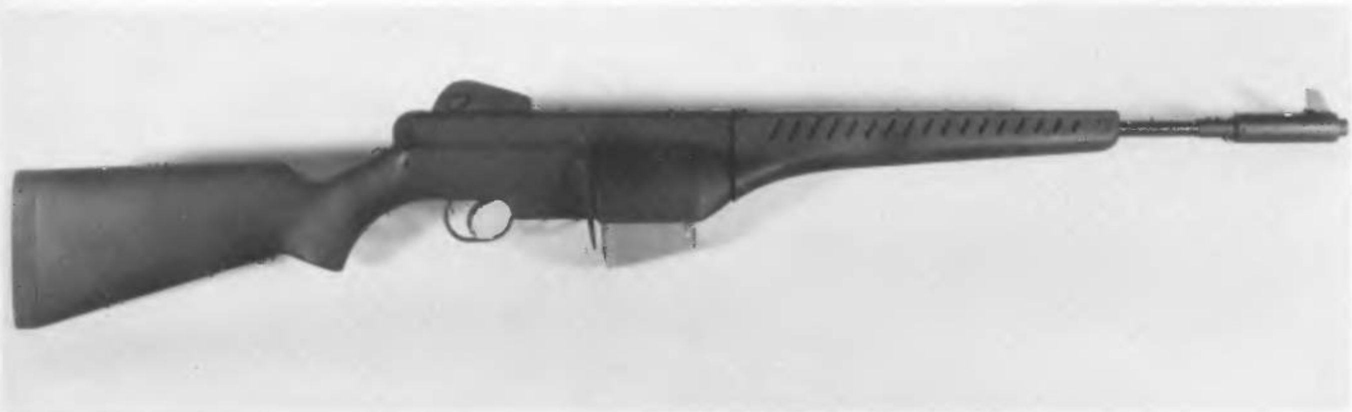
One specification which the Army vigorously defended throughout the whole SPIW program was the ability to fire both the point- and area- portions of the weapon from the same trigger; not an easy thing to do, considering the rigorous weight restrictions and the distance separating the rifle trigger from the front-mounted grenade launcher. To fire the 1966 Springfield launcher, for example, the regular rifle trigger had to be pulled while a selector lever was simultaneously depressed with the thumb. A connection was thus effected, by a complex series of levers and rods, between the point target trigger and the launcher sear, but this resulted in an area-fire trigger pull of approximately twenty-five pounds.

All in all it appeared that, although the Armory SPIW team had taken the project to heart and made it a "labor of love", the very tight timing and funding constraints of Secretary McNamara's termination order were very evident in this second generation Springfield design.



71. Figure 1-6 from the 1966 Springfield SPIW POMM, illustrating the weapon's bayonet-knife and (M8A1) scabbard. The bayonet's handle moved in a lateral track in the crossguard, locking either into the mounting position shown here or a central position for sheathing. Arguably the most absurd product of the entire SPIW program, although as its designer patiently explained, the bayonet stipulation had to be met, and there was simply no other way to mount it on the complex front end of the weapon without either obscuring the rifle sights (top), the grenade sights (left side), or blocking the launcher itself.

The AAI Corp. Second Generation SPIW



72. ABOVE: the first plastic-stocked prototype of the improved 1966 AAI SPIW, designed around the new, longer 5.6×57mm XM645 piston-primed cartridge. Point target configuration only. BELOW: the weapon disassembled. Note the admirably simple, one-piece plastic buttstock/rear sight housing/magazine well assembly. In the second row of components are (from the left) the firing pin/actuator, bolt, double recoil spring assembly, and takedown/change lever. Below these are in succession the butt cap and the remarkably slim receiver-and-barrel assembly (note the gas relief holes near the front end of the barrel), the stripper, and the muzzle device. At the bottom of the illustration are the trigger mechanism with its retaining pin and the 60-round XM645 drum magazine. (Compare with figure 77, below). AAI Corporation.

AAI's SPIW program had by far the longest "pedigree" of any of the four original contenders', due to that company's having originated the flechette concept in the first place. Indeed, AAI's 1964 SPIW had been by all accounts the odds-on first-generation winner, if such an honor had in fact ensued from that competition. The mood at AAI was therefore one of determination and conviction: while a number of features on Springfield's second generation gun were brand new and born of desperation, AAI's were mostly refinements of early ideas

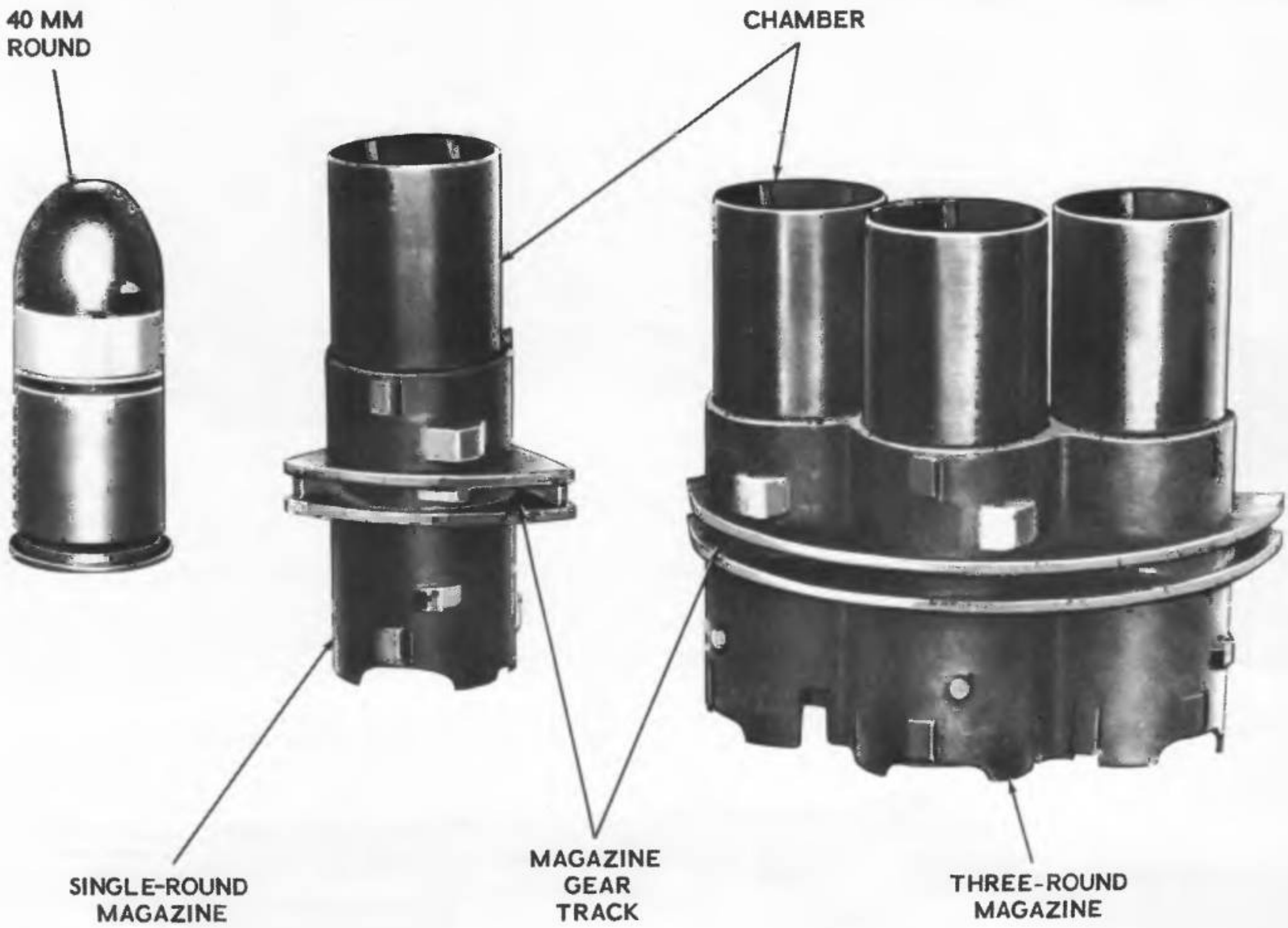
73. A disassembled view of the early AAI 60-round drum magazine for the XM645 cartridge, a complex and expensive design machined from aluminum alloy. This magazine was later made from fiberglass-filled nylon (see figure 76, below). *AAI Corporation.*

which already had comparatively lengthy firing record. AAI had already fitted their 1964 model SPIW with a conventional buttstock, and had fielded this rifle, still chambered for the XM110 cartridge, as a test vehicle for the several grenade launcher concepts they were offering.

Meanwhile, a parallel program of redesign had resulted in a very well-conceived new plastic-stocked AAI SPIW prototype (figure 72), featuring a number of improvements including a distinctive new muzzle device. The new pattern soon emerged fully engineered for second-generation production, with an internal change from the original double or tandem action spring design to a single spring, positioned on the left side of the bolt. The drum magazine and the action stroke were both slightly longer in AAI's 1966 model SPIW, due to the extra 4mm in the length of the new XM645 cartridge case. The non-expendable 60-round drum was now made from fiberglass-filled nylon.

74. Three views of the AAI SPIW from a photo dated January, 1966. ABOVE: weapon right side, point target configuration only, with sling. CENTER and BELOW: fitted with the "harmonica" grenade launcher. *AAI Corporation.*

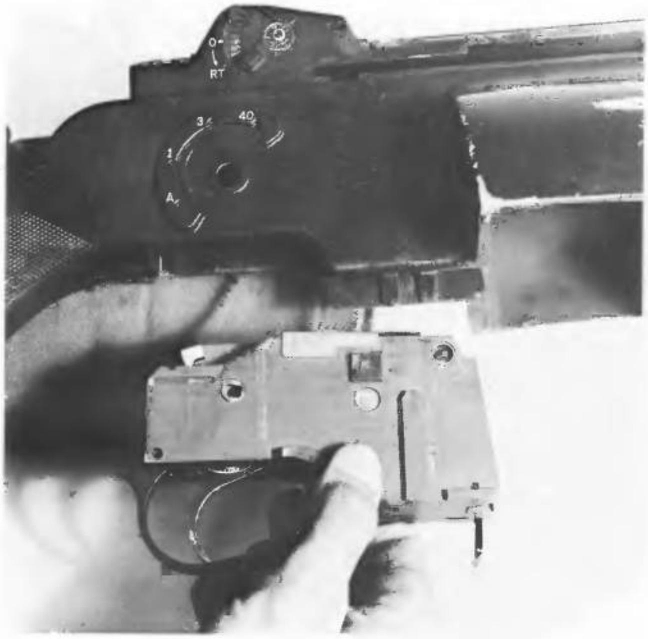
AAI's second generation semi-automatic area target device was described as working on the "harmonica" principle, wherein the grenades were separately encased; either singly in a one-shot cylinder or side-by-side in a curved, articulated firing chamber. A loaded chamber, inserted into one side of the launcher and hand-tensioned against a torsion spring built into the launcher, indexed sideways one position each time the device was fired. When empty, the cylinder or chamber simply fell out of the other side of the launcher; certainly not the most practical concept in the world.



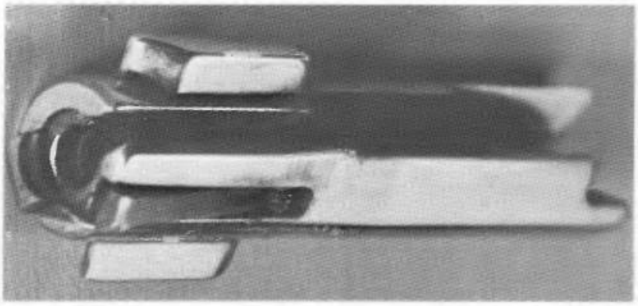
75. Closeup of the two types of AAI "harmonica" grenade launcher magazines. At first glance the "harmonica" system does not appear as logical or desirable as a reciprocating-bolt design, but an explanation reveals the rationale behind its conception. The 400-meter range stipulation for the M406 grenade (left) was hard to meet even from a single shot launcher due to the grenade's extremely light propellant charge. In a launcher which used part of the energy from the cartridge to cycle the action, such as the Springfield blow-forward design, the maximum range of the M406 fell below the acceptable level. The AAI three-round "harmonica" magazine was inserted and then hand-tensioned against an internal torsion spring in the launcher, thus providing the required semi-automatic capability without bleeding any power from the (already marginal) grenade. The AAI "harmonica" grenade launcher was soon proven impracticable and superseded, but the idea remains as one more example of the ingenuity born of desperation that was needed again and again in the SPIW program, simply in an attempt to stay even with the specifications! AAI Corporation.

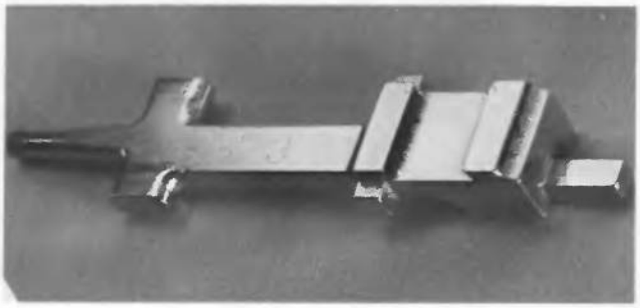
76. ABOVE: a three-quarter rear view of the 1966 AAI SPIW, showing the rear sight windage adjustment (it will be remembered that earlier tests by both the Infantry Board and the Arctic Test Board had confirmed NO elevation adjustment requirement with the flat-shooting AAI flechettes from 0 to 400 yards), selector lever (the "40" position fired the grenade launcher) and the fiberglass-filled nylon drum magazine. INSET: the 60-round magazine removed from the weapon showing its five "indicator windows". AAI Corporation.


77. Continued improvements to the 1966 AAI SPIW point fire weapon, shown here field stripped. Compare with figure 72: note the change to a single recoil spring, positioned on the left side of the action. AAI Corporation.



78. Removal of the change lever alone permitted withdrawal of the entire "fire control assembly" on the 1966 AAI SPIW. Due to the three-round burst counter mechanism and the requirement for area-fire capability from the same trigger, this assembly was, like its Springfield counterpart, extremely complex and NOT designed for further operator disassembly or repair. AAI Corporation.





79. The front-locking rotary bolt (three-quarter front view) and the primer-actuated firing pin (rear three-quarter view), from the 1966 AAI SPIW. The spring-loaded device in the bottom of the bolt face was known as the "scooper", essential for proper cartridge feeding at the extremely high burst-fire rates which the AAI SPIW featured. Note the large aperture in the face of the bolt, through which the piston primer set back to impart initial rearward motion to the heavy firing pin. AAI Corporation.

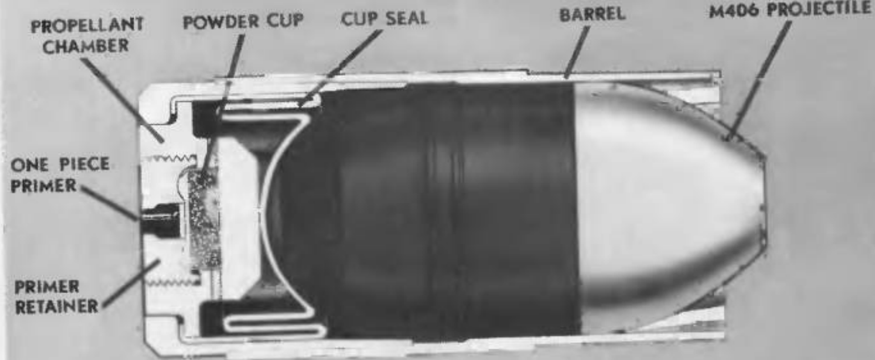
The DBCATA Grenade

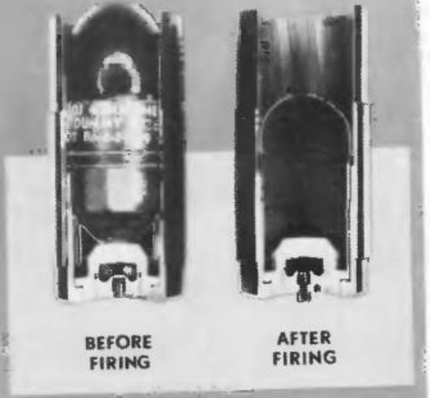
Realizing the marginal range characteristics of the M406 grenade, AAI was already hard at work perfecting a most promising new concept in grenade firing: the DBCATA grenade (Disposable Barrel and Case Area Target Ammunition). With the DBCATA, AAI had taken ultimate advantage of the "high-low" grenade cartridge design in hopes of bypassing the bulk and awkwardness of a complex launcher mechanism entirely. AAI had long chafed at the forced and uneasy marriage of point-and area-fire capabilities together in the SPIW: as an observer later remarked, the combination was "from the human engineering standpoint the poorest thing imaginable". The DBCATA was therefore yet another incredibly ingenious attempt to *circumvent* the impossibly divergent SPIW weight and firepower specifications.

The DBCATA cartridge looked and worked much like a standard 40mm grenade, but was made with somewhat thicker, longer, rifled walls so that it truly served as its own chamber and barrel. The projectile itself was the standard M406 grenade. Inside the DBCATA, an expandable metal bellows now surrounded the internal high-pressure chamber. When the round was clipped on to a light, simple launcher-plate and fired, the chamber ruptured as before, but now into the *bellows*, which expanded abruptly, projecting the grenade into the roughly two inches of rifling in the forward portion of the case. This imparted both the required spin and velocity to the grenade, while the bellows itself remained intact to contain all the gases of the explosion. The result was a revolutionary new flashless, virtually noiseless and almost weightless grenade launcher. While the DBCATA was not quite ready in time for the 1966 trials, AWC was initially said to be enormously interested in it, and with excellent reason, it would seem.

The Army ultimately balked at the added expense of the separate barrel and bellows built into each round of DBCATA ammunition: while not perhaps too significant when considered as a unit cost, this amounted to a sobering sum indeed when multiplied by the quantities of grenades required to support full-scale combat issue. It was also deemed inadvisable to confound the system with *two types* of 40mm cartridges. Therefore, although AAI pursued the DBCATA idea through several extremely interesting variations, including a superlight plastic-cased version, in the end it was never adopted.

THE DBCATA ROUND





CHARACTERISTICS

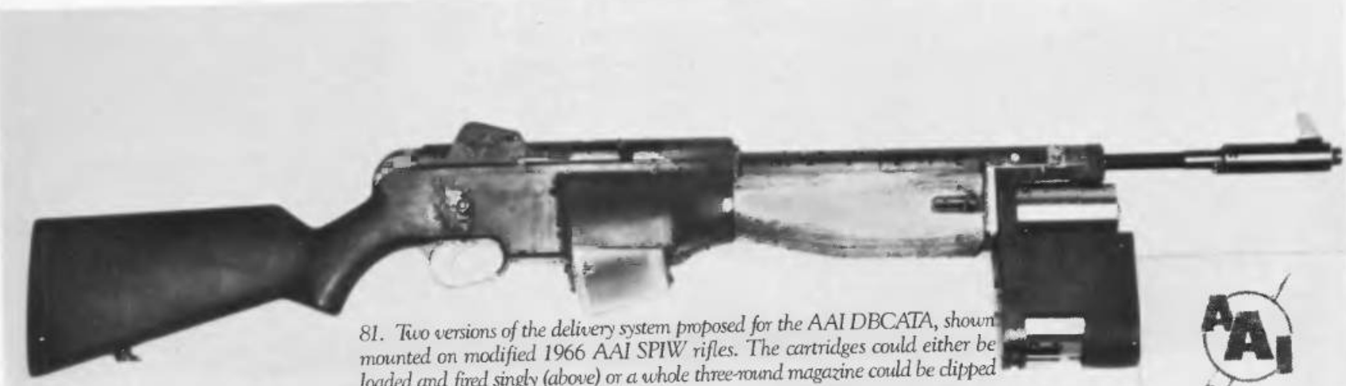
PERFORMANCE

MUZZLE VELOCITY-	245 fps
MAXIMUM RANGE-	400 meters
ACCURACY-Equivalent to cartridge,	40 MM: HE, M406
SIGNATURE: SMOKE-	nil
FLASH-	nil
NOISE-Slightly less than M406	

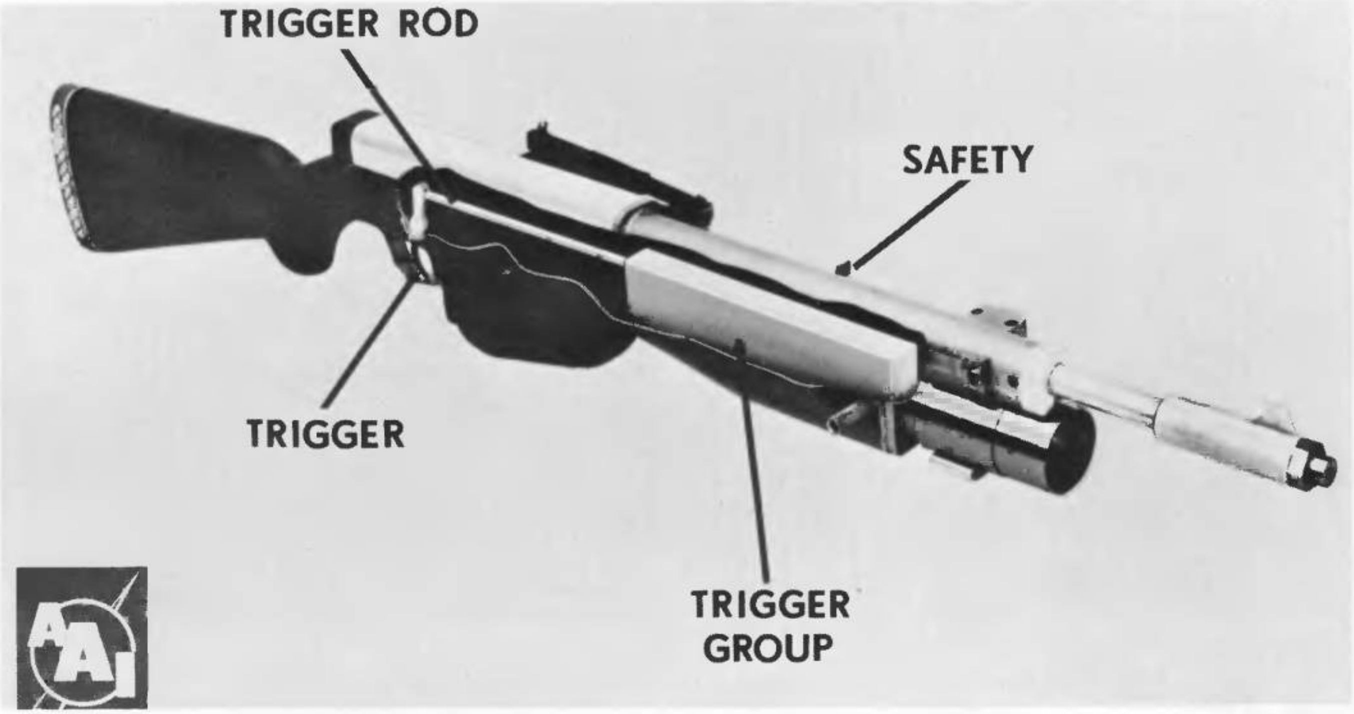
PHYSICAL

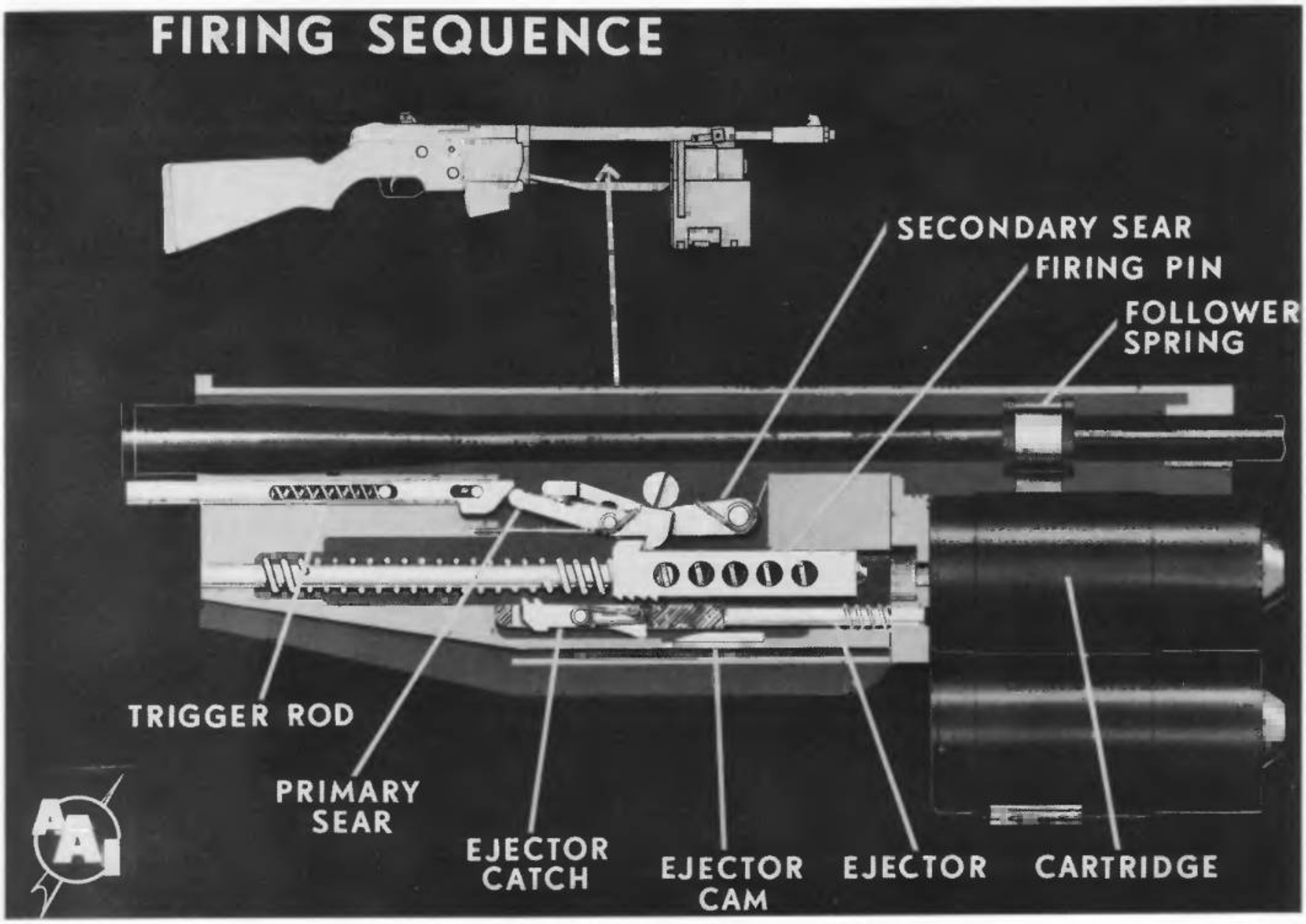
LENGTH	3.83 in.
DIAMETER	1.75 in.
TOTAL WEIGHT	.65 lb
PROJECTILE WEIGHT	.38 lb
PROJECTILE	40 MM: HE, M406

80. The characteristics and nomenclature of the revolutionary, AAI-developed DBCATA (Disposable Barrel and Cartridge Area Target Ammunition) grenade cartridge, which fired the standard M406 grenade while serving as its own flashless, virtually noiseless, and almost weightless grenade launcher. Yet another incredibly ingenious offshoot of the SPIW program. The action of the DBCATA is described in the text: its internal bellows can be seen before and after firing in the upper right illustration. AAI Corporation.



81. Two versions of the delivery system proposed for the AAI DBCATA, shown mounted on modified 1966 AAI SPIW rifles. The cartridges could either be loaded and fired singly (above) or a whole three-round magazine could be clipped to the same, simple launcher-plate.
AAI Corporation photo, dated January, 1966.





82. *Training aids prepared by AAI to illustrate the firing sequence and operation of the DBCATA grenade-launching portion of the 1966 SPIW.*
Courtesy AAI Corporation.

Results of the Second Generation SPIW Trials

The later Comptroller General's report on the SPIW program records that a second generation engineering design test was conducted by the Infantry Board at Fort Benning, from August 26 to October 31, 1966. These trials, or more accurately, comparative evaluations, were in a word disastrous.

Springfield later complained that, although their flechette ammunition had been loaded by Frankford Arsenal, it perforce was loaded with flechette-and-sabot packages supplied by AAI. Being an old-line Ordnance agency, Springfield had paid considerable attention to point-target accuracy in their new rifle, and had been quite satisfied with the results they had been getting prior to the Infantry Board trial. Mr. Colby later recalled:

"We had one lot of [XM216] ammo that had only .60 mil round to round dispersion. We used this ammo to check out our guns before delivery. Every gun met every accuracy requirement when fired in all the positions . . . Some of the lots delivered to Fort Benning had round to round dispersions as large as two mils."

Officers serving on the Infantry Board later seconded the bitter words about the poor quality of the test ammunition that was supplied them, but this was only one small part of the problem. The one supreme flaw in the SPIW program still, which AWC had steadfastly refused to face or even consider right from the outset, was the gulf separating the specifications from what was humanly possible to design and construct. The Infantry Board had been ordered to evaluate the SPIW candidates as *combat arms,* not laboratory specimens. Even thus constrained, however, the Board's report on the 1966 comparative SPIW evaluations contained clear indications that this gulf had again proven too wide and deep to bridge:

Deficiencies of SPIW

Weapon System — all components

1. The weapon did not meet the weight requirements.
2. The weapon was not simple in design and construction. The grenade launcher was complex and had an excessive number of controls and the rifle point target magazine was difficult to insert.
3. The weapon easily became entangled in brush and vines. In addition, the weapon was difficult to carry in the ready or port arms position when the grenade launcher was loaded.
4. The point-fire and area-fire elements demonstrated very poor performance capability at minus 65° Fahrenheit.
5. The weapon was not sufficiently rugged to withstand normal usage encountered in training and combat. The weapon also lacked ruggedness for bayonet training.

Rifles

1. The rifles produced excessive noise and muzzle flash when fired.
2. The rifle's cartridge ejection patterns interfered with adjacent firers.
3. The bolt did not remain open after the last round in a magazine was fired.
4. The rifle sight was unstable, and the bipod lacked rigidity and durability and caused barrel bending.
5. A positive, tamper-proof means of providing only semiautomatic fire was not included. The safety restrictions imposed by the safety release were too stringent to accept for an infantry individual weapon.
6. The rifles were not easy to maintain under combat conditions, and excessive maintenance was required.

Grenade launcher

1. The launcher sights were not properly calibrated. They also required a special tool for adjustment.
2. The launcher could not be fired from the left shoulder.
3. The launchers failed to meet the requirement for prevention of accidental firing.

Point Target Ammunition

1. The ammunition for the engineering design test appeared to be of poor quality.
2. Tracer ammunition was only 50% reliable. Requirements call for such ammunition to be least 80% reliable.

The Emperor's New Clothes

83. Close-up of the front end of the AAI 1966 SPIW with extended bipod and prototype bayonet (a modified wood-handled M7). Note the improved muzzle device: this was the final change made to AAI's second generation weapon before the fateful "comparative evaluations" of August-October, 1966. AAI Corporation photo, dated April, 1966.

Meanwhile, as luck would have it for our story, AWC was trying to find a civilian firm willing to continue the development of the Springfield SPIW. (The SPIW program was to receive no further funding at the Armory regardless of the outcome of the second generation trials: that bastion was being adamantly wound down in response to Secretary McNamara's termination order). A meeting was therefore set up at Fort Benning in October, while the 1966 evaluations were still in progress, to demonstrate the second generation SPIWs to representatives of a selected few companies who had expressed interest in taking the Springfield project over. (As it turned out, no one did; at least not for another two years, as we shall see.)

The real if inadvertent importance of this AWC demonstration was that it provided some highly qualified but uncommitted outsiders their first real look at the SPIW in action. Among those attending the Fort Benning meeting was Mr. Robert E. Roy, then the Engineering Project Manager for Colt's Inc. Colt's had purchased the rights to the AR-15 from ArmaLite back in 1959, and had since shrewdly piloted the "little black rifle" all the way to quasi-adoption in the US armed forces. With America's massive builtup in Vietnam went more and more Colt-made M16 rifles: Colt's had more at stake than virtually anyone should the SPIW be successful. They therefore took a very sharp and direct interest in these proceedings. A saboted flechette load in the regular 5.56mm case already existed, for example, as did experimental smoothbored M16s.

As mentioned, the Infantry Board was necessarily constrained to report its findings *exclusively in terms of the requirements.* (The requirements stated clearly that SPIW was a *weapon*). Colt's was not so restricted; Mr. Roy wanted to know how the SPIWs looked and functioned in a real-world sense: perhaps Colt's *should* consider taking over the Springfield program. The bottom line was, how long did Colt's have until the SPIW put the M16 out of business? Mr. Roy's confidential report to his superiors soon calmed any fears on that score:

> *. . . the morning meeting revealed some of the problem areas, namely reliability of both point and area fire weapons, inability to meet weight requirements which are already perhaps too great for the average soldier, and cost of producing the point fire ammunition.*
>
> *The afternoon phase consisted of a firing demonstration of the weapons at Farnsworth range . . . It was apparent that both Springfield and AAI weapons suffered from engineering problems which were a direct result of forced development, i.e. springs overstressed, trigger mechanisms that "doubled", high incidence of part failure . . . The afternoon demonstration emphasized the above problems. Both the point and area fire weapons of both Springfield Armory and AAI experienced many malfunctions. In some cases malfunctions were so high that the weapons were replaced on the line.*
>
> *None of the weapons seemed to operate with any degree of reliability. In addition, it appeared as though the point target ammunition was extremely erratic. In many cases a good portion of the projectiles was seen to strike the ground 50-100 yards from the shooter while he was firing at the 200 yard butts.*
>
> *It appears to me that the SPIW system is still far from fruition as an operational weapons system. The "all things to all people" approach that has been used in setting requirements for this weapon has resulted in many problems that appear almost insurmountable, since many of the requirements are at odds with each other.*

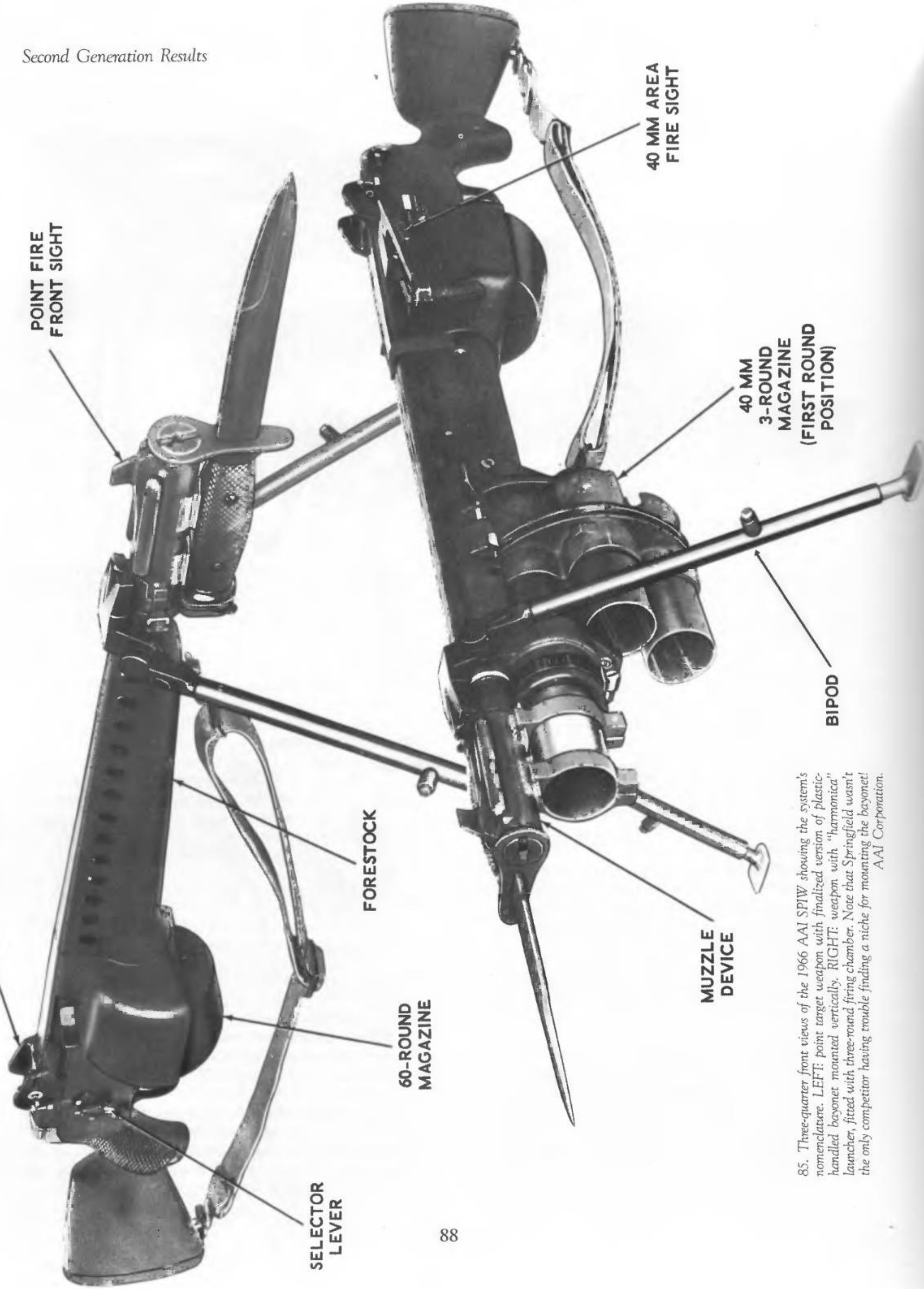
Mr. Roy went on with some extremely insightful comments regarding what he had witnessed:

84. Ready at last: five of the ten finalized 1966-model AAI SPIWs, as fielded for the summer's disastrous second generation "comparative evaluations". Shown here fitted with "harmonica" launchers, loaded with single-shot grenade chambers (figure 75). *AAI Corporation.*

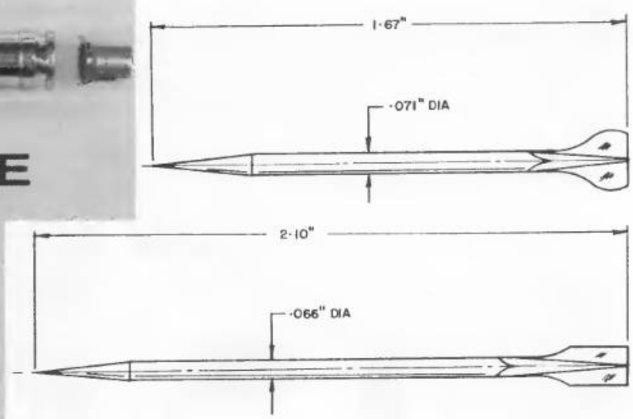
. . The normal tendency when [the flechette] strikes flesh or bone is for the shaft to bend slightly and then to tumble. It is this property that makes such a small, light projectile lethal. When the flechette tumbles, it has lethality comparable with the 7.62 NATO. The flechette does not alway tumble, however, and this has been a source of embarrassment to the supporters . . If the flechette does not tumble, it has very little stopping power and a person might hardly know he is shot . . . Armor penetration . . is quite impressive. 9/16" mild steel plate will be penetrated, whereas 3/8" plate will stop the 5.56mm. Penetration of sandbags is very poor, however, [and] the brush penetration quite erratic.

Both SPIW cartridges have been designed to be as light as possible. The case walls are very thin and therefore, are easily deformed in the event of poor feeding or rough handling. The [XM645 neck] thickness is approximately .008" compared to .012" for the 5.56mm. Packaging and handling techniques will have to be upgraded to prevent high ammunition casualty rates in the field.

In order to keep SPIW ammunition as light as possible, cartridge cases have been made to the minimum size possible. This makes it necessary to use relatively slow-burning powders in order to get the necessary energy for full velocity. The result . . is very high pressure at bullet exit. I would estimate bullet exit pressures are in the order of 25,000 psi. This not only gives high noise levels and heavy flash, but also makes it more difficult to extract the empty case with the quickness necessary to get the high cyclic rates presently required . . . the noise and flash produced by these weapons is far in excess of the M14 or M16 and at least the equal of our M16 Commando sub-machine gun without *the noise-flash suppressor. . AWC states that decibel readings will have to be under 160dB. [Note: Audio experts have long pegged the threshold of pain at around 112dB]. Springfield's SPIW is now 162dB while AAI's is 159dB. I believe the 160dB reading is a compromise and will be opposed by the user. I have fired the AAI weapon, which meets this specification, and it is definitely uncomfortable to fire without ear plugs. The M16 in 5.56mm [firing] SPIW projectiles, has a noise level of approximately 152dB.*



85. Three-quarter front views of the 1966 AAI SPIW showing the system's nomenclature. LEFT: point target weapon with finalized version of plastic-handled bayonet mounted vertically. RIGHT: weapon with "harmonica" launcher, fitted with three-round firing chamber. Note that Springfield wasn't the only competitor having trouble finding a niche for mounting the bayonet!
AAI Corporation.



86. *Disassembled and cutaway versions of the controversial XM645 flechette cartridge. These were mounted for demonstration and publicity purposes in clear plastic paperweights, and proved a popular handout from AAI, despite the disastrous performance of both flechettes and weapons during the 1966 evaluations.* AAI Corporation.

87. *AAI's investigations continued, in spite of the atmosphere of negativism which followed the collapse of the second generation SPIW trials. Here a conventional flechette, above, is compared with a proposed "long-range" version, which features reduced fin diameter for less drag.* AAI Corporation.

The high cyclic rate, which is considered essential for maximum burst-fire accuracy, places a great burden on the cartridge and the reciprocating parts of the weapon . . . Extremely high bolt velocities and very lightweight parts are necessary to achieve such high cyclic rates. This combination makes early parts failure virtually a certainty, especially when the weapon is used in an adverse environment . . . I believe the cyclic rates will have to be reduced . . even at the risk of decreasing burst-fire accuracy, in order to obtain reliable functioning and reasonable parts life under combat conditions.

Mr. Roy summed up his very close-to-the-mark opinion of the true state of the SPIW program as follows:

Present plans call for design finalization by early 1968 and initial production by 1969. After looking at the hardware available, witnessing the firing, and firing the weapon myself, I can't see how this schedule can possibly be met. SPIW is still an R&D effort and will require at least one more complete redesign, and the solving of several basic problems before it can be seriously considered as a military weapon. This will take several more years, assuming funding is continued at the present rate.

The SPIW weapon in its present form is an "ultimate" weapon. It has so many features designed into it, that it is complicated, cumbersome and unreliable. The more it is developed and the closer it comes to an operational weapon, the more it will be simplified . . . SPIW is pointing the way toward the military weapon of the future. Even if SPIW is not adopted, as such, many of its features will be incorporated in future weapons.

Again, as had been the case in 1964, the most charitable conclusion was that neither of the "weapon concepts" was acceptable in its present state. The AAI SPIW was chosen the better of the two: hardly a choice at all in view of the enforced termination of the Springfield program and the lack of any immediate civilian interest in its continuance.

Early in the fittingly gray month of November, 1966, the Infantry Board formally recommended to the Chief of Staff of the Army that the whole SPIW program be radically pruned back. Instead of launching yet another bravely worded program of AWC-funded advanced development, the Board recommended that the SPIW should be relegated to the status of an exploratory program at AAI. In other words, let AAI build something, then the Army would test it. If it worked, they could talk further.

On November 7, the Office of the Chief of Staff accordingly directed that the SPIW program be "reoriented" from full-scale engineering development back to exploratory development, becoming in the process just one facet of a broadened, long-term small arms R&D program for the future. The same memorandum announced the formal intention to adopt the Colt XM16E1 rifle as standard for the US Army everywhere but in the European theater.

With the Army having thus come full circle and now solidly behind the M16, the pressing need for the SPIW simply vanished. For the SPIW itself, the collapse of the second generation program marked the end of the lavishly-funded *grande époque*, the likes of which would never be seen again.

88. The 5.56×45mm Stoner system, designed by Eugene Stoner for Cadillac Gage Corporation in response to a Marine Corps User Specification. The appearance of this highly versatile weapon in the midst of the already complex SPIW-versus-M16/M14 debate did a good deal to trigger the monumental two-year SAWS Study.

Chapter Six

A Phoenix From the Ashes

Meanwhile, a potentially serious confrontation had been two years a-building between two unlikely protagonists: Army Materiel Command (AMC) and the Marine Corps.

Eugene Stoner, the designer of the ArmaLite AR-15, had joined the Cadillac Gage Company, of Warren, Michigan, in 1963. There he had refined the AR-15's basic turning-bolt action into a whole new *family* of weapons called the Stoner system. Here was logistics that made sense: starting with the same basic receiver and adding various barrels and other components, a complete series of six weapons could be assembled, from a sturdy belt-fed light machinegun right down to a handy 30-shot carbine.

The design criteria for the 5.56mm "Stoner 63" had in fact originated in a USMC User Specification. Not surprisingly, therefore, the system received an enthusiastic reception among the Marines, who began to press for its adoption. However, the Marine Corps depended on the Army (more specifically on AMC supply channels) for its logistics support. Notwithstanding the commonality of caliber with the M16, the Army balked at the Stoner, arguing that there was really nothing the Stoner system could do that an M16, properly modified for the role, could not. The AMC weapons people concluded that the only real result of adopting the Stoner 63 for the Marine Corps would be a further complication of the supply system.

Not to be put down, the Marines officially took their case all the way to the Chief of Staff of the Army in August, 1964. There they complained of "an effort by some Army individuals to submerge the [Stoner] program". Army Weapons Command was deeply embroiled in the confidential first-generation SPIW trials by this time, and SPIW was still targeted for adoption ten months hence. Enough trouble had already been encountered in stonewalling the adoption of the M16: AMC was certainly in no mood to consider yet another "conventional" 5.56mm rival. On the other hand, needless to say, the Marines felt strongly about the weapons they chose to fight with. They were of the opinion that they had found in the Stoner 63 a true weapon *system*, superior to the M16.

In the face of continued inaction by the Army (which the Marines, unaware of the impending "success" of the first-generation SPIW program, had read as stalling) USMC officers heatedly briefed the Deputy Secretary of Defense himself that the Army "had a closed mind" on the issue, and had been "dragging its feet".

Largely in response to the Marine Corps' complaints, General Johnson, the new Army Chief of Staff, announced a new and far-reaching study on November 11:

"I believe that we can and should completely re-evaluate our small arms weapons program, starting with a review of doctrine. Our posture is such that we can afford to take this action over the next year or two with a minimal risk. Only by such a deliberate and thorough approach will I be confident that our small arms program reaching into the seventies will be on a firm footing . . ."

In the same announcement, General Johnson craftily affirmed that the Marines had given their "oral assurance" that they would abide by the results of the new study, thereby defuzing or delaying a confrontation, at least until the end of the study.

89. Improvements continued at AAI, despite the ignominious failure of the second generation SPIW program. Investigations into barrel cooling were given top priority due to the disastrous emergence of the phenomenon known as "cook-off". By mid-1967, AAI had evolved the distinctive muzzle device shown here, along with a barrel heat "radiator" (visible through the vents in the handguard). AAI Corporation.

The Small Arms Weapons Systems (SAWS) Study

Implementation of the SAWS study was begun by the Army's Combat Developments Command (CDC) the following month, in December, 1964. Over the next eighteen months, a comprehensive array of the world's best small arms weaponry was subjected to an exhaustive series of engineering, service and troop tests. These were conducted in the continental USA and in Europe, the Arctic and the Caribbean. In the individual weapon category, SAWS compared the few examples which could be made available of both generations of SPIW prototypes with the M14; the M2 Carbine; the XM16E1 (the Army's preferred version of the M16, featuring a number of controversial "improvements" including the thumb-operated bolt-closure device); a later ArmaLite 5.56 rifle called the AR-18; the Stoner 63, and the Soviet AK-47. Also featured were World War II German MP44 *Sturmgewehrs*, FG42 paratrooper rifles and the late-war, roller-locked Stg.45, plus the current German NATO-caliber G3; and from Belgium the 7.62mm FN FAL and the 5.56 CAL (*Carabine Automatique Légère*, or Light Automatic Carbine). SAWS was a monumental endeavor: the final report, published in December, 1966, ran to over thirty volumes.

CDC was forced to admit early in 1965 that SPIW was "still under development and . . not available in time to compete on an equal basis with the 5.56mm [Colt, ArmaLite and Stoner] systems." By this time the 35-month "second generation" SPIW development plan, discussed above, was well under way: AWC was still totally committed to the serial flechette concept and wanted every possible "break" for the floundering SPIW. Thus began perhaps the most important and far-reaching SAWS sub-project of all: a study of rifle combat done by computer *simulation*. The Army's rationale was that there simply weren't enough firing SPIWs in *existence* to produce any meaningful comparative results. (What they *didn't* say was that the few which *were* available were unperfected and unreliable, incapable of anything other than *theoretical* participation with the rest of the illustrious field mentioned above.)

Combat Developments Command contracted for the computer simulations with an agency of Booz-Allen Applied Research, a prestigious private research firm. The actual programs were to be written by Booz-Allen's Combined Arms Research Office (CARO), working alongside the US Army Combat Development Agency at Fort Leavenworth, Kansas.

No sooner had the SAWS study begun when Colt's, noting the massive escalation of the US military presence in Vietnam, pressed harder for a decision on the full adoption of the M16 rifle. The Army's mood of partisanship towards the SPIW may be inferred in the following brief sent by ACSFOR (the Assistant Chief of Staff for Force Development), CDC's overseeing agency, to the Chief of Staff in answer to the latter's query about the matter:

"Prior to the completion of the SAWS project, the Army has no logical or compelling reasons to expand the current basis of issue of the M16 rifle. Such an expansion might in fact be damaging to SAWS in that it could be interpreted as pre-judgement of the expected results of the study".

By the fall of 1966, even as the second generation SPIW plan was unravelling so dismayingly, CDC had already compiled and analyzed a vast amount of SAWS data from the eighteen months of trials. Regarding the combat simulations, an interesting interim report through ACSFOR to the Chief of Staff would seem to confirm that the SPIWs' *theoretical* characteristics had been entered directly into the computers with little or no value being assigned their physically unperfected nature: "the SPIW, as defined by its military characteristics, consistently ranked higher than any other rifle in the study, such characteristics representing a significant improvement over currently available small-arms families".

Notwithstanding all the favoritism afforded the SPIW during the SAWS study, the utter collapse of the second generation trials left no option for continued hope of a successful candidate, even within the rescheduled 1968 time limit. On December 17, 1966, exactly two years and a day after SAWS had begun, the Secretary of the Army advised the Secretary of Defense of the following findings:

" — The XM16E1 rifle is generally superior for Army use . . . [Rifle procurement] in the forseeable future should be limited to the XM16E1.

— The current SPIW program is unlikely to result in a satisfactory weapon as early as previously forecast. . .

— The Stoner family of 5.56mm weapons has some attractive features, but no effectiveness advantages that might warrant adoption by the Army at this time."

Thus, SAWS upheld the Chief of Staff in his announcement the previous month of his intent to adopt the XM16E1, and in his reorientation of the SPIW to just one facet of the mentioned new long-term research program soon to be christened the Future Rifle Program (FRP). Unfortunately, however, the two years spent in waiting for the rather predictable SAWS results had proven far from the "minimal risk" General Johnson had prophesied. At the inception of the SAWS study in December 1964, the SPIW had been officially slated for adoption in six months: the Army had made their famous November 1963 "one-time buy" of M16 and XM16E1 rifles; and most Americans had never heard of Vietnam. By the end of 1966, the Army had run out of M14s and had resorted to degreasing Korean-war-vintage M1 Garands for the ever-greater numbers of combat troops in Vietnam, whence General Westmoreland had just firmly called for 100,000 more M16s; and the whole of the very expensive SPIW program was disgraced and in limbo,with *any sort* of satisfactory outcome now described, with as much face as could possibly be saved, in the admirable understatement "unlikely . . as . . forecast".

The Small Arms Weapons Systems study did have some long-term influence and effect on future rifle plans, but for all its monumental stature it did little at the time except put everything on "hold" for two years, in a doomed attempt to buy enough time to perfect the SPIW. General Johnson did not even entirely succeed in confounding the Marines: the US Navy SEAL teams later adopted limited quantities of a special short, heavy-fluted-barrel version of the improved Stoner 63A1, belt-fed from an underslung 100-round box, as the "MK 23 5.56mm Machine Gun (Commando MG)". The Stoner Commandos saw extensive service with the SEALs in Vietnam.

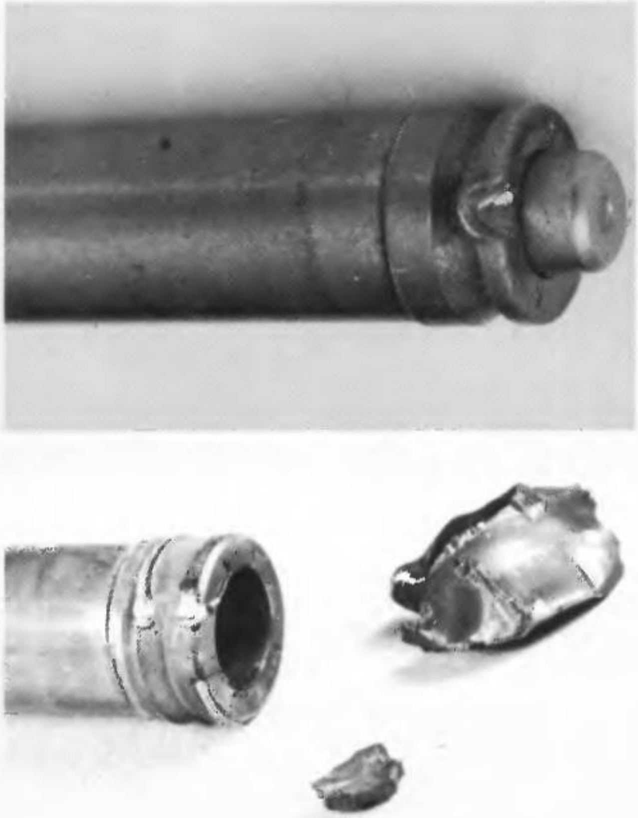
A Heady Turning Point — The AAI "Nominal Fee" Contract

The AWC-dominated SPIW executive committee reconvened in February, 1967, reluctantly agreeing that the program was indeed disgraced and in disarray. In a desperate attempt to salvage what they could of the SPIW, and in contemplation of participation in future projects like the Future Rifle Program, it was decided that "All effort was to be terminated in such a way that if the [SPIW] program was reactivated at a later date some continuity with the earlier effort could be maintained. Only effort which would contribute directly to the reoriented program was to be initiated or continued."

To this end AAI had already been granted a "nominal fee" contract to conduct a further weapon improvement study, largely with their own funds, on their 1966 SPIW. This was to be a drastically pared-down attempt to correct some of the most glaring deficiencies which had contributed to the default of the second-generation SPIW engineering design test. No new weapons were to be built; AWC simply returned two of AAI's ten 1966 SPIW prototypes for modification.

First, it was decided that the worst problems centered around the muzzle-device-and-barrel assembly, and the friction-prone 60-round drum magazine. In keeping with the adamant terms of the phaseout plan, subsequent trials by AAI of the improvements they were to make under this last-gasp contract were to be considered their part in the orderly termination of the first phase of the 35-month, second generation SPIW R&D program. Thus, with

90. These AAI SPIWs from the 1966 evaluations featured in the remarkably successful 1967 "nominal fee" contract modifications and trials. ABOVE: point target weapon, featuring AAI's new, distinctive muzzle device. BELOW: weapon fitted with the latest DBCATA launcher-plate; front handguard removed. The finned barrel "radiator" appears in front of the shortened forestock. Photo date November, 1967.



91. ABOVE: a fired XM645 case, showing the normal position of the piston primer after it had set back against the cushion of the spring-loaded firing pin. Note the deeply impressed ejector mark, indicative of the extremely high velocities attained by the AAI SPIW's moving parts. BELOW: the results of the dreaded phenomenon of "cook-off", wherein the intense heat remaining from previous sustained fire ignited the powder inside a chambered cartridge spontaneously, while the firing pin was still cocked. The unsupported primer usually blew right out of its seat, as shown here, creating a wide, clear passage for the hot powder gases directly into the action, right in front of the firer's face.
US Army photo.

fortunes for the SPIW program at their lowest ebb so far in its rollercoaster existence, AAI duly began the nominal-fee contract modifications. In the process they appear to have performed a minor miracle.

Following the modifications, AAI ran two series of in-house trials, beginning in September, 1967. Among the many seemingly insurmountable problems encountered during the 1966 engineering design tests had been the Army's adverse reaction to the basic physical characteristics of the weapon ("excessive weight and bulk, and unsatisfactory appearance on visual inspection"), plus ammunition characteristics unsuited for combat use, excess muzzle flash and recoil impulse, poor accuracy, chronic malfunctions and parts breakages associated with the extremely high rate of burst fire, and objectionably loud muzzle blast levels. Amazingly, it was concluded that these low-budget September tests were a qualified success, and that the modified AAI SPIWs would, with a specific number of further design changes, satisfactorily accomplish the entire 1966 test plan.

The second set of trials, begun that November, concentrated on the rather ironic emergence of yet another dangerous problem. As the improved AAI SPIW began to shoot longer strings without jamming or malfunctioning, it consequently got hotter. Eventually, what was arguably the most serious misadventure associated with the piston-primed XM645 cartridge could occur: cook-off. Always a problem when light, air-cooled weapons are subjected to sustained fire, "cook-off" is the result of the breech becoming so hot from the repeated explosions that the transfer of heat from the barrel will ignite the powder of a chambered cartridge spontaneously.

Never a disirable happenstance even with normal cartridges, a cook-off in the AAI SPIW could easily prove disastrous for both weapon and firer. As can be seen from the illustrations, the XM645 featured a primer unique not only in its method of operation but in its relative size. Compared to the usual relationship of primer-to-base diameter, the XM645's combination of slim case, large piston-primer and high pressure resulted in a very thin and potentially weak case rim and base. In the case of a cook-off, the primer was sent hurtling to the rear faster than normal, as it was unsupported by the usual cushioning action of the (still cocked) firing pin. The primer was therefore prone to blowing right out of the back of the case, possibly even taking a portion of the case rim with it. This instantly created a wide, clear passage directly into the action, right in front of the firer's face. Due to the large size of the primer, this passage was very nearly the full diameter of the bore itself, and offered little if any restriction to the full flood of high pressure, ultra-hot powder gases. The disastrous results can well be imagined.

The November 1967 trials were therefore an attempt to come to grips with the dreaded phenomenon of cook-off by measuring the effect of the AAI's high rate of fire on barrel temperature, thereby determining the number of rounds which could be fired in a string before entering the "cook-off zone". As it turned out, due mostly to improvements in the metallurgy of the barrel extension and the design of the heat-dissipating barrel radiator, this upper limit was found to be beyond the sustained fire requirement stated in the engineering test plan, and the test ended on a very optimistic note with four out of five approved rapid fire test cycles actually being successfully completed. AAI was further able to report that inspection of the modified SPIWs subsequent to the rapid fire schedule showed they had survived "without detriment to function or parts life".

92. A proud family portrait from AAI Corporation circa 1967, showing (from left) early iterations of their privately-developed flechette-firing light machine gun and sub-machine guns; an improved 1966 SPIW fitted with a DBCATA launcher-plate (complete with dummy DBCATA round); and a point-target-only version of the 1967 SPIW rifle, mounted on a centrally-positioned bipod.

New Hope For The SPIW

Though few could have known it at the time, fate's pendulum had again started a heady upswing into a new and dramatic, if short-lived, period of well-timed good fortune for the SPIW, due to the highly favorable comments gleaned from the computer-generated SAWS study reports. The unexpected success of AAI's efforts in the nominal fee contract modifications further aided and abetted this new mood of enthusiasm.

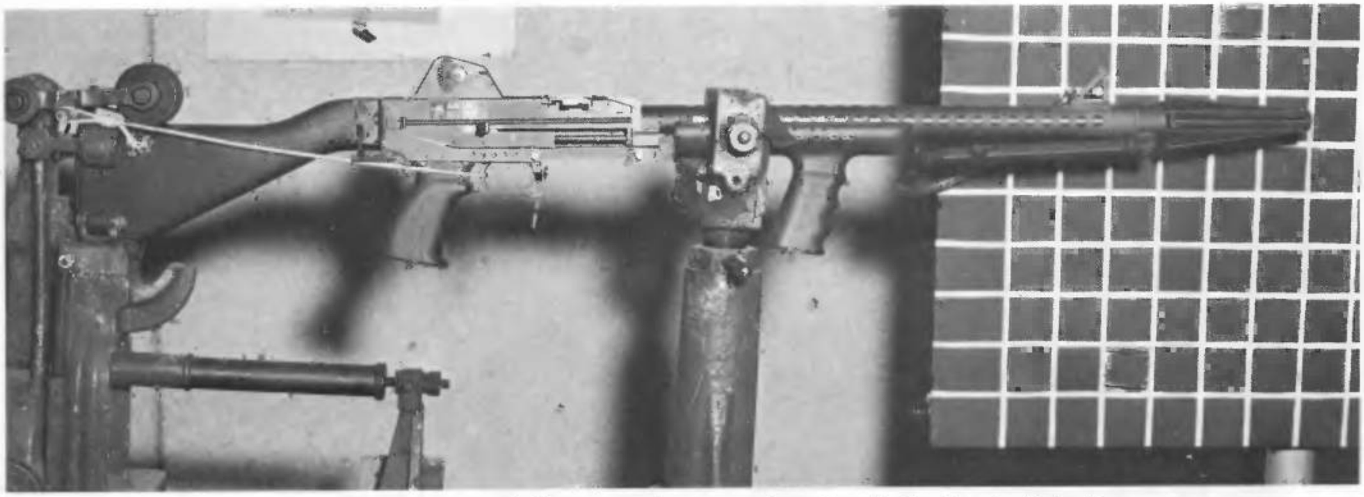
Meanwhile, another flechette ammunition study had added a further timely and positive note: Frankford Arsenal's *SPIW Ammunition Cost Estimate Study* was released on November 1, 1966. It proved to be a refutation of an earlier 1965 study done by the Deputy Chief of Staff for Logistics (DCSLOG), which had reported in the negative regarding the feasibility of cost-effective mass manufacture of flechette ammunition. Frankford had taken a harder look: its 1966 objectives had been nothing less than "to develop cost estimates for the fabrication and packaging of SPIW point-target cartridges by mass production methods and to predetermine . . the costs of facilities and equipment . . to fabricate and package one billion rounds a year."

After completing this exacting study, Frankford had concluded that a concentrated program of advance production engineering (APE) *would* result in flechette ammunition at a reasonable cost.

Concurrently, the Planning Research Corporation, a private research firm based in Los Angeles, had been running a year-long, contracted cost-effectiveness study on the second generation AAI and Springfield SPIWs, evaluating them and comparing them with other "existing and developmental" small arms systems. The conclusions and recommendations of this weighty study were released in June of 1967, just in time to add further momentum to the upswing of the SPIW's fortunes:

> *The SPIW concept is more combat effective in the situations studied than are the standard weapons. In terms of cost effectiveness, present SPIW point-fire weapons fall considerably below standard weapons. Further development to improve SPIW reliability will bring these weapons to a level with the XM16E1 . . . The AAI Corporation rifle was more reliable than the Springfield Armory rifle. The AAI rifle with the [DBCATA] launcher should be selected . . for further development . . .*

Nor was all the new evidence merely theoretical. The prestigious Ballistic Research Laboratories (BRL) added their approving voice to the new mood of favor for the flechette in two sequential reports of actual SPIW firings in early 1968. The first, released in February, was entitled *SPIW Modes of Fire* (BRL No. 1864), and concerned the applicability to the AAI SPIW of then-current Army doctrine which had been evolved for full automatic fire from other rifle systems:



93. A later version of the AAI "LMG-XM645" pictured above, mounted in an AWC firing jig and undergoing trials at Rock Island Arsenal with an experimental straight line bar-type flash suppressor.
US Army photo, dated March 15, 1973.

94. A close-up of a late-model AAI SPIW sub-machine gun, a compact "bull-pup" version of the standard 1967 rifle. Caliber 5.6×57mm XM645, 60-round magazine.
AAI Corporation.

A study was made to investigate the most effective mode of aimed fire . . with the rifle portion of the Special Purpose Individual Weapon (SPIW) system. Basic test data were generated by a group of riflemen firing a total of approximately 23,000 rounds at different types of simulated targets on the range facilities at Fort Benning, Georgia.

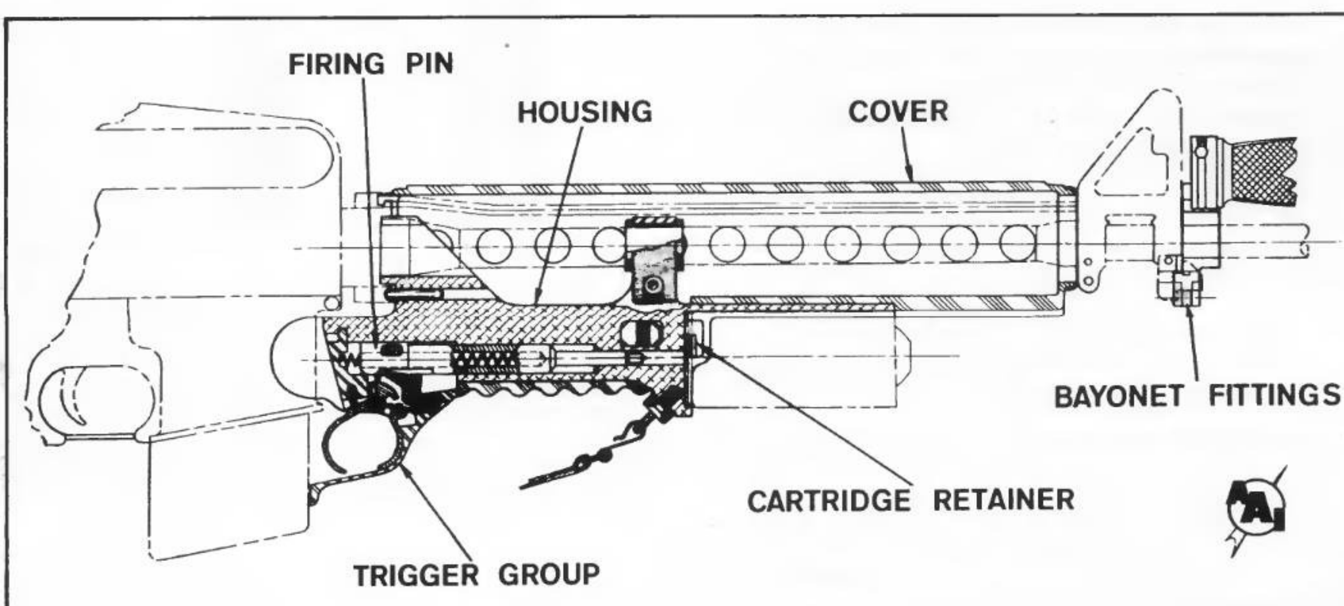
BRL reported they had obtained 18 percent multiple hits in the trigger-manipulated mode, compared to 42 percent multiple hits with the controlled-burst mode, noting that one of the modified 1966 AAI SPIWs provided "a rate of fire of approximately 2,000 shots per minute for the controlled burst mode and approximately 450 shots per minute for the full-automatic mode . . . A firer would have to squeeze the trigger once every 3 seconds to provide a volume of fire comparable to 60 shots in one minute [the maximum sustained rate of fire for the M14A2 automatic rifle]."

Each single-flechette XM645 cartridge was found to yield only about .54 pounds-seconds of recoil impulse. (By way of comparison, the standard M193 5.56mm produces 1.20 lb/sec of free recoil impulse.)

BRL concluded that "Current doctrine can be applied to the SPIW . . the doctrinal requirement for accuracy . . and volume . . of automatic fire is met by the [SPIW's] controlled-burst mode." The report implied that BRL's extended SPIW firings had given them considerable first-hand experience with the "severe mechanical stresses" engendered by the very high controlled-burst rate of fire, and problems related to the extra complexity of the rate reducer for the slower automatic mode. BRL suggested that limiting the SPIW to one optimum rate of fire and removing the controlled-burst feature altogether might go a long way towards alleviating reliability problems:

95. Two deadly rivals in comparison. ABOVE: the Colt-made M16A1 (with thumb-closer mechanism). Total number of parts: 121. BELOW: the 1967 AAI SPIW, point target configuration only. Total number of parts: 113. Compare with figures 72 and 77. Note the finned barrel radiator, and the alloy "heat sink" now fitted below the barrel and chamber. AAI Corporation.

96. *If you can't beat 'em, join 'em! The versatile and popular AAI-developed XM203 single-shot, pump-operated 40mm grenade launcher for the M16A1 rifle, an outgrowth of the Army Small Arms Program (ARSAP). Adopted in 1968 as the M203 following a competition featuring several rival launcher designs. ABOVE: method of attachment to the M16. BELOW: the launcher in place; rifle fitted with modified forend and grenade sights. A "low-risk, high-payoff" offshoot of the SPIW program.*



97. *AAI was nothing if not persistent when it came to promoting its own innovative products. Here is a drawing of AAI's proposed DBCATA launcher attachment for the M16 rifle!* AAI Corporation.

The test results . . indicate [that] weapon controllability, as it pertains to projectile dispersion at the target area, is comparable when firing either extended bursts of low-rate full-automatic fire or rapidly-triggered controlled bursts. The amount of ammunition expended during any given period of time is also about equal.

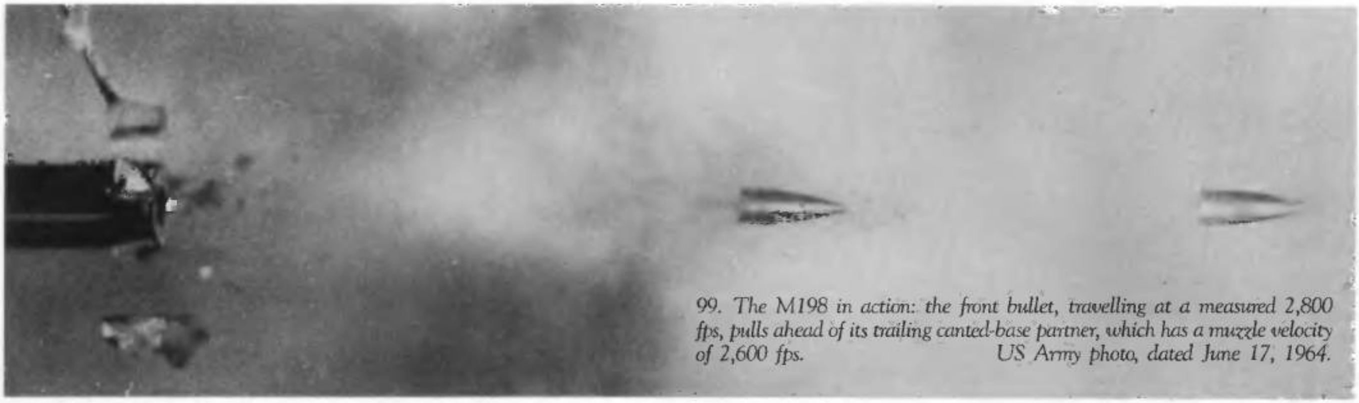
The second favorable BRL memorandum report (no. 1919), entitled *Accuracy of Rifle Fire*, came out the very next month. This was an interesting extension of *SPIW Modes of Fire*, discussed above. It appeared that AAI had indeed accomplished some behind-the-scenes wizardry on their modified 1966-model SPIWs:

Studied were the [AAI] Special Purpose Individual Weapon (SPIW), the M16A1 and M14 rifles. Basic test data [for the SPIW] were generated by a group of riflement firing a total of . . 13,000 rounds at . . Fort Benning . . . Data [for the M16A1] were obtained for a two-round mechanically-counted burst and a two-to-four-round trigger-manipulated, full-automatic burst, and . . [for the M14] for the M198 Duplex and M80 ball cartridges . . .

On the basis of successful trigger pulls, the SPIW hit a greater percentage of targets engaged than either the M16A1 or M14 rifles. Firing M198 Duplex ammunition in the M14 rifle increases the hit capability . . to the point of being competitive with the SPIW firing short trigger-manipulated bursts of full automatic fire. The [M198's] added second projectile would be expected to increase its hit capability; however, the extent of the increase is surprising. The M14 . . firing either M198 Duplex or M80 ball . . hit a greater percentage of targets engaged than did the M16A1. The average number of rounds fired per trigger pull in the trigger-manipulated mode with the SPIW was greater than [with] the M16A1 . . . with the lower level of recoil impulse and lower rate of fire of the SPIW, it was less difficult to control the burst length by trigger manipulation. The riflemen were able to maintain their . . fire on the target and therefore fired a longer burst. The subjects were able to fire at a greater number of silhouettes with the M16A1; however, due to the burst dispersion, a significantly fewer number were hit.

The addition of a two-round burst control mechanism improves the performance of the M16A1; however, the rifle is still not competitive with the SPIW in either controlled-burst or full-automatic modes fire. The SPIW in either . . mode . . is significantly more controllable than the M16A1 . . firing two-to-four-round bursts of automatic fire.

98. *ABOVE: the final product of Project SALVO's nested-multiple-bullet concept, developed by Frankford Arsenal and adopted as the green-tipped 7.62 NATO M198 Duplex round. The M198 featured two 80- grain solid-steel, copper-plated bullets nested one behind the other. The base of the lower bullet is canted at a 9-degree angle, which proportionally increases its dispersion when fired. Curiously, although it was proven that the M198 significantly increased a soldier's hit probability over conventional rounds at ranges up to 150 meters, it was never fielded in any but token quantities. BELOW: the M80 lead-core ball version of the 7.62mm NATO round. American Ordnance Association.*



99. *The M198 in action: the front bullet, travelling at a measured 2,800 fps, pulls ahead of its trailing canted-base partner, which has a muzzle velocity of 2,600 fps.* *US Army photo, dated June 17, 1964.*

The Future Rifle Program's Three-Fold Plan

In ordering the closing of Springfield Armory, Secretary McNamara had mistakenly assumed that most of the small arms R&D people there would move to Rock Island and carry on with their duties. Unfortunately, only about 4% of the Armory's civilian R&D staff agreed to move to far-off Illinois, the rest stubbornly electing early retirement or accepting other work. By August of 1968, it had become embarrassingly apparent that Rock Island Arsenal had failed to fulfil the small arms R&D role. The Army accordingly created a new agency called the US Army Small Arms Systems Agency (USASASA), based back at the Aberdeen Proving Grounds. USASASA was given control of the Army Small Arms Program (ARSAP), a gigantic new "co-ordinated package" of *all* the Army's current and proposed small arms activities. As mentioned, the area of endeavor concerned with future weapons development within the overall ARSAP program was designated the Future Rifle Program (FRP).

Conceived as a face-saving retrenchment plan after the acute embarrassment of the SPIW's collapse, the purpose of the Future Rifle Program was virtually the same as the SPIW's had been, except on a broadened front: instead of all the Army's eggs being concentrated in the basket of just one new weapon, like the SPIW, the FRP was to embrace three main sub-projects: the SPIW, or as it was renamed the serial flechette rifle (SFR), the serial bullet rifle (SBR), and the multiflechette. The FRP further subdivided these various developments into four different time-frames: "immediate" (within five years), mid-range (1975-1980), long-range (1985-1990), and continuing. A later press release explained:

> *In addition to the [SFR (SPIW)], two other design concepts are being considered. . The first of these would be a micro-caliber, high velocity bullet firing system, possibly utilizing the Springfield Armory-developed SPIW mechanism. The second is a multi-flechette system which launches from three to five flechettes simultaneously down the same barrel. These [projects] are directly managed by the US Army Weapons Command, rather than the AMC Project Manager-Rifles. Both are scheduled for transfer to the US Army Small Arms Systems Agency (USASASA).*
>
> *None of these systems are developed to the extent of the [SPIW], but offer alternatives with various advantages and disadvantages . . . Caseless ammunition is also being developed. If it is successful in the time frame allotted, caseless ammunition may become a feature of the Army's future rifle.*

Thus, the new and carefully-worded goal of the FRP was to provide "contender systems" which would yield "increased effectiveness by having higher reliability and durability, and high hit probability and/or lethality, compared with current systems". The FRP would result in a replacement for the Army's M14 and M16 rifles, but with a target date now postponed to somewhere "before 1980".

The SPIW's Golden Age – AAI Corp's XM19 Serial Flechette Rifle (SFR)

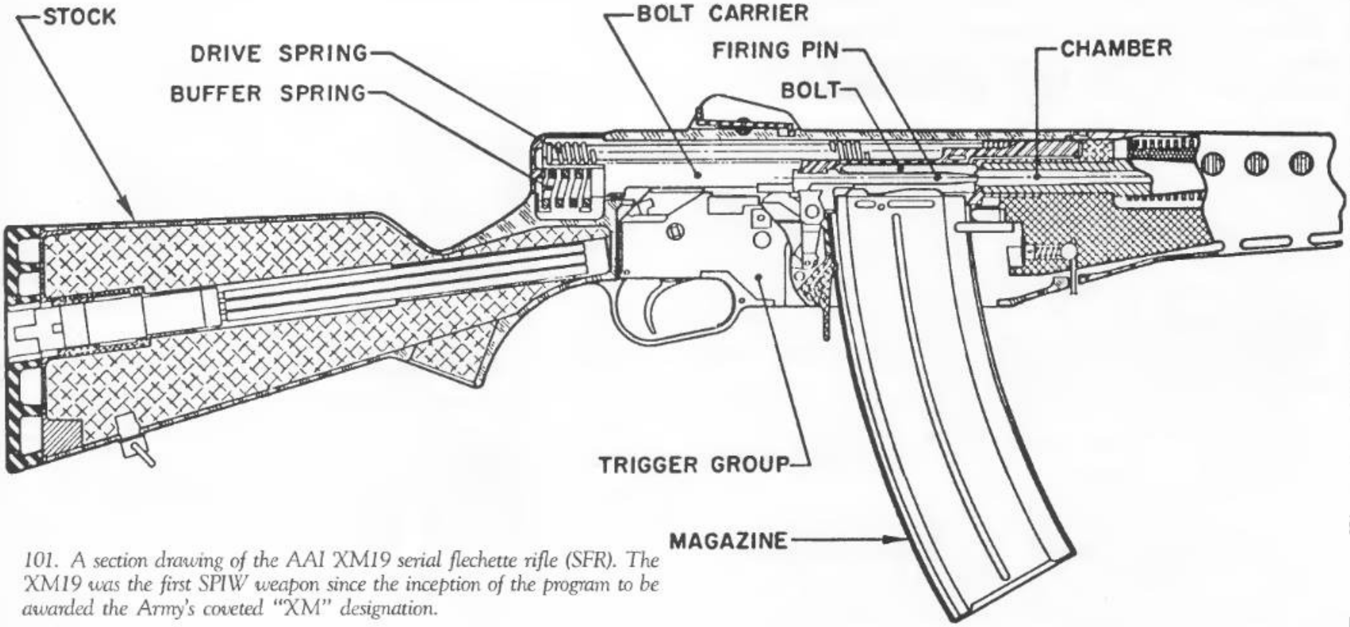
Only too eager to let bygones be bygones, the Army had seized on the limited but encouraging success of AAI's 1967 nominal-fee contract modifications, authorizing an additional $500,000. from its "Procurement of Missiles and Equipment, Army" fund (PEMA) in fiscal 1968 to step up produceability studies on flechette ammunition. As part of bumping the SPIW program back up to the advanced development stage, a second contract for the manufacture of XM645 cartridge cases and one-piece piston-primers was placed with the Canadian government ammunition facility at Val Cartier, Quebec (headstamp IVI 69). Mr. Barr and his AAI SPIW team, who had just weathered a thinly-funded year-and-a-half of grim penance, now found their faith and hard work doubly rewarded: not only was the SPIW program *not* to be terminated after all, but a new development contract was in the offing.

The Army's new four-phase serial flechette rifle (SFR) contract with AAI became a reality in October, 1968. AAI agreed to begin the system improvement studies cautiously, using only modified existing weapons, until "all known deficiencies" were resolved. Phase two called for the manufacture and trial of four new weapons embodying the phase one modifications; phase three would then consist of further design studies or modifications indicated by these trials. In phase four, more of the latest prototypes were to be fabricated for extensive trial by the Test and Evaluation Command (TECOM) and the Combat Developments Command. A field experiment had already been tentatively scheduled for April, 1970, wherein the new SPIW would be compared with the M16A1 under simulated combat conditions.

100. Two views of the first AAI XM19 prototype to be fitted with a 50-round box magazine in response to the Army's amended 1968 SFR contract. (These 1971 photographs show the modified rifle as it was later used, as a mounting platform for an experimental single-shot 30mm grenade launcher). ABOVE: prototype XM19 left side, magazine removed (grenade launcher closed for firing).

BELOW: close-up of the right side of the rifle's action, showing the modifications to the plastic stock surrounding the magazine well. (The 30mm grenade launcher, a later development, is shown open for loading).

US Army photos, dated November 4, 1971.



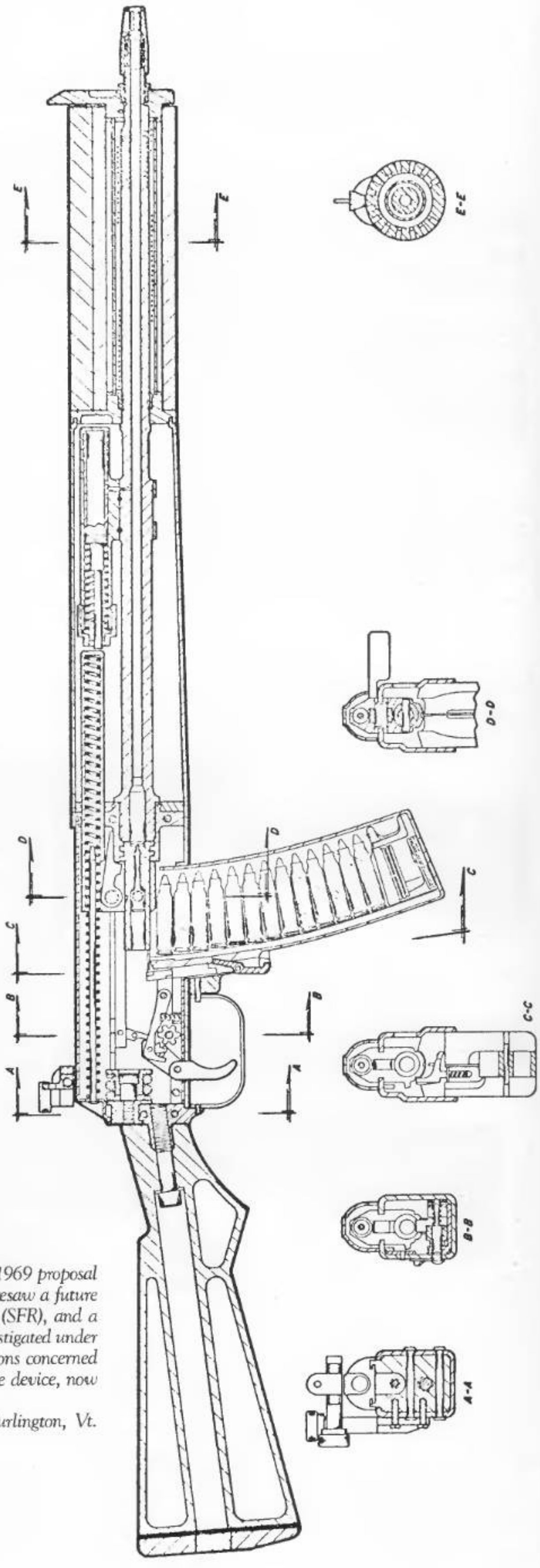
101. A section drawing of the AAI XM19 serial flechette rifle (SFR). The XM19 was the first SPIW weapon since the inception of the program to be awarded the Army's coveted "XM" designation.

102. With time having nearly run out for the SPIW, the gap between the two rivals for adoption as the universally standard US small arm was being narrowed even further. As predicted by Mr. Rob Roy, Colt's representative at the 1966 AWC SPIW demonstration (Chapter 5), "The more [the SPIW] is developed and the closer it comes to an operational weapon, the more it will be simplified . . ." ABOVE: the point target version of the AAI "XM19 Rifle, 5.6mm, Primer Activated, Flechette Firing", showing its box magazine and capacity loading of fifty XM645 cartridges. BELOW: the Colt/ArmaLite M16A1, by this time "Standard A" for American troops everywhere but in the European theater, pictured with the smaller of its two issue magazines, and 20 rounds of 5.56mm ammunition. AAI Corporation.

HQ Army Weapons Command (now called WECOM) publicly confirmed the awarding of the letter contract to AAI on January 21, 1969, "for continued development of the Special Purpose Individual Weapon (SPIW) and its associated ammunition". A scant six months later in June, WECOM announced that the phase-two prototypes, now officially called the "XM19 Rifle, 5.6mm, Primer Activated, Flechette Firing", were under construction. This first bestowal of an official "XM" number on a SPIW candidate weapon was an important and long-awaited honor: it signified formal recognition that the SPIW had advanced one indispensable step closer to becoming the Army's next rifle system.

Rock Island's June, 1969 press release announcing the XM19 contract went on:

> *. . [the weapon] is capable of firing ten-grain flechettes single shot, in a controlled burst of three rounds, or fully automatic . . . The miniature piston in each round of [XM645] ammunition eliminates the need for a gas system in the weapon. This in turn simplifies the rifle mechanism and decreases its weight. The weight of the XM19 [point fire configuration only] is approximately seven pounds . . . A [50-round] box magazine is currently being considered by the designers at AAI Corporation. [The] XM19 also has the capability of mounting a single shot grenade launcher which can be fired from the same trigger by further rotation of the selector lever. Two 40mm launcher attachments are being considered for the area fire capability . . the XM203 pump launcher currently under development [at AAI] as an attachment to the M16A1 rifle and the Disposable Barrel Cartridge Area Target Ammunition (DBCATA) launcher . . . Twenty prototypes will undergo engineering design tests at Aberdeen Proving Ground . . . and Fort Benning . . . It is planned that an additional quantity will be fabricated for field experiments . . at Fort Ord, California. The delivery of the prototypes and the start of the tests is programmed for the spring of 1970.*



103. A section drawing from the General Electric Company's 1969 proposal for a renaissance of the 1966 Springfield Armory SPIW. GE foresaw a future for the modified Armory SPIW, both as a serial flechette rifle (SFR), and a serial bullet rifle (SBR); two of the three new avenues being investigated under the Army's Future Rifle Program (FRP). GE's main modifications concerned the SPIW's objectionable flash and blast; hence the new muzzle device, now larger in internal area and rounded in cross-section.

General Electric Company Armament Department, Burlington, Vt.

The General Electric Company's Dual SFR and SBR (Serial Bullet Rifle) Proposal

Meanwhile, initial exploratory studies had been funded, to the tune of a very cautious $1,000.00, at the General Electric Company's Armament Department, headquartered in Burlington, Vermont. GE was examining a possible renaissance of the moribund 1966 Springfield Armory SPIW, both in the serial flechette mode and as a serial bullet rifle (SBR), firing the new micro-caliber (.17", or 4.32mm) bulleted ammunition.

GE later described the history of this involvement in its *Proposal for Development of a Special Purpose Individual Weapon* of February, 1970:

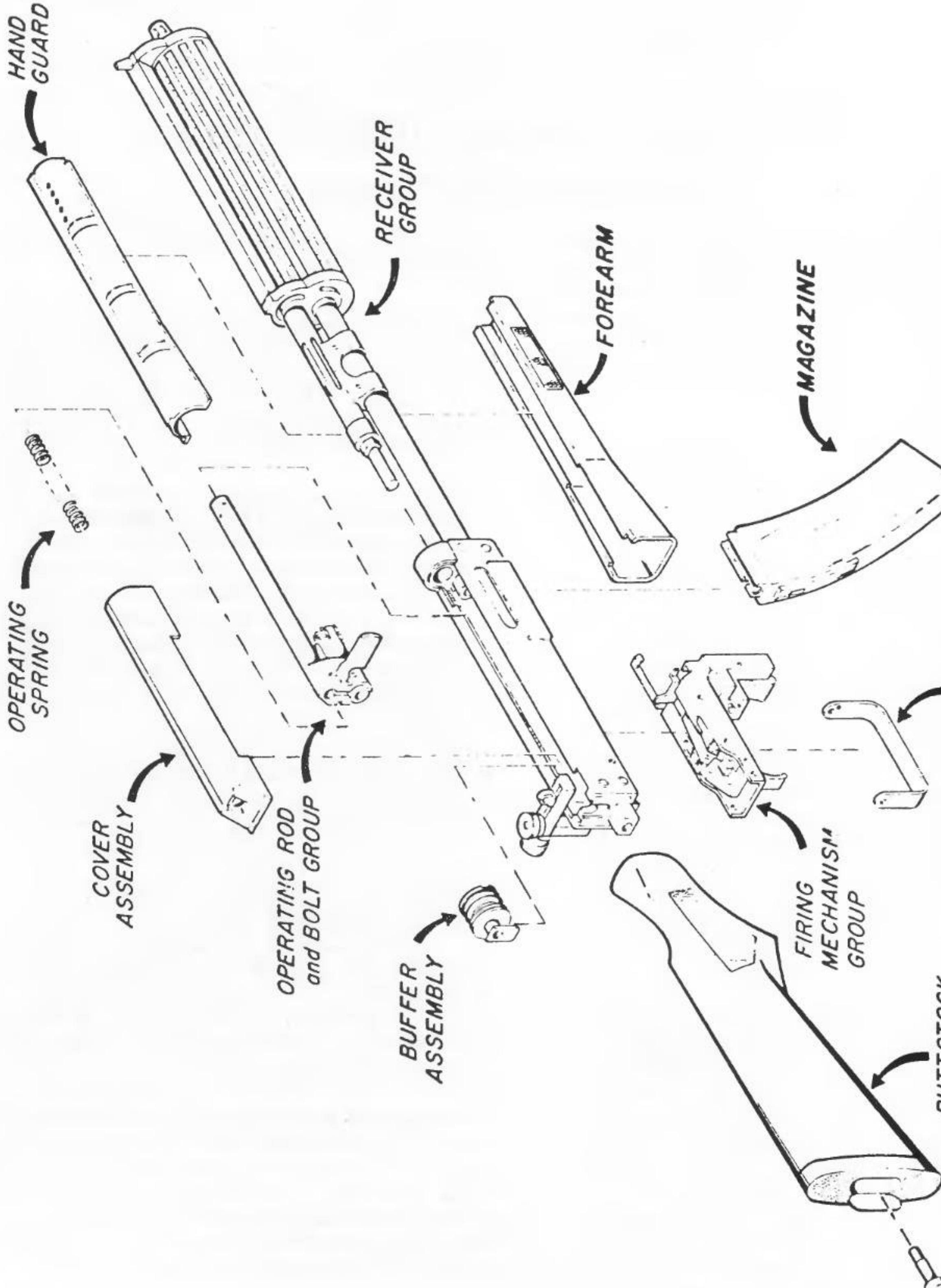
> *In 1967 the Department of Defense closed the Springfield Armory, . . the primary source of the country's small arms design and development for 174 years. When [the closing] was announced, the General Electric Company arranged . . for the rental of part of the Armory's [Federal Square Complex] facilities . . to augment the production capacity of the [GE] Armament Department and to produce a quantity order of M73, 7.62mm and M85, caliber .50 machine guns. In addition to renting the manufacturing facilities and hiring many former Armory production employees, a group of highly talented weapon design engineers joined GE and have formed the New Single-Barrel Gun Engineering Unit . . under the leadership of R.H. Colby (Springfield's project engineer for SPIW). This group represents over 90 years of experience in small arms development . . .*
>
> *The Army reactivated the SPIW program in 1968 with a contract award to AAI for advanced development on the basis of [AAI's 1967] in-house effort. That same year GE asked the Project Manager-Rifles for Springfield SPIW weapons and ammunition . . to undertake a company-funded engineering study to continue development . . Contract DAAF03-69-C-0043 was the result . . [with] GE to investigate problems with the [Springfield] 1966 SPIW involving (1) premature ignition, (2) ammunition magazine malfunctions, and (3) inadequate muzzle brake/ compensator design, as well as to evaluate the capability of the design to fire micro-caliber bullet ammunition."*

During its 1969 engineering investigation, the GE Armament Department's Springfield operation had modified one of the 1966 Springfield SPIWs, which in their words now combined:

> *the best features of the 1964 bullpup and the 1966 . . design, [which] should minimize the deficiencies and shortcomings revealed during the 1966 tests at Fort Benning and Aberdeen . . . The new version of the GE/Springfield SPIW . . has 58 fewer parts [than the 1966 model] . . .*
>
> *Another advantage of firing conventionally primed ammunition is that the GE . . is adaptable to either a single flechette rifle (SFR) or a single bullet rifle (SBR) . . We recommend that both types of ammunition be used during the evaluation. This will be possible if the case dimensions and the overall cartridge length are the same for both rounds (the standard M193 cartridge case used with 5.56 ammunition could be used). Only a barrel change will be necessary . . .*
>
> *The SPIW has an unusually large noise, blast and flash at the muzzle caused by over-pressure. Anything that reduces this over-pressure will reduce the flash and blast. One way to do this is to increase the volume of the gun bore, thereby increasing the expansion ratio . . either by increasing the length or diameter of the bore. Since we are recommending use of the M193 cartridge case, it would be possible to increase the diameter of the sabot for the flechette projectile from its present 5.56mm to 6.0mm, while still maintaining an adequate shoulder on the cartridge for headspacing. Adding .44mm to the bore diameter adds volume equivalent to 5 inches of added barrel length . . ."*

It appeared that the major thrust of GE's 1969 modifications concerned the SPIW's flash and blast. As Mr. Colby pointed out, it is nigh on impossible to design a *universal* muzzle device; that is, one which will function as a compensator, recoil reducer and flash suppressor all at the same time; because these three requirements are mutually exclusive. The GE contract proposal concluded:

> *No SPIW designers on earlier programs ever developed a muzzle device which lowered flash and blast at the muzzle to an acceptable level. "Cut-and-try" empirical methods are almost the only way to tackle this problem . . .*



104. *An exploded view of the proposed 1969 GE/Springfield SFR/SBR, which according to the GE report on the project contained 58 fewer parts than the 1966 Armory SPIW. An eclectic design, featuring what looks like a Stoner 8-lug rotating bolt within an AK-47 operating rod and cover assembly, cycled by a top-mounted version of the White patent gas cutoff and expansion system as used in the M14 rifle. The Army did not pursue the GE proposal.*
General Electric Company Armament Department, Burlington, Vt.

With the AAI XM19/XM645 program admittedly much more advanced, it appears that the Army never pursued GE's proposal to manufacture and test the 1969 GE/Springfield hybrid much past the exploratory point reached above. The serial bullet rifle (SBR) concept itself, however, went on to become a most important and face-saving "relief valve" wherein all efforts were to be channeled after the flechette-firing SPIW was finally "removed from immediate consideration" in December of 1973.

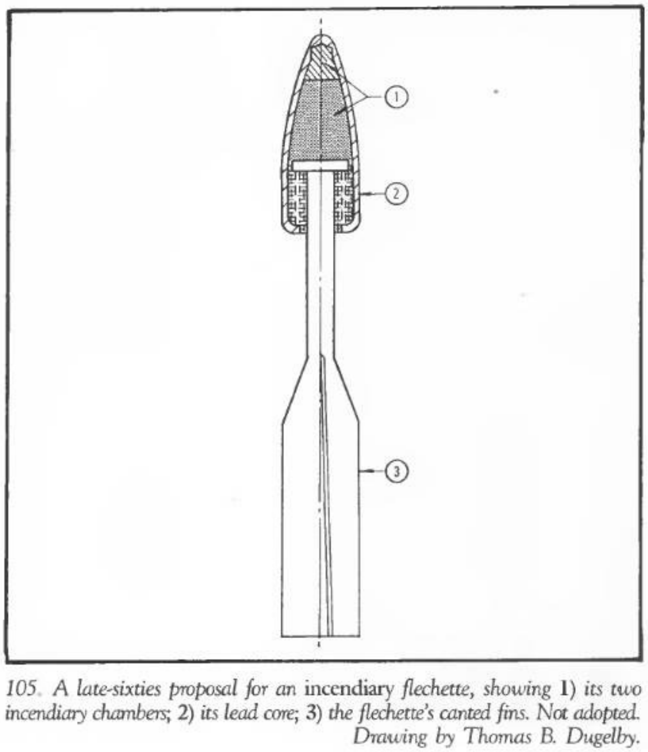
The Multiflechette Concept

Multiflechettes, the FRP's third main avenue of exploration, harked back to the third and last of AAI's 1957 ideas, the push-launched "type C" flechette, and combined it with the simultaneous salvo concept to produce a number of different multiflechette cartridges and loadings. The inherent problem associated with multiflechettes is perhaps best described in a warning quote from the conclusions to BRL's *SPIW Modes of Fire* report, discussed above:

> *. . The multiple-flechette round also should be considered . ., however this approach may not neccesarily be the solution to the problem! Additional flechettes per cartridge, launched at approximately the same muzzle velocity, dictate a higher impulse imparted to the rifle per cartridge fired. An increase in impulse level reduces the rifleman's control of the weapon . . The advantage gained with the multiple-flechette round may be lost when attempting to fire the automatic rifle from the shoulder in the full-automatic mode . .*

In spite of this *caveat,* several different approaches to the multiflechette idea were funded through the late sixties and early seventies, both at Frankfort Arsenal and with private industry. One such, a "Preliminary Design and Systems Analysis Study", contract DAA-2569-C0013, was concluded in June of 1969 by Olin's Winchester Group. Winchester had begun picking up the threads of Frankford's earlier research into multiple flechette loadings a year or two previous to this 1969 study, which in Winchester's words compared

> *push launch multiple flechette systems having three, four and five flechettes in the ammunition . . . the results . . ruled out the three flechette system but showed no significant difference between the four and five flechette systems. Weapon size and weight influenced the decision in favor of developing the four flechette system.*



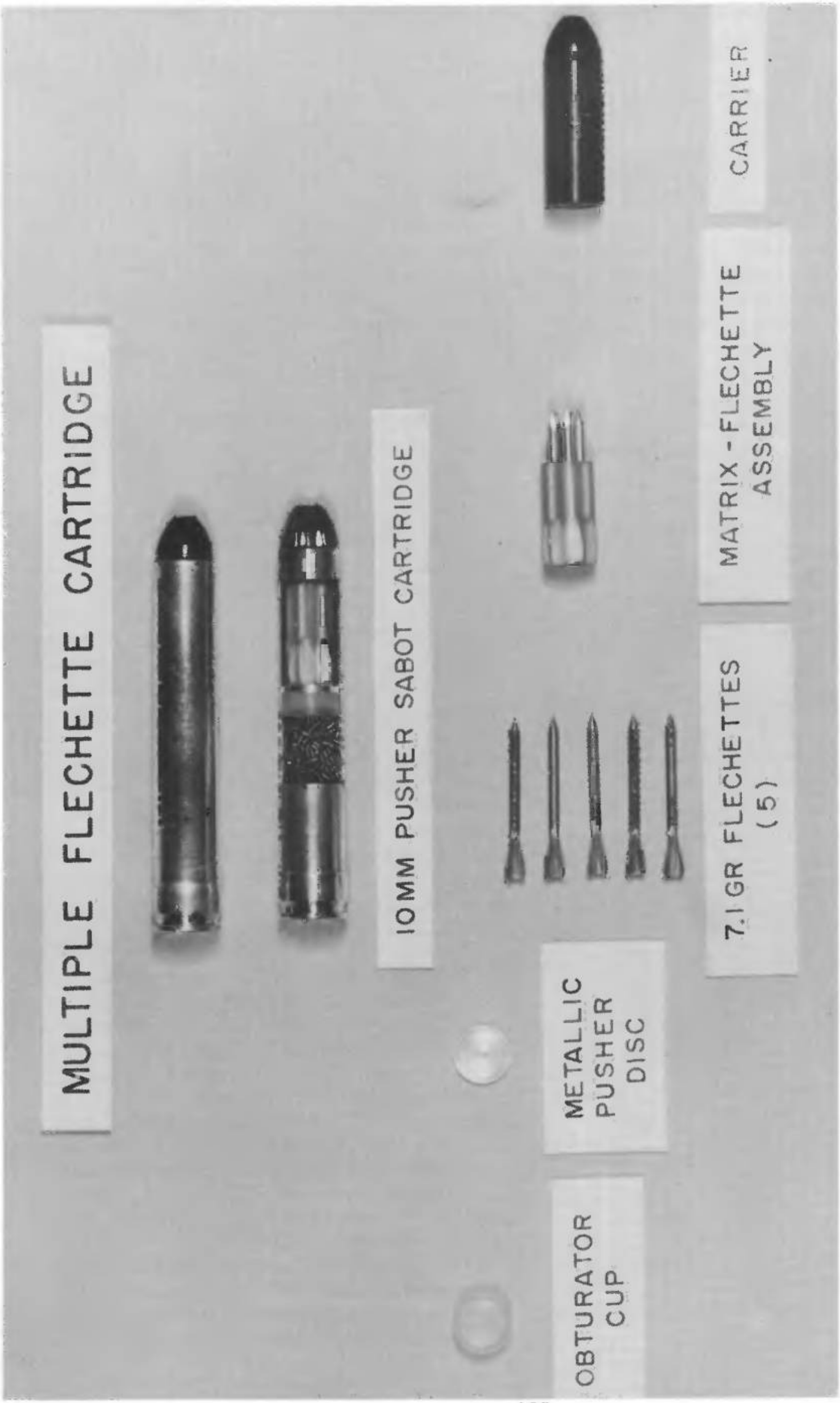
105. A late-sixties proposal for an incendiary flechette, showing **1)** *its two incendiary chambers;* **2)** *its lead core;* **3)** *the flechette's canted fins. Not adopted. Drawing by Thomas B. Dugelby.*

Winchester had so far produced three tentative loadings for their multiple, push-launched flechette cartridge; a "ball" load of four flechettes in a single carrier, plus single-flechette tracer and armor-piercing "penetrator" rounds.

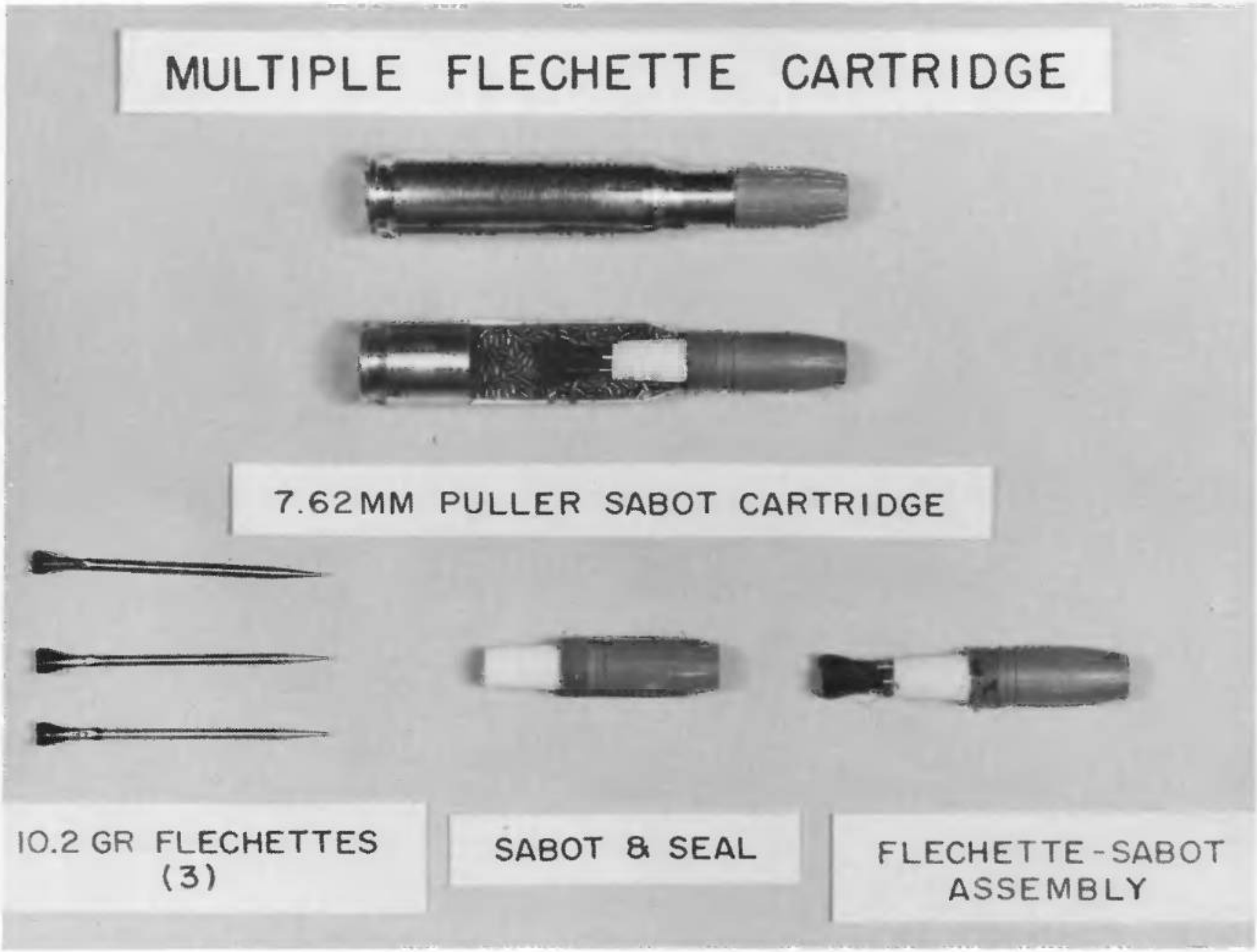
In October of 1970, Winchester concluded a new "Multiple Flechette Weapon System Development Contract", No. DAAF03-70-0012, reporting that they had finalized and tested a 9.53mm rimmed cartridge with a case made of 7475 Alcoa aluminum alloy. The ball loading featured four new "double point angle push launch" flechettes of Winchester's own devising, which were held in a two-piece Delrin carrier assembly fitted at its base end with a metallic "pusher disc" and a plastic "obturator cup". The tracer round now held two ball flechettes plus a single tracer flechette. The four-flechette ball load, fired from a Winchester test fixture, apparently turned in an instrumental muzzle velocity of 4,240 fps.

In addition to the new cartridge, Winchester had conducted parallel feasibility studies into a suitable weapon design for the new system. Further company-funded research had also been done into other parameters of aluminum cases and other brass substitutes, and had even touched on the feasibility of a caseless multiple flechette weapon system. Winchester concluded that, within certain parameters, aluminum had proven to be a suitable cartridge case material, and would reliably perform at pressures up to 75,000 psi. The results of the tracer flechette project were disappointing, however, as the report states:

> *. . dispersion of the two ball and one tracer flechette was poor . . [and] could be improved only at the expense of trace ignition reliability. Tracer flechettes with a larger tracer cavity than the SPIW tracer*



106. A brass-cased, 10mm version of the pusher-sabot multiflechette cartridge, this circa-1968 variation holding four 7.1-grain flechettes.



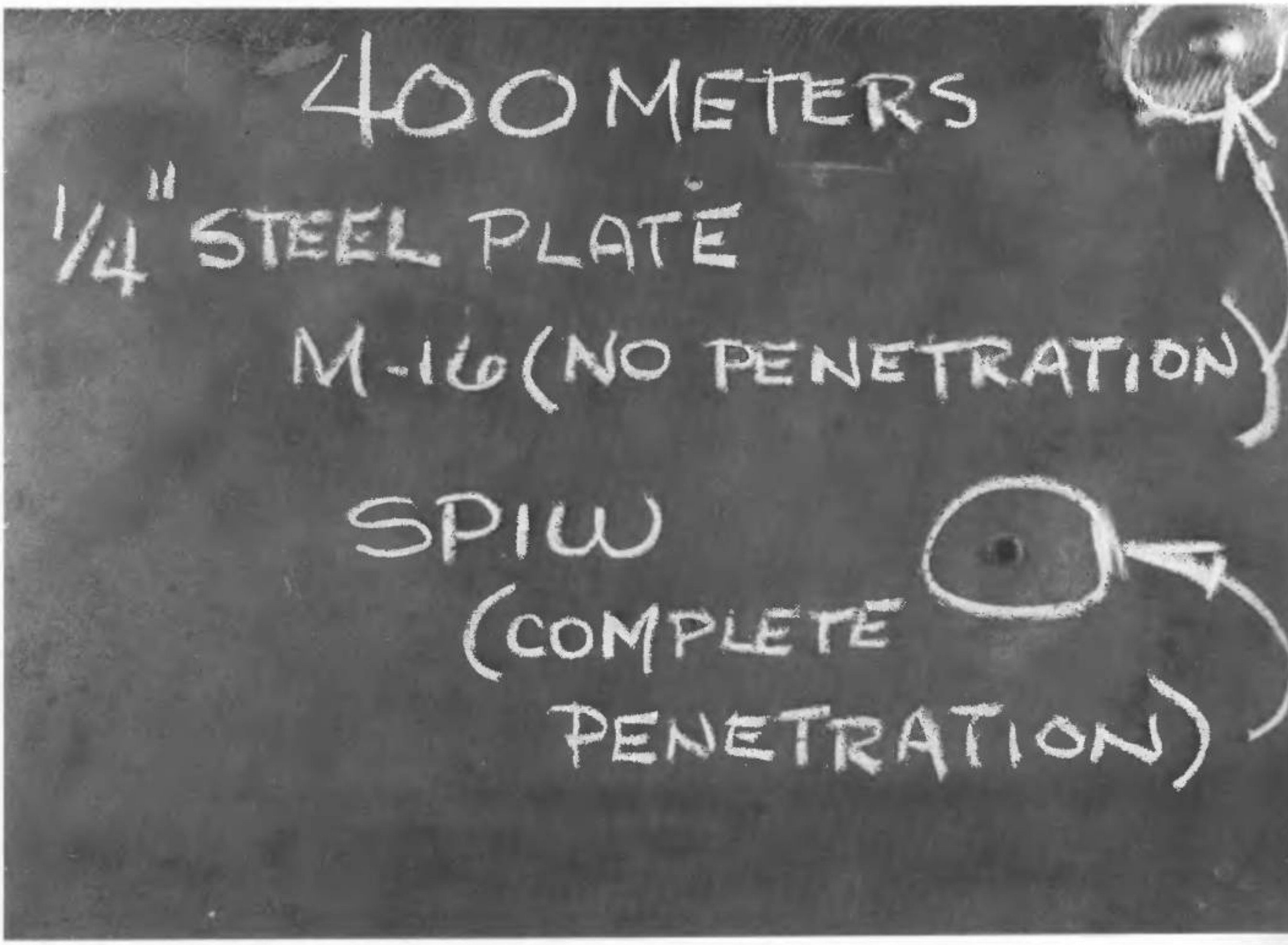
107. The multiflechette concept applied to the 7.62mm NATO round, with three standard 10.3-grain AAI flechettes held in a "puller" sabot.

were tested but these flechettes burst in flight at short ranges. Visibility of the small tracer flechettes, both the SPIW and the modified version used in the push launch ammunition, is inadequate for daytime use. Indeed, one needs to be immediately behind the gun to see the trace and even then it is easy to miss.

It was only natural that in addition to the development of new cartridges, some attention be given to a .30 caliber version of the multiple flechette round. Winchester describes just one advantage of such a study:

The 9.53mm system has an extremely rapid pressure rise and decay and a very short bore time. The extent to which this contributes to the ability of the aluminum case to withstand pressures above 70,000 psi is not known . . . Performance of the 7475 alloy under more severe conditions can be accomplished by modifying the tooling used in the final stages of processing the 9.53mm case to create a bottlenecked, rimless case suitable for use with a .308-inch diameter bullet. This would permit study of the changes in case performance caused by headspacing on the shoulder versus the rim. . .

Study contracts with Winchester into the various ramifications of multiflechettes continued for some months, but interest paled in the face of new and severe scrutiny being accorded the whole of the Army's conduct regarding the Future Rifle Program.



108. Despite the rising chorus of discontent with the SPIW program, there were unquestionably some areas where the XM645 AAI flechette cartridge was superior to the 5.56mm round. One of these was in armor penetration, thanks to the flechette's excellent sectional density (length/width). AAI Corporation.

Chapter Seven

Enough Already!

In retrospect, it seems that the situation at this point resembled nothing so much as the classic cartoon sequence wherein someone walks off the edge of a building, oblivious, along a straight path into thin air. The joke, and the fall, come only with the realization. To an increasing number of observers both in and outside the program, the curious and continued determination to ignore the fundamental gulf between the SFR (SPIW) requirements and the real world appeared to be placing the Army in a somewhat similar position.

Enter the Auditors

On July 30, 1969, Congressman Richard L. Ottinger of the House of Representatives wrote a formal letter to the Comptroller General of the United States. By this time, some aspects of the Future Rifle Program were already under investigation by the US General Accounting Office (GAO). Mr. Ottinger's letter sums up the situation as it then existed:

> *I am writing in regard to the Special Purpose Individual Weapon (SPIW) currently being developed by the AAI Corporation for the Department of the Army . . . it is my understanding that after seven years of research and development and the expenditure of some $20 million, the SPIW is still not ready for production and use. I further understand that some five different engineering deficiencies have been identified and that it is anticipated that some additional 12 to 18 months will be necessary to correct these deficiencies.*
>
> *I would appreciate your advising me as to how much more will it cost to correct the five present deficiencies and whether any additional research and development funds will be spent; why is this weapon being developed in the first place; . . [and] when will the SPIW be ready for use by our Armed Forces personnel?*

The resulting GAO scrutiny of every aspect of the FRP, promptly ordered by the Comptroller General, put the cat amongst the pigeons in no uncertain terms. The sequence of events which followed proved to be most complex, however, as the three main sub-projects of the FRP; the SFR (SPIW), the SBR and the multiflechette, had collectively built up an immense amount of momentum, due in large part to the "some $20 million" already invested or committed. Among the myriad DoD agencies and private companies involved were many well-connected "believers" who fought desperately to protect the programs and keep them alive until the final benefits could be reaped. In the opposing camp were skeptics like Congressman Ottinger, who felt with gathering vigor that the wisest move would be to cut the taxpayers' losses on the SPIW and go on with some other avenue of approach. The sheer vastness of the whole issue, and the relatively limited power of each of its adversaries, guaranteed a prolonged and bloody struggle.

The First Deadly Strike

The first of several major lunges at the very jugular of the flechette concept came, ironically, from within the Army itself. For over a year there had been increasing concern among Infantry officers about official reliance on *patterns* of projectiles to ensure high hit probability. Finally, a formal amendment was filed to the existing materiel need (MN), a standing document which spelled out the parameters of the weapon the Infantry desired (the *raison d'être* for developing the SPIW in the first place). The amendment stated that henceforth the *single round* hit probability requirement for the XM645 flechette cartridge on the large "E" target at 300 meters was to be 0.4 hits per shot. As discussed, the basic, built-in concept of the flechette was its patterned performance as a burst-fire missile. This new accuracy standard was simply not attainable with each single round of the existing XM645 serial flechette cartridge.

In reaction to this, AWC introduced a rather effective delaying tactic by terminating USASASA involvement with the SPIW and once again transferring overall responsibility for the XM19 program, this time to the General Thomas J. Rodman Laboratory back at Rock Island Arsenal.

Ironically, it appears that by this time the AAI weapon was virtually at the point of perfection, and yet as the XM19 neared this tantalyzing goal its detractors gained in voice and power, and the mood of good fortune which had begun in 1967 began to slip away, never to return.

109. The enigmatic and expensive XM645 piston-primer cartridge, shown with its needle-sharp 10.2-grain flechette. When fired, this cartridge produced a chamber pressure of very nearly 70,000 psi within less than five thousanths of a second (.5 msec).

More on the XM19 SPIW System

Despite these latest developments in the plot to kill the SFR program, AAI had just completed a gruelling 6,000- round endurance test with their latest XM19 prototype, during which they had paid particular attention to problem areas which had long since been recognized as the weapon's chief weaknesses. They proudly reported the XM19's latest accomplishments to AWC as follows:

— the *drive spring*, which had in the past been prone to failure and collapse during the extremes of burst fire, had been improved and had survived the trial. This problem was now considered solved.

— the *trigger group* was now a sealed unit, and had been used without cleaning throughout the trial, with no attributable stoppages.

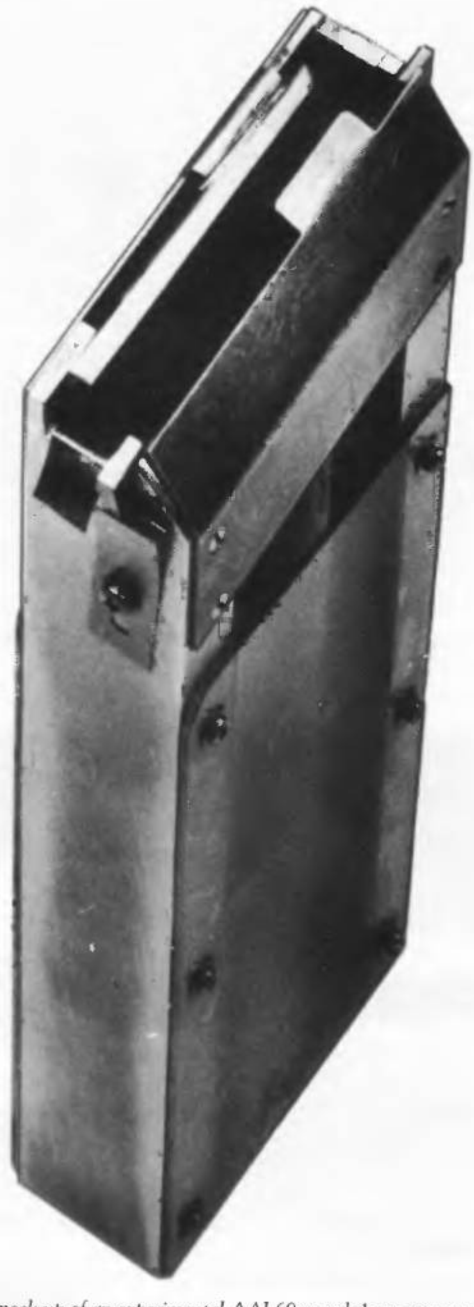
— a new, lighter *muzzle brake* had proven satisfactory throughout the endurance trial and also during the cook-off test, wherein the last 391 rounds of the endurance test were fired off in a blistering 3 minutes and 43 seconds, to ascertain that the XM19 was now proof against the dreaded phenomenon of *cook-off*. A fresh round, quickly chambered at the end of the test and left for some minutes, had not cooked off.

110. An early XM19 serial flechette rifle (SFR), showing removal of the 50-round magazine. Note the "ribs" on this first type of box magazine, and the reworked plastic stock in the magazine well area (originally curved to accept a 60-round drum). AAI Corporation.

111. XM19 SFR, showing removal of molded plastic forestock. Note the vented barrel extension, made of a special material called "Waspalloy" to withstand the intense heat generated by the weapon's 2,400 rpm burst fire rate, and the alloy barrel "radiator". AAI Corporation.

The XM19 registered an overall malfunction rate of 7.2 per 1,000 rounds fired during this 6,000 round trial, inclusive of all "repetitive malfunctions". (A chronic feeding problem during the latter portion of the test was traced to a bent lip on the rifle's aluminum, 50-round box magazine. The rifle with a replacement magazine fired the remaining 2,300 rounds with a very respectable malfunction rate of 2.6 per 1,000 rounds.)

Regarding the XM645 cartridge, a third contract was placed in Canada at this time for cases and piston primers (headstamp IVI 71). Cases and piston primers produced in



112. A mock-up of an experimental AAI 60-round three-row magazine. An interesting proposal, but the Army's relaxation of the 60-round requirement came before it could be perfected. *AAI Corporation.*

Canada were being utilized by Frankford Arsenal in the production of both the standard XM645 "ball" flechette, and a tracer version named the XM649. Frankford also produced a red-based flechette proof round for the XM645 system (called by the Arsenal the FAT247 cartridge), which the Army had christened the XM647.

Some of the most interesting examinations of the SPIW and its flechette ammunition were performed during this last, ill-fated period. For example, a most informative BRL study had been sponsored by USASASA shortly before the mentioned change in management led the program back to Rock Island. The report on this project, *A Technique for Quality Control of Piston Primer Ammunition* (BRL No. 2193), dated May 1972, states in part:

> *[USASASA] requested the Interior Ballistics Laboratory to develop a technique for measuring the round-to-round and lot-to-lot variation in the motion of the piston [primer] during acceptance testing in order to ascertain the reliability of the ammunition.*
>
> *. . When a round is fired, the piston primer is propelled rearward a distance of 0.12 inch imparting its energy to the firing pin which in turn is propelled rearward . . [and] travelling in cam paths within the bolt carrier, causes the bolt to unlock . . . The energy which the piston imparts to the firing pin is the primary source of energy available for cycling the gun . . If the piston velocity is lower or higher than specifications . . the gun will either fail to refire, or the mechanism will be subjected to excessive impact forces. Thus [the need for] a technique to monitor the velocity of the piston during acceptance testing of the ammunition.*
>
> *[AAI] SPIW, Model E, Number 12 was used in this program. The gun . . was placed in a modified plastic stock. A slot, approximately ¾ inch long and ¼ inch wide, was machined in the left side of the gun in line with the groove in the bolt . . The base of the cartridge, the piston [primer] and the firing pin could be viewed through the slot as they came into battery and the firing pin impacted the piston primer. The cartridge was modified by machining off the extraction lip to make the piston visible before the round was fired . . The end of the piston and the firing pin were polished so that they would reflect sufficient light to produce a displacement vs time photographic record. The extraction lip from an unmachined case was cut off and glued to the bolt face to compensate for the dimensional change of the machined cases. A slot was cut in this ring to line up with the groove in the bolt . . . The record shows that the firing pin does not bounce when it impacts the piston primer and also that the firing pin and piston move together for the full length of the piston travel after the propellant ignites. It became apparent that the difficult-to-photograph piston motion could be followed by photographing the firing pin motion alone . . ."*

113. *Four brand-new XM19 serial flechette rifles, as supplied by AAI for the long-scheduled "third generation" phase four field experiment by the Combat Development Experimentation Center (CDEC) at Fort Ord, California, in both drum- and box-fed versions. An August, 1973 US Army Armament Command fact sheet listed the characteristics of the XM19 rifle (point target only) as follows:*

weight: 7 lbs (3.2 kg)
length: 42 inches (1067mm)
muzzle velocity: 4,800 fps
maximum range: 2,000 meters
effective range: 700 meters

The CDEC trials were generally successful, but the Army was adamant about its newly-amended single round accuracy requirement, which the XM645 simply could not meet. AAI Corporation.

The report goes on to describe the model of the proposed test device which BRL had developed for testing XM645 ammunition by monitoring firing pin velocity. It was never to be used.

By this time the XM19 had as mentioned matured considerably from its inception in 1967, so much so that during the early seventies the long-scheduled, phase four field experiment capping the 1958 SFR contract with AAI was at last carried out by the Combat Development Experimentation Center (CDEC) at Fort Ord, California. However, the generally positive results which CDEC reported after testing the newest XM19s came too late to reverse the growing climate of negativism: even weapons which functioned perfectly meant little in the face of the Infantry's adamant new single round accuracy criterion, which attacked the very fundamentals of the flechette concept.

A Second Grave Stroke

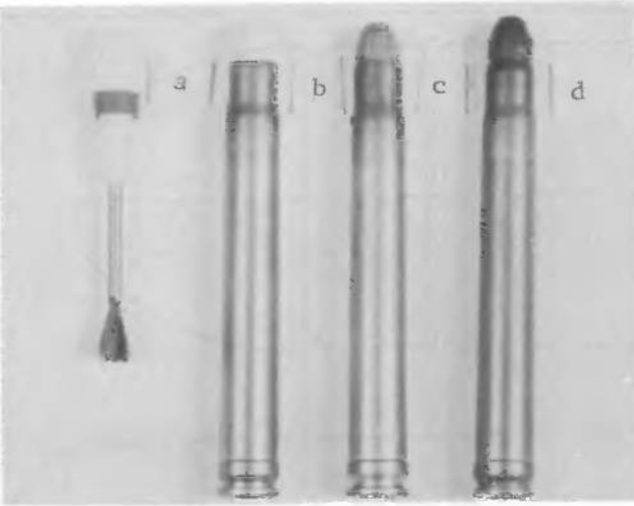
The second thrust at the SPIW's vitals came also from within the military, ironically as a result of these successful CDEC field trials. It cut just as close to the bone as had the amended accuracy requirement discussed above, finding, among other things, serious fault with the composition of both the powder and the sabot as used in the XM645 cartridge. Completed at BRL in November of 1972, the *Resume of Special Tests of the XM19 Rifle and XM645 Ammunition* (BRL No. 2245) was largely in response to complaints to the US Army Surgeon General from troops who had served on the various SPIW test teams. It subsequently appeared that some soldiers who had test-fired the XM19 had suffered inflammations or even injuries, due to microscopic particles of the shredded fiberglass sabots being blown back into their eyes by the wind. Some had also experienced severe nausea after inhaling residual powder gases. Some of BRL's comments are of great interest:

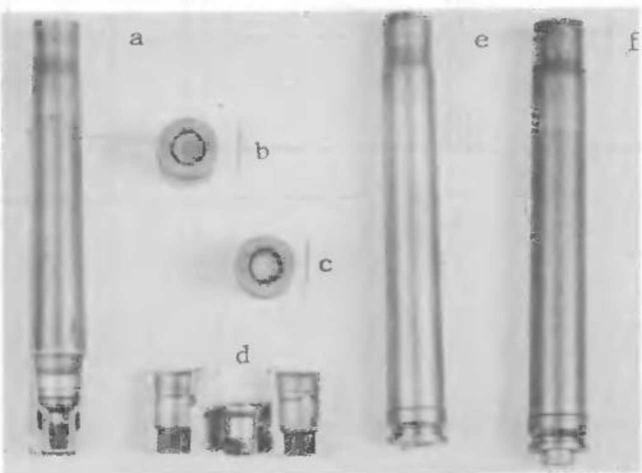
. . Several modifications have been made to the [XM19] rifle since its first appearance so that the rifle presently under test is referred to as the third generation XM19 rifle. However, in order to determine what effect further modifications would have on gun functioning, the US Army Weapons Command requested that the Interior Ballistics Laboratory (IBL) perform firing tests and obtain measurements using a second generation XM19 rifle . . . they are also requested that an analysis of the effluent gases and fiberglass sabot particles be conducted to determine if there was a possible health hazard . . .

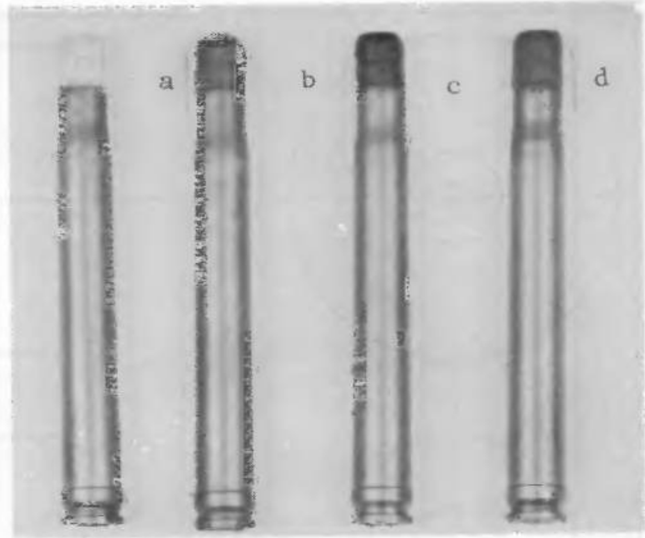
The XM645 round has a fiberglass sabot which breaks up into small particles when it passes through the stripper at the . . muzzle end of the barrel. In order to reduce the quantities of small fiberglass particles, two different [new] sabots have been developed. The Aircraft Armaments, Inc. (AAI) Molded Sabot requires the use of a stripper in the gun. The Honeywell Sabot does not . . as it breaks up aerodynamically upon leaving the muzzle . . .

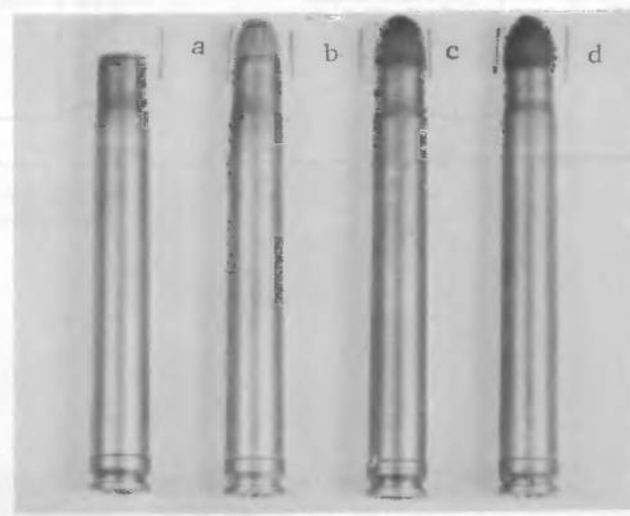
When the sabot goes through the stripper . . it breaks up into particles ranging in size from submicron up to at least .22mm. Depending on particle weight and wind conditions, the smaller particles may remain airborne for considerable periods of time . . . [and] may be inhaled by the soldier, get into his eyes, or cover his clothing to provide a future source of irritation. Particles ten microns or less in size can reach the lungs, if inhaled, and cause internal irritation and other problems . . . The final result showed that 2.08×10^5 *[208,000] particles per round had been collected [in our plastic test tent]. Since it was not possible to quantitatively collect all the very small particles . . the result obtained is a minimum number.*

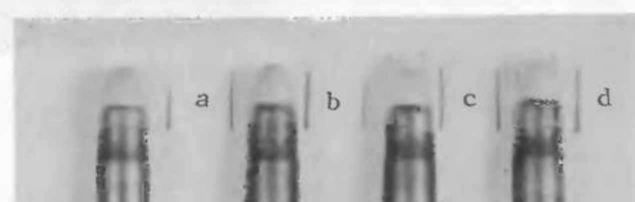
During field tests of the XM19 rifle, some of the troops complained of nausea. The Weapons Command requested an analysis of the gaseous effluents . . to determine . . if any of the constituents produce nausea . . . Twelve XM645 rounds were fired and gas samples were collected . . The gaseous components detected [were] nitric oxide, nitrous oxide, carbon monoxide, methane, acetylene, ethylene, ethane, propylene, propane, allene, carbonyl sulphide, cyanogen, and hydrogen cyanide . . . Carbonyl sulphide and cyanogen will produce nausea."











114. Actual size photographs of various experimental attempts to form a waterproof seal around the XM645's sabot and piston primer, from a Frankford Arsenal study entitled Scaling of Sabot and Primer of XM645 Cartridge (SFR). *In spite of these intensive investigations, a successful means of ensuring 100% waterproofing for XM645 flechette cartridges was never completely achieved.*

TOP LEFT: *Machined R&D Sabot of polyester resin, glass-fiber reinforced composite with and without nitrocellulose seal.*

a)-Sabot-flechette assembly [white sabot with brick-red rubber obturator] before insertion in case.
b)-Bare [white], unsealed.
c)-Teflon-coated sabot [light green].
d)-Nitrocellulose formulation seal [dark green].

TOP RIGHT: *Compacted ("crushed") R&D [Sabot with]various seals.*

a)-Bare sabot [white], unsealed.
b)-Microcrystalline wax seal [light brown].
c)-Polyvinylbutyral (+M_0S_2) seal [dark green].
d)-Nitrocellulose formulation seal [green].

CENTER LEFT: *Piston Primer.*

a)-Normal position in case.
b)-Drilube 108 applied.
c)-Nitrocellulose coating formulation (adjusted for flow and setting).
d)-Sectioned primer showing penetration of nitrocellulose formulation.
e)-Normal case.
f)-Position of primer cup in case after firing of round.

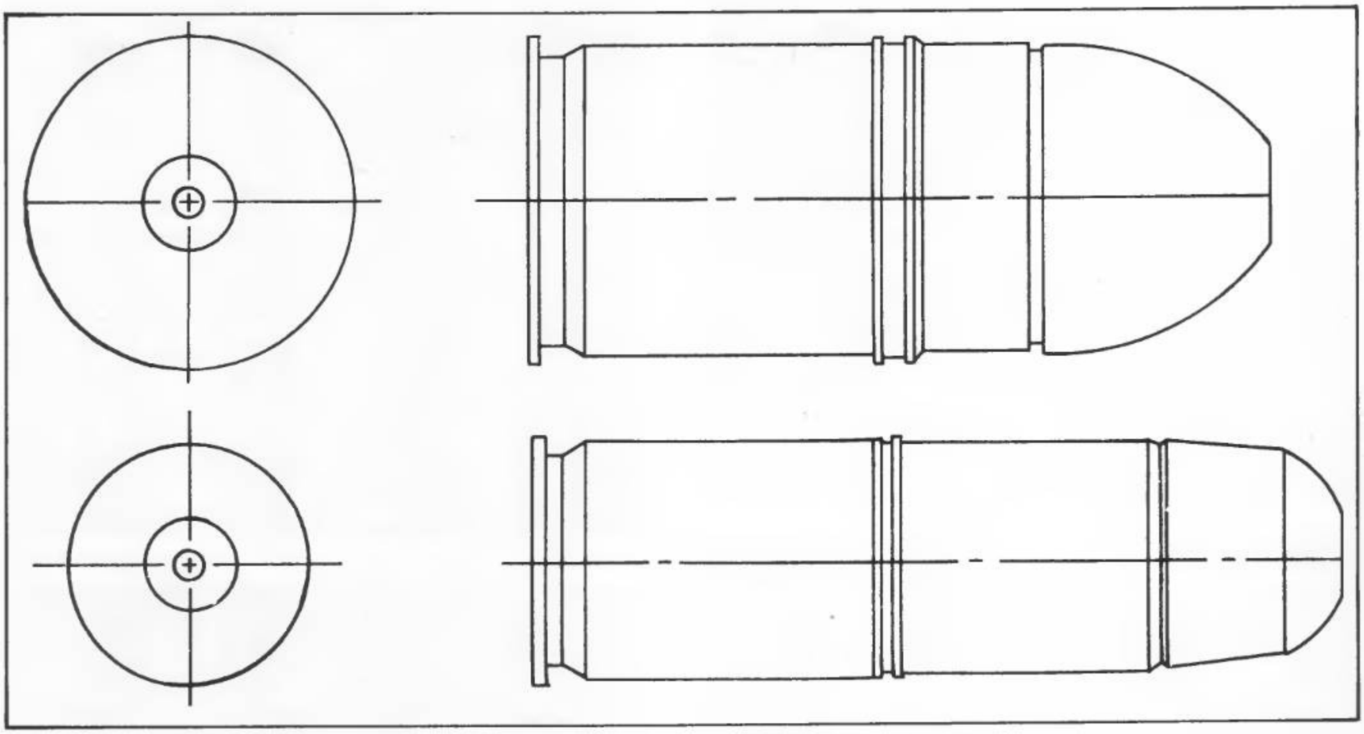
CENTER RIGHT: *Machined R&D Sabot, with and without microcrystalline wax seal.*

a)-Bare, unsealed [white].
b)-Teflon-coated sabot [light green].
c), d)-Microcrystalline wax seal [dull red].

BOTTOM RIGHT: *Preformed cap seals.*

a), b)-Cellulose polymer [clear over white sabot], dry shrunk.
c), d)-Vinyl chloride polymer [clear over white sabot], heat shrunk.

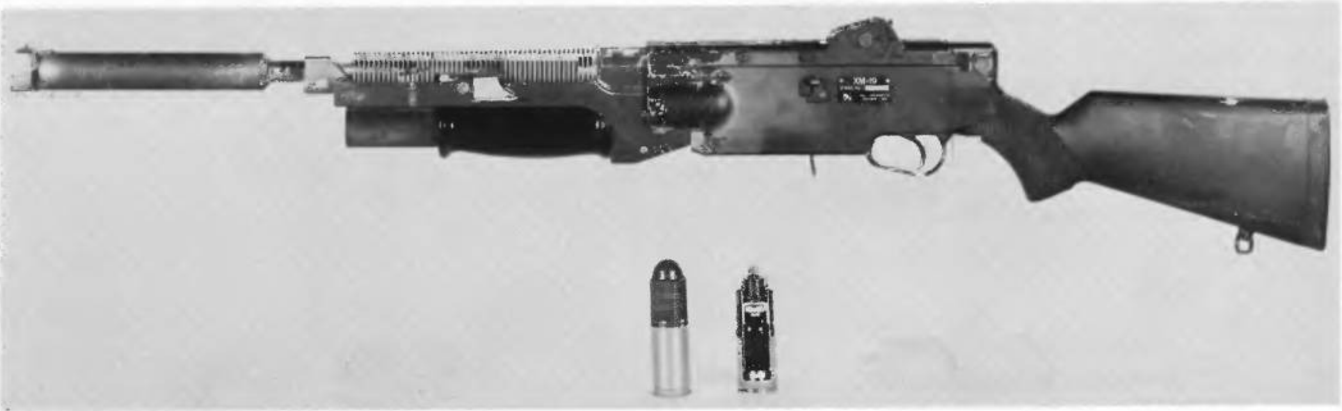
Frankford Arsenal Report No. R-2049, dated July, 1972.

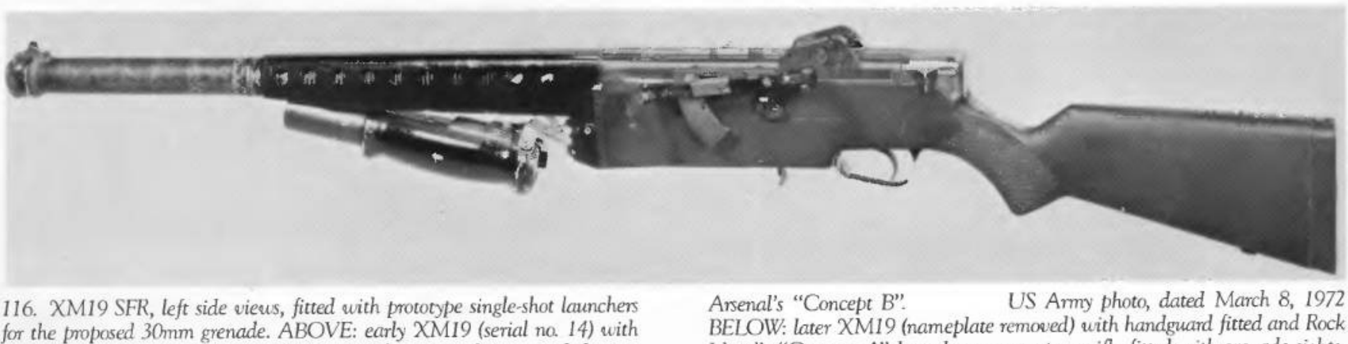


115. A comparison of the standard M406 H.E. 40mm grenade, (above), with Picatinny Arsenal's proposed 30mm grenade:

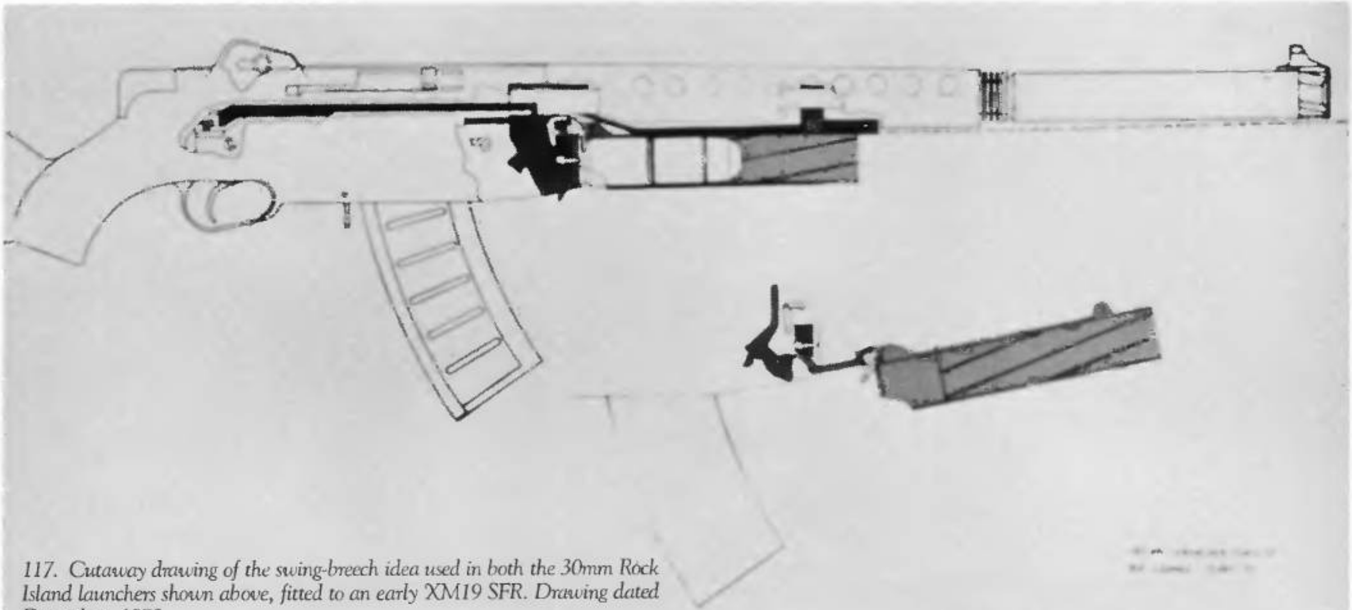
	40mm	30mm
Velocity:	245 fps.	278 fps
Launch angle:	38-42 degrees	28 degrees
Max range:	400 meters	398 meters
Weight:	.5 lb.	.42 lb.
Recoil Impulse:	3 lb/sec.	3 lb/sec

Rock Island Arsenal Weapons Systems Directorate, 1971.

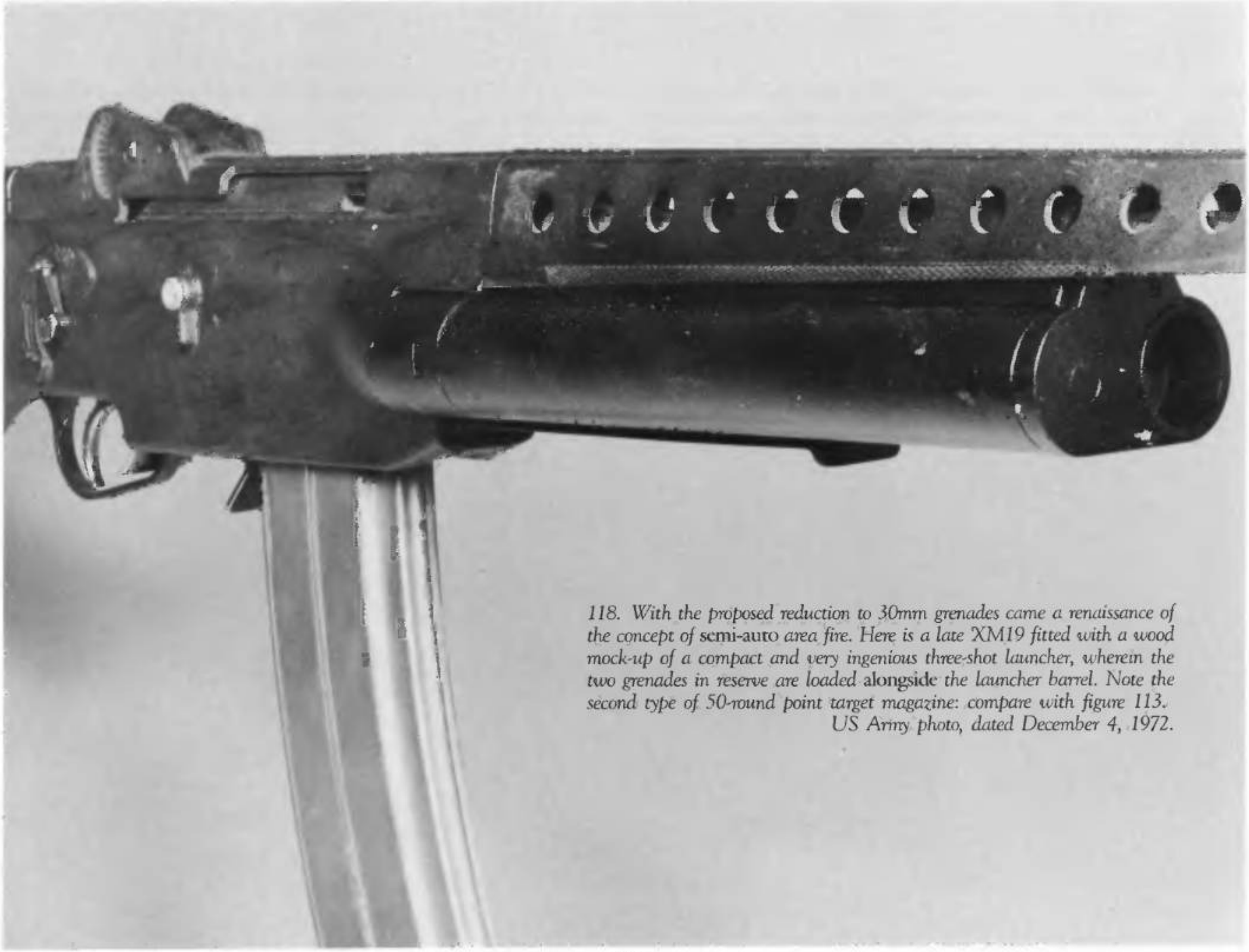




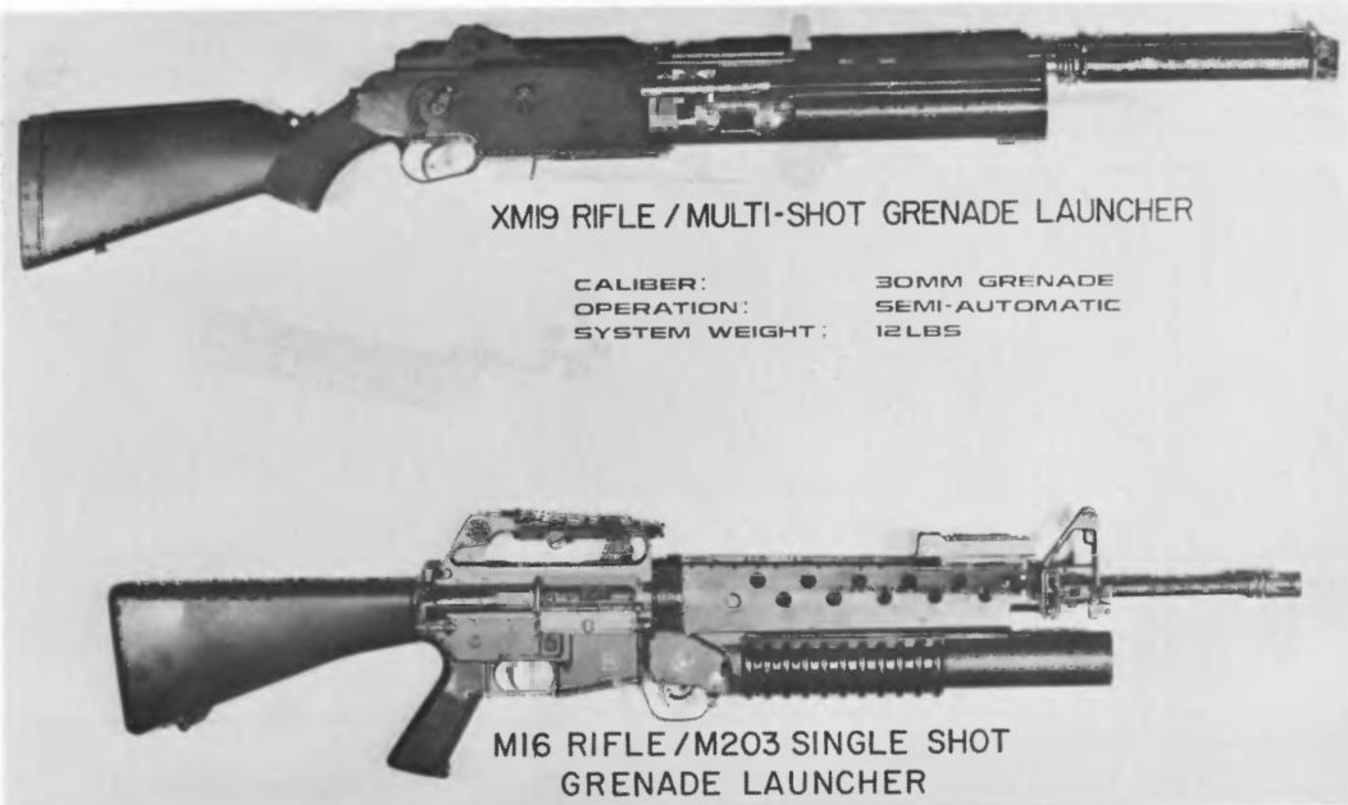
116. XM19 SFR, left side views, fitted with prototype single-shot launchers for the proposed 30mm grenade. ABOVE: early XM19 (serial no. 14) with magazine and handguard removed, showing barrel "radiator" and dummy and cutaway (instructional) 30mm grenades. The launcher is Rock Island Arsenal's "Concept B". US Army photo, dated March 8, 1972
BELOW: later XM19 (nameplate removed) with handguard fitted and Rock Island's "Concept A" launcher swung open; rifle fitted with grenade sights. US Army photo, dated July 26, 1972.



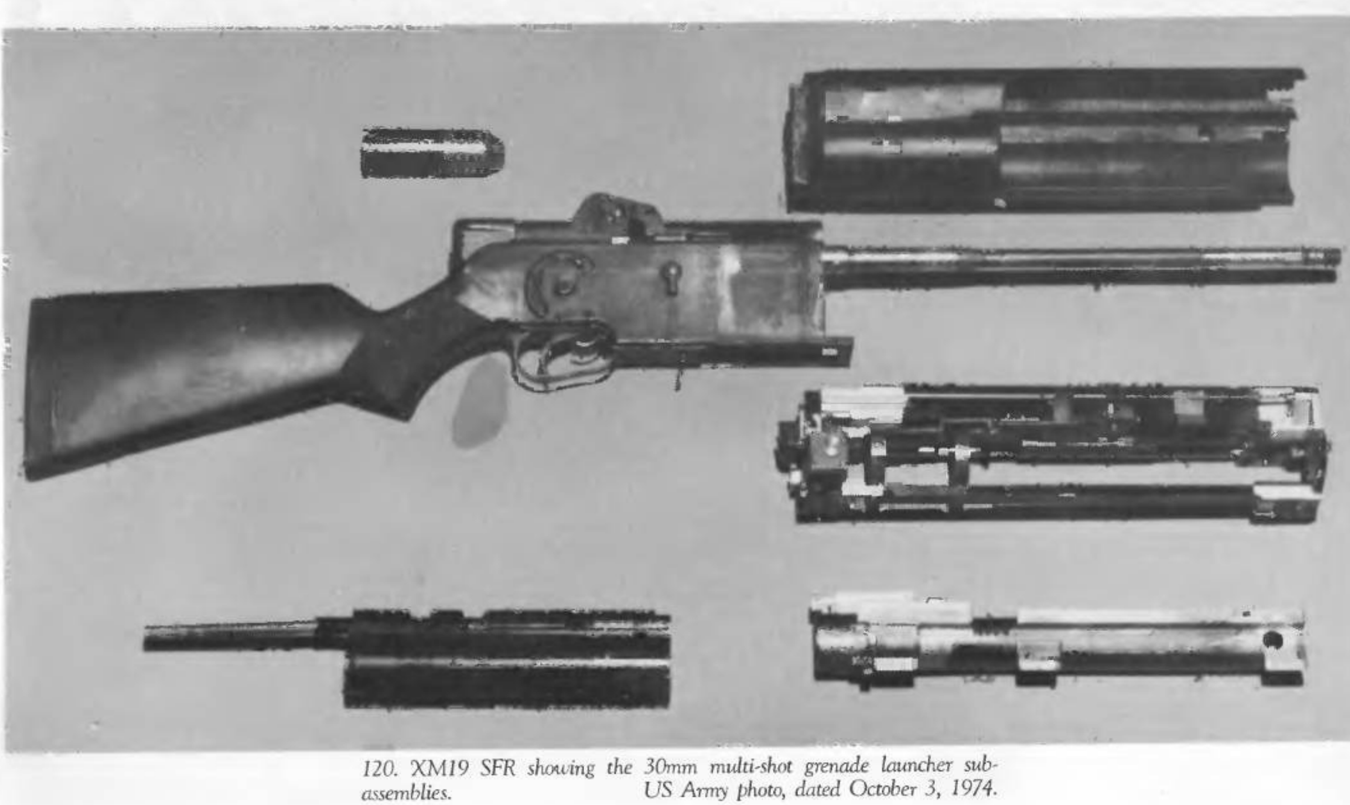
117. Cutaway drawing of the swing-breech idea used in both the 30mm Rock Island launchers shown above, fitted to an early XM19 SFR. Drawing dated December, 1970.



118. With the proposed reduction to 30mm grenades came a renaissance of the concept of semi-auto area fire. Here is a late XM19 fitted with a wood mock-up of a compact and very ingenious three-shot launcher, wherein the two grenades in reserve are loaded alongside the launcher barrel. Note the second type of 50-round point target magazine: compare with figure 113.
US Army photo, dated December 4, 1972.



119. The multi-shot 30mm SFR launcher concept, a product of the RIA Small Arms Laboratory design team, was pursued through to a second generation prototype. Here it is shown fitted on a late XM19 (with the receiver buffer housing and rear sight removed), and compared with an M16A1/M203 combination. US Army photo, dated June 6, 1974.



120. XM19 SFR showing the 30mm multi-shot grenade launcher sub-assemblies. US Army photo, dated October 3, 1974.

121. An important data-gathering experiment in the war against cook-off. This late model XM19 is shown fitted with heat-sensing devices to record time-and-temperature for number of rounds fired in both open- and closed-bolt modes. Heat was a real problem in the closed-bolt, rapid-fire XM19. Even a limited firing schedule resulted in a measured temperature in excess of 1,200 degrees F. at the "critical" location (four inches forward of the chamber). These trials pointed the way to the final evolutionary step for the AAI SPIW family, the open-bolt XM70. AAI Corporation.

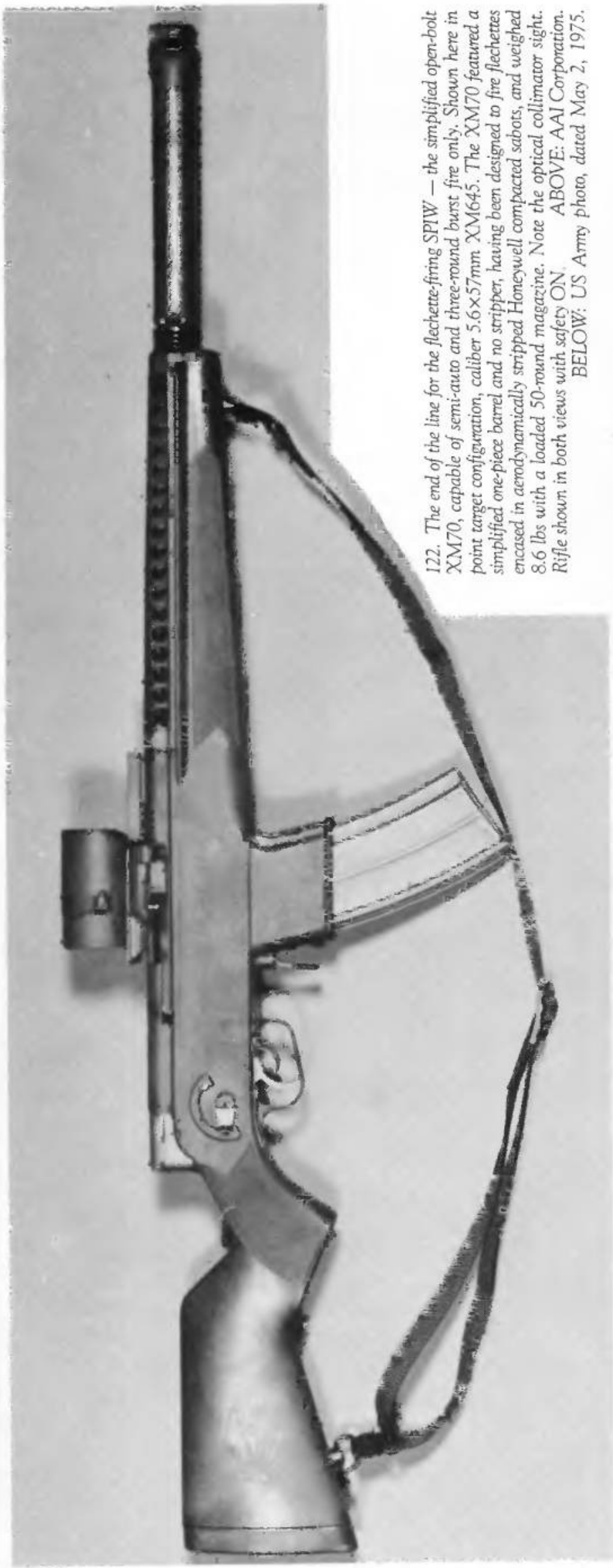
The AAI XM70 — A Final Desperate Evolution

Such was the momentum of the XM19 program that, even in the face of the combined effect of the devastating attacks and investigations mentioned above, a further two-phase development contract was granted to AAI by Rock Island's Army Armaments Command in 1972. Contract no. DAAF03-72-C-0172 was originally a no-frills, fourteen-month mandate to simplify the XM19 rifle, with the first ten months allotted to design study and the remaining four for fabrication of two new state-of-the-art working models. The Army actually expanded the scope of this contract in mid-period, extending its deadline several more months: the final report on what became known as the "XM70 Simplified Serial Flechette Rifle" was therefore not submitted until May, 1974. Apparently, only one model of the 109-component (108 plus the AAI nameplate; point fire configuration only) XM70 was constructed.

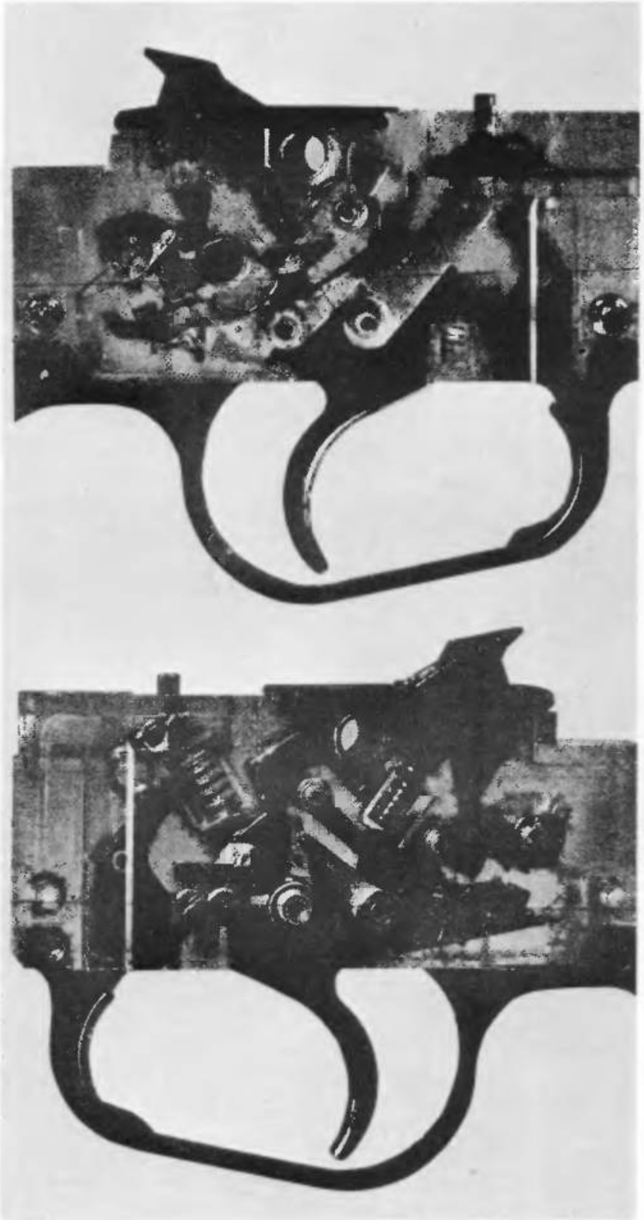
The XM70 was an admirable, last-ditch attempt to lighten ship and pare the SPIW down to its most simplified and acceptable form. It featured a sealed plastic trigger group which permitted semi-auto and three-round-burst fire only, both from an open bolt. The XM19's two-piece, exotic-alloy barrel and front barrel extension had given way to a simpler, one-piece Inconel barrel. The new one-piece plastic stock had a higher comb, for improved control on burst fire. Above the receiver an enveloping plastic mount housed a new collimator sight, the optics for which had been supplied by Frankford Arsenal. The barrel radiator had been eliminated altogether, in favor of a simplified bar-type alloy heat sink attached to the barrel. The stripper also was gone, for the first time since the beginning of the program: the XM70 was designed to fire flechettes mounted in the mentioned new Honeywell "compacted" sabots, which were aerodynamically stripped. The point-fire portion of the 42"-long XM70 weighed 7.5 lbs empty, and 8.6 lbs with a loaded 50-round magazine. As part of the contract, AAI made up several interesting single-shot grenade launcher designs, to fire the latest 30mm reduced-diameter grenades as developed by Picatinny Arsenal.

AAI submitted its *Final Report — Design and Develop a Simplified Serial Flechette Rifle* (AAI Report No. ER-7896) in May of 1974, which further described the XM70:

> *The configuration of the [XM70] trigger group assembly. . possessed a number of . . XM19 counterpart[s]. Aside from relocating the sear to accommodate open bolt operation and utilizing a pulling type motion for the [burst] counting sequence in lieu of the original pusher system, no other significant design modifications were adopted. Since the automatic mode of fire was deleted, the mechanism could be simplified and a significant reduction in weight achieved . . . At the conclusion of the test program a total of 5,845 rounds was fired . . . after 3,845 rounds, eight miscounts were encountered . . After replacing [an overstressed counter spring] with an improved design, an additional 1,000 rounds was expended and no malfunctions were experienced. This is equivalent to an overall malfunction rate of 1.4/M.*



122. The end of the line for the flechette-firing SPIW — the simplified open-bolt XM70, capable of semi-auto and three-round burst fire only. Shown here in point target configuration, caliber 5.6×57mm XM645. The XM70 featured a simplified one-piece barrel and no stripper, having been designed to fire flechettes encased in aerodynamically stripped Honeywell compacted sabots, and weighed 8.6 lbs with a loaded 50-round magazine. Note the optical collimator sight. Rifle shown in both views with safety ON. ABOVE: AAI Corporation. BELOW: US Army photo, dated May 2, 1975.



123. The encapsulated, plastic-bodied trigger group of the XM70, which utilized a number of the concepts already proven in the XM19. The sear was relocated to accommodate open-bolt-only operation, resulting in a measured trigger pull of 14 lbs. A "pulling" type motion was substituted in the burst-fire counter mechanism in place of the XM19's "pusher" type. With the requirement for full automatic fire deleted, the trigger mechanism was simplified and its weight significantly reduced. In the XM70 test program, this mechanism was responsible for an overall malfunction rate of only 1.4/M (1.4 malfunctions per 1,000 shots fired). *AAI Corporation.*

The . . muzzle attachment . . on the XM70 . . was essentially identical to . . the XM19 . . . Minor modifications were made . . to compensate for dimensional differences between the one-piece barrel and the previous barrel/barrel extension assembly.

Because the test weapon was used extensively for heat tests, the barrel bore was severely eroded and considerably oversize. Because this condition can produce "slips" — abnormally low muzzle velocities when launching the flechettes, accuracy tests were not conducted with the [Honeywell] aerodynamically stripped sabot cartridge.

One of the objectives of the program was to eliminate the radiator and redefine the requirements for the heat sink. Since the weapon operates from the open bolt position, the cook-off problems associated with the XM19 rifle were eliminated . . . To provide some safe operating margin, it is recommended that the firing schedule for the XM70 rifle be limited to 100 rounds per minute for a period of 3½ minutes. (350 rounds). Based on this, the temperature developed at the critical mid-barrel location should be approximately 915 degrees F. At this temperature, . . the corresponding [barrel] yield strength is approximately 90,000 psi.

One of the major design features of the XM70 rifle was the use of a reflex collimator sight in lieu of the conventional metal peep sight arrangement. The envelope of the sight was controlled by the optics supplied by Frankford Arsenal. The design provides for internal retical adjustment with a total movement in elevation and azimuth of 11 mils. A tridium [sic] light source is used for nighttime applications."

124. ABOVE: part and parcel of the XM70 development program was the continuation of the 30mm semi-auto grenade launcher concept. Here the XM70 is shown with its collimator sight removed and fitted with the multi-shot launcher which AAI developed. BELOW: the dismaying complexity of the 30mm multi-shot grenade launcher is graphically portrayed in this exploded view. Note that, other than the muzzle device and barrel cover, all the components shown here are from the launcher; *the point target portion of the rifle has not been stripped.* *US Army photos, dated November 12, 1975.*

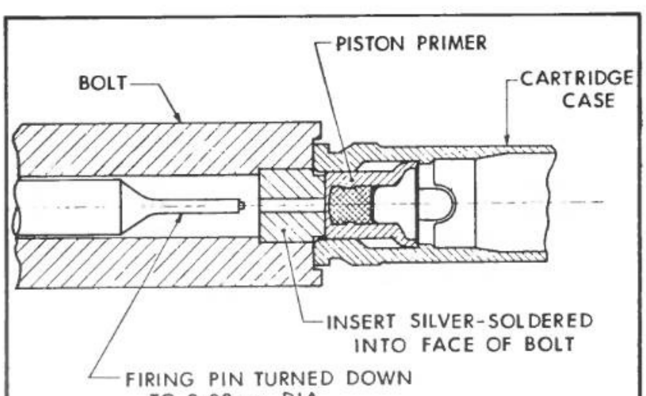
The Unkindest Cut of All

This valiant but exceedingly ill-timed attempt to pull the SPIW through yet another tight squeak was unsuccessful. The forces of fate had at last withdrawn their final vestiges of support, leaving the XM70 Simplified Serial Flechette Rifle to the mercies of its opponents.

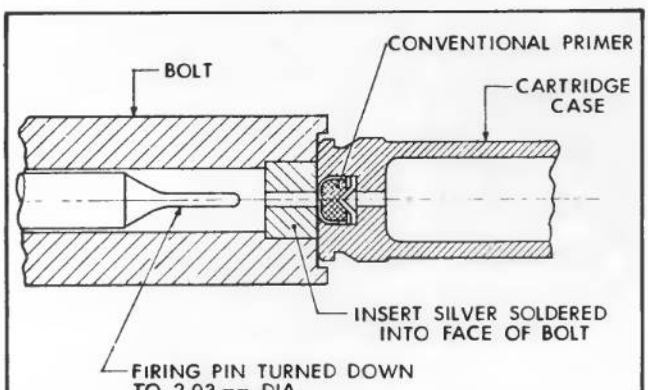
Even in defeat, however, with its fundamental concepts hacked off and dissected one by one, the serial flechette program refused to die. Such was its momentum, perhaps, or such the sheer magnitude of its potentiality, that some threatening shadow of its former power still remained. In any case it was felt that there was a need for a final refutation of the very heart of the AAI flechette weapon and ammunition system: the piston primer.

The final word was BRL's, in a report entitled *Computer Study and Experimental Verification of a Short Gas Tube and Floating Piston Gas System for the XM19 Rifle* (BRL No. 2600), published in March of 1976:

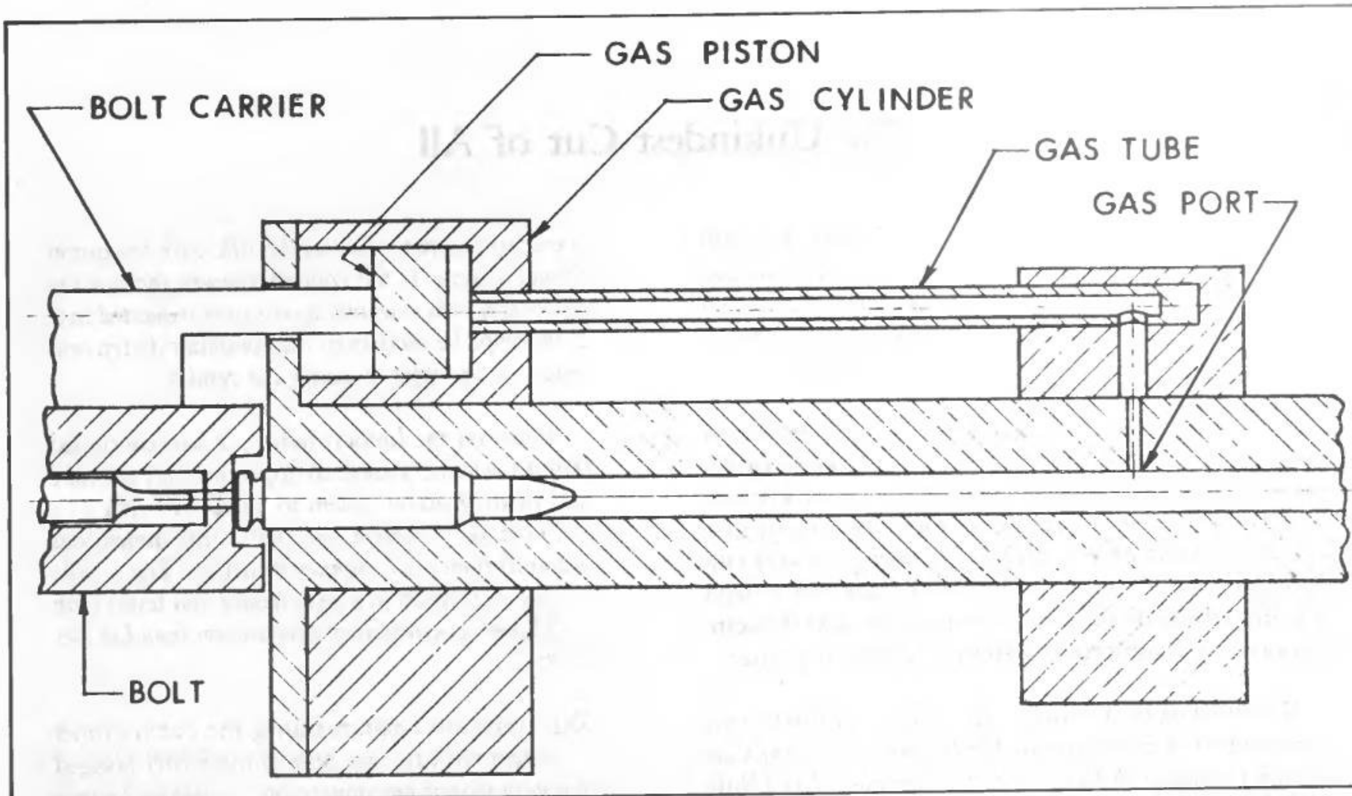
> *[USASASA] requested that the Interior Ballistics Laboratory perform a computer study to determine the feasibility of using a short gas tube and floating piston . . on the XM19 rifle instead of its piston primer. . . It was desired that the rifle with the . . gas tube and . . piston [would] have the same operating characteristics as the rifle with the piston primer system. If the computer study showed the gas system to be feasible, it was then requested that a prototype be built from the computer design and tested on the rifle to verify the results.*
>
> *. . Based on the [initial] results, it was concluded that it would be feasible to apply the short gas tube and floating piston system to an XM19 rifle . . . A prototype . . system was built using dimensions obtained from the computer model . . . The . . rifle . . was constrained in a rigid mount and tested with . . XM645 piston primer ammunition from Lot No. 3096-7.*
>
> *Tests were also conducted using the piston primer . . system with the gas port in the barrel plugged to obtain records for comparison . . . Before the tests were conducted with the . . gas system, the piston primer. . system . . was disabled by turning down the end of the firing pin to 2.03mm in diameter and silver-soldering an insert into the face of the bolt to fill the area behind the piston primer. This prevented the piston primer from pushing the recoiling parts rearward upon firing.*



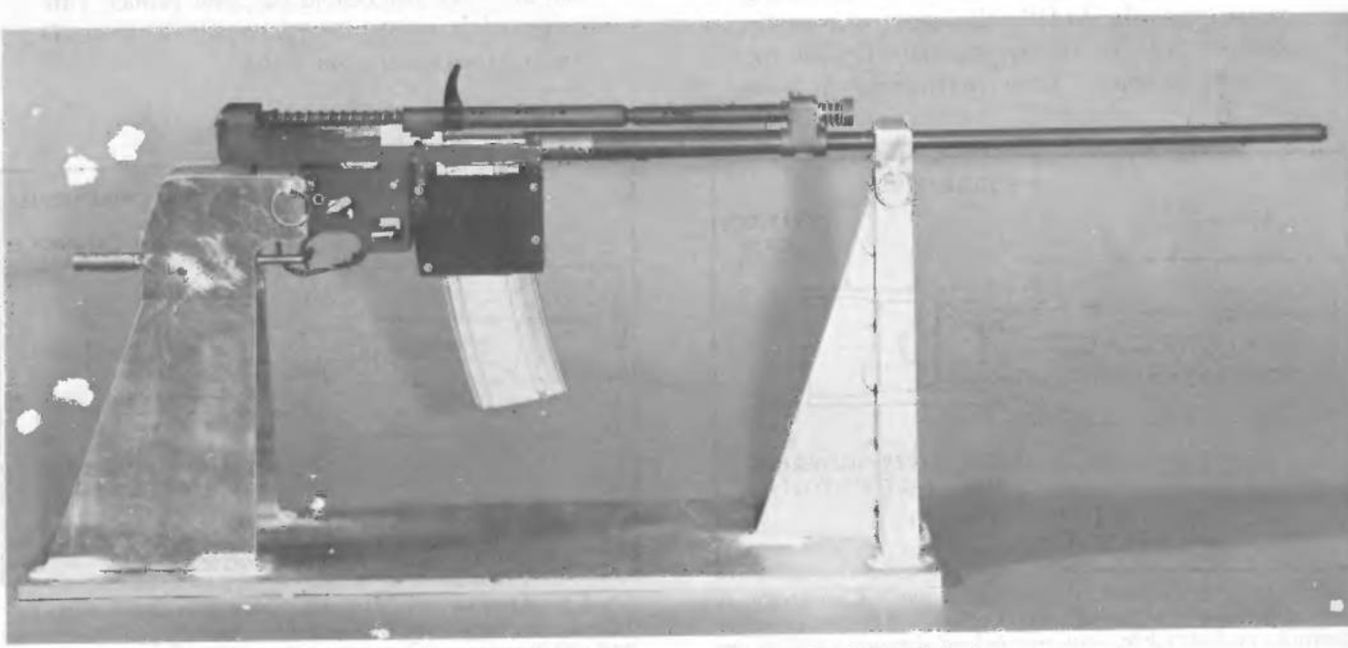
125. *Figure 5 from the March, 1976 BRL report entitled* Computer Study and Experimental Verification of a Short Gas Tube and Floating Piston Gas System for the XM19 Rifle, *which examined and ultimately refuted the very heart of AAI's XM645 flechette cartridge, the piston primer. Here are illustrated the modifications made to the bolt of the test fixture, in order to disable the piston primer of the XM645. These prevented the piston primer from pushing the recoiling parts rearward upon firing.*
BRL Report No. 2600, dated March, 1976.



126. *Figure 9 from the same BRL report, showing further modifications. Here the firing pin nose has been rounded and the chambered XM645 cartridge fitted with a conventional Boxer primer. Three different lots of such cartridges, utilizing special primers and (unheadstamped) cases made up under contract by Les Industries Val Cartier (IVI) of Quebec, Canada, were manufactured by Frankford Arsenal at the request of USASASA to support this BRL investigation.* *BRL Report No. 2600, dated March, 1976.*



127. A schematic of the short gas tube and floating piston gas system as used in the BRL attempt to refute the piston primer concept. It was concluded, both by computer study and subsequent firing tests with an actual working model, that an XM19 rifle with a short gas tube and floating piston had the same operating characteristics as an unmodified XM19 firing piston primed ammunition. However, the XM645 case design was found to be too weak when fitted with a conventional primer, as the case head was no longer supported by the steel piston primer. BRL Report No. 2600, dated March, 1976.



128. AAI's first firing test model of a serial bullet rifle, chambered for the conventionally-primed 4.32×45mm "micro-bulleted" cartridge, and featuring the short gas tube and floating piston gas system of operation as proven feasible in the BRL examination described above. AAI Corporation.

129. The wood-stocked prototype of the AAI 4.32×45mm serial bullet rifle (SBR), left side view, fitted with the optical collimator sight and a 30-round magazine. US Army photo, dated January 13, 1976.

Based on the data obtained with both systems firing XM645 piston primed ammunition, it was concluded that the XM19 rifle with the short gas tube and floating piston gas system had the same operating characteristics as the . . piston primer . . system. These results were predicted by the computer study.

[USASASA subsequently] requested Frankford Arsenal to manufacture a limited amount of ammunition with its piston primer replaced by a conventional primer. Three different lots . . [FAT-186E1(W2), X2374.13(sub 4), and FAT- 186E2(SR-1)] . . were delivered by Frankford Arsenal and limited tests were performed on each lot by the Interior Ballistics Laboratory to determine if the rifle with the . . gas system firing conventional primer ammunition had the same operating characteristics as the rifle with the . . piston primer. . system firing XM645 piston primer ammunition.

It was concluded that . . the . . operating characteristics . . [were the same]. However, in using lot no. FAT-186E1(W2) the fired primers on some rounds fell out of the primer pocket into the weapon mechanism upon extraction . . which caused malfunctions in the weapon . . . It was found that the primer wall thickness of lot no. FAT-186E1 (W2) was only 0.178mm while that of the other two was 0.279mm . . . The cases of the three lots . . had the same external dimensions.

* * *

130. Prototype AAI serial bullet rifle, field stripped, showing the gas piston and rotating bolt assembly. The method of breaking the weapon open for takedown appears much akin to that of the M16.
US Army photo, dated January 13, 1976.

In the midst of all these acrimonious thrusts and investigations, the 1973 end of the American military presence in Vietnam effectively "pulled the plug" on any urgent, large-scale development plan for a new US individual weapon. Small arms research, development and engineering (RD&E) money dried up abruptly with the end of US involvement in the war, adding an indisputable air of finality to the last SPIW developments.

Finally facing up to the disappointments and failures of the serial flechette program did not mean the end of the quest for improved performance, however. The Army continued its search for a super-lethal, controlled-burst, low-recoil weapon, substituting the 4.32mm micro-caliber bullet in a conventionally-primed case for the unpredictable XM645 flechette and expensive piston primer. (In the process they fell heir to a whole new set of problems, notably serious barrel erosion and the worrisome tendency of the tiny .17 caliber bullets to lose their "integrity", flying to pieces after exiting from the muzzle). Further development contracts were instituted at AAI, albeit on a more limited scale, wherein the flechette-firing XM70 was transmogrified into a 4.32mm serial bullet rifle (SBR). As stated in the *Research, Development and Engineering RD&E) Laboratory Posture Report* for fiscal 1974, prepared by Army Armament Command at Rock Island (No. RCS AMCDL-101):

In December 1973, the decision was made to remove flechette ammunition from immediate consideration within the FRS (Future Rifle Systems) Program because of technical problems which may not be correctable in the time frame of the future rifle. Follow-on activities were therefore initiated in [fiscal year] 1974 to address the application of the XM70 mechanism to a bulleted approach (4.32mm). Weapon developmental efforts on this bulleted XM70 version are addressing . . . barrel development and alternative weapon actuation systems . . . The feasibility of obtaining high cyclic rates with a modified gas system was demonstrated in 1974 . . . The follow-on effort will utilize these design parameters in the conversion of XM70 flechette firing hardware to gas operation firing the 4.32mm round of ammunition . . .

131. The AAI serial bullet rifle (SBR), fitted with optional iron sights. The AAI serial bullet rifle featured semi-auto and controlled, three-round burst fire, and an impingement-type gas system. The firing system is interesting in that semi-auto shots and the first round of a three-round burst were hammer-fired from a closed bolt, while for the second and third rounds of a burst the hammer was temporarily "fixed" in the forward position, and the weapon fired from an open bolt, stripping the cartridges off the feed lips and firing directly upon chambering and locking.

Significantly, while the 28-grain micro-bullet SBR did away with a number of the problems and expenses inherent with the flechette, it could never match the ultra-tight mean burst spread of the 10-grain serial flechette as fired in the SPIW.

The AAI SBR had a higher cyclic rate and produced more flash than the M16. Its physical characteristics were as follows:

length: 34.5 inches (876mm)
weight, w/empty magazine: 10 lbs (4.58 kg)
caliber: 4.32×45mm
recoil impulse: .63 lb/sec.
noise level: 156dB

Epilogue

It seems that whatever blame there is to be placed for the failure of the SPIW should be laid chiefly at the feet of the program's managers, whose gigantic case of overweening optimism created an impossible series of interdependent stumbling blocks.

The first and most fundamental of these, as we have seen, was the setting of, and stubborn insistence on, mutually exclusive requirements. To sum up just a few of the basic specifics, the point target portion of the SPIW was to fire controlled bursts of 10-grain projectiles at *2,400 rpm*, thus taking advantage of the flechette's minimal recoil to achieve a deadly, ultra-tight *mean burst spread*. (As regards this crucial characteristic, the SPIW still reigns supreme, far superior to the M16 on full-automatic fire; even the 4.32mm micro-bullet SBR is no match). For such a light projectile to be lethal, however, a muzzle velocity in the order of *4,800 fps* was required. This in turn necessitated a chamber pressure approaching *70,000 psi.*

Management then set a series of highly unrealistic deadlines for the fulfilment of these specifications, which forced the harried designers into an atmosphere of pressure and strain. In the frantic attempt to perfect weapons capable of attaining these pressures and velocities (to say nothing of bayonets, area-fire capability or the stringent weight and size restrictions), many frontiers of knowledge had to be pushed back, all at the same time.

This in turn uncovered a veritable host of new technological problems which could not possibly have been foreseen, and which, ironically, were largely misconstrued as poor engineering. It was the previously unheard-of *magnitude* of these new problems — heat; erosion; muzzle blast; component overstressing and flechette cartridge complexity — which ultimately proved insurmountable within the overall timing and funding constraints set for the program.

The Comptroller General's report on the SPIW Program, released on May 7, 1970 in response to Congressman Ottinger's July 1969 letter of inquiry, had gently taken the Army to task for being "overoptimistic" in its SPIW forecasting. On a slightly sharper note, however, the report suggested that the "unanticipated technical difficulties" encountered with the SPIW might have led to less program cost overruns if an "orderly development process" had been resorted to. The 32-page report concluded:

> *It is our opinion that, because of the large quantities of ammunition used in combat by a small arms system, the per unit cost of the ammunition is critical in determining the cost effectiveness of the overall . . system. The Army does not intend to procure more flechette-firing SPIWs than are necessary for testing until such time as it is demonstrated that the production costs of the rounds can be reduced to the point that the overall . . system is cost effective . . .*
>
> *We believe that this is a prudent and logical course of action.*

* * *

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