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GB WARHEADS FOR ARMY BALLISTIC MISSILES 1950-1966 (U)

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CONTENTS

CHAPTER 1

(C) EARLY PROJECTS

(U) When toxic agents were first used in modern warfare, in the spring of 1915, the delivery system was extremely simple: the cylinders of compressed gas were pointed at the enemy lines and opened at a time when the wind would carry the resulting gas cloud in the right direction. It was not long before artillery and mortar shells were found to be more consistent and usually more effective means of getting toxics to the target, especially when the target was not immediately opposite the attacker. Although aerial dissemination by spray or bomb was also developed, tube-fired shells remained the principal vehicle for tactical use of toxic agents through World War 2. Before the end of that conflict, the appearance in warfare of rocket-propelled ballistic missiles indicated to the chemical warfare tactician, as well as to the artilleryman, the prospect of a new means of hitting a target, and a corresponding need for new technical development.

(U) Almost simultaneously with the revelation of German missiles near the end of World War 2 came the unveiling of German development of organophosphorus toxic agents – the nerve gases. These materials significantly upgraded the effectiveness of chemical warfare, particularly in the field of lethal non-persistent agents. They offered the prospect of putting a much more concentrated and quick-acting lethal chemical on a target than was ever practical before, without long-term contamination of the terrain. GB, as the Army called the German Sarin, was selected as the nerve agent of choice by the Chemical Corps shortly after World War 2, and was standardized in 1951. GB is a colorless, odorless liquid at ordinary temperatures, with an appearance and a volatility comparable to water. Its effectiveness on targets is relatively brief, extending up to several hours in cases of heavy contamination and favorable meteorological conditions. Like other organophosphorus toxic agents, it acts by interfering with the enzyme systems that promote the passage of nerve impulses. In so doing, it disrupts muscle action, and this disruption, especially in the respiratory and circulatory systems, can be of lethal extent after very small dosages of agent, smaller by several orders of magnitude than dosage requirements of World War 2 agents. GB's toxic effects are most apparent when the agent is inhaled as vapor. Incapacitation resulting from visual symptoms, tightness in the chest, headache, nausea, and convulsions, may occur within five minutes after exposure; death may supervene within the hour. Casualties incapacitated by sublethal dosages of agent are out of action for one to three weeks at least, and convalescent for some time longer, but suffer no lasting injury.

(C) Following the standardization of GB, the Chemical Corps began a crash program to provide the Army with a stockpile of the new agent. Two production facilities, one for a chemical intermediate, the second for final agent production, were designed and built, in accordance with the production method deemed most ready for rapid exploitation. By the mid-1950's a stockpile of GB was in existence. It was first-production grade material, of uncertain storage stability, but it provided the Army with a new and enhanced capability in chemical warfare – that is, to the extent that munition systems could be developed to employ it effectively.

(U) It was natural, therefore, that the Chemical Corps, in seeking to keep pace with advances in weaponry, while at the same time anxious to exploit the extraordinary capabilitites of its new agent, should turn to the development of GB missile warheads, along with other means of dissemination. Indeed, the first American investigations of the problem of delivering agents by missile went back to 1944, before the acquisition of nerve agents by Germany's enemies. In September 1943 glide bombs and remotely-controlled planes were demonstrated at Muroc Army Air Base in California. Among the onlookers were representatives of the Chemical Warfare Service, who reported that these guided missiles could be used as carriers for massive chemical munitions. By the beginning of 1944 a CWS research project in this area had been formally established.[1]

(U) In the years immediately following the end of World War 2 the study of the basic principles of agent dispersal by missile warhead continued. The first user to express interest was the Air Force. By the spring of 1948 requirements for Chemical Corps warheads, including warheads using toxic agents, had been expressed for several of the jet-propelled guided missiles then under Air Force development. These weapons, mostly of subsonic speed, and pursuing a level flight to the target area, were designed to carry payloads in the 3000-5000 pound range, the minimum needed for area contamination with the high-dosage toxic agents produced by the CWS in World War 2. The basic design of all chemical warheads then under study was a cluster of cylindrical bomblets contained in a cluster adapter resembling a massive bomb. Such a concept was intended to produce a

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[1] Chemical Warfare Technical Committee (CWTC) Item 931, 16 Jan 44

more efficient distribution of agent over an area target, but this depended on effective dispersal of the bomblets from the cluster adapter after release, a goal which was found to be elusive in practice.[2]

(U) By mid-1950, after the outbreak of the Korean War, the Air Force terminated its programs for specific chemical warheads, substituting a research requirement for such weapons which could be used on vehicles interchangeably with other warheads.[3] But the Army, which had begun to develop rocket-propelled ballistic missiles of the V-2 variety for tactical use, was now beginning to express an interest of its own in chemical warheads. The approaching standardization of GB offered the prospect of a significant upgrading in chemical warhead effectiveness against troops, despite the limited weights that ballistic missiles could carry. A study on GB warheads for the Hermes family of missiles then under development by the Army Ordnance Corps was produced in 1950 to provide specific estimates of the weaponry needed to neutralize a target in 30 seconds. Before the end of September 1950, the Chemical Corps had been informed of Army requirements for 1500 pound GB warheads for two of the Hermes missiles, and a development project was initiated.[4]

(U) The general military purpose of a GB missile warhead, as of other non-persistent lethal chemical munitions, was to kill, or at least incapacitate, enemy personnel. A large-capacity warhead, carried by a missile capable of penetrating behind the forward battle area, could reach area hard targets, including those within troop assembly areas, which might be protected against conventional high explosives, since the agent could enter any structure not provided with air-tight protective filter systems, however well protected against fragmentation or blast. In effective concentrations, it would put out of action all personnel not already masked or capable of donning a mask within a few seconds. Furthermore, the antipersonnel effects of the weapon would be exercised with a minimum of damage to facilities and materiel, should that be desirable,in contrast to both high explosive and atomic weapons. On the other hand, specific surprise antipersonnel effects would have maximum effect in disrupting execution of enemy operations in troop assembly areas. Where the target area was

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[2] Semi-Annual Progress Rept on Guided Missiles, Technical Command, Army Cml Center, 1 Jan 50

[3] MIPR 51-521-AMCE-CC, 13 Jul 50, cited in Semi-Annual Progress Rept on Guided Missiles, Technical Command, Army Cml Center, 1 Jan 51

[4] Chemical Corps Technical Committee (CCTC) Item 2167, 28 Sep 50

wooded, use of GB in preference to nuclear weapons would achieve effective antipersonnel results without leaving behind the kind of forest wreckage which would interfere with subsequent maneuvers by attacking friendly forces. The missile as a delivery system would make it possible to achieve the effects sought under conditions not favorable for the employment of tactical aircraft. The concept of an area target involved a stretch of terrain of an order of magnitude comparable to a square kilometer or more – roughly 100,000 square yards, or a circular tract with a diameter of 1000 feet. One or another of these approximately equivalent expressions usually turned up in the formulation of specific minimum requirements for chemical warheads.[5]

(C) The Hermes project immediately faced technical problems beyond those experienced in earlier investigations. The new warheads were to be employed at supersonic speeds, carried on ballistic trajectories that differed radically from the level flight of jet-powered drones, and utilized for Army tactical missions, rather than strategic combing. The smaller payload made effective dispersion of the agent more necessary than ever, yet funding limitations prevented the development of wholly new submunitions. Instead, the cylindrical bomblet (designated E54) used in the massive Air Force warhead projects was to remain the basic munition. This ten-pound cylinder, with a parachute in its base to control its fall, required a cluster adapter for clustering even if contained in a rocket warhead skin. It was estimated that if such a cluster of E54 bomblets functioned in an optimum manner, a 1500 pound warhead could produce an effective surprise gas attack over an area with a diameter of 870 feet in 30 seconds.[6]

(U) The concept of a 1500 pound tactical GB warhead for mass antipersonnel effects in the enemy's reserve assembly area was transferred to the Corporal missile project in 1951, to match the Ordnance missile development program, in which the earlier Hermes missiles were being phased out. Corporal was a liquid-fuel rocket-propelled ballistic missile weighing something over five tons when ready for firing; about 1500 pounds of this was available for warhead and payload. Its effective range was about 75 miles. It was designed for use by corps artillery, emplaced some miles behind the main line of resistance. Although some years of research on rocketry lay

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[5] (1) Draft, Product Master Plan, USAMUCOM, for E19R2 Warhead Section (XM50 Honest John), 2 Jan 63 (2) Draft rept, "Guided and Remotely Controlled Conveyances and Large Rockets in CBR Operations," CmlC Board Combat Development Project Rept CMLCD 58-5, Mar 62

[6] Semi-Annual Progress Rept on Guided Missiles, Technical Command, Army Cml Center, 1 Jan 51

behind it, the Corporal project was still in many ways a pioneering effort – it was destined to provide the first offensive guided missile system to be actually deployed by the Army – and suffered from the complexity and doubtful reliability characteristic of first-generation systems. Its complexity limited the rate of fire of the missile unit, a fact which suggested to an Army Field Forces Board the possibility that an effective GB concentration could not be built up in the target area, considering the non-persistent character of the agent. The board study proposed the short-term development of a mustard gas (HD) warhead for Corporal, without bomblets, in the hope that this would give the missile system an area denial capability while an optimum GB dispersal system was being developed. It was thus considered probable, even at the outset of the GB warhead program, that current development plans might not be immediately successful.[7]

(C) The formulated Army requirement for the Corporal GB warhead, as ultimately established, called for a munition capable of producing a lethal concentration of agent (LCt_{50}, a concentration sufficient to produce lethalities in half the troops exposed) over a minimum target area of 100,000 square yards in 30 seconds. This was about one-quarter more than the target diameter (870 feet) considered attainable with a 1500 pound GB warhead in 1950.[8] Tests of the dispersal patterns of the E54 bomblet in its cluster adapter were undertaken, using both older Air Force guided vehicles and the few Corporal missiles available for Chemical Corps tests. The results were not encouraging, and more attention began to be paid to alternate concepts. Triconic (vase-shaped) bomblets were tested in a Navy wind tunnel and found to be unstable at supersonic speeds. Spherical bomblet shapes were also brought under consideration.[9]

(U) At this stage, in 1952, a requirement was also stated by United States Continental Army Command (USCONARC) for a 1500 pound warhead for the Honest John rocket. Unlike the Corporal, which was a corps artillery surface-to-surface guided missile meant for distant strong points and troop concentrations up to 75 miles away from the rear-area launch point, the Honest John was a free rocket designed for use by divisional artillery for conventional or extended artillery ranges. It utilized a highly mobile self-propelled launcher. Its planned deployment was scheduled for

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[7] Ibid, 1 Jul 51

[8] CCTC Item 3016, 30 Mar 55

[9] Semi-Annual Progress Rept on Guided Missiles, Chemical and Radiological Labs, Army Cml Center, 1 Jan 52

the late 1950's, somewhat later than that planned for the Corporal. The corresponding GB warhead project was established in September 1952, and at first closely resembled the Corporal project; in fact, interchangeability of the two items was listed as a desirable characteristic.[10] The first warhead designs, the E9, called for utilization of the familiar 10 pound E54 bomblet, the E56 cluster adapter, containing 140 bomblets, and two parallel fuzing circuits using modified M152 E3 bomb tail fuzes, all contained in a contractor-supplied rocket nose casing. This was essentially the same payload already being developed for Corporal.

(C) Corporal test results with the E54 bomblet and its associated systems gave little promise of success with devices originally designed with World War 2 aircraft in mind. Malfunction of the bomblets in consequence of the heavy strains of rocket acceleration and release from a near-vertical trajectory was to be expected; bomblet damage after release by collision with the missile also proved to be a problem. The impact pattern of the bomblets showed clearly, moreover, that even with improved functioning an effective target area of more than 900 feet in diameter was unlikely to be achieved without some method of forcing the submunitions to fly outward during descent – that is, without using a new shape with different aerodynamic characteristics. An analytical study made for the Army in 1955 declared that without at least a 100% increase in the radius of the impact pattern, the mission of the Corporal GB warhead could be more effectively and economically carried out by manned bombers. It recommended that the existing development model GB warhead be dropped from the Corporal program, so that effort could be concentrated on new concepts.[11] Thus the hope of achieving a quick and inexpensive warhead development finally had to be abandoned.

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[10] CCTC Item 2532, 9 Sep 52

[11] C. R. Clark and J. T. McIntyre, **Operational Effectiveness of the CORPORAL Guided Missile with Clustered GB Warhead** (ORO-T-317), Operations Research Office, Johns Hopkins University, Nov 55

CHAPTER 2

(C) THE FIRST STANDARD WARHEAD

(C) The Chemical Corps had been concerned since 1953 over the less than optimum performance of its warhead components. In the latter part of that year the discrepancy between the theoretical capabilities of GB when properly distributed and the actual contamination which the prototype Corporal warheads seemed likely to produce led to the institution of a development plan for self-dispersing bomblets and effective measures of bomblet release from a supersonic warhead. Thereby, the short-term economical approach of using readily available components for the Corporal warhead, previously required of the developers, was in effect abandoned for a more fundamental development program. In mid-1954 a research and development contract was concluded with Cook Research Laboratories of Skokie, Illinois, a subsidiary of the Cook Electric Company, calling for two major tasks to be accomplished:

1. Investigation of the concepts of disseminating chemical agents uniformly over large area targets by means of self-dispersing bomblets released at high altitudes from high-speed guided missiles.
2. Development and evaluation of guided missile warhead designs capable of disseminating agents uniformly over various-sized targets and from various types of missiles.[1]

(C) Initial work under this contract included instrumentation and test procedure development, investigation of candidate bomblet shapes, and warhead studies, including tests with one of the proposed new sub-munitions. Instrumentation techniques undertaken included methods for determining the path of experimental bomblets in flight, such as solar-aspect telemetry (broadcast by a device within the bomblet of signals varying in accordance with the transmitter's position in relation to the sun) and radio tracking.[2]

(C) A number of possible bomblet configurations were tested in the course of the study. Glide bomblets shaped like conventional aircraft, or designed with a delta-wing structure, had high potential dispersion characteristics; so did the Flettner rotor, an H-shaped configuration. The fourth type considered was a fluted sphere, a type on which a fair amount

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[1] CmlC Annual R&D Rept, Project 4-16-16-020, 31 Dec 55
[2] Ibid

of data was already available. Chemical Corps munitions experiments in other fields had indicated the utility of small spheres as self-dispersing aerial submunitions as early as 1952, when developers found that adding an aerodynamic fluting pattern to the surface of a small sphere gave it enough spin during its fall to impel it outward as well as downward.[3] Though the glide shapes had the greatest theoretical dispersion capability, their capacity for stabilized flight seemed doubtful. A Flettner-type bomblet, designated as E112 and a 5 1/4-inch fluted sphere of plastic-jacketed steel, numbered E118 drew more serious attention.[4]

(C) The E112 and E118 bomblets both achieved self-dispersing characteristics through rotation in flight. The E112 was capable of a greater angular departure from vertical fall than the E118, but the latter could carry a greater percentage of agent payload in relation to total weight, while its self-dispersal characteristics were sufficient to achieve optimum target effects with GB, or other agents of the same order of toxicity. The E118 had been designed for use in a cluster adapter, as had been the case with the E54 canister bomblet, but warhead studies led to the conclusion that a quadrant pattern, in which the bomblets were stacked on a cruciform framework dividing the interior of the warhead horizontally and vertically, could produce release patterns that would make the cluster adapter unnecessary. The spherical bomblet was then redesigned with this use in view, producing a 4 1/2-inch ribbed steel sphere, the E130. This munition, weighing about 3.6 pounds and carrying about 1.1 pounds of agent, along with an explosive burster, was considered by 1956 as the bomblet of choice for existing warhead projects.[5]

(C) A contract was awarded to Aircraft Armaments, Inc., of Cockeysville, Maryland, to design and build quadrant-type warheads for the Corporal missile. In the course of 1957 two successful flight tests of this E18 warhead were conducted at White Sands Proving Ground in New Mexico. The E18, conforming in its exterior plan to the general Corporal design, could contain about 340 E130 bomblets (equivalent to about 375 pounds of GB) in a quadrant interior. On functioning, the warhead skin was cut longitudinally into four sections by primacord explosion, liberating the

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[3] CmlC Advisory Council, Dissemination Subcommittee Minutes, 23–24 Oct 52

[4] CmlC Annual R&D Rept, Project 4-16-16-020, 31 Dec 55

[5] (1) Ibid (2) CmlC R&D Command staff study: "Historical Summary of the CmlC Research and Development Program," Mar 58

bomblets, which produced an impact pattern approximating one square mile in extent – roughly fifteen times as great as the area covered in tests with advanced canister-type bomblets.[6]

(C) This was good news for the bomblet developers; they had in the E130 a submunition that was mechanically compatible with the stresses of supersonic delivery along a ballistic trajectory while at the same time capable of adequate exploitation of the target potentialities of its payload. But it was already too late to help the Corporal warhead program. By 1957 the Army had decided that Corporal was too complex and unreliable to be used as more than an interim weapon until the next generation missile was ready, and secondary warhead development was ordered terminated. The Chemical Corps was able to salvage about half of its FY 1958 funds for the project – $435,000 out of an original request for $800,000 – to carry out the tests described above, on the plea that the work constituted research for future warheads of similar type. But as of the end of 1957 the project for a GB warhead for the Corporal missile system was formally terminated.[7] Despite this negative result, the Chemical Corps had produced, in the E18, the prototype of future GB missile warheads.

(C) Of the many potential GB warhead projects of the early 1950's, only one, that for the Honest John rocket, was still in being. To this was now added an additional program, a GB warhead for the companion Little John rocket, a smaller, 318mm version of the big divisional weapon, meant for medium-range artillery utilization. A requirement for this project had been expressed by USCONARC in December 1955, and preliminary feasibility studies preceded formal establishment of the project late in 1957. The plan was to utilize essentially the same submunition system under development for Corporal and Honest John, as opposed to a single-unit massive load of agent. Still in the future was official establishment of a project for a GB warhead for Corporal's destined successor, the solid-fuel Sergeant guided ballistic missile, but preliminary work toward this end, including, of course, application of the principles of the E18 warhead, was under way.[8]

(C) Honest John, with a warhead very similar in size and capacity to those designed for the Corporal system, had been under formal

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[6] CmlC Annual R&D Project Rept, Project 4-16-16-020, 31 Dec 57

[7] (1) CmlC Advisory Council, Dissemination and Field Testing Committee Minutes, 6–8 Nov 57 (2) CmlC Annual R&D Project Rept, Project 4-16-16-020, 31 Dec 57

[8] CmlC Annual R&D Project Rept, Project 4-16-16-020, 31 Dec 57

development since 1952. The big rocket's relative simplicity and reliability had permitted more successful test flights with experimental warheads than had ever been completed with Corporal. These tests had routinely confirmed through 1953 and 1954 the limited area coverage and mechanical vulnerability of the E54 canister, contained in an E9 warhead, when mated with such a vehicle. The transfer of interest to the E130 bomblet and the quadrant-structured warhead in 1955 resulted, as in the Corporal, in a more successful approach. The equivalent of the E18 Corporal warhead in the Honest John system was designated the E19, first tested late in 1956. This 1500 pound warhead was designed for a load of 356 E130 bomblets. By the end of 1957 the design of the E19 warhead was considered proved by tests to be final in all essential characteristics. As in the E18 warhead, the bomblets were stacked in a quadrant-divided warhead casing, whose skin was severed by primacord upon activation over the target area. Impact patterns approximated one square mile.[9]

(C) The remaining test program for the Honest John warhead, whose finalized design was designated as E19R1 after some structural modifications to increase resistance to acceleration and aerodynamic stresses, called for flights with actual GB fill to check on effective agent dispersal. This was accomplished in the course of 1959 at Dugway Proving Ground (DPG). Three E19R1 warheads each produced bomblet impact patterns of 3500-foot diameter when warhead functioning was initiated at 5000 feet above the terrain surface. The estimated available dosage of GB was 100 mg a minute per cubic meter of air over an area of 1,100,000 square meters – somewhat less than half a square mile. Dosages lowering to one-tenth this level would have been experienced over an additional 600,000 square meters.[10] Other tests demonstrated the predicted increase in impact pattern diameter as the release altitude of the bomblets increased, the ratio of increase in ground diameter being roughly proportional to the ratio of increase in warhead functioning altitude. Thus, a test with warhead functioning set for 11,500 feet produced an impact pattern with a diameter of 6500 feet.[11]

(C) With the completion of these and the customary additional tests – transportability, rough handling, environmental, and the like – the Honest

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[9] Ibid

[10] CmlC Annual R&D Project Rept, Project 4C16-16-020, 31 Dec 59 The estimated median incapacitating dose for GB was 35 mg min/m^3.

[11] John L. Kratzer, "Delivery of Chemical Agents by Missile Systems," Edgewood Arsenal (EA) Technical Library (CRDL 285-344), p. 19

John E19R1 warhead was ready for submission to the type classification process, the formal termination of successful development by the acceptance of the item as standard. It was the first chemical ballistic missile warhead since the beginning of work in the field to proceed so far. The recommendation for type classification was duly made in February 1960, and approved by the Army on 14 April 1960. But the achievement was not complete, for technical progress in the missile field had overtaken the E19R1. The original Honest John rocket system, the M31 series of Ordnance rockets, was in the process of replacement by an improved version, the XM50 Honest John, a more powerful rocket than its predecessor. The E19R1, though technically compatible with the XM50 system, since its improved stress resistance was sufficient to meet the challenges posed by the higher acceleration rate of the newer rocket, was heavier by about a fifth than an XM50 system warhead was supposed to be for maximum range, though equivalent to other "heavy" warheads in the system. Its type classification, therefore, was Standard-B, marking it as a substitute item for use if necessary, until a better version could be made ready. For the time being, there would be no procurement of the E19R1, though it would bear henceforth the impressive designation of Warhead, 762mm Rocket, Gas, Non-Persistent GB, M79.[12]

(C) As finally type classified as an interim standard weapon, the M79 GB warhead was a 115-inch ogival-shaped aluminum alloy projectile with a maximum diameter of 30 inches. Its weight when loaded approximated 1625 pounds. The outer assembly, or casing, consisted of a 315 pound aluminum shell, constructed in three sections to facilitate loading and fuzing. The sections were subdivided into four by interior longitudinal panels, producing the quadrant structure characteristic of chemical warhead design after 1955. Four strands of 50-grain plastic-coated detonating cord were threaded through grooves in the structural members of the sections to force the casing open at the time of functioning. The casing was painted gray, with a single green band to indicate the nature of its load.

(C) The load consisted of 356 E130R1 4.5-inch spherical bomblets, redesignated as M134 after standardization. The M134 was a smooth steel sphere covered with a plastic outer shell fabricated with a fluted surface of nine circumferential ribs, giving it a spin in flight which served both to give a horizontal moment to its fall, for dispersal purposes, and to arm its fuzes.

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[12] CCTC Item 3694, 14 Apr 60

The XM911 bomblet fuzes were two in number, one at each end of the spin axis, and served to actuate a burster charge placed in a plastic cylinder between them. The rest of the bomblet, allowing for a small void, was filled with about 1.1 pounds of liquid GB. Its total weight when loaded was 3.3 pounds. Thus a fully-loaded warhead contained about 390 pounds of agent, just under a quarter of its total weight.[13]

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[13] Ibid

CHAPTER 3

(C) COMPLETING THE DEVELOPMENT PROGRAM

(C) The completion of the development program for the M79 Honest John warhead left the Chemical Corps with two closely related programs for GB rocket warheads still in progress – Little John, and a modified M79 for use with the XM50, the Improved Honest John. The latter warhead, the E19R2, was, as its symbol indicated, much like its standardized predecessor, the principal difference being in the submunition. The casing for the E19R2 was a somewhat stronger and lighter version of the outer assembly of the M79. The bomblets it was to contain, however, were 350 of the E130R2 model, a completely new spherical munition, which the Little John warhead, designated E20, was also to use. The new bomblet traced its development back to 1957, when experimental fabrication of an aluminum sphere was begun. The concept was to produce another 9-ribbed bomblet like the plastic-jacketed steel E130R1, but with the external fluting worked directly into the aluminum body, eliminating the jacket. A 4 1/2-inch sphere of this type weighed only 2.4 pounds, of which 1.3 pounds represented agent payload, as compared to the 3.3 pounds of the E130R1, with its 1.1 pound payload. This meant a 25% reduction in overall weight, coupled with a simultaneous 18% increase in payload – an attractive increase in efficiency.[1]

(C) Unfortunately, the 9-ribbed aluminum bomblet body turned out to be easier to design than to build. The original rib configurations were stamped out readily enough, but test flights showed up some aerodynamic instability. The rib design was then altered, but forming methods for producing aluminum hemispheres in quantity proved unequal to the task of reproducing the altered design. Accordingly, a second redesign was initiated, and a 6-rib aluminum bomblet – still bearing the symbol E130R2 – was created and found to be workable as a production item. The ribs were separately punched, and spot-welded into place, in a chevron pattern. Bomblet weight and dimensions remained unchanged. The first test models of the 6-rib E130R2 bomblet were found to be successful in terms of aerodynamic characteristics; when released from warheads in flight they sailed outward at an angle of over 22° from the vertical during

[1] CmlC Annual R&D Project Rept, Project 4-16-16-020, 31 Dec 57

their fall, an angle more than 4° greater than the best performance of the E130R1. The spin imparted by the 6-rib chevron, angled back 12°, was sufficient to guarantee arming the bomblet fuzes, a function which had sometimes failed to occur in the older designs. The E130R2 became, therefore, the basic submunition for GB warheads under development in 1960. By the beginning of 1961 its engineering development was regarded as virtually complete.[2]

(C) The existence of an appropriate submunition in an advanced state of development appeared to promise rapid completion of the Improved Honest John and Little John warhead programs. The former involved a weapon which, aside from its E130R2 bomblets was virtually identical with the already standardized M79. The problems of developing and demonstrating casing structure, compatibility with the basic rocket system, warhead functioning, and the like had been solved during the original Honest John warhead program and required little further attention. The Little John warhead, on the other hand, was a separate development project, but one which had not hitherto been troubled with unexpected difficulties. It had been formally added to the Chemical Corps program at the end of 1957, following establishment of Army requirements and completion of a feasibility study.[3]

(C) The Little John rocket system (XM51) was a miniature of the Honest John – a free surface-to-surface ballistic rocket 12 1/2 inches across (318mm) and about 12 feet long. Its motor utilized a solid propellant. Relatively lightweight, both as regards the rocket itself and the associated rocket launch rails and equipment, it was considered particularly suitable as a divisional artillery weapon for airborne units. Its range and payload were, of course, an order of magnitude below the Honest John system capabilities. The Little John rocket system called for a warhead in the 250 pound range, as opposed to the 1500 pound payload of Honest John. In terms of GB effectiveness this relatively small size made for sharply limited target areas. The feasibility study conducted in 1957 prior to inauguration of the development project had recommended that the Little John warhead, like the other chemical warheads then under development,

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[2](1) CmlC Annual R&D Project Rept, Project 4C16-16-020, 31 Dec 59 (2) United States Army Munitions Command (USAMUCOM), Product Master Plan (Draft), Warhead Section, Non-Persistent Gas, 1238 Pound E19R2, 2 Jan 63

[3]After 1955 Army requirements were expressed in successive editions of the Combat Developments Objectives Guide (CDOG), in which requirements for GB warheads for Honest John, Little John, and Sergeant appeared in par 438j.

carry and release its agent payload in submunitions, rather than attempt efficient agent dispersal from a single massive-load unit.[4] Given the limited size of the proposed warhead, this meant a GB payload roughly one-seventh that of the Honest John. The limited target effectiveness of a weapon so much smaller than other missile-borne chemical warheads was offset by its capacity for use by airborne troops and an expected utilization of several rockets in rapid sequence. A warhead design, denominated E20, was prepared, following the general pattern of the E19 warheads, except for size. The slim casing, matching the configuration of other Little John warheads, held 52 E130R2 spherical aluminum bomblets and weighed about 262 pounds. Successful flight tests of the Little John E20 warhead by 1960 confirmed its ability to function in the same manner as the M79 Honest John warhead, and to produce the expected impact pattern of bomblets, varying in size in proportion to the altitude of the warhead at the time of functioning. A salvo of four Little John rockets produced an impact pattern which was estimated to be capable of achieving GB casualties over about 60% of the area over which an M79 warhead would be effective.[5]

(C) It was at this point, with development of both the E19R2 and E20 GB warheads well along toward completion, that signs of trouble began to appear. The new E130R2 aluminum bomblet, common to both weapons, though produceable, weldable, aerodynamically stable and effectively self-dispersing, developed unexpected shortcomings. When filled, it tended in some cases to bulge, threatening both its seal and its configuration. Although this unpleasant phenomenon was noted on occasion even with simulant fill, it was blamed primarily on a gas-evolving reaction of the GB itself with the bomblet's aluminum alloy. The GB used for filling was a Chemical Corps arsenal product, produced as rapidly as possible after the standardization of the agent in 1951 in order to provide the Armed Forces with a usable stockpile. It tended to include some impurities; it had been stabilized by addition of tributylamine, but this in turn appeared to be facilitating the unexpected chemical reaction with the aluminum munition. Such a reaction, which had not occurred when high-purity GB was tested with aluminum, was intolerable, since it not only

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[4] John L. Kratzer, "Preliminary Chemical Warhead Study for the Little John Rocket," CWL Tech Memo 30–32, Oct 57

[5] Kratzer, "Delivery of Chemical Agents by Missile Systems," pp. 22, 30–31

promoted pressure-induced leakage of agent but also made extended storage of warheads impractical, whereas the military characteristics guiding the developers called for safe, leakproof storage for up to five years.[6]

(C) Two remedial methods were tried to correct this dismaying shortcoming. One involved treating the internal surfaces of the aluminum hemispheres of which the bomblet was composed in the hope of making it non-reactive. No satisfactory results were obtained in attempts to carry out this approach. The second method involved treating the agent itself with additives, to promote greater chemical stability. Several possible stabilizers were tested, and one of them, diisopropylcarbodiimide, seemed to be effective enough for adoption. Accordingly, subsequent fills of aluminum bomblets with stockpiled GB were restabilized with diisopropylcarbodiimide, and the characteristic pressure buildup in earlier agent-filled E130R2 bomblets ceased to recur in later lots during the test program.[7]

(C) Engineer and service test phases of the Improved Honest John warhead, conducted as a single consolidated test program, were carried out at Fort Bliss, Texas, White Sands Missile Range, and Dugway Proving Ground in 1961 and the first two months of 1962. The engineering tests were generally satisfactory, but it was remarked that compatibility of the GB fill with the aluminum E130R2 bomblet under long-term storage conditions had not yet actually been demonstrated, though short-term storage experience with restabilized agent had been promising. Problems were noted in the tendency of some test bomblets to function ineffectively, apparently because the explosive mixture (RDX) comprising the booster portion of the burster sub-assembly tended to crumble. But in general, the engineering test personnel at Dugway Proving Ground found that the E130R2 bomblet was an efficient disseminator of GB, that the E19R2 warhead gave controllable bomblet impact patterns, that agent dissemination on target was superior to requirements, and that the GB Honest John warhead was, therefore, a satisfactory candidate for type classification.[8]

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[6] (1) USAMUCOM Product Master Plan, E19R2 (Draft), 2 Jan 63 (2) CmlC Annual R&D Project Rept, Project 4C16-16-020, 31 Dec 59

[7] USAMUCOM Product Master Plan, E19R2 (Draft), 2 Jan 63

[8] Final Engineering Testing of E19R2 GB Warhead for Improved HONEST JOHN Rocket, DPGR 320, Vols I (Jun 62) and II (Jul 62)

(C) Concurrent service tests by the Artillery Board led to some less optimistic conclusions. It was noted that a tendency existed for the high-spin E130R2 bomblets to glide away from the center of the target area toward the periphery, so that instead of a completely random distribution of bomblet impacts over the area, a "doughnut" pattern emerged, with impacts occurring mostly in a ring around a relatively unaffected center. This pattern was more or less dependent on the length of bomblet flight, being more obvious for high-altitude warhead bursts. The Artillery Board testers felt that this characteristic warranted restudy of the warhead's target capabilities under varying meteorological conditions, to determine whether the agent cloud resulting from a doughnut-shaped impact pattern would be a fully effective casualty producer over the target area. The Board's own estimate was that only 40% area coverage, in effective dosages, would be achieved, although it did not indicate how this might be related to the larger target capabilities achieved by the kind of high-altitude bursts that produced the most pronounced "holes" in the impact pattern.[9]

(C) The Board also noted some other problems observed in the course of the test program. The E130R2 bomblets (simulant-filled, in this case) showed a disconcerting tendency to leak at the ring joining the hemispheres. It was uncertain whether the specially-designed plastic barrier bag for storing and shipping the warhead was fully effective in preventing hazards from GB vapor inside the warhead casing, should any be present there, and would have preferred a casing redesigned to be vapor-proof, as a safeguard for handling and operating personnel.[10]

(C) The Chemical Research and Development Laboratories (CRDL) at Army Chemical Center, as proponents of the E19R2, considered the findings of the service tests, and found nothing in their negative aspects to delay proposals for type classification. The bomblet leakage phenomenon was stated to be a minor problem of production engineering, which had been corrected in the later portion of the test period by more careful production methods and closer tolerances on critical parts, as well as by the successful use of stabilized GB to avoid pressure build-up within the munition. The crumbling of the RDX booster was considered a fortuitous experience occurring in bomblets that had been disassembled in the course

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[9] USA Arty Bd, Rept of Project No. FA 5158, Consolidated Engineer-Service Test of Warhead Section, 762mm Rocket, Chemical, E19R2, 17 Oct 62

[10] Ibid

of test procedures, and not reproduced in subsequent tests. The suggestion that the casing be redesigned to be vapor-proof was rejected as uncalled for in the military characteristics and contrary to the understanding with USCONARC, as the original generator of the requirement for development of the warhead, that the casing would be the same as that standardized for the M79. The barrier bag, which was also indicated for use with the (unprocured) M79 warhead, was declared to be the basic protection against agent leakage, as far as handlers were concerned. As for the critical question of target effectiveness, CRDL asserted that current data indicated an ability to cause 30% casualties over a target area of 1.7 square miles. On this basis, the case for type classification of the E19R2 GB warhead for the Improved Honest John was presented to the Chemical Corps Technical Committee (by this time an organ of the newly-formed Army Materiel Command (AMC) Technical Committee) at the end of 1962. The Committee accepted the proposal on 20 December 1962, including its plan to contract for procurement of 259 warheads in the current fiscal year, at a cost of about $11,000 apiece.[11]

(C) But the approval of the Committee's action by the representative of the Army General Staff, representing the Secretary of the Army and the Army Chief of Research and Development, was withheld, preventing the acceptance from going into effect. The new US Army Combat Developments Command (USACDC), which had incorporated the functions of service boards and doctrine development agencies in the course of the Army's 1962 reorganization, had refused to accept CRDL's rebuttal of the Artillery Board's reservations about the readiness of the E19R2 warhead to complete its development phase. Its position was summarized early in 1963 in a statement to the Chief of Research and Development, DA. The question of bomblet leakage propensities could be answered properly only by further tests with live bomblets, it asserted. Furthermore, it wished to see the detailed analysis CRDL had not yet completed, which was to back up the claims of target effectiveness made before the Chemical Corps Technical Committee. Finally, the capability of the barrier bag to perform effectively in preventing GB vapor leakage was not accepted pending specific test findings.[12]

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[11] CCTC Item 4080, w/inclosures, 20 Dec 62

[12] (1) Ltr, MAJ H. A. Hunt, USACDC to CRD, DA, 19 Feb 63, subj: Classification of Warhead Section, 762mm Rocket, Gas, Non-Persistent, GB, M190 (2) Ltr, COL R. L. Doupé, OCRD to CG, AMC, 21 Mar 63, same subj

(C) Accordingly, the schedule for type classification and procurement of the GB warhead for the XM50 Honest John rocket had to be pushed back into the mid-1960's, in order to allow for a program of check tests to examine and, hopefully, satisfy the reservations of Combat Developments Command. The check tests were duly carried out by US Army Test and Evaluation Command (USATECOM) in 1963–64, with the final test report completed in March 1964. No recurrence of leakage or pressure buildups in bomblets was noted. The following month, Headquarters, AMC, the proponent command, again recommended that the E19R2 be standardized. In May 1964 representatives of AMC met with USACDC personnel at the Army Artillery and Missile Center, Fort Sill, Oklahoma, to resolve their respective viewpoints. The principal remaining area of difference was the safety factor for artillerymen handling loaded GB warheads. It was finally agreed that Combat Developments Command would concur with the request for standardization, subject to certain conditions. These included, along with speedy publication of applicable technical manuals and instructions, a certification attached to the type classification action by the appropriate elements in AMC that the warhead would be safe to handle after the barrier bag was removed, that the leakage and pressure buildup problems no longer existed, and that confirmatory testing of production-line warheads would be undertaken in due course. After stipulating for this much, USACDC went on to recommend, as its own opinion, that, because of the doughnut-shape impact pattern the E130R2 produced, it would be advisable to abandon the spherical bomblet altogether in favor of the next-generation submunition under development in CRDL.[13]

(C) The guarantees demanded were promptly supplied by CRDL, bearing out the statements made at the Fort Sill conference. A hazard evaluation was provided which demonstrated that in the event of bomblet leakage within the E19R2 warhead casing sufficient to saturate the air inside the casing with GB vapor, the diffusion of this vapor out of the casing, even under severe conditions of temperature rise in storage, would not be sufficient to endanger an unprotected man in close proximity to the warhead for the hour and three-quarters that it would take to mate the warhead to the rocket at the firing site. At all other times, the barrier bag would be in place. The test results obtained during preceding months at Dugway Proving Ground on other munitions utilizing E130R2 bomblets were cited as demonstrating the absence of pressure buildup or

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[13] Ltr, MAJ J. T. Hayes, USACDC to CG, AMC, 4 Jun 64, subj: Classification of Warhead Section, 762mm Rocket, Gas, Non-Persistent, GB, M190

leakage in current production lots of bomblets. The demand for confirmatory testing was accepted. The suggestion that the E130R2 bomblet be replaced by a newer type still in development was rejected, however, as requiring extensive additional development effort and flight testing for the warhead.[14]

(C) The agreement at Fort Sill by Combat Developments Command to concur in type classification of the E19R2 warhead in view of the guarantees offered by CRDL ended the deadlock over approval of the Chemical Corps Technical Committee action of December 1962. On 8 June 1964 formal approval by the Office of the Chief, Research and Development, DA, on behalf of the Army General Staff was transmitted to the AMC Technical Committee (AMCTC), and type classification action was complete.[15] The newly standardized munition, designated Warhead Section, 762mm Rocket, Gas, Non-Persistent, GB, M190, was classified as Standard-A, for use with either the older M31-series or improved XM50-series Honest John rocket. The interim standard M79 warhead was concurrently declared obsolete. Like its predecessor, the M190 had an aluminum ogival casing 115 inches long and 30 inches maximum diameter. The quadrant internal structure and primacord-actuated functioning method characteristic of the M79 served the M190 also. The essential difference was the spherical submunition, now standardized as the M139, of which 368 went into each fully loaded warhead. The M139 consisted of two smooth-surface hollow aluminum-alloy hemispheres, joined circumferentially, and containing an impact-type fuze (M912), armed by rotation at a speed of 1800 rpm, a spherical burster (M45) of Composition B explosive, boosted by a pellet of RDX, and 1.3 pounds of liquid GB (stabilized with 4% diisopropylcarbodiimide) filling all but 8% of the remaining space. The loaded M190 warhead weighed about 1265 pounds, of which about 478 pounds represented agent payload, roughly three-eighths of the total weight – a ratio about 50% higher than that provided by the M79. For shipping and storage the warhead was placed in a heat-sealed, close-fitting plastic barrier bag, containing five tubes for use in withdrawing samples of the air within to check for leakage of GB vapor. The plastic-wrapped warhead was then placed in a steel shipping container.[16]

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[14] DF, B. Berger, CRDL to Dir Commodity Mgmt, EA, 19 Jan 64, subj: Statements Applicable to USACDC Provisos for Type Classification of the E19R2 (M190) Warhead Section

[15] AMCTC Item 2621 (CCTC Item 4187), 17 Jun 64

[16] Ibid

(C) The final development stages of the E20 GB warhead for the Little John system closely paralleled those of the M190. It went through similar engineering and service tests in 1962, the former at Dugway Proving Ground, the latter at White Sands Missile Range, New Mexico, and Fort Bliss, Texas, by the Artillery Board. The Chemical Corps engineering test reports from Dugway Proving Ground (which did not become part of the newly-organized USATECOM until after the reports were prepared) indicated some concern over leaks and pressure buildups in the E130R2 bomblets, but this problem was felt to be unimportant once the effective chemical stabilization of the agent in the munition had been demonstrated. Otherwise, the tests were accounted satisfactory. The warhead in flight had displayed a controllable impact pattern, depending upon altitude at point of functioning, and it met the applicable military characteristics. Of course, the weapon was at the lower limit of effective size for a chemical warhead, and tests only tended to make this more apparent. Effective coverage of a target with an agent cloud was achieved only under ideal meteorological conditions with a single E20 warhead, but the Dugway report declared that, when fired in salvos of two or more at a time (the system permitted up to four rockets to be fired simultaneously), more general target effectiveness was obtained. On this basis, standardization of the warhead was recommended.[17]

(C) The service test report by the Artillery Board touched on the uncertainties introduced by the leakage experience with the E130R2 bomblet, and went on to comment on the doughnut-shaped impact pattern which flights of E130R2-loaded warheads produced, the E20 as well as the M190 Honest John. The Board considered this as a possible source of reduced effectiveness on targets. In general, it was uncertain as to the effectiveness of the E20 even at best, when compared with other delivery systems (tube artillery utilizing agent-filled shells), and urged re-evaluation of the warhead before further action toward standardization. It noted further that tactical doctrine for the employment of the weapon was not developed. Under the circumstances, the Board recommended that type classification be held in abeyance.[18]

(C) The Chemical Research and Development Laboratories at Edgewood, in commenting on this report, remarked that the problem of

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[17] Final Engineering Testing of E20 GB Warhead for Little John Rocket, DPGR 321, Vol I (Jun 62; Vol II (Jul 62)

[18] USA Arty Bd, Rept of Project No. FA 1259-3, Service Test of Warhead Section, 318mm Rocket, Chemical, E20, 13 Nov 62

bomblet leakage was considered solved, as had been stated in connection with the same question after the service testing of the Honest John warhead. As for the questions of utilization and effectiveness of the E20 warhead, CRDL cited studies of the Chemical Corps Field Requirements Agency and its own Systems Analysis Division. The former, in a study draft prepared the previous year, had concluded that GB could be exploited profitably by the Little John system:

a. to provide airborne divisions with organic GB weapons for targets beyond the range of tube artillery.

b. to provide maximum surprise effects on medium-range targets.

c. to supplement tube artillery in concentrating chemical attack on critical troop concentrations or fortified hard targets. It recommended that the E20 warhead, though admittedly more expensive and less precise than chemical shells, be supplied to airborne units using the Little John rocket system.[19]

(C) The Systems Analysis statement summarized a study of the capabilities of the E20 warhead against targets. The study was based on the assessment of a salvo of four E20 warheads under average meteorological conditions. The criterion for target effectiveness was the customary 30% casualty expectancy. While calculations indicated that high altitude functioning scattered the payload too broadly to meet this criterion, release height of 750 meters or less gave effective dissemination of agent on targets (unmasked troops) at and beyond medium range. Target areas in these calculations ranged up to about one-third of a square mile. Calculations for troops with protective masks available indicated that when the warheads functioned at a height of 400 meters or less, the criterion would be met at medium ranges for target areas of about one-eighth of a square mile. The study concluded that this was sufficient to defeat 75–80% of the targets in a typical target complex, using the 30% casualty attainment as a criterion of target defeat, and including in the target complex those longer range targets for which Little John would not be the weapon of choice. The study and the data included therein were presented by CRDL as a basis on

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[19] 1st Ind, CRDL to CG, CBR Agency, 21 Jan 63, subj: Rept of Project No. FA 1259-3, Service Test of Warhead Section, 318mm Rocket, Chemical, E20, w/incl, Extract, Draft Study, "Concepts for Employment of Chemical Warheads for the LITTLEJOHN Rocket," USACCFRA CMLCD 61-11, Oct 61

[redacted]

which to reach the decision on E20 effectiveness which the Artillery Board had been reluctant to make.[20]

(C) Meanwhile, the newly-organized Army Test and Evaluation Command had taken cognizance of the test program for the E20 just completed at Dugway Proving Ground and elsewhere, and appended its own views to the test reports which it forwarded to Headquarters, AMC in December 1962. The general opinion of USATECOM was that it was doubtful whether the tests had demonstrated effective dissemination of agent. It suggested more study of the military characteristics by Combat Developments Command, more storage experience on the E130R2 bomblet, and a subsequent program of check tests. While AMC and its concerned elements – USAMUCOM and CRDL – were satisfied with the status of the bomblet after stabilization of the GB fill, and considered the question of effectiveness sufficiently answered by the study completed by CRDL in January 1963, the decision on carrying the E20 forward to type classification was allowed to lie over pending the completion of check tests on the warhead for the Improved Honest John. This stage was complete by the spring of 1964.[21]

(C) When, in June of 1964, the last demurrers to the type classification of the E19R2 warhead for the Improved Honest John were withdrawn, Headquarters, AMC moved to expedite type classification of the E20 also. Combat Developments Command and Test and Evaluation Command were given current data and doctrinal studies in support of standardization action and requested to reconsider past objections. USACDC, after reviewing the situation, concluded that the data indicated that type classification of the E20 warhead was indeed justified, especially as the component E130R2 bomblet had already been accepted by the Army as an efficient GB dissemination item.[22] USATECOM also accepted the bomblet as a fully developed submunition, in view of its standardization in the M190 Honest John warhead, and the successful check tests of storage stability and functioning which preceded that action. But it reiterated its dissatisfaction with the target

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[20] DF, Actg C, Syst Anal Div, CRDL to C, Mun Dev Div, CRDL, 16 Jan 63, subj: Report of Project No. FA 1259-3, Service Test of Warhead Section, 318mm Rocket, Chemical: E20, w/incl, Digest Rept Syst Anal Div, 16 Jan 63, subj: Effectiveness of the Little John Missile with the E20 GB Warhead When Fired in a Salvo of Four

[21] CCTC Item 4185, 5 Jun 64

[22] Ltr, CPT J. A. Ward, Jr., USACDC to CG, AMC, 2 Jul 64, subj: Proposed Classification of Chemical Warhead Section, 318mm Rocket, Gas, Non-Persistent GB, (E20)

[redacted]

effectiveness of the E20 warhead as displayed in its engineering and service tests, despite the effectiveness estimates which AMC had adopted. Consequently USATECOM did not endorse the request for type classification. Nevertheless, the request was carried forward by AMC for final action. The Chemical-Biological Subcommittee of the AMC Technical Committee proposed standardization on 5 June 1964. Five weeks later Headquarters, AMC, citing the check tests on the E130R2 bomblet, CRDL's effectiveness study of January 1963, and the concurrence of Combat Developments Command, requested approval of type classification from the Chief of Research and Development, DA. This approval was forthcoming on 17 July 1964, and the E20 warhead thereby became a Standard-A munition: the M206 Warhead Section (Little John).[23]

(C) The M206 warhead, as standardized, was a 79-inch long, projectile-shaped, ogival rocket section with a maximum diameter of 12 1/2 inches at the base. The casing before loading weighed 138 pounds. It was constructed of aluminum alloy in three sections, joined with forged aluminum ring frames. The center of the base section contained a ballast tube to hold the bomblet submunitions in place. Three internal longerons contained detonating cord which, on the functioning of the warhead's M421 fuze, split the casing into three longitudinal parts, releasing the bomblets. These bomblets were the same M139 (E130R2) submunitions that were standardized with the Improved Honest John GB warhead. It took 52 bomblets to fill the casing. Fully loaded, the M206 weighed about 262 pounds, of which about 67 pounds represented GB agent, a little over 25% of the total weight of the munition. The M206 was regarded as vaporproof. Its shipping and storage container was the same M477 container developed by Ordnance for other Little John warheads – a sheet steel structure with internal shock-resistant cradling to carry the warhead. The M477 was modified for use with the M206 warhead by the addition of a sampling port at each end to enable surveillance checks for agent leakage to be made. Two M11 canisters, a type developed for use with gas masks, were also installed in the M477 container at pressure relief points to provide an additional safety factor against agent leakage.[24]

(C) The uneven progress toward achievement of standard GB warheads for free rockets was paralleled to some extent by the course of development of a GB capability for a standard guided missile. The discontinuance in

[23] AMCTC Item 2442, 23 Jul 64

[24] Ibid

1957 of the program to produce a 1500 pound GB warhead for the Corporal missile system had left open the question of a related warhead program for Corporal's successor. The Army's candidate for this role as the post-1960 corps artillery guided missile was Sergeant, a vehicle of about the same size and range as Corporal, but more mobile, more quickly emplaced and fired, and more reliable in functioning. The Sergeant guided missile system was formally inaugurated as a development project by the Army at the beginning of 1955, following preliminary feasibility studies. The missile was designed to operate over a range of 25–75 nautical miles. It weighed about 10,000 pounds and utilized a 1500 pound warhead. Its solid-propellant motor could drive it at supersonic speeds on a ballistic trajectory, which could be modified by an inertial guidance system. The system, including launching station equipment and transport vehicles, was considered nearly as mobile as a 155mm howitzer. The basic missile and control system development program was essentially complete by mid-1961. So much of the development of the E18 Corporal warhead seemed applicable to the Sergeant system, and so much of the logic of a GB capability for Corporal could be invoked for its successor, that a formal requirement for a GB warhead for Sergeant was included in the Combat Developments Objectives Guide, along with the GB requirements for Honest John and Little John.[25] CRDL began in 1957, before the E18 project was terminated, and before any specific program for Sergeant had been set up, to carry out preliminary design studies for a Sergeant warhead, using funds from its generalized program for warhead studies. A contract with Cook Research Laboratories followed, in July 1957, for design and fabrication of the warhead.[26]

(C) The basic concept followed the pattern of the E18 Corporal design. The warhead was to contain a payload of self-dispersing GB bomblets, whose dispersion area would increase in proportion to the increase in altitude of the warhead at the time of functioning. The submunition envisioned for the project was the spherical aluminum E130R2 bomblet, the same munition under development for ultimate use in Honest John and Little John warheads. The dimensional characteristics of Sergeant warheads indicated a probable capacity of about 327 bomblets per casing. The

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[25] (1) CDOG, par 438j (2) Annual Rept, Sperry Utah Co, Sergeant, 1 Jul 60 – 30 Jun 61

[26] CmlC Annual R&D Rept, Project 4-16-16-020, 31 Dec 58

contractor fabricated several prototype casings, fitted them to the aluminum warhead skin provided by the missile system prime contractor, and demonstrated successful peeling away of the skin by primacord explosion.[27]

(C) In the meantime, the Sergeant GB warhead was formally launched as a development project, on the basis of the USCONARC requirement in the Combat Developments Objectives Guide. The institution of the project in the Chemical Corps project program, 27 August 1958, was accompanied by a set of military characteristics which specified the essential requirements for conformability with the structure and aerodynamic characteristics of the parent missile system, along with the usual demands for simplicity of operation, transportability, and reliability. The requirement, common to other GB warhead projects, that the munition must be capable of five years' storage without leaking was also included as a matter of course. But no specific performance goals were stated, except that the warhead "should provide efficient dissemination of the agent in airborne form," a requirement which seemed to leave a fairly wide field open for effectiveness analysis.[28]

(C) Along with its general resemblance to the Honest John GB warheads, which approximated it in weight, payload, and method of function, the prototype Sergeant warhead which emerged from the design contract had certain individual characteristics. A stressed-skin, or monocoque structure, rather than a design depending on internal support, was utilized for the casing, in order to prevent possible skin deformation and consequent alteration of aerodynamic characteristics under the stress of supersonic flight. The quadrant principle was utilized for storage of submunitions within the warhead casing, but in this case nylon panels were attached to each quadrant, folded to provide a three-point suspension to retain the bomblets between panel and casing. The design was such that on the rupture of the warhead skin at the point of functioning, the nylon panels would eject their load of bomblets outward as if they were slingshots. The need for this accelerated ejection was demonstrated when flight tests of earlier models resulted in bomblets striking the missile body in flight.[29]

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[27] Final Summary Rept, Cook Research Labs, Contract DA 18-108-CML-6422, Design and Fabrication of a Chemical Warhead Casing for the Sergeant Missile, 9 Jan 59

[28] CCTC Item 3467, 27 Aug 58

[29] (1) CmlC Annual R&D Rept, Project 4-16-16-020, 31 Dec 58 (2) AMCTC Item 2874, 29 Dec 64

(C) The first two prototype Sergeant GB warheads produced by the contractor were subjected to static functioning after operational stress experience, and to laboratory preflight testing. Results were encouraging, and on 21 October 1958 a third warhead was flight tested as part of the Sergeant missile development program at White Sands Missile Range, New Mexico. The warhead functioned successfully at 10,900 feet above ground level and its submunitions produced a ground impact pattern 8500 feet in diameter – about two square miles. The extremely limited number of Sergeant test flights which were to be made available for the GB warhead program, however, threatened to delay further progress. The design contractor was therefore given a supplementary contract to study the feasibility of using available Corporal missiles as test vehicles for a Sergeant warhead. The study was completed in the course of 1959, and indicated that the Corporal could, in fact, be used to duplicate Sergeant functioning environment at various ranges and burst heights.[30]

(C) During 1959 and the first half of 1960 no Sergeant missiles in the system's flight test program were available for the GB warhead project, but the warhead development went forward. As projected by the feasibility study, Corporal missiles were adapted for use as warhead test vehicles. Ultimately, four of these "hybrids" were successfully flight tested at White Sands Missile Range. The second Sergeant missile to carry a GB warhead in flight testing was launched on 23 September 1960; a third Sergeant test flight occurred in May 1961, and a fourth in September 1961.[31]

(C) By that time the design of the GB warhead, designated as E21 during the development program, was more or less fixed, with its stressed-skin exterior, quadrant payload section, and a specially-designed warhead fuze in the nose cone, capable of arming the warhead in flight when altitude and launch timing are correct and of preventing function when these predetermined conditions are not met. Engineering and service tests at Picatinny Arsenal, Dugway Proving Ground, Fort Bliss, and White Sands

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[30] (1) Final Summary Rept, Cook Research Labs, 9 Jan 59 (2) Final Summary Rept, Cook Research Labs, Contract DA-18-108-CML-6422, Study of the Feasibility of Adapting a Sergeant Chemical Warhead on a Corporal Type I Missile, 15 Sep 59

[31] (1) AMCTC Item 2874, 29 Dec 64 (2) Annual Rept, Sperry Utah Co, Sergeant, 1 Jul 60–30 Jun 61

Missile Range were carried on in 1962–63. By the time these were complete a total of thirteen E21 warheads had been fired. Most of these functioned successfully, and produced impact patterns which exceeded predictions, a fact which alerted testers to the need for revising calculations of target areas when using the E21. The US Army Artillery Board, which carried out the service tests, concluded that the E21 was sufficiently developed to warrant acceptance as standard, once technical literature was revised and completed, and a few minor improvements made in the warhead's shipping container. It commented, however, on the fact that, as far as suitability for field artillery use was concerned, a firm determination of target effectiveness (casualty potential) ought to be made.[32]

(C) The engineering test results were also generally satisfactory, with no major deficiencies in design reported. Inasmuch as the service test firings at White Sands Missile Range had been carried out with simulant-loaded bomblets, there was no direct measure of the success with which the E21 had provided "efficient dissemination of the agent in airborne form," as required by the military characteristics guiding the development project. The test personnel at Dugway Proving Ground got around this difficulty by exploding single E130R2 bomblets, loaded with GB, measuring the agent dissemination resulting therefrom until a firm figure per bomblet was established, and then extrapolating this figure into the bomblet dispersion patterns obtained at White Sands Missile Range. The resulting target dissemination estimate was deemed conclusive of efficient GB dissemination by the E21 warhead. Most of the other requirements of the military characteristics – weight, transportability, conformity with basic missile system, and the like – were tested and declared achieved. The question of agent leakage during long-term storage was not completely answered, but known storage characteristics appeared favorable, and the heart of the issue, the capability of the agent-carrying submunitions to remain leakproof, had been settled during the testing of the M190 and M206 warheads.[33]

(C) USATECOM, in reviewing the engineering and service test reports in the summer of 1964, concurred in recommending that the E21 be carried forward to type classification, after minor shortcomings were corrected, but suggested that long-term surveillance tests of production models of the warhead be carried out thereafter. On 1 October 1964, Edgewood Arsenal

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[32] USA Arty Bd, Rept of USATECOM Project No. 5-3-0030-06 (USAARTYBD FA 4159) Service Test of Sergeant Chemical Warhead, 11 Sep 63

[33] DPG, Final Rept of Development, Engineering-Service Test of . . . Sergeant Missile, USATECOM Project No. 5-3-0030-02, 13 Aug 64

reported that the necessary corrections in shipping equipment had been made, and that a target effectiveness study of the E21 had been completed so as to provide the materials for tactical employment instructions which the Artillery Board had requested in its test report.[34]

(C) With all agencies concerned prepared to concur in type classification, a situation verified at an in-process review meeting at Edgewood Arsenal on 21 October 1964, action by the AMC Technical Committee to classify the E21 warhead as Standard-A was not long in following. Approval of standardization by the representative of the Army General Staff on 29 December 1964 made the designation final, and the E21 was henceforth the M212 Warhead Section, Guided Missile (Sergeant).[35]

(C) The M212 GB warhead, as a standard Army munition in the XM15 Sergeant missile system, consisted of two principal sections, the warhead proper (M213) and the M71 fuzing section. The former, estimated to cost $32,031 per unit as a procurement item, included the stressed-skin aluminum casing, with a maximum diameter of 31 inches, the submunition bomblets, and the primacord warhead detonators. The casing, with its quadrant-model interior and nylon ejection panels, had a detonating block, with 12 RDX 1/4-inch pellets, at its forward end, adjacent to the fuzing section. Four primacord detonators, symmetrically placed down the perimeter of the casing and retained in steel longerons, operated on functioning to split the casing into four sections, whose load of bomblets was ejected by the nylon panels. The bomblets were the M139 spherical type, standardized with the Honest John and Little John rocket warheads. The casing, when loaded, contained 330 bomblets, with a total GB agent load of about 429 pounds. The M71 fuzing section, designed to be assembled to the forward end of the warhead before delivery to the user, was 15.8 inches in diameter at its base, weighed 140 pounds, and was estimated to cost $20,099 per unit (bringing the total estimated procurement cost of an M212 warhead to $52,130). Since the equipment in the fuzing section was considered to be liable to degradation if in contact with GB, it was provided that the M71 would be shipped and stored separately, being mated to the warhead only on delivery to the user. When this assembly was made, the complete M212 warhead, loaded, weighed about 1611 pounds, just over a quarter of which represented agent payload.[36]

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[34] AMCTC 2874, 29 Dec 64

[35] Ibid

[36] Ibid

(C) Separate shipping and storage containers for the M213 and M71 components of the M212 warhead were authorized by the standardization action. The M71 fuzing section utilized an airtight, skid-mounted steel container, equipped with a vent and a humidity indicator. For the M213 section, the warhead proper, a skid-mounted steel container was also provided, with an air sampling port at each end for surveillance against agent leakage from the submunitions. As with the container provided for the M206 Little John warhead, two M11 gas mask canisters were installed within the container at the venting valves to take up whatever GB vapors might be present.[37]

(C) With the type classification of the M212 Sergeant warhead, the Army completed the acquisition of three GB rocket and missile warheads as standard munitions within the six-month period June–December 1964. This may be regarded as the culmination of the long development effort for provision of such an Army capability, a development effort that went back to 1950. It had been characterized by repeated setbacks, in part (as with the attempt to use unsuitable submunitions because they were readily available) because of undue economies in schedules and fiscal resources, in part because of the short development life of such early missile types as Hermes and Corporal, which became obsolescent while chemical warheads for them were still on the drawing boards. But in the mid-1960's, GB warhead development appeared to have caught up at last with the weapons of the decade, and put chemical warfare into the missile age. At the same time, preliminary work was under way for the extension of this GB capability to the missiles of the 1970's, at least those corps or division artillery missiles of a range and capacity comparable to Sergeant. Though studies had failed to make a convincing case for GB as a payload for the longer range, field army missiles of the Pershing type, such projects as Missile B (subsequently named Lance) appeared likely candidates for GB payloads.

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[37] Ibid

CHAPTER 4

(C) WARHEADS IN PRODUCTION

(C) The type classification actions of 1964 gave the Army a group of GB warheads with which a missile-age chemical warfare capability might be achieved. But these GB warheads would become Army capabilities only as they were actually produced and turned over to user agencies to enter the Army stockpile. The question of production requirements thus became uppermost as type classification actions were at length concluded. The type classification actions themselves systematically included first year procurement requirements, based on the Army Materiel Plan. Thus the M190 Honest John warhead was supposed to go into production with a first-year procurement schedule of 259 warheads, at an estimated cost of $10,935 apiece. The M206 Little John warhead had a first-year production plan calling for 85 items, at about $6,769 each. In the case of the M212 Sergeant warhead, a tentative first-year program for procurement of 61 units, at $52,130 per unit, was indicated in the type classification documentation, but this was predicated on an as yet unaccomplished requirements analysis and establishment of day-of-supply rates by Combat Developments Command. Production plans called for procurement of casings and bomblet bodies from contractors, with filling and assembly to be carried on at Rocky Mountain Arsenal.[1]

(C) As far as actual procurement schedules went in the ensuing fiscal year (FY 1965), production was to be limited to the M190 and M206 warheads, in the amounts indicated above; no procurement was scheduled for the time being for the M212 (a situation which continued through subsequent years). Contracts for components required by Rocky Mountain Arsenal for assembly of the first preproduction lots were awarded in the fall of 1964, the major awards, for warhead skins and castings, going to Magnesium Aerospace Products, Inc., after competitive bidding. The contract for bomblet bodies went to Norris Thermador. Picatinny Arsenal awarded contracts for shipping containers and US Army Ammunition Procurement and Supply Agency (USAAPSA) undertook procurement of fuzes and explosive components. Preproduction evaluation of the technical data package was to be carried on for the first few warheads produced,

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[1](1) AMCTC Item 2621, 17 Jun 64 (2) AMCTC Item 2442, 23 Jul 64 (3) AMCTC Item 2874, 29 Dec 64

hopefully before June 1965, with completion of the first inventory production orders scheduled for FY 1966 in the case of the M206, and FY 1967 for the larger lot of M190 warheads. The total cost of the procurement plan was calculated at about $5 million for the M190 and $600,000 for the M206.[2]

(U) There was no delay experienced in making contract awards for those components to be supplied directly to Rocky Mountain Arsenal (RMA), nor in the establishment of a filling and assembly line there. Moreover, savings of $175,000 were achieved in making the contracts, as against earlier estimated costs. The production program thus seemed likely to get off to a good start.[3] This impression, however, was not long maintained. To begin with, Picatinny Arsenal and USAAPSA both experienced difficulty in getting their contractors started on shipping containers and bomblet fuzes, indicating a slippage of two months or more in the overall preproduction lot program. Components for the warhead casings began to arrive early in 1965, but shipments tended to lag some weeks behind schedule, as the contractor experienced difficulties in welding and forming to specifications. When they did arrive, it was found that a few accessory parts (pressure seals) were unsatisfactory, and that the steel tie rods specified would bring the warhead weight above acceptable limits. They were replaced with aluminum bars. Bomblet body deliveries were three months behind schedule when the preproduction evaluation quantity of 5000 (10,000 bomblet halves) was finally complete early in June 1965.[4]

(U) Actual assembly of the first M190 warhead began in March 1965. There were additional problems thereafter in meeting configuration specifications (which turned out to be more rigid than those for the rocket as a whole) until the configuration jigs on the assembly line were modified. By mid-summer it was possible to forecast completion of the preproduction evaluation phase and beginning of regular inventory production for about 1 October 1965, a few months behind schedule. Assembly of M206 warheads did not begin until July 1965, but the technical data package for this item required less modification, and preproduction evaluation proceeded somewhat more smoothly than in the case of the first M190's. The filling

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[2] (1) Army Materiel Plan, FY 64–71, Vol III, Pt. I, Jun 65 (2) Rocky Mountain Arsenal Hist Rept, Jul–Dec 64 (3) Commodity Manager's Repts, EA, M190 and M206, Jul–Dec 64

[3] RMA Hist Rept, Jul–Dec 64

[4] (1) Ibid (2) Commodity Manager's Repts, EA, M190 and M206, Dec 64–Jun 65

of M139 bomblets was also under way, not without problems. Early production line experience was indicating a bomblet rejection rate, principally for leakage, of up to 10%, much above the 2% regarded as a reasonable limit. The entire supply of M912 bomblet fuzes had to be examined by X-ray at Rocky Mountain Arsenal before assembly into bomblets, because of uncertainty over the supplier's inspection procedures and the possibility that some fuzes might have become armed. Nevertheless, the final loading and acceptance for Army inventory of a number of M190 and M206 warheads was achieved by the fall of 1965, when a new difficulty brought matters to a halt.[5]

(U) The Navy had taken an interest in the M139 bomblet as a component for future naval chemical munitions. It had, therefore, obtained a supply of bomblets in order to run its own evaluation tests on them. When the test bomblets were put through the Navy's vibration tests, it was observed in subsequent examination that the M140 booster pellets, of molded RDX explosive compound, had disintegrated under the stress, recalling the experience of some test items during the engineering-service tests of the M190 warhead. As word of this development reached the Army, it was decided that a new booster pellet had to be provided for the M139, if the risk of duds was to be minimized. The effect of this conclusion was to shut down the warhead filling lines at Rocky Mountain Arsenal in December 1965.[6]

(C) The stoppage made rescheduling of the bulk of the warhead inventory production inevitable, but it was not considered likely to extend beyond three or four months. USAAPSA sought an improved booster pellet from the Lone Star Army Ammunition Plant, but samples submitted proved to be unequal to the rigorous vibration testing that had destroyed confidence in the M140 booster. Picatinny Arsenal thereupon undertook to produce a vibration-resistant booster pellet in quantity by the end of February 1966. Edgewood, meanwhile, had arranged to fund a rework project to replace the booster pellets in bomblets already filled, a program which involved the preliminary unloading and demilitarization of the munitions. A substantial supply of new booster pellets reached Rocky Mountain Arsenal by the end of March, but a new factor supervened to

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[5](1) Commodity Manager's Repts, EA, M190 and M206, Jun–Oct 65 (2) RMA Hist Rept, Jul–Dec 65

[6](1) R&A, EA, 2d Qtr, FY 66, p. 11 (2) RMA Hist Rept, Jul–Dec 65

delay resumption of production. Surveillance examination of another GB aluminum munition in Army stockpiles had just revealed that the agent, while in storage, had begun to eat away at the inner surface of the metal, leaving it pitted. This discovery, immediately recalling the difficulties experienced with the aluminum M139 bomblet before restabilization of GB with diisopropylcarbodiimide, made further investigation of the condition of those bomblets already loaded and stored imperative. Resumption of warhead filling was again put off.[7]

(C) The check of loaded M139 bomblets did indeed reveal pitting of some of the surfaces exposed to restabilized agent. There was no immediately obvious cause for this. It was known from earlier work with high-purity GB that (unlike the agent stabilized with tributylamine) it did not ordinarily react with aluminum. Recent lots of restabilized GB had also been redistilled, to remove most of the free acids and other impurities that had formed during long-term storage. Eventually, analysis of the agent revealed the presence of trace amounts of ions of heavy metals – copper, lead, nickel, iron, and mercury – apparently introduced in the redistilling process. It was subsequently determined that some of these ions, especially copper and lead, had begun electrolytic reactions with some of the aluminum alloys in the inner bomblet surfaces exposed to agent. While not every lot of GB used in filling operations evidenced this dangerous contamination, its occurrence was sufficiently frequent to keep the GB warhead production program quiescent for the time being.[8]

(C) It was hoped at first that some sort of "quick fix" would get the M190 and M206 production program, now about a year behind schedule, under way in a few weeks or months. But it was soon determined that only a refined agent redistillation procedure, followed by surveillance testing for at least six months, could produce an agent fill that could be loaded into the M139 bomblet with confidence. Such a program was, in fact, undertaken later in 1966, and was carried on through 1967. The production program for Honest John and Little John GB warheads, however, remained in abeyance throughout the period, and the long-sought Army capability for missile-borne chemical warfare continued to be an unrealized goal.[9]

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[7] Commodity Manager's Repts, EA, M190 and M206, Jan–Apr 66

[8] (1) RMA Hist Rept, Jan–Jun 66 (2) Annual Historical Summary, USAMUCOM, FY 66, pp. 9–28 to 9–30

[9] Commodity Manager's Repts, EA, M190 and M206, Apr–Dec 66

CHAPTER 5

(C) THE NEXT GENERATION

(U) Throughout the early history of chemical warheads for missiles the Chemical Corps items had been not only secondary elements of the basic missile systems (necessarily so, in view of the conditional status of chemical warfare in general), but in the nature of afterthoughts, added to the systems after basic system characteristics had already been developed. With the advent of development of a new generation of medium-range division support missiles in the 1960's, the opportunity of including a chemical capability at a relatively early stage in system planning was at last seized upon.

(C) Of the various potential configurations for a successor to the Honest John as a division artillery general support missile, the project which was ultimately fixed upon for development by the Army was the so-called Missile B. This was a lightweight, mobile, rapid-fire missile that could cover the Honest John 75-kilometer maximum range, while at the same time being controllable (as the Honest John was not) by a guidance system simple enough to fit into a single small box. Thus the system combined the simplicity and portability of the free rocket with at least a measure of the control in flight provided by the control vans of larger guided missile systems like Sergeant. The new missile, at the time it was accepted for advanced development, was a 20-foot long surface-to-surface rocket, with a maximum diameter of 19 inches and a weight of about 2710 pounds. Its liquid-fueled propulsion system was a prepackaged unit, like its 1000-pound warhead. Its lightweight launcher (2595 pounds) could be carried and operated on a tracked vehicle, or transported by helicopter, while its guidance system controls were contained in a package whose greatest dimension was barely over a foot. A launcher could fire at the rate of six missiles per hour.[1]

(C) The Chemical Corps began feasibility studies in mid-1961 and drafted a weapons system proposal for a GB warhead for Missile B early in 1962, the plan envisaging completion of the project by FY 1968. An incendiary warhead was also proposed.[2] The proposals were incorporated

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[1] USA Missile Command, Rept RF-TR-63-8, Free World's Missile Threat to the Soviet Field Army, Vol II, 1 May 63, pp. 1–4, 55

[2] Ltr, CmlC Exec Off to CG, CmlCMATCOM and CO, CmlCENCOM, 22 Mar 62, subj: Missile "B" Total Feasibility Study

into the formal requirement for the new missile as expressed in the Combat Developments Objectives Guide (subparagraph 434a(8)), making the GB warhead an integral part of the system. As of November 1962, Missile B was officially named Lance by the Department of the Army.[3]

(C) The approved Qualitative Materiel Requirement which included the GB warhead for Lance defined the basic objectives as follows:

1. The chemical warhead section shall deliver toxic GB bomblets.

2. The chemical warhead section must be air-burst and deliver these bomblets over a roughly circular area.

3. The chemical warhead section shall present no storage or handling problems.

4. The warhead section will be interchangeable with, and have the same ballistic characteristics as, other warhead sections required for this missile.[4]

The requirements, therefore, looked to a bomblet-carrying warhead, as was the case with earlier chemical warhead projects, which would perform more or less as these did.

(C) One of the first major problems requiring solution was the choice of a bomblet. It appeared that the principal limiting factor in determining warhead capacity was that of volume, rather than weight, and that consequently the clustering efficiency of a bomblet configuration would be of major importance. The volume limitations of the 19-inch warhead diameter specified in the original plans were, in fact, so restrictive that by the beginning of 1963 the Lance project manager approved a new missile design with a maximum diameter of 22 inches, increasing the volume of the warhead about 25%.[5] This was of considerable assistance to designers of the GB warhead, since it gave greater promise of an agent payload large enough to be an effective area weapon, but it was not so great an increase as to reduce the emphasis on bomblet clustering characteristics. This immediately put spherical shapes at a disadvantage, despite the fact that in 1963 a fully developed spherical bomblet, the E130R2 (later M139), was already available. In terms of economical use of packaging space, both cubes and cylinders exceeded spheres. Nevertheless, the Lance system developers

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[3] Ltr, Dir Dev, OCRD to Distribution, 23 Nov 62, subj: Lance Missile System

[4] Approved Qualitative Materiel Requirement for Non-nuclear Warhead Sections for Division General Support Missile (Lance), 3 Jun 63

[5] Trip Rept, J. L. Kratzer and J. P. Sansonetti to Dir, Weapons Systems, CRDL, 13 Feb 63, subj: Report of Visit to Chance Vought Corporation. Chance Vought (later Ling-Temco-Vought) was the contractor for the Lance system.

thought a spherical bomblet (perhaps the smaller, 3-inch E136 sphere, which had been designed in CRDL's bomblet research program) might be the simplest solution from a cost effectiveness standpoint, cost effectiveness being a major management criterion in the Lance development program.[6]

(C) Cost effectiveness studies of spherical, cubical, and cylindrical bomblets, based on CRDL designs, were accordingly undertaken. The spheres were undeniably cheaper, considering each warhead payload as a unit, but it was also undeniable that only about 730 E136 spheres could be stacked in a warhead, as compared with over 1100 cubes or cylinders.[7] After a formal analysis was made by CRDL, showing costs as related to munition effectiveness, it was recommended by Edgewood Arsenal in December 1963 that a bomblet design based on a cylinder 2 1/2 inches in diameter and 2 1/4 inches long be accepted as the submunition of choice for the GB warhead project with a cubical bomblet as second choice in the event of development failures in the cylinder. This recommendation was based on cost, technical, and weapons effectiveness considerations, the cylinder and cube being regarded as superior to the sphere on a total cost-effectiveness basis, and the cylinder being considered a better item than the cube in terms of aerodynamic stability. This recommendation was accepted in January 1964, and the cylindrical bomblet became the heart of the GB Lance warhead.[8]

(C) The successful prototype bomblet, designated E139 (as the GB warhead it was intended for had been numbered E27), was a 3/4-pound cylinder containing a little over four ounces (0.262 pounds) of GB agent payload and a high explosive (tetryl) bursting charge. It was constructed of two cylindrical cups of aluminum alloy welded together at their periphery, with a lead band added at the midsection to increase rotational inertia in flight. At one end of the cylinder was a filling opening, sealed after fill by a pressed double ball closure; the other end contained the

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[6] Ltr, C, Nuclear Munitions Off, USAMUCOM to CG, CBR Agency, 12 Mar 63, subj: Cost Effectiveness of Chemical Munitions for Lance

[7] DF, Dir, Industrial and Engineering Services, USAEA, to Dir, Commodity Management, USAEA, 11 Jun 63, subj: Cost Effectiveness of Chemical Munitions for Lance

[8] (1) CRDL Technical Memorandum 83-4, Analysis, Based on Criteria of Cost and Effectiveness, of Candidate Submunitions for the Lance Missile with Chemical (GB) Warhead (2) Ltr, C, Weapons System Div, Dir of Commodity Management, USAEA to CG, USAMUCOM, 19 Dec 63, subj: Selection of Bomblet for Lance Chemical Warhead Section (3) Minutes, In-Process Review (IPR) No. 6, GB Warhead Section for Lance Missile, 15 Dec 66, Annex 4

burster well with its tetryl charge and an M219 grenade fuze. The essential self-dispersing flight characteristics were imparted by six longitudinal driving vanes or fins, contained on an aluminum collar which was pressed onto the bomblet body and fastened to the lead band. The aerodynamic effect of the vanes in flight produced a spin of the bomblet around its longitudinal axis, driving it outward and arming its fuze, which fired on impact with the ground. The subsequent burster explosion dispersed the agent into the air.[9]

(C) The E27 warhead itself had the same external configuration and dimensions as the other Lance warheads under development in the system. It was an aluminum alloy projectile-shaped munition 97 inches long, with a maximum diameter of 22 inches. Like the M212 Sergeant warhead, and for the same reasons (minimizing effects of aerodynamic heat stress resulting from high missile velocities) the E11 casing for the E27 warhead was designed as a skin-stressed, or monocoque, structure, with a minimum of internal support members and joints. Three longitudinal bars held prima-cord tightly against the inner surface of the skin, to rupture it on warhead activation. The payload of some 1140 E139 bomblets, containing roughly 300 pounds of GB agent (30% of the total weight of the warhead), was stored in the main section of the casing, to the rear of the nose cone. This section was sealed to reduce possible agent leakage to a minimum; an inner lining of charcoal diffusion felt was also provided to absorb agent vapor from any bomblet leak. The internal positioning of the bomblet stacks, after hand loading, was maintained by blocks of polyethylene foam. As in the case of the M212 warhead, an internal bomblet ejection system was provided, to thrust the bomblets clear of the missile afterbody upon warhead functioning, so as to prevent bomblet damage. After some study of other procedures, a nylon panel ejector, operating something like a slingshot when the warhead skin broke away, was adopted.[10]

(C) The fuze provided for the E27 warhead – the XM811E3B electronic time fuze – also served to actuate some of the other warheads in the Lance system. It contained five modular sub-assemblies housed in the missile nose cone: a tuning fork oscillator used as a time base, an electronics module to do the actual time reckoning, a battery unit, a detonator module, and a group of setting switches, with ranges of 8 to 199.9 seconds. At the

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[9] Minutes, IPR No. 6, E27 Warhead, 15 Dec 66, Annex 4

[10] Ibid

time set for warhead functioning the fuze detonators would go off, initiating RDX explosions which, relayed by a tetryl pellet, would activate the primacord in the main warhead section. The warhead skin would thereupon be peeled away in three sections, and the airstream breaking in on the warhead interior would evert the nylon panels which enveloped the bomblets, thrusting the latter outward.[11]

(U) During 1963, before a final decision on the bomblet of choice had been made, test flights of proposed bomblet designs had begun, using Little John rockets and warhead casings as test flight vehicles. These flights, the first of which was in April 1963, continued into 1964, and tested ejection methods as well as bomblet stability and dispersion characteristics. After seven such trials with Little John, an eighth research flight was made in May 1965 with an Honest John rocket, its warhead modified for radial ejection. By this time several E27 warheads had been fabricated, assembled, and put through some preliminary testing. It was expected that one of these would be flight tested on a Lance missile before the end of 1965. Slippages in the overall system schedule, however, made this impossible, and the first flight of an E27 warhead was therefore rescheduled for accomplishment with an Honest John rocket as the vehicle. A transition section to enable the warhead to be mated to the rocket was fabricated late in 1965, and the flight itself took place in January 1966 at White Sands Missile Range. The warhead and its contained bomblets functioned satisfactorily. Two days later, the E27 was flight tested with a Lance missile for the first time, but missile malfunctions aborted the test before the warhead was armed.[12]

(C) Subsequent research trials of the E27 warhead on Honest John rockets indicated a need for minor redesign of the ejection system to decrease the chance of bomblet damage; this was accomplished promptly. Overall results of these test flights indicated that the percentage rates of bomblet damage or malfunction were low and that the E139 bomblet performed aerodynamically as expected. Consequently, dispersion characteristics of bomblet impacts were predictable, varying with height of warhead functioning as planned. Impact pattern diameters varied from 1300 to 4000 feet, giving initial target areas of up to nearly half a square mile.[13]

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[11] Ibid

[12] Commodity Manager's Repts, EA, Lance Warhead Section, Jan 64–Jan 66

[13] Test Summary, E27 Warhead, Field Evaluation Div, Tech Support Dir, USAEA, 15 Dec 66

(U) The first successful flight of an E27 warhead on a Lance missile took place in July 1966, and was followed by two more later in the year. Bomblet performance was again found to be satisfactory. The test flight program continued through 1967, using both Lance and Honest John as vehicles, with tactical prototype warheads succeeding the engineering models of the earlier tests. By the spring of 1967 contracts were being awarded for procurement of warheads and bomblets for the engineering and service test phase, as the engineering design phase appeared headed for a successful conclusion.[14]

(C) As it happened, however, the overall Lance system was in the process of making basic schedule changes. Previously, slippages had resulted in stretch-outs of the original schedule. Now, the program called for a second development phase for an extended range version of Lance, with a modified propulsion system. By decision of the system project manager, the E27 warhead was placed on the extended range schedule only, stretching out its development schedule at least two years, though no basic warhead redesign was required. The test programs continued as before, with type classification now looked for not before 1970. In the meantime, as a consequence of the agent compatibility problems experienced by other aluminum munitions with certain lots of GB, a program was set up at Rocky Mountain Arsenal for surveillance testing of E139 bomblets loaded with redistilled GB largely free of the heavy metal ions that had been responsible for previous reaction with aluminum. This surveillance test began in the summer of 1967.[15]

(C) In general, it appeared by that time that an effective chemical warhead had already been achieved in the E27. An effectiveness study made at Edgewood Arsenal concluded that, with 30% casualties as a criterion of target defeat, one warhead per target against a standard target complex could defeat 98% of the complex when troops have no protective masks, and 90% when masks are available, but not worn before attack. Additional warheads, up to a total of four per target, would defeat 99% of the target complex even with masks available to troops.[16]

(U) In four previous attempts, the Edgewood laboratories had entered into advanced development of chemical warheads for major missile systems

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[14] Commodity Manager's Repts, EA, Lance Warhead Section, Jul 66 – Jul 67

[15] R&A, USAEA, 4th Qtr FY 67, p. 10

[16] Technical Memorandum 421-4, USAEA, Jul 66, Effectiveness of the Lance Missile with the E27 Warhead

late enough in the development life of those systems to make it difficult for warhead progress to keep pace with system progress. With the E27 warhead, development had not only kept pace with the parent missile system, but appeared likely to outpace it. Though this did not produce a new GB missile warhead capability for the Army in the late 1960's, as the first Lance schedules had promised, there was at least a lively prospect for such an accomplishment in the next decade.

CHAPTER 6

(C) CONCLUSION

(U) As the proponent of chemical warfare in a generation which had fought two wars without it, the Chemical Corps was more or less on the defensive in the 1950's. Firmly believing in the military utility of its special weapons, with their flexible and selective antipersonnel effects, it found it hard to fix the attention of the Army as a whole on such possibilities against the competition of the new nuclear and missile technology. One thing seemed certain – if chemical warfare were ever to be called for, the means to wage it must be available and up to date. Long range missiles and nuclear warheads tremendously enhanced the ability of the Army to place large-scale explosive charges on specific targets behind the front lines, the traditional function of big guns. Chemical warfare, which had also depended largely on artillery shells in the past, had to follow suit, offering as the counterpart of the new power of an atomic charge the new virulence of a nerve agent.

(C) The development of GB-loaded missile warheads was a natural course for chemical weaponry to take in the years following the standardization of the agent. Unfortunately, the available technology had not kept pace with the rapid onset of the missile age. Attempting with limited resources to use what was at hand at the outset of the 1950's, developers faced the task of mating subsonic and relatively bulky submunitions to a warhead designed for supersonic performance and sharply limited in total payload. A new submunition technology was needed. By the time this fact was recognized, essential time had gone by. New concepts finally were sought for and obtained, but by that time the first generation of standard Army guided missiles, the Corporal, was ready for deployment, and the opportunity of providing it with a chemical warfare capability had passed by.

(C) There remained the missiles still in development; if the 1950's were to pass without a GB capability achieved, the next goal was the armament of the 1960's. Using the more advanced techniques worked out too late for the Corporal, the chemical munitions developers, at first for the Chemical Corps, and from mid-1962 onwards to AMC, succeeded in bringing to standardization GB warheads for the Sergeant guided missile and the Honest John and Little John rockets. Yet even these successes, by the time they were registered in 1964, were behind-hand in terms of the development schedules of the missiles themselves. Subsequent efforts to produce and stockpile standardized warheads, so as to translate a development achievement into a capability in being, led to further delays.

(C) The accidental discovery that the redistilled agent being loaded into the M139 aluminum bomblets standardized for use with the new warheads was in fact incompatible with aluminum had the effect of ending the last prospect that chemical warheads for a system in being could be supplied to the Army in quantity in the 1960's. It was ironic that the very redistillation undertaken to improve the stability of existing lots of GB was the source of the contamination that made it unfit for use in the new weapons. Doubly ironic was the fact that it was the new aluminum bomblet, whose light weight and aerodynamic effectiveness in increasing the size of the target area had made possible the successful development of the new chemical warheads, which now proved to be incompatible with the available stocks of its destined payload. Further redistillation would in time salvage both agent and bomblet, but not before the decade neared its end. Meanwhile, with the passing time, the life cycles of the missile systems concerned were advancing, and the strength of the Army's requirement for associated warheads was likely to decline proportionately.

(C) Some ambiguity had already developed in that requirement. Though it had been formally promulgated, it was nevertheless true that the missiles had never been conceived primarily for use in chemical warfare and could be deployed without the chemical warheads they were supposed to require. The unwillingness of the Army to institute a production plan for the expensive M212 Sergeant GB warhead at the time of its standardization emphasized the uncertain character of the demand which warhead developers were working to satisfy. Chemical warfare had an accepted role in the nation's defense posture, in theory, but it was hard to rely on that fact in practice. The long postponement of production of the M190 and M206 warheads – a postponement which would, of course, have involved the M212 also, had it been on a production schedule, since all three warheads utilized the M139 bomblet – tended to cast doubt on the likelihood of their ever forming a significant part of the Army's stockpile of weapons. Thus, after some twenty years of effort, the ready availability of chemical warheads, marking the addition of the chemical warfare dimension to the Army's missile age, remained an unrealized goal.

(U) Frustrating as they might be, the incidental delays in development and standardization, and even the serious difficulties in production, were not the heart of the problem. This was, to begin with, the fact that for the first and second generations of Army missiles chemical warheads were in the nature of an after-thought, undertaken late and not always with adequate resources. Given the relatively brief life cycles of these missiles, such conditions made it necessary that development and production of chemical warheads be achieved at the most rapid rate possible, while at the same time limiting the likelihood that this could be done. Thus, for example, lack of funds with which to develop new submunitions led early in the 1950's to the waste of three or four years in the ill-fated attempt to work out a supersonic warhead incorporating the incompatible E54 subsonic bomblet. Underlying these conditions, in turn, was an unspoken uncertainty about the place of chemical warfare in the defense structure.

(C) The Lance chemical warhead program, as the 1960's drew to a close, seemed to offer something of a contrast to its predecessors. In this case the development program for the warhead was initiated at an early enough stage in the missile program to keep pace without difficulty. Indeed, with the stretch-out of missile development for the purpose of achieving extended range, the warhead program was, so to speak, left waiting upon missile development – for the first time since chemical warheads had come upon the scene. Profiting by the experience of the M139 bomblet, the Lance E139 bomblets were being tested betimes with newly redistilled GB, to avoid any unpleasant surprises in future production. There was every reason to believe that the Lance missile system, when standardized and ready for deployment, would have a standardized, producible, and practical GB warhead available as one of its payload options, should chemical warfare be resorted to. The prospect of a standard Army missile for chemical warfare still seemed just over the horizon as the 1970's approached. Whether this extension of chemical weaponry, so long anticipated and so laboriously brought into being, would indeed reach the field remained to be seen.