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FINAL REPORT

TECHNICAL FEASIBILITY TEST

OF

M16A1E1 RIFLE

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US ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MD 21005

2.12 HUMAN FACTORS EVALUATION

2.12.1 Objective

The objective is to determine the effectiveness of the man-machine interface of the product improved rifle and its accessories from the human-factors viewpoint.

2.12.2 Criteria

a. The design shall adhere to the principles of sound human-factors engineering in accordance with MIL-STD-1472B in all aspects of operation and maintenance (AR 702-3, ref 13).

b. The product improved barrel will accommodate the mounting of all accessories or munitions presently mounted on or fired from the standard barrel to include the following (devised by Test Agency):

(1) M203 40-mm grenade launcher.

(2) M7 bayonet.

(3) MILES (not available during test time frame).

(4) M234, RAG launcher (for information purposes only).

(5) M261, conversion kit.

(6) M29, rifle grenade.

(7) M15A2, blank firing attachment.

2.12.3 Data Acquisition Procedure

a. An initial human-factors evaluation inspection of the test items was conducted during the initial inspection to determine if conditions exist that render the item unsuitable for test personnel to operate.

b. Testing personnel monitored the human-factors man-item relationship throughout the test. Methods pertaining to weapon accessories, disassembly and assembly, and maintenance operations were fully described in those subtests.

c. Human performance reliability was evaluated as far as possible in terms of frequency and consequence of human errors committed during assembly, operation, and maintenance of the weapon.

2.12.4 Results

a. Initial evaluation inspection did not reveal any condition that would render the item unsuitable for test personnel to operate.

b. Human performance reliability was very good. It was noted that there was an occasional error of trying to place the 30-shot magazine into the rifle upside down. This is common to both models and lies in the design of the magazine. Dimensions permit the insertion of the base area into the magazine well and if forced, will bind making it hard to remove.

c. The accuracy shooters (5) provided the following opinions/comments regarding the M16A1E1 design. It should be noted that the comments were gleaned from marksmanship oriented personnel (civilian and military) as opposed to combat oriented military personnel.

(1) A longer buttstock or the means to lengthen the present one for individual users would be desireable.

(2) The rear sight aperture was too large for general use. At least one of the apertures could be smaller to obtain clearer sight pictures.

(3) The front sight was also felt to be too large in diameter. It was felt that a diameter the same or slightly smaller than the present M16A1 would be ideal.

(4) The round handguard on the M16A1E1 was liked by all personnel. The increased frontal area was thought to be very comfortable.

(5) The increased barrel weight improved handling, shooting, etc. It was felt a few more ounces in the barrel area would be beneficial in the automatic mode and in the standing position.

(6) The butt plate was too smooth and moved on the shoulder while firing. More checking of the butt plate would be beneficial.

(7) One accuracy shooter was left handed and was very appreciative of the spent case deflector design. No problems were encountered by any shooters due to spent cases striking the firer (para 2.14).

(8) The trigger pull weight and feel were felt to be an area that could be improved. The trigger pull was too heavy and the feel was not good. The standard M16A1 had an overall better trigger weight and feel.

(9) The overall design of the rear sight was good, rugged, and easy to use. The adjustments were positive and easily made.

(10) The muzzle brake compensator did not hinder or help the rifles performance on the M16A1E1.

2.12.5 Analysis

All shooters believed that the M16A1E1 would be superior to the M16A1 in all aspects with the exception of trigger pull and feel.

2.12.6 Conclusion

a. The M16A1E1, as evidenced during testing, is superior to the M16A1 model as issued. However, minor human engineering refinements would enhance its positive qualities even further.

b. The criteria were considered met with the exception that the M234 RAG launcher cannot be mounted on the M16A1E1 rifle due to barrel configuration at the mounting point.

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2.13 RELIABILITY EVALUATION

2.13.1 Objective

The objective was to collect, evaluate, and compare reliability data from the standard and improved rifles, including bore wear data.

2.13.2 Criteria

a. The reliability and durability of the test weapons during the first 6000 rounds of firing shall not exceed the limits cited in table 1 of MIL-R-45587A (ref 7).

b. The improved plastic handguards and buttstock failure rate will not exceed the failure rate of the control item (Test Agency, TECOM approved).

2.12.3 Data Acquisition Procedure

a. Testing was in accordance with TECOM TOP/MTP 3-2-059, Hand and Shoulder Weapons (ref 12).

b. Data were drawn from testing as outlined in paragraphs 2.3 through 2.6, where relevant. Where environmental treatments or other extreme conditions warranted, reliability indices were calculated separately.

2.13.4 Results

a. The reliability and durability of the test rifles during the first 6000 rounds of firing were not to exceed limits of table 1 of MIL-R-45587A. That table is presented below as table 2.13-1.

TABLE 2.13-1. MALFUNCTIONS PERMITTED IN 6000 ROUNDS

Malfunctions	Single Rifle	Four Rifles
Failure of bolt to lock	2	4
Failure to fire	2	4
Failure to feed (from magazine)	4	9
Failure to eject	2	4
Failure to chamber	3	7
Failure to extract	1	2
Bolt fails/hold rear	3	8
All other malfunctions	0	0
Total, above malfunctions combined	9	22

b. Five control rifles (M16A1) were fired. One fired 12,080 rounds, two fired 12,066 rounds each, and two fired 10,920 rounds each. Likewise, five test rifles (M16A1E1) were fired, using XM855E1 ammunition with each barrel being unserviceable after 6080 rounds. Table 2.13-2 below presents a summary of the stoppages for each weapon out to 6000 rounds.

2.13.4 (Cont'd)

TABLE 2.13-2. SUMMARY OF STOPPAGE DATA, FIRST 6000 ROUNDS OF ENDURANCE TEST[a]

Rifle Type	Rifle No. (APG)	Total Rd Fired	Number of Stoppages FF1	FFD	FBC	FFR	FXT	FEJ	Total
M16A1 with M193 cartridge	1A	6000	4						4
	2A	6000	9	1	2				12
	3A	6000	36	8					44
	4A	6000	1						1
	5A	6000	17	2	1	1			21
Total first four weapons			50	9	2				61
Total all weapons			67	11	3	1			82
M16A1E1 with XM855E1 cartridge	1D	6080	1			3			4
	2D	6080	2					1	3
	3D	6080	2						2
	4D	6080	4	1		3			8
	5D	6080	1			4	1		6
Total first four weapons			9	1		6		1	17
Total all weapons			10	1		10	1	1	23

[a]All stoppages were classified as class I, clearable by immediate action.

FF1 = Failure to feed first round in magazine.
FFD = Failure to feed.
FBC = Failure of bolt to close.
FFR = Failure to fire.
FXT = Failure to extract.
FEJ = Failure to eject.

c. Parts failure during the entire testing period were low. Table 2.13-3 shows the maximum number of unserviceable parts allowed by MIL-R-45587A. Table 2.13-4 presents parts failure data throughout endurance testing.

2.13.4 (Cont'd)

TABLE 2.13-3. UNSERVICEABLE PARTS PERMITTED IN 6000 ROUNDS

Unserviceable Parts	Minimum Life Rounds[a]	Four Rifles Combined[b]
Ejector spring	3000	2
Extractor spring	2000	4
Other parts[c]	3000	1
Total unserviceable parts, above		
Total unserviceable parts, combined		4

[a]Minimum life rounds is defined as the minimum service life of an individual part, whether it is the original part or a replacement part, expressed in the number of weapon rounds fired with the part assembled in the weapon. For example, an extractor spring failing prior to firing 2000 rounds on a new rifle, has not met the minimum life rounds. The failure shall be recorded and shall be cause for test failure.

[b]The allowable number of unserviceable parts shown for four rifles combined applies only to parts failing after the minimum life rounds have been fired on the weapon. For example, ejector springs failing at 3500 rounds on one rifle, and at 4100 rounds on a second rifle, fall within the allowable limits of two unserviceable parts on four rifles combined; however, failure of an ejector spring on a third rifle after firing 3000 rounds which exceeds the allowance, shall be cause for test failure.

[c]Other parts shall be limited to trigger spring, disconnect spring, hammer spring, extractor pin and extractor.

2.13.4 (Cont'd)

TABLE 2.13-4. SUMMARY OF DAMAGED PARTS

Part Nomenclature	Subtest	Part Rd	Stoppage Cause	Rifle Type
Carrier key screw[a] (2)	High temperature	1456	Yes	M16A1
Buffer assembly[a]	Low temperature	1828	Yes	M16A1E1
	Low temperature	2286	Yes	M16A1E1
	Low temperature	2043	Yes	M16A1E1
	Low temperature	2323	Yes	M16A1
	Endurance	6600	Yes	M16A1
Cam clutch spring[b,c]	Low temperature	1803	No	M16A1E1
	Endurance	5760	No	M16A1E1
Lower receiver[a]	Low temperature	Drop test	Yes	M16A1
Bolt ring[a]	Endurance	4800	No	M16A1
Bolt[a]	Endurance	6000	No	M16A1E1
Barrel[b] (1:7 twist)	Endurance	6000	No	M16A1E1

[a]Parts that are common to M16A1 and M16A1E1.
[b]Part that is peculiar to M16A1E1 only.
[c]Cam clutch springs were examined and found to be improperly formed. New springs were obtained within tolerance with no failures experienced.

d. The improved plastic handguards and buttstock failure rate did not exceed the failure rate of the control parts. M16A1E1 high- and low-temperature drop test and rough handling samples exhibited minor abrasion to minor cracking of the improved plastic parts. The control plastic parts indicated the same amounts of abrasion; however, the plastic parts had higher failure rates. The specific damages are listed in paragraphs 2.4 and 2.7.

e. A summation of rifle stoppage data, for appropriate subtests, is presented in table 2.13-5. Those subtests not listed did not have stoppages.

TABLE 2.13-5. STOPPAGE DATA SUMMARY

Subtest	Rifle Type	Sample Size	No. of Stoppages	Rd Fired
Inspection	M16A1			
	M16A1E1			
Endurance (first 6000 rounds)	M16A1	5	82	30,000
	M16A1E1	5	23	30,400
Endurance (all rounds)	M16A1	5	162	58,052
	M16A1E1	5	37	[b]48,466
High temperature	M16A1	5	19	6,000
	M16A1E1	5	9	6,000
Low temperature	M16A1	5	40	6,000
	M16A1E1	5	181	6,000
	M16A1[a]	3	15	3,600
	M16A1E1[a]	3	4	3,600
Salt water immersion	M16A1	2	51	600
	M16A1E1	2	58	600
Sand and dust	M16A1	2	3	240
	M16A1E1	2	4	240
Unlubricated	M16A1	1	20	600
	M16A1E1	1	0	600

[a]Retest with SS109 cartridge.
[b]Less 6000 rounds on each of three rifles when no stoppage data were taken.

2.13.5 <u>Analysis</u>

a. From the reported results only the M16A1E1 rifle firing SS109 cartridges, met the reliability criteria for the endurance and accuracy test. The original M16A1E1 barrel, for three of the test weapons (rifles numbered 1D, 3D, 5D), was removed and a new barrel placed on the lower receiver group. Each of the three weapons then fired 6080 rounds of SS109 ammunition to bring barrel rounds up to the total number of rounds that were fired on the original barrel. Stoppage data were not recorded for these firings. Since stoppages were not recorded for the first 6000 rounds fired using the M16A1E1 rifles with SS109 ammunition, no determination of stoppage rates could be made. Firing continued for these three weapons from that point to 12,012 rounds with stoppages being recorded. Table 2.13-6 presents the summary of results and reliability estimates of mean rounds between stoppages for the endurance and accuracy phase for the total rounds fired.

2.13.5 (Cont'd)

TABLE 2.13-6. SUMMARY OF RESULTS AND RELIABILITY ESTIMATES FOR MEAN ROUNDS BETWEEN STOPPAGES FOR THE ENDURANCE/ACCURACY TEST

Rifle Type	Ctg Type	Rifle No. (APG)	Barrel No. (APG)	Total Rd Fired	No. of Stoppages	MRBS	Lower 90% Conf Limit on MRBS
M16A1	M193	1A	1A	12,066	17	710	511
		2A	2A	10,920	25	437	333
		3A	3A	12,080	79	153	131
		4A	4A	12,066	17	710	511
		5A	5A	10,920	24	455	345
		All		58,052	162	358	323
M16A1E1	XM855E1 (FN)	1D	1D	6,080	4	1,520	760
		2D	2D	6,080	3	2,027	910
		3D	3D	6,080	2	3,040	1,142
		4D	4D	6,080	8	760	467
		5D	5D	6,080	6	1,013	577
		All		30,400	23	1,322	998
M16A1E1	SS109	1D	C4	6,022	5	1,204	649
		3D	C7	6,022	7	860	511
		5D	C5	6,022	2	3,011	1131
		All		18,066	14	1,290	897

b. The M16A1 control rifles failed to meet the allowable number of malfunctions permitted in 6000 rounds (table 2.12-1 and 2.12-2). The M16A1E1 met the allowable number of malfunctions when XM855E1(FN) ammunition was used; however, all barrels used were beyond serviceable life at the 6000 round interval. It is notable that during the extended endurance and accuracy testing, the M16A1E1 barrel life using SS109 ammunition was acceptable through the 12,000 round interval. While no stoppage data were recorded on the first 6000 rounds of the M16A1E1/SS109 endurance phase, no out-of-the ordinary number of malfunctions were experienced and the rates for the interval from 6000 to 12,000 rounds were acceptable.

c. Within the confines of the cyclic path of the bolt mechanism and the feeding mechanism both types of rifles are identical by design. Both rifles were manufactured by the same factory (Colt Industries) except at different times. The M16A1 rifles were provided from depot storage. The magazines were randomly assigned to each weapon from the same batch received for the test, all were from the same manufacturer (Adventure Line, Inc.). All magazines were loaded on the same APG magazine loading fixture utilizing, in both cases, carton-packed cartridges. The rifles were tested side by side by the same gun crews. The projectile weights and shapes (fig. 36, app B) are slightly different but not so much as to affect feeding by themselves. At this point, there is no apparent reason for the disparity in the number of feeding stoppages between the two rifle types. The number of feeding stoppages for the M16A1 far exceeds the limits imposed by MIL-R-45587A (ref 7) and the results of the most recent production comparison test performed by APG (ref 30). Areas for further investigation might include the force of the action springs and dimensional differences in the barrel extensions.

d. Parts failures were considered minimal and within the allowable range (table 2.13-3). Overall parts durability of both models was considered very good.

2.13.6 Conclusions

a. The reliability and durability criterion (para 2.13.2a) was not met for the M16A1 firing M193 cartridges or the M16A1E1 firing XM855E1 cartridges; the criterion was met by the M16A1E1 firing SS109 cartridges.

b. The parts (including the improved plastic handguards and buttstock) failure rate criterion of paragraph 2.13.2b was considered met.

2.14 SAFETY AND HEALTH EVALUATION

2.14.1 Objective

The objective is to determine if the product improved components affect the safety of the M16A1 rifle.

2.14.2 Criterion

The basic safety features and safety record of the M16A1 rifle shall not be degraded by the product improved components (devised by Test Agency, TECOM approved).

2.14.3 Data Acquisition Procedure

a. Testing was in accordance with TECOM TOP 3-2-054 and 3-3-065.

b. After initial examination of the weapons and review of related literature, a determination was made as to whether additional safety checks were necessary before permitting shoulder firing by test personnel.

c. Each barrel or weapon was examined for proof marking.

d. Observations were made continually throughout all testing for actual, incipient, or potential safety hazards. Any safety hazards found were identified and categorized in accordance with MIL-STD-882A, System Safety Program Requirements, 28 June 1977.

e. Subtests that have specific application to the safety evaluation include cookoff, sustained fire, high and low temperatures, and rough handling.

2.14.4 Results

a. During the initial inspection of the M16A1E1 and the M16A1, safety and selector mechanisms were examined and tested. All performed in a satisfactory manner. Other preliminary and secondary safety factors were evaluated. A complete description of all safety features is given in paragraph 2.2.4. The developer-prepared technical manual and the developer's safety assessment report, and the results of testing at the Quantico, VA Marine Corps Base were searched for safety related problems. Except for safety problems relating to fired cartridge case ejection path, nothing other than the necessity for normal small arms related safety precautions were noted.

b. During the initial inspection firing, one potential safety problem was noted in the case ejection path of the M16A1E1. Expended cartridge cases are ejected toward adjacent personnel. Initially, this problem was noted during a visit to MCDEC, Quantico, VA to observe operational tests. This situation was monitored throughout the test and was found to give a case ejection path of between two and four o'clock (referenced to the line of fire as 12 o'clock) depending upon the mode of fire and the characteristics of the individual weapons. The ejection path of the M16A1 is between 2 and 5 o'clock.

c. The M16A1E1 has a proposed brass deflector design that will be milled out of the original forging as a protrusion of the upper receiver group. The test models had the same dimensions as the production model will have but due to limited-run manufacturing costs, they were temporarily bonded in place as an expedient. This design is primarily to eliminate the spent case from hitting the left hand shooter in the right facial area. The design worked very well and prevented the ejection pattern from coming further to the rear than the four o'clock position.

d. Cookoff test results (para 2.5.4) indicate that 170 rounds of the SS109 ammunition could be safely fired in the M16A1E1 rifle for the particular firing schedule (85 spm) used in that test. The M16A1 rifle, firing the same schedule, reaches the cookoff level (M193 cartridges) at 150 rounds.

e. Sustained fire test results (para 2.6.4) substantiated that 450 rounds of the SS109 ammunition could be safely fired in the M16A1E1 rifle, for the lower firing schedules (15, 20 and 30 spm) used in that test. At higher firing rates (40 and 60 spm) the rifle will cookoff. Cookoff occurs with the M16A1/M193 system at 30, 40 and 60 spm.

f. Noise level test results (para 2.10.4) revealed that the M16A1E1 rifle produced excessive noise levels (140 to 155 dB). The levels of the M16A1 rifle, also excessive, were from 142 to 158 dB.

2.14.5 <u>Analysis</u>

a. While accuracy and endurance firings were being conducted, it was noted that the 2 o'clock through 4 o'clock ejection path did not change. This pattern will produce interference with the adjacent firer to the right of the rifle (i.e., range practice, firing from a foxhole, etc.). Hot cartridge cases coming into contact with adjacent firers have caused at least two serious accidents since 1980 (ref 28). The hot cases became entrapped under a firers collar and in an effort to get them out he lost control of the weapon and accidently shot personnel nearby. There is also the good chance of adjacent firers being struck in the eye by the spinning case.

b. While observing operational testing of the subject rifles on the USMC range at Quantico, VA, APG personnel noted from one-third to one-half of all fired cases struck adjacent firers on the upper body. Because of prevailing low temperature conditions the operational test subjects were dressed in appropriate winter clothing which insulated and protected bare skin areas. Cartridge cases are hot enough to cause second degree burns in just momentary contact with bare skin.

c. The cartridge case ejection problem with the M16A1E1 rifle has been judged to be a deficiency of the system with a hazard probability/severity rating of catastrophic/occasional based on table 2.14-1. The military standardization handbook of Human Factors Engineering Design for Army Material (ref 31) recommends that the ejection path be directed toward the right and forward (1 to 2 o'clock). The ejection path of the M16A1E1 is an improvement over the M16A1.

2.14.4 (Cont'd)

d. The results of the cookoff and sustained fire tests define the cookoff and safe levels for full automatic and semiautomatic firing. The cookoff level for the M16A1E1 is higher under both conditions. The noise level exceeded 140 dB; therefore, hearing protection (plugs or muffs) are required by personnel near the weapons under training conditions, as is true also with the M16A1.

2.14.4 (Cont'd)

TABLE 2.14-1. HAZARD PROBABILITY VERSUS HAZARD SEVERITY

		HAZARD PROBABILITY					
		FREQUENT	REASONABLY PROBABLE	OCCASIONAL	REMOTE	EXTREMELY IMPROBABLE	IMPOSSIBLE
SPECIFIC INDIVIDUAL ITEM		Likely to occur frequently	Will occur several times in life of item	Likely to occur sometime in the life of item	So unlikely, can be assumed that this hazard will not be experienced	Probability of occurrence cannot be distinguished from zero	Physically impossible to occur
FLEET OR INVENTORY		Continuously experienced	Will occur frequently	Will occur several times	Unlikely to occur, but possible	So unlikely, can be assumed that this hazard will not be experienced	Physically impossible to occur
HAZARD SEVERITY		A	B	C	D	E	F
CATASTROPHIC - May cause death or system loss	I	DEFICIENCY	DEFICIENCY	DEFICIENCY	DEFICIENCY	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
CRITICAL - May cause severe injury or illness, or major system damage	II	DEFICIENCY	DEFICIENCY	DEFICIENCY	SHORTCOMING	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
MARGINAL - May cause minor injury or illness, or minor system damage	III	DEFICIENCY	SHORTCOMING	SHORTCOMING	SUGGESTED IMPROVEMENT	SUGGESTED IMPROVEMENT OR ACCEPTABLE	ACCEPTABLE
NEGLIGIBLE - Will not result in injury or illness, or system damage	IV	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE

2.14.6 Conclusion

The basic safety features and safety record of the M16A1 rifle will not be degraded by the M16A1E1 rifle. The criterion is considered met.

2.15 LOGISTIC SUPPORTABILITY

2.15.1 Objectives

a. To ensure that each maintenance action performed during testing will be sufficiently defined to provide adequate data to perform the logistic supportability analysis.

b. To determine the adequacy of technical data/equipment publications and support and test equipment.

c. To ensure that the test items meet the design requirements and adhere to good maintainability design principles.

d. To determine if safety and human-factors aspects of maintenance operations are satisfactory.

2.15.2 Criterion

Adoption of this weapon will not generate additional personnel requirements. Skills required for operation, organizational and direct support maintenance will not exceed those skills currently associated with the M16A1 rifle (devised by Test Agency, TECOM approved).

2.15.3 Data Acquisition Procedure

a. Testing was in accordance with TECOM TOP/MTP 3-4-059 (ref 5).

b. All maintenance operations were in accordance with instructions in the relevant equipment publications, utilizing the support and test equipment authorized in the system support literature. All organizational and DS/GS maintenance operations were monitored to accumulate the required quantitative data; operator's daily checks and services were observed sufficiently to obtain a representative time to perform these tasks. Note was made as to whether or not support and test equipment are actually needed, could be replaced with common items, or if additional support and test equipment is needed. Notes were also made relative to inadequacies in equipment publications and to their content adherence to standards of production for technical manuals. One hundred percent of operator, organizational and DS maintenance tasks were reviewed, including simulated maintenance actions as necessary, and comments provided regarding adequacy of available maintenance instructions, repair parts information, support equipment, maintenance level assignment, and personnel skills. Tasks currently assigned to depot level were reviewed for possible reassignment.

c. Throughout the test, all maintenance operations were observed and records maintained relative to ease of access and installation of components, modular design considerations, interchangeability of parts, feasibility of replacing parts peculiar to the test item with standard items, ability of protective devices to prevent damage during maintenance, and other factors that indicate the equipment design has (or has not) been directed towards minimizing maintenance and reducing logistical requirements. DARCOM pamphlet 706-134 (ref 19) was used as a guide in determining maintainability design characteristics. In conjunction with the above observations, records were maintained that involve the man-item relationship and the safety of maintenance. Information in MIL-STD-1472B (ref 20), DARCOM pamphlet 706-134, and TECOM TOP/MTP 1-2-610 (ref 21) including the HEDGE (Human Engineering Data Guide for Evaluation) were used for guidance.

2.15.4 Results

2.15.4.1 Maintenance actions.

a. The maintenance actions for the M16A1 and M16A1E1 are summarized in table 2.15-1. The data were summarized only for the five rifles of each type fired during the endurance test.

b. Normal scheduled maintenance (clean, inspect, and lubricate) was performed at 1200 round intervals, and before and after each subtest. The average time required was 0.66 man hours per rifle.

c. Detailed parts replacement schedules were not furnished for the M16A1E1 rifles. Parts were not replaced until failure occurred, in order to determine actual part life. Table 2.15-2 summarizes part failure data. With the rifles used in all other subtests, maintenance was not necessarily performed on a scheduled basis, and parts were sometimes replaced before failure in order to permit a better assessment of weapon performance under the conditions of the various subtests. (For example: If, during maintenance before the low temperature test, a plastic part i.e., grip, stock etc., were subjected to rough handling etc., these parts were replaced in order to provide the best operating conditions for the rifle. During the endurance test, parts were not replaced until failure or until malfunctions related to a specific part occurred.)

2.15.4.1 (Cont'd)

TABLE 2.15-1. MAINTENANCE INDICES

Item	Value M16A1	Value M16A1E1
Operator level		
Number of maintenance actions (MAs)	[a]0	0
Organizational level		
Number of MAs	2	5
Time (manhours)	0.06	1.66
MTTR (hours)	0.03	0.332
Total:		
Number of MAs	2	5
Time (manhours)	0.06	1.66
MTTR (hours)	0.03	0.332
Rounds fired	48,212	[b,c]66,706
MRBMA	24,105	16,677

[a]No parts are available at operator level. Only cleaning and lubrication permitted at this level.
[b]Changes in test plan, references 2, 3, and 4 accounted for the difference in rounds fired between rifle types.
[c]Rounds counted for endurance on the M16A1E1 include the initial XM855E1(FN) ammunition segment, as well as the SS109 ammunition segment.

Maintenance ratio (MR):

$$MR = \frac{\text{Total active maintenance man hours (all levels)}}{\text{Total rounds fired}}$$

Mean-time-to-repair (MTTR). Compute for organizational level of maintenance and overall.

$$MTTR = \frac{\text{Total corrective maintenance time, clock hours (for organizational level)}}{\text{Total number of malfunctions corrected at each level}}$$

Mean-rounds-between-maintenance-actions (MRBMA):

$$MRBMA = \frac{\text{Total number of rounds}}{\text{Total number of maintenance actions}}$$

2.15.4.2 Maintenance equipment.

a. No special operator type maintenance kits were supplied. The standard M16A1 rifle cleaning equipment was used and was adequate for the M16A1E1 rifle. The standard issue cleaning items were used in all operations and worked very well. The cleaning rod, brushes, and cleaning equipment were storable in the buttstock cavity of the rifle. The cavity size is the same as on the standard M16A1 rifle.

b. The set of manuals for the M16A1E1 was adequate even though it was not written in the format currently associated with US military technical manuals. The manuals included an operator's manual (-10 type) and an armorer's manual. The extensive experience of the civilian maintenance staff obtained during previous tests of this type ensured that proper maintenance procedures were followed.

2.15.4.3 Design for maintainability.

a. The M16A1E1 was designed to be simple and easy with respect to maintenance. The rifle could be broken down into the same subassemblies as the M16A1 standard rifle which are easily cleaned and replaced at the operator/organizational level.

b. The causes of malfunctions were easy to determine which in turn localized the problem to a specific modular assembly. The rifles were all maintainable by adequately trained maintenance personnel at the organizational support level. No special tools are required for operator level assembly or disassembly.

c. Adoption of the M16A1E1 would not generate additional personnel requirements, from the maintenance standpoint. The skills required for operator and organizational maintenance will not exceed those skills currently associated with the M16A1 rifle.

d. The average times required to field strip and reassemble the M16A1E1 are identical to the standard M16A1 rifle as subassemblies are identical.

2.15.4.4 Parts.

a. All repair parts were furnished in a system support type package with the exception of spare 1:7 twist barrels obtained by ARRADCOM personnel.

b. The parts that failed, part life, and types of failures are tabulated in table 2.15-2. Parts that failed in endurance are indicated as well as parts causing stoppages.

c. The cam clutch spring is part of the burst control device and is assembled with the control cam on the new hammer as shown in figure 11 of appendix B. Figure 34 shows samples of properly and improperly formed and broken cam clutch springs.

d. The new adjustable rear sight assembly should be relegated to the direct support level or higher, for assembly or disassembly, due to the tools required and the numerous small parts.

2.15.4.4 (Cont'd)

TABLE 2.15-2. PART FAILURE DATA

Part Nomenclature	Federal Stock No.	Rifle Type	Part Life (rd)	Maintenance Level	Remarks
Buffer assembly[a]	1005-937-3078	M16A1	6600	Organizational	Failed in endurance.
Bolt ring[a]	1005-992-7287	M16A1	4800	Organizational	Noted at 4800 rd C-I-L.
Bolt assembly[a]	1005-992-7285	M16A1E1	6000	Organizational	Noted at 6000 rd C-I-L.
1/7 twist heavy barrel[b]	NA	M16A1E1	6000	Organizational	Excessive dispersion noted at 6000 rd accuracy firing (3 ea).
Cam clutch spring[b,c]	NA	M16A1E1	5760	Organizational	Rifle continued to function.

[a]Parts that are common to M16A1 and M16A1E1.
[b]Parts that are peculiar to M16A1E1 only.
[c]Cam clutch springs were examined and found to be improperly formed.
New springs were obtained within tolerance with no failures experienced.

2.15.5 Analysis

a. The maintenance data accumulated during the endurance test were used to compute the maintainability indices in table 2.15-1 to quantify the maintainability of the M16A1E1. Scheduled maintenance actions were not included in these computations.

b. Attention is directed to the MRBMA figures for the M16A1E1 rifle. This figure reflects the three of the five original barrels that had fired the XM855E1(FN) ammunition and were considered unserviceable. These were replaced at the 6000 round interval with new barrels and the originally scheduled 12,000-round endurance test was fired using SS109 Belgian ammunition. In essence only two unscheduled maintenance actions were performed on each type rifle during the endurance firings. It is noted that failure of the cam clutch spring of the M16A1E1 will not create a stoppage of the rifle. The purpose of this spring is to engage the ratchet clutch of the three shot BCD. This limits the automatic fire mode to three shots duration. Spring breakage will allow the rifle to fire until the magazine is empty or the trigger is released. In essence, the rifle mechanism simply reverts to the same fire selection modes as the M16A1 standard rifle.

c. Both the M16A1 and M16A1E1 models had very few parts failures throughout testing. The overall majority of the parts are common between the two models, thus making organizational maintenance easier.

2.15.6 Conclusion

Adoption of the M16A1E1 rifle will not generate additional personnel or skill requirements. The criterion was met.

SECTION 3. APPENDICES

APPENDIX A - CRITICAL ISSUES, OTHER ISSUES AND TEST CRITERIA

Part 1. Critical Issues

Item	Source	Issue	Applicable Subtest	Remarks
1	TECOM TDP, para 3a	Will the new barrel (with the 1 in 7 twist be capable of withstanding a firing of 12,000 rounds (6000 rounds for Marine Corps decision point and comparison to MIL-R-45587A) without exhibiting a velocity drop of 200 fps (61 m/s) when comparing the average cold barrel velocity when new to the average hot barrel velocity at the end of each 1000-round test group? A barrel will also fail if 20% or more of a 100-round yaw group exhibits yaw of 15° or more if the extreme spread exceeds 17.8 cm at 91.4 meters.	2.3	Original barrels (with 1 in 7 twist) failed prior to the 6000 round point when using XM855E1(FN) ammunition. Velocities and yaw were still within stated limits. Final testing using new (1 in 7 twist) barrels and SS109 ammunition with respect to durability, disperion, dispersion, and yaw achieved 12000 round life.
2	TECOM TDP, para D6	Is the accuracy of the improved rifle equal to or better than the standard M16A1/M193 combination?	2.3, 2.11	The accuracy/dispersion with XM855E1(FN) was not as good as the M16A1/M193 combination. The accuracy/dispersion with SS109 ammunition was better than the M16A1/M193 combination (see Endurance and Accuracy).
3	TECOM TDP, para D4	Is the durability of the improved plastic parts equal to or better than the current buttstock and handguards?	2.4, 2.7 2.8	The durability of the improved plastic parts was better than the current buttstock and handguards.
4	TECOM TDP, para D4	Does the increase in barrel outside diameter improve the barrel's resistance to bending when subjected to suspected operational stresses?	2.8	The increase in barrel outside diameter improved the the barrel's resistance to bending when subjected to operational stresses.
5	TECOM TDP, para D1	Is the RAM-D of the basic M16A1 design under ambient and extreme temperature conditions, degraded by the addition of the M16A1E1 improvements?	2.3, 2.4	The RAM-D of the basic M16A1 design was not degraded by the addition of the M16A1E1 improvements.
6	TECOM TDP, para 5D	Is the hit probability of the improved rifle better than that of the standard rifle? What improvements affect hit probability?	2.11	Testing conducted at Fort Dix, ARRADCOM test site. From data received and analyzed, there does not appear to be any difference between the standard and product improved rifle.

Item	Source	Issue	Applicable Subtest	Remarks
7	TECOM TDP, para D7	Does the firing of M193 round in the M16A1E1 or XM855 in the M16A1 present any functioning or safety problems in those weapons?	2.2	No functioning or safety problems were noted. Use of XM855E1(FN) and SS109 in the M16A1 results in extreme dispersion of shots. This is because the M16A1 has a 1 in 12 twist barrel. The above projectiles require a faster pitch rifling to stabilize the heavy projectile.
8	TECOM TDP, para D8	Does the M16A1E1, utilizing the XM855 cartridge, present any hazardous conditions to the gunner?	2.14	No.

Part 2. Other Issues

Item	Source	Issue	Applicable Subtest	Remarks
1	TECOM TDP, para 6	Are the new plastic parts compatible with common cleaning and lubricating fluids?	2.8	The new plastic parts are compatible with common cleaning and lubricating fluids.
2	TECOM TDP, para 6	Is the function and accuracy of the new rear sight (ARS) degraded by rough handling?	2.7	The function and accuracy of the new rear sight were not degraded by rough handling.

Part 3. Test Criteria

Item	Source	Criteria	Applicable Subtest	Remarks
1	Devised by Test Agency, TECOM approved	The test items shall be adequately and clearly marked and undamaged.	2.2	Met.
2	MIL-R-45587A, para 3.4.3	The trigger pull shall be free of creep and shall be within the range of 5.5 to 8.5 pounds. Creep shall be interpreted to mean any perceptible rough movement between the trigger slack is taken up and the hammer is released. After partial or completed trigger pull, the trigger shall return to its normal forward position (cocked and uncocked) under spring action.	2.2	Partially met.

Item	Source	Criteria	Applicable Subtest	Remarks
3	MIL-R-45587A, para 3.4.1	The headspace shall not be less than 1.4646 inches nor more than 1.4706 inches when measured to the 0.330 inch datum diameter on the first shoulder of the chamber.	2.2	Met.
4	MIL-R-45587A, para 3.3.4.2	Firing-pin protrusion shall be 0.028 to 0.036 inch.	2.2	Met.
5	MIL-R-455877A, para 3.4.2	When the bolt is closed and the firing mechanism is released, the firing pin indent shall be not less than 0.020 inch. The firing pin indent shall not be off center more than one-half the maximum diameter of the indent. When, in a vertical, muzzle down position, the bolt carrier assembly is released from the full recoil position and the firing mechanism is not actuated, the firing pin indent shall not be more than 0.008 inch.	2.2	Partially met (para 2.1). Firing pin indent below minimum at initial inspection.
6	MIL-R-45587A, para 3.4.5	The cyclic rate of fire for a 30-round continuous burst using a 30-round magazine shall be within 700 to 900 shots per minute when firing Government standard weapon (M16A1 and ammunition M193 ball).	2.2	Met.
7	MIL-R-45587A, para 3.4.6	Targeting and accuracy. A series of 10 rounds fired from each rifle at a range of 91.4 meters shall be within the rectangular outline of the targeting and accuracy diagram (17.6 by 11.6 in.) when front and rear sights are set as follows. The normal rear sight peep (sight rotated fully rearward) shall be used with the rear sight set centrally in the slot for windage within ± two (2) clicks. The top edge of the front sight post flange shall be set flush to 0.030 inch below the bottom surface of the front sight slot. Ammunition shall be Government standard M193, 5.56-mm ball cartridges and shall have been certified by the Government to be of quality that	2.2	Partially met (para 2.1). Five M16A1 and two M16A1E1 rifles (out of 10 each) failed to meet requirements.

Item	Source	Criteria	Applicable Subtest	Remarks
		will group within a mean radius of 1.2 to 1.4 inches at 200 yards.		
8	MIL-R-45587A, para 3.4.7	The reliability and durability of the test weapons during the first 6000 rounds of firing shall not exceed the limits cited in table I of MIL-R-45587A.	2.3, 2.4, 2.14	Not met (para 2.14).
9	Devised by Test Agency, TECOM approved	The product improved barrel will accommodate the mounting of all accessories or munitions presently mounted or fired on the standard barrel to include the following:	2.4	Partially met. See below.
		a. M203 40-mm grenade launcher.		Yes.
		b. M7 bayonet.		Yes.
		c. MILES.		Not available for test.
		d. M234 RAG launcher.		No.
		e. M261 conversion kit.		Yes.
		f. M24 rifle grenade.		Yes; replaced by M31 grenade.
		g. M15A2 blank firing attachment.		Yes.
10	Devised by Test Agency, TECOM approved	The accuracy of the product improved rifle will be equal to, or better than, the standard rifle at ambient temperature.	2.3	Met.
11	Devised by Test Agency based on MIL-R-45587, TECOM approved	The life of the product improved barrel is required to be 12,000 rounds with serviceability being determined by the following:	2.3, 2.6	Original barrels (with 1 in 7 twist) failed the dispersion requirements prior to the 6000 round point when using XM855E1(FN) ammunition. Final testing to the 12,000 round point using new 1 in 7 twist barrels and SS109 ammunition met the criteria.
		a. At no time shall 20% or more of the rounds in a group exhibit a yaw of 15° or more.		

Item	Source	Criteria	Applicable Subtest	Remarks
		b. The velocity loss during the firing of a hot barrel shall not be more than 200 fps or more than 6% of that initially recorded during inspection.		
		c. Extreme spread will not exceed 17.8 cm at 91.4 meters.		
12	Devised by Test Agency, TECOM approved	The performance and durability of the product improved weapon shall not be adversely affected by the extreme temperature (-46° C and +68°C) conditions.	2.4	Partially met (para 2.4.4.2). Performance at low temperature degraded in comparison to ambient (+21° C) temperature performance.
13	Devised by Test Agency, TECOM approved	The before-test condition of the product improved plastic components must be free from defects or deviations from normal production that would adversely influence test results.	2.2	Met.
14	Devised by Test Agency, TECOM approved	The improved plastic handguards and buttstock failure rate will not exceed the failure rate of the control item.	2.13	Met.
15	Devised by Test Agency, TECOM approved	The durability of the product improved plastic components must equal or surpass that of the control components at ambient and extreme temperatures of AR 70-38 (categories A1 and C2; -46°, +21°, and +68° C) and in adverse environments.	2.3, 2.7, 2.8	Met.
16	Devised by Test Agency, TECOM approved	Function and performance of the test weapons must not be affected by the product improved plastic components.	2.3, 2.6, 2.7	Met.
17	Devised by Test Agency, TECOM approved	The material of the product improved plastic components must not be degraded by chemical reaction to various fuel and lubrication compounds.	2.8	Met.

Item	Source	Criteria	Applicable Subtest	Remarks
18	AR 702-3	The design of all product improvements shall adhere to the essential principles of human factors engineering in accordance with MIL-STD-1472B in all aspects of operation and maintenance.	2.12	Met.
19	Devised by Test Agency, TECOM approved	The basic safety features and safety record of the M16A1 rifle shall not be degraded by the product improved components.	2.14	Met (para 2.14.4).
20	Devised by Test Agency, TECOM approved	The test projectiles shall completely perforate one side of the standard M1 helmet, with liner, at a range of 800 meters from the muzzle.		Not addressed. Test deleted by TECOM. See ref 27 for data on similar test.
21	Devised by Test Agency, TECOM approved	The cookoff level obtained with the modified barrel should be equal to or higher than that of the standard barrel, under similar conditions.	2.5	Met.
22	Devised by Test Agency, TECOM approved	The function and reliability of the modified rifle under adverse conditions shall be at least equal to that of the standard rifle under equal conditions.	2.9	Met (para 2.4.4.2).
23	Devised by Test Agency, TECOM approved	The aural and visual signature produced when firing the improved rifle and ammunition shall not be greater than the signatures that exist when firing the standard rifle and ammunition.	2.10	Met.
24	Devised by Test Agency, TECOM approved	The hit probability of the rifles equipped with the BCD should be equal to or better than those using the standard automatic sear.	2.11	Test conducted and evaluated at Fort Dix. Considered met within the limited evaluation completed.
25	Devised by Test Agency, TECOM approved	The hit probability of the rifles equipped with the MBC should be equal to or better than those using the standard flash suppressor.	2.11	Test conducted and evaluated at Fort Dix. Considered met within the limited evaluation completed.

Item	Source	Criteria	Applicable Subtest	Remarks
26	Devised by Test Agency, TECOM approved	Adoption of this weapon will not generate additional personnel requirements. Skills required for operation, organizational and direct support maintenance will not exceed those skills currently associated with the M16A1 rifle.	2.15 2.13	Met.
27	Devised by Test Agency, TECOM approved	The performance and durability of the product improved weapon shall be equal to or better than that of the standard weapon after salt-water and high-temperature humidity conditioning.	2.4	Not met.
28	Devised by Test Agency TECOM approved	The sustained rate of fire, in the semiautomatic mode, of the produce improved rifle shall be equal to or better than that of the standard rifle.	2.6	Met.

Figure 1. Right-side view of M16A1 (top) and M16A1E1 (bottom).

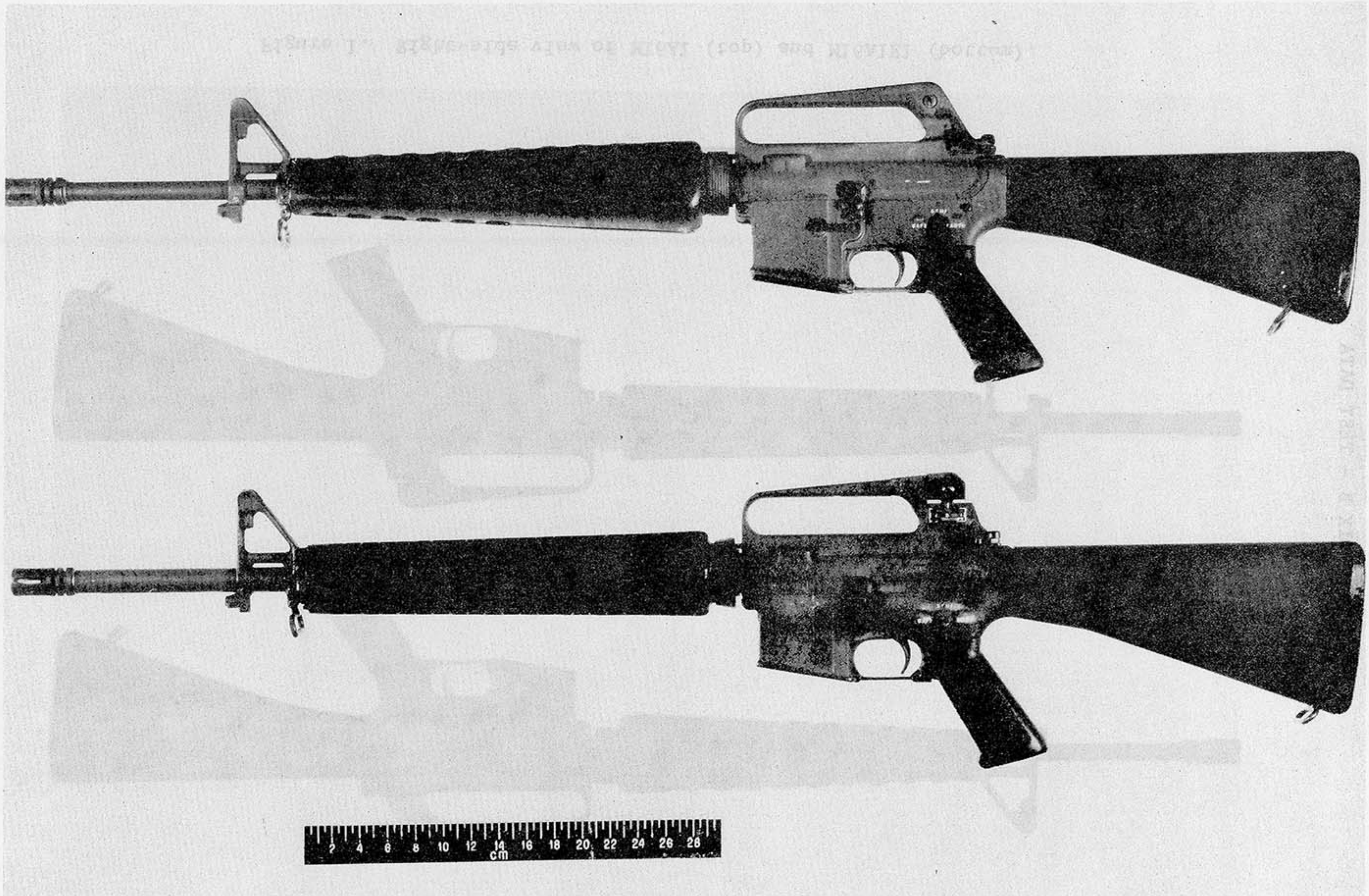


Figure 2. Left-side view of M16A1 (top) and M16A1E1 (bottom).

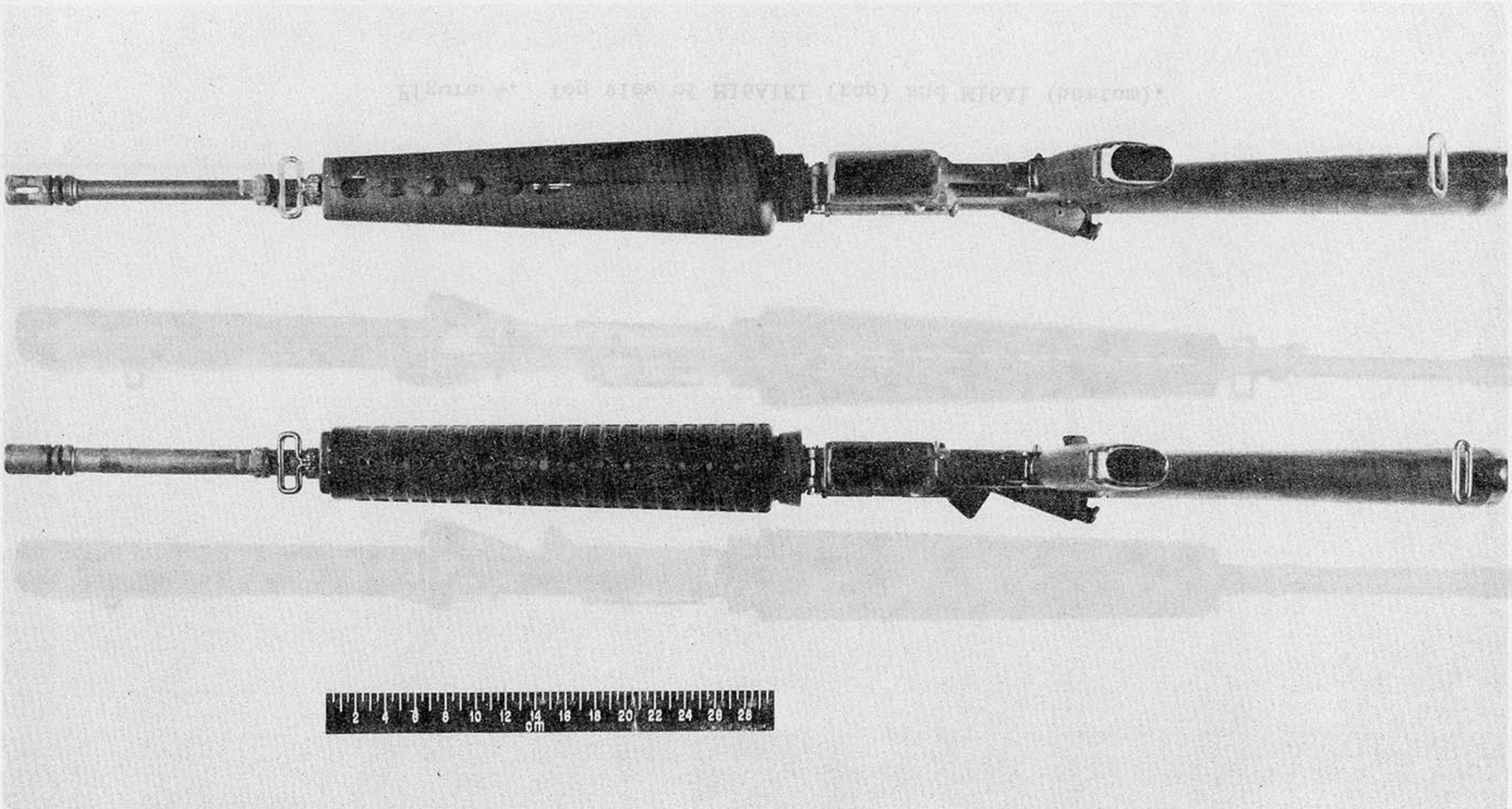


Figure 3. Bottom view of M16A1 (top) and M16A1E1 (bottom).

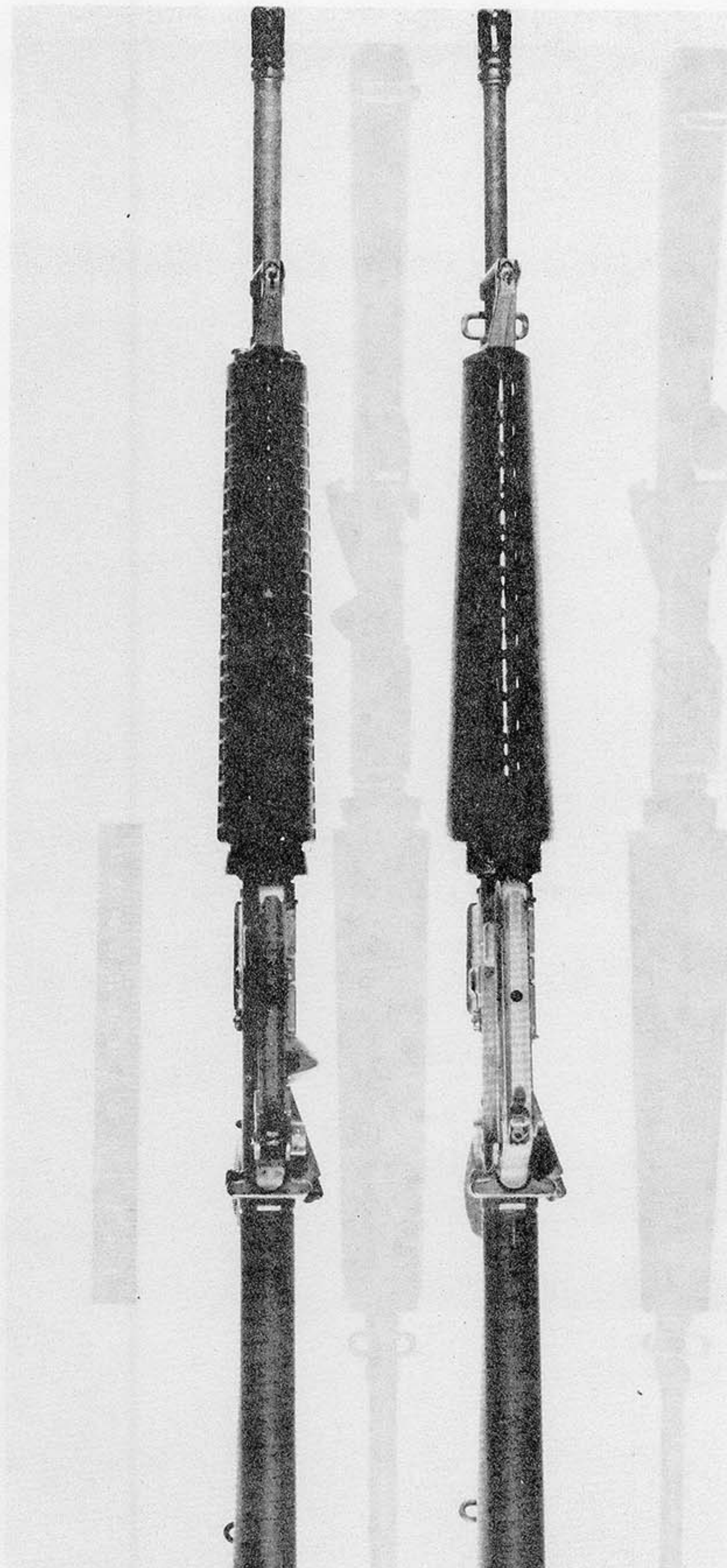


Figure 4. Top view of M16A1E1 (top) and M16A1 (bottom).

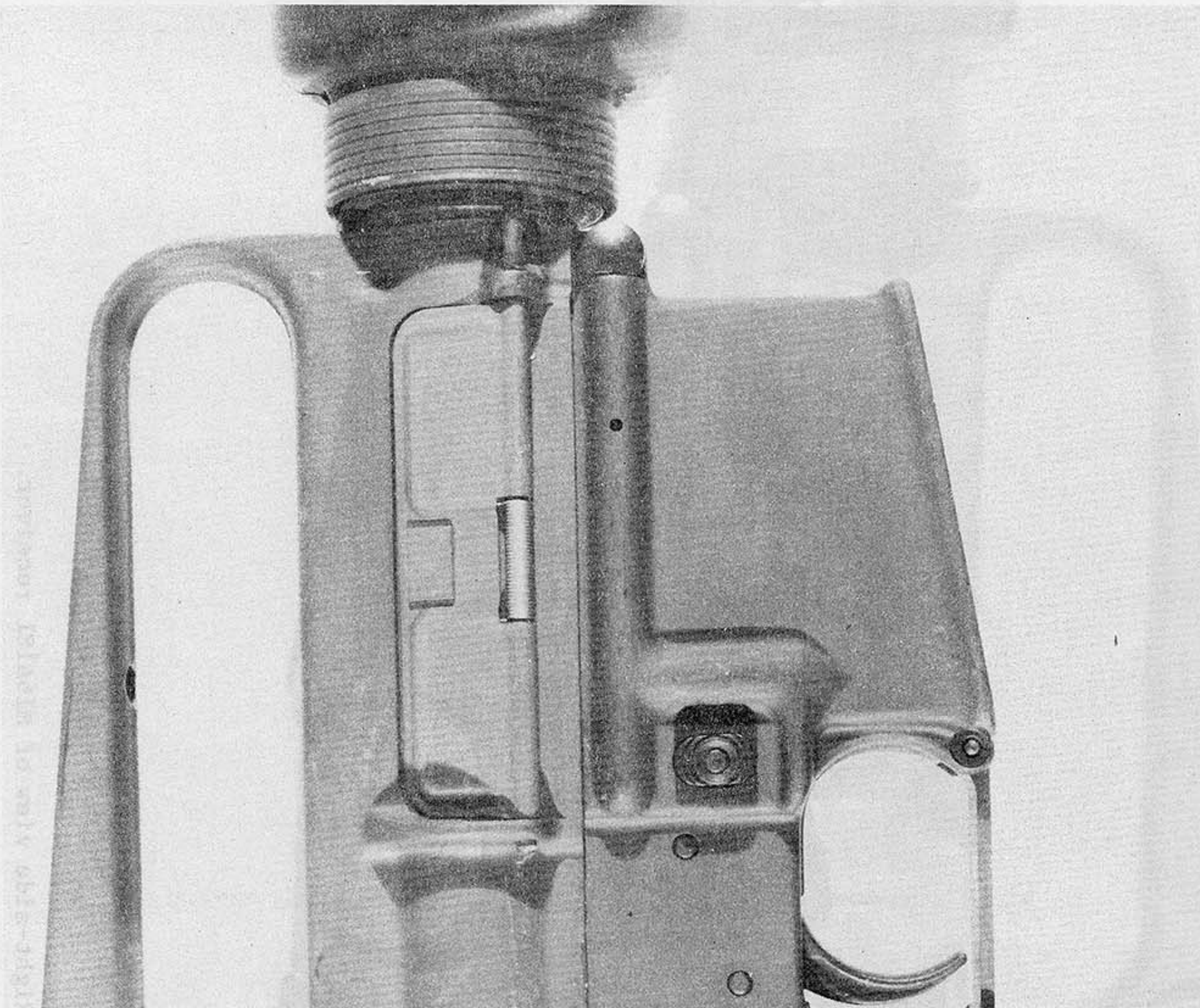


Figure 5. Right-side view of M16A1 receiver.

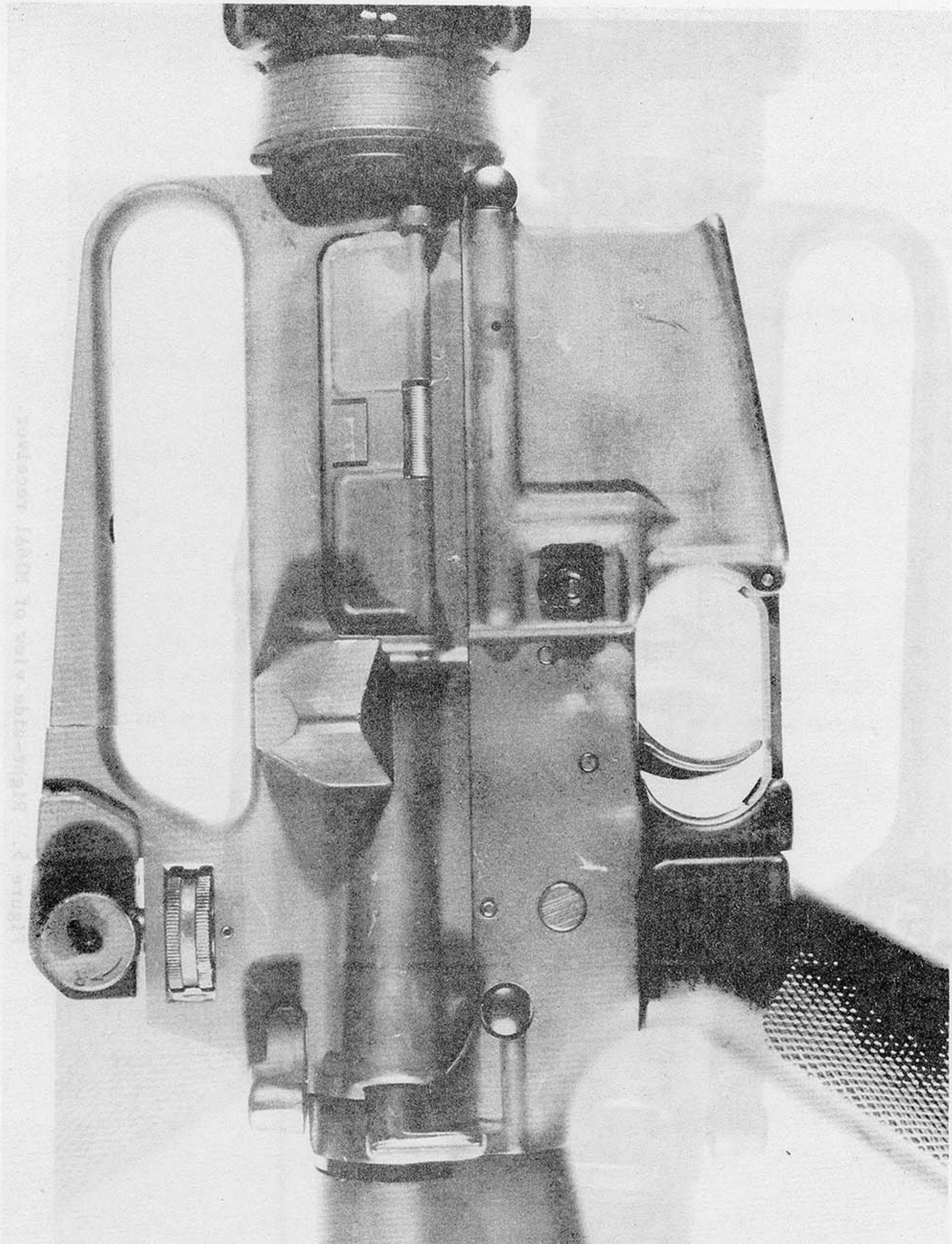


Figure 6. Right-side view of M16A1E1 receiver.

Figure 7. Left-side view of M16A1 receiver.

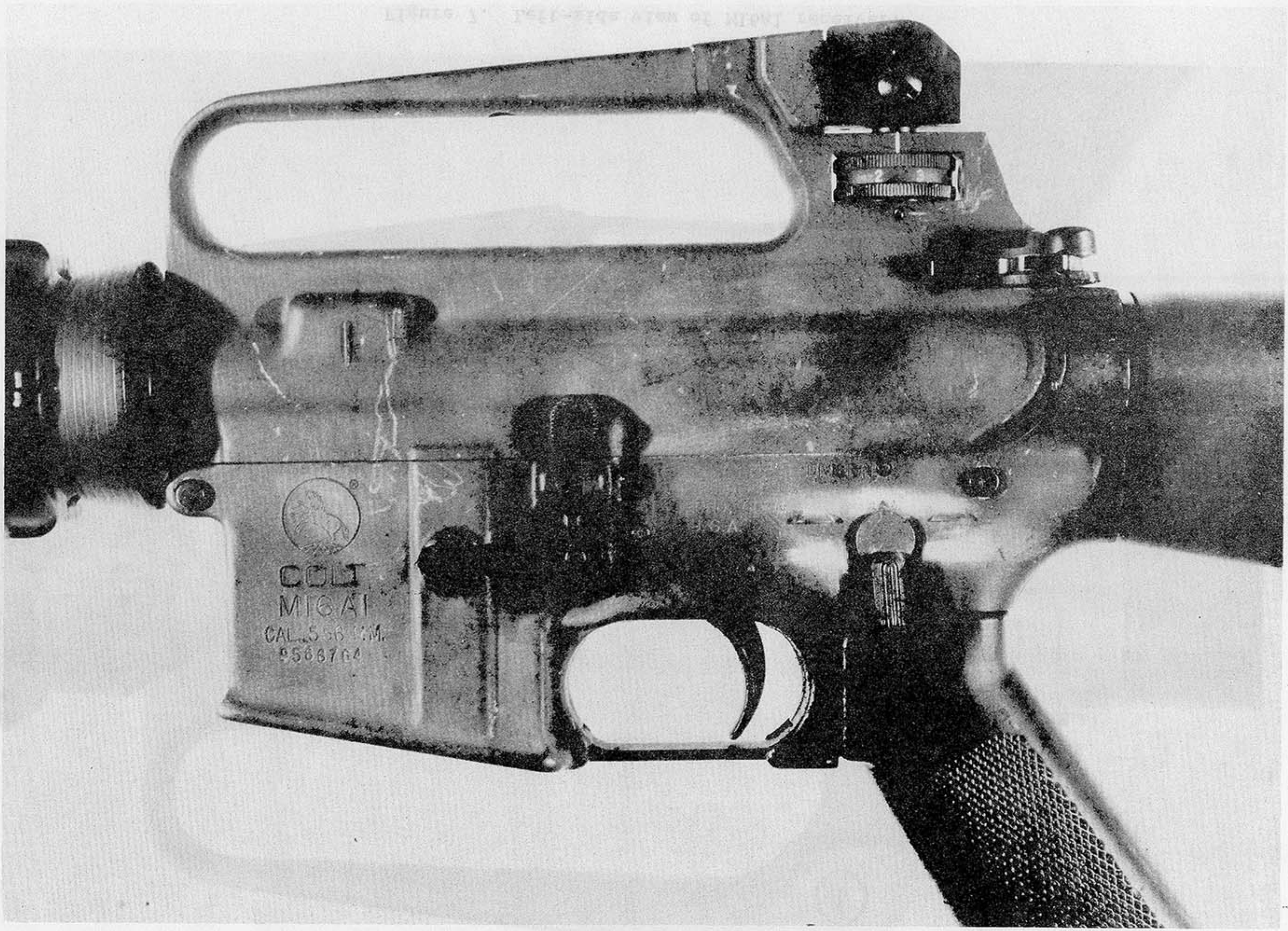


Figure 8. Left-side view of M16A1E1 receiver.

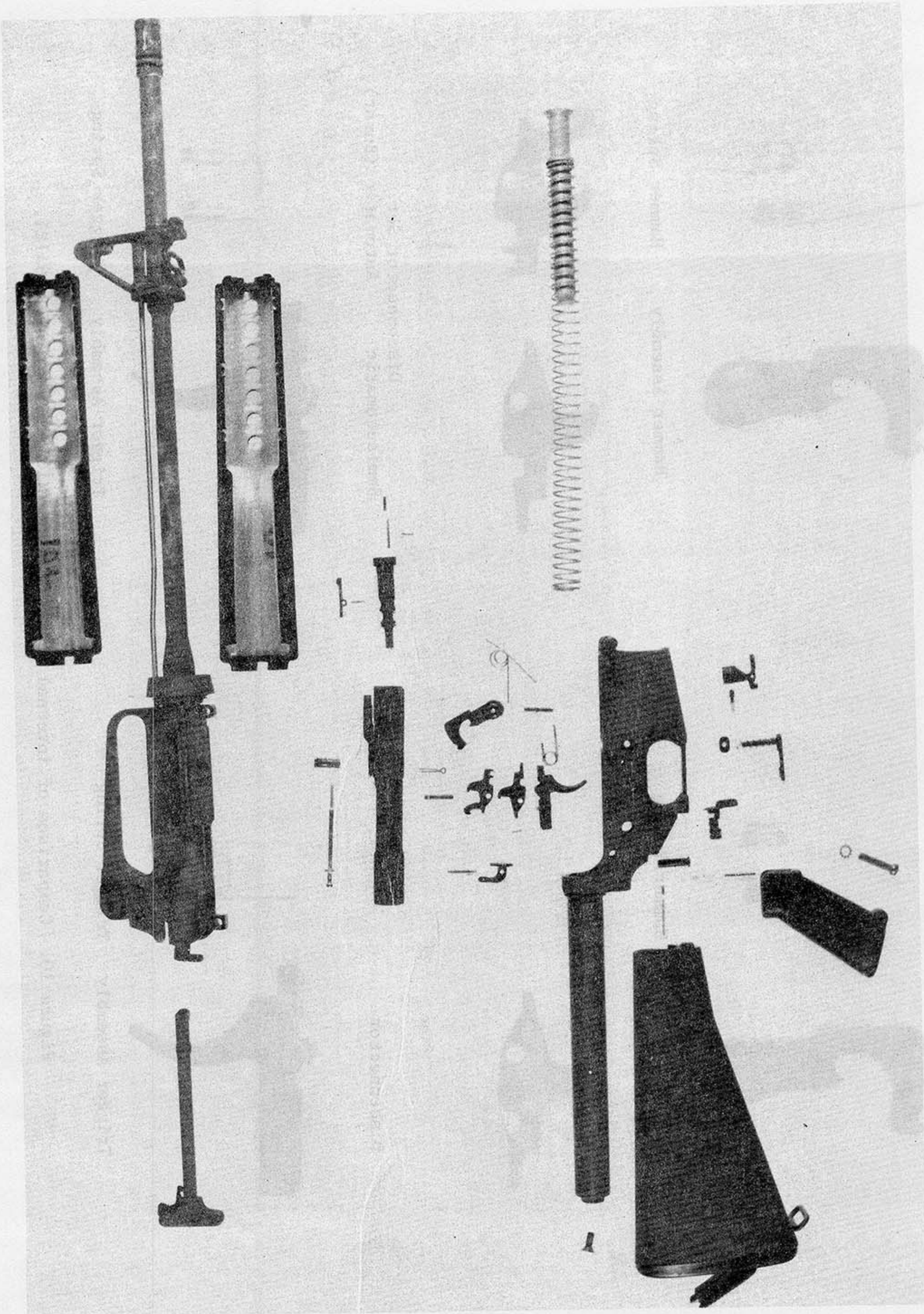


Figure 9. M16A1E1 basic disassembly.

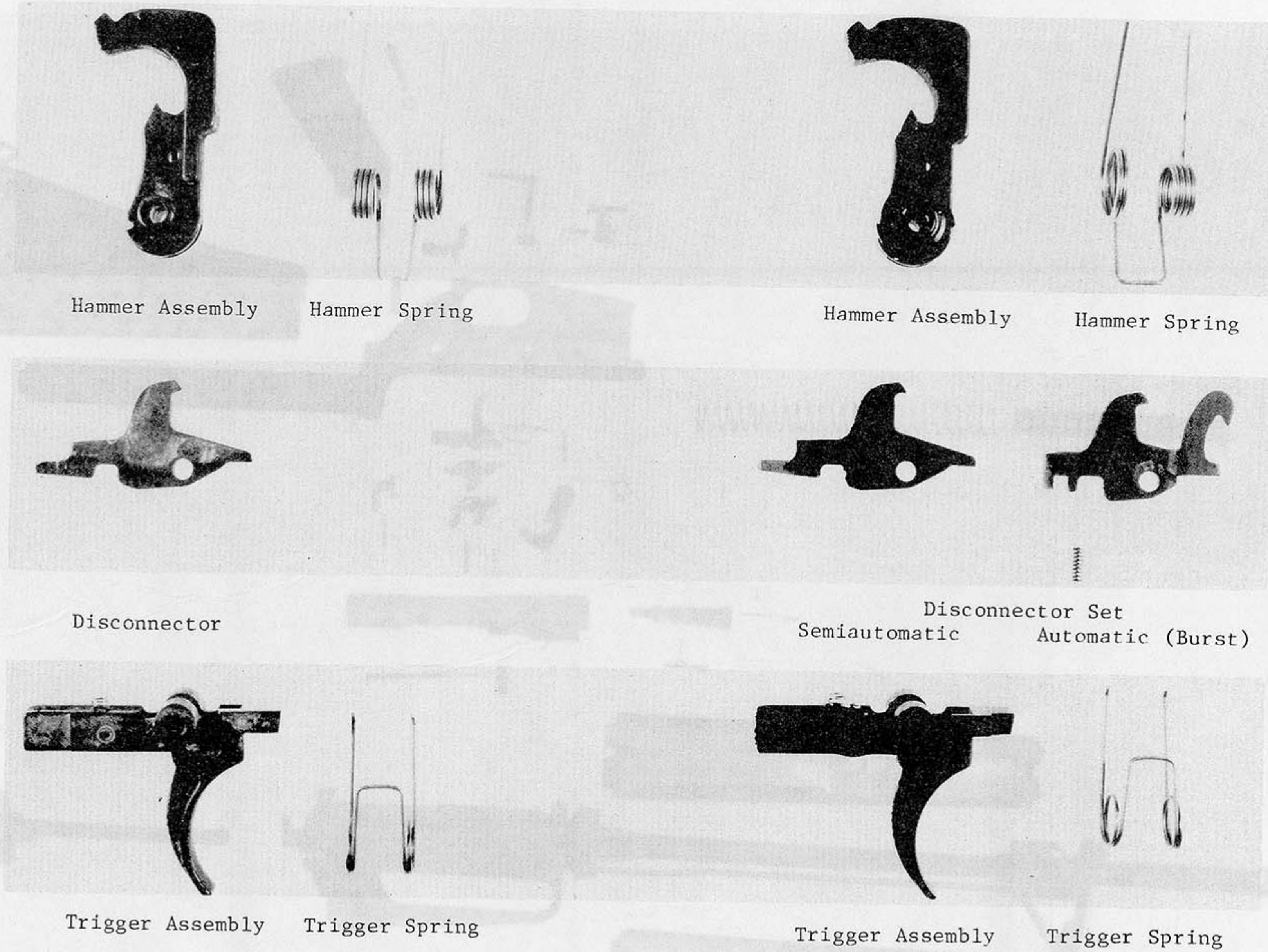


Figure 10. Comparison of internal parts changes, M16A1 (left) and M16A1E1.

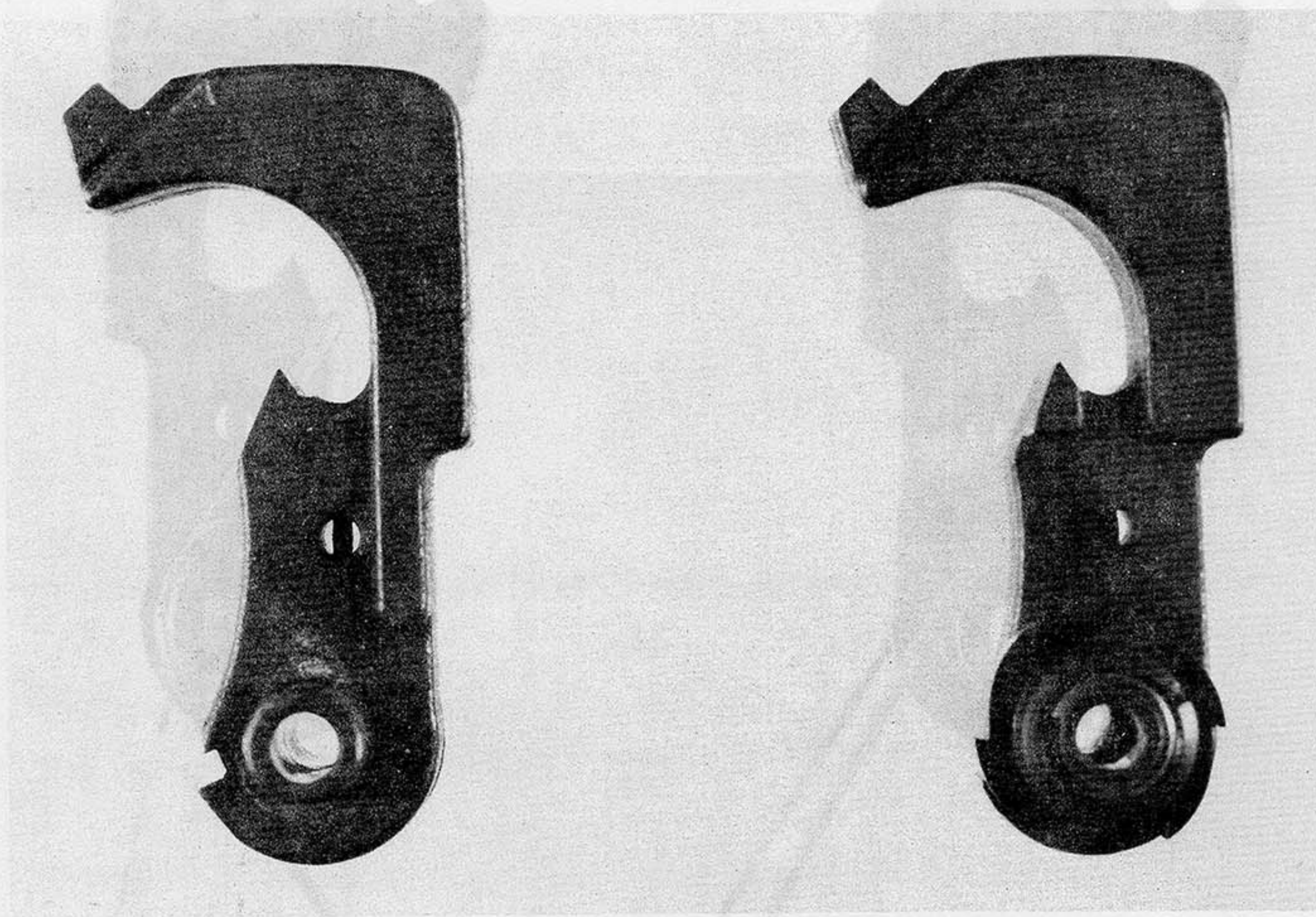


Figure 11. Hammer assembly for M16A1 (left) and M16A1E1.

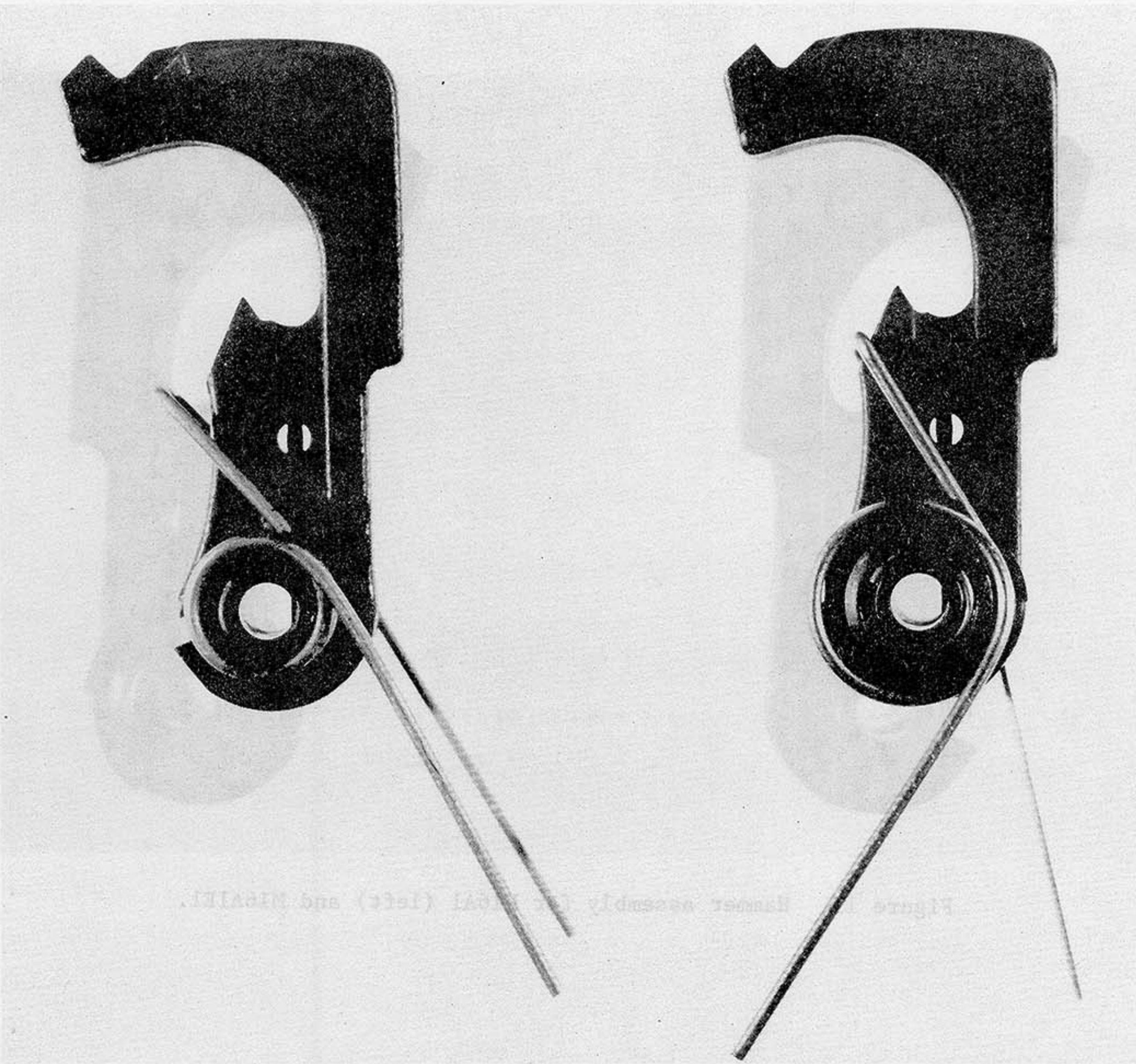


Figure 12. Hammer assembly with hammer spring in place, for M16A1 (left) and M16A1E1.

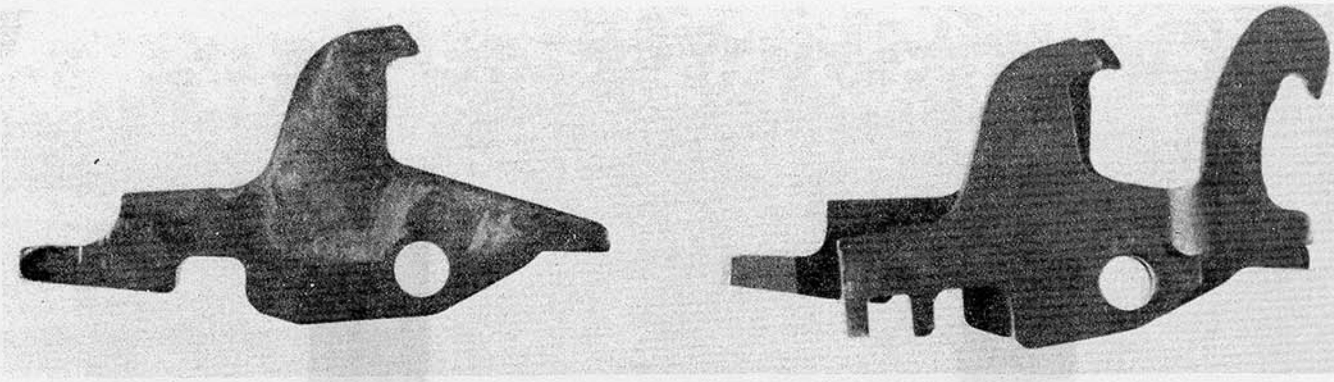


Figure 13. Disconnector for M16A1 (left) and disconnector set for M16A1E1.

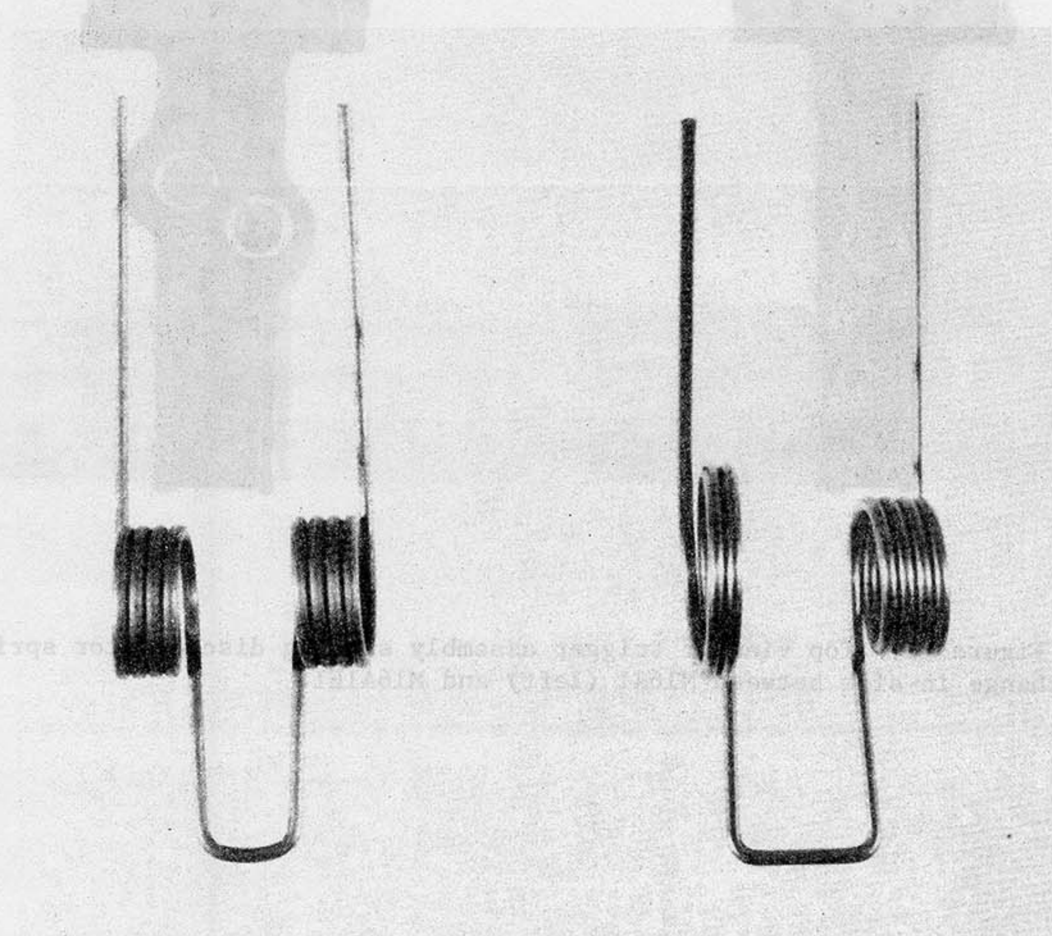


Figure 14. Hammer spring for M16A1 (left) and M16A1E1.

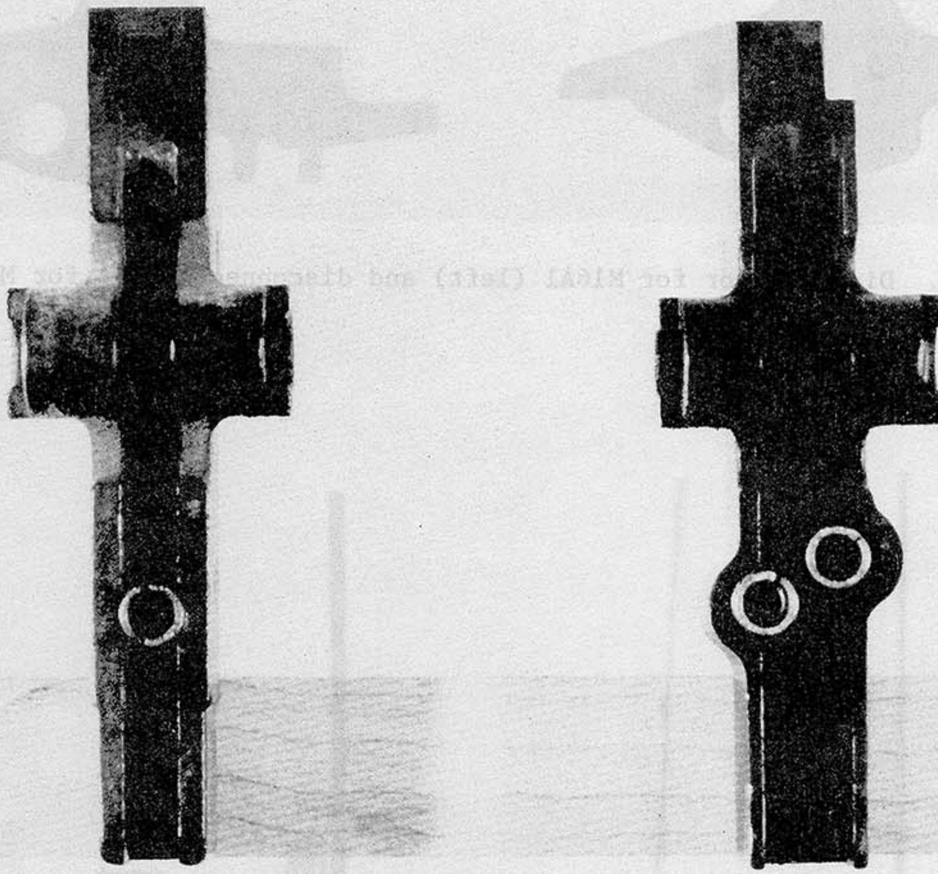


Figure 15. Top view of trigger assembly showing disconnector springs and change in size between M16A1 (left) and M16A1E1.

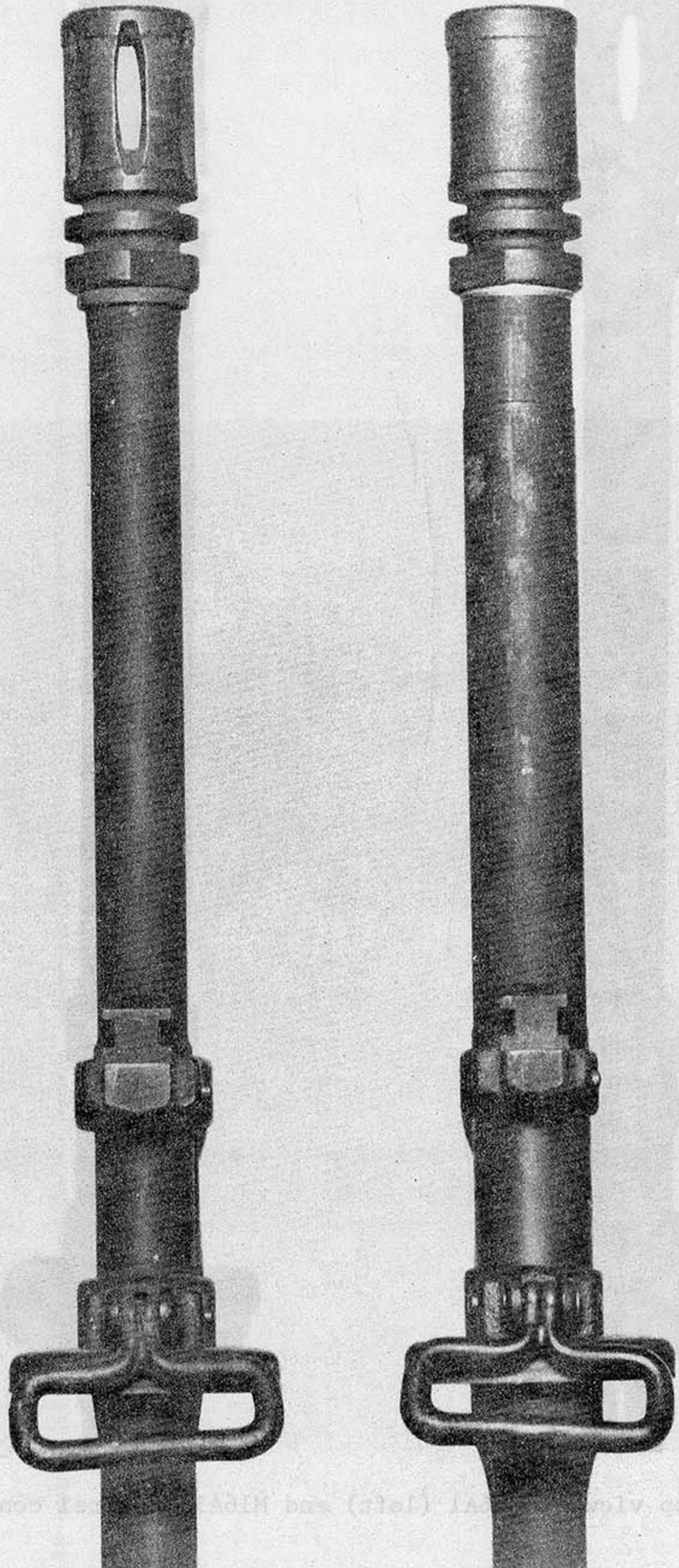


Figure 16. M16A1 (left) and M16A1E1 barrel configurations. Note differences in M16A1 flash suppressor and M16A1E1 muzzle brake compensator.

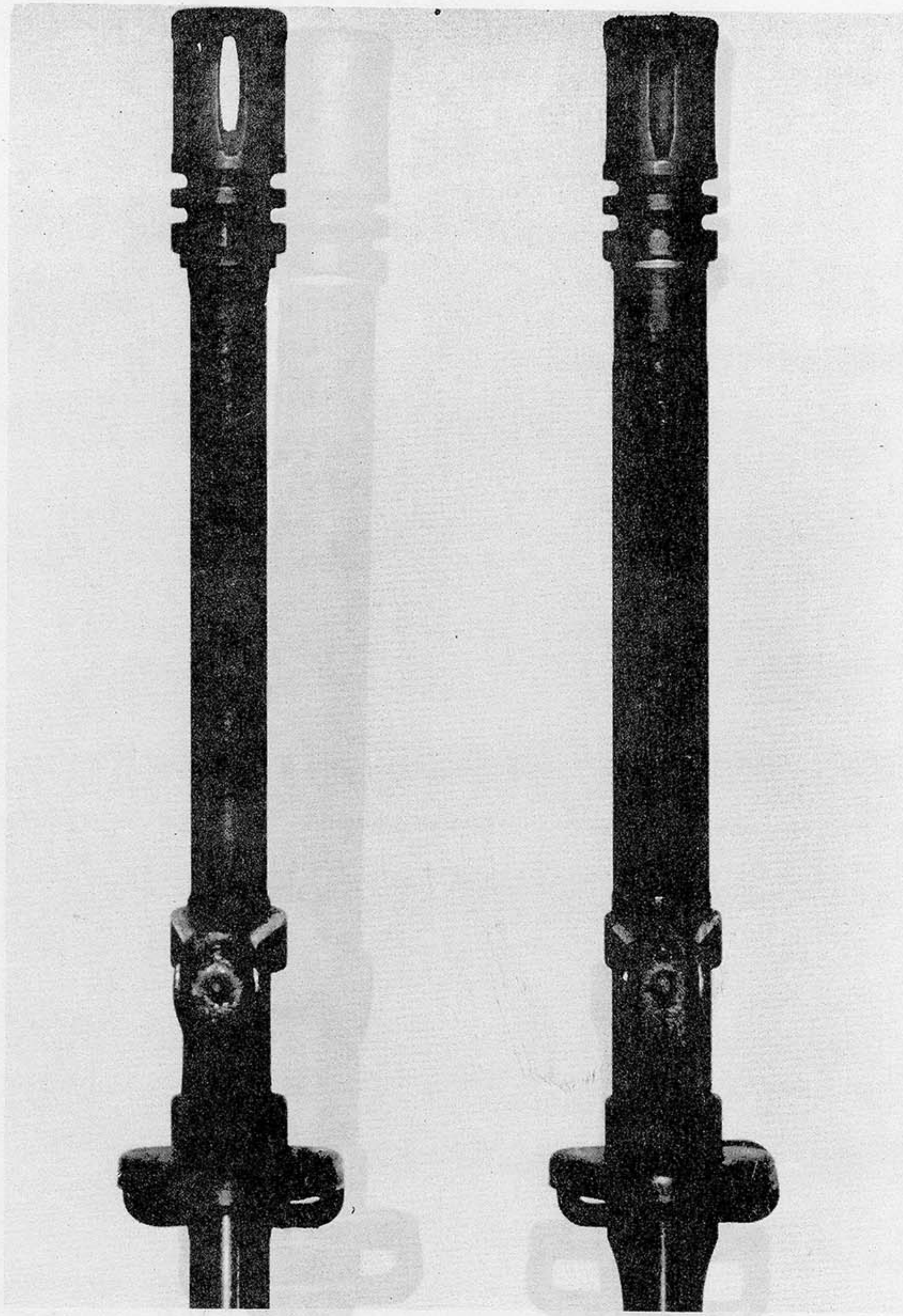


Figure 17. Top view of M16A1 (left) and M16A1E1 barrel configurations.

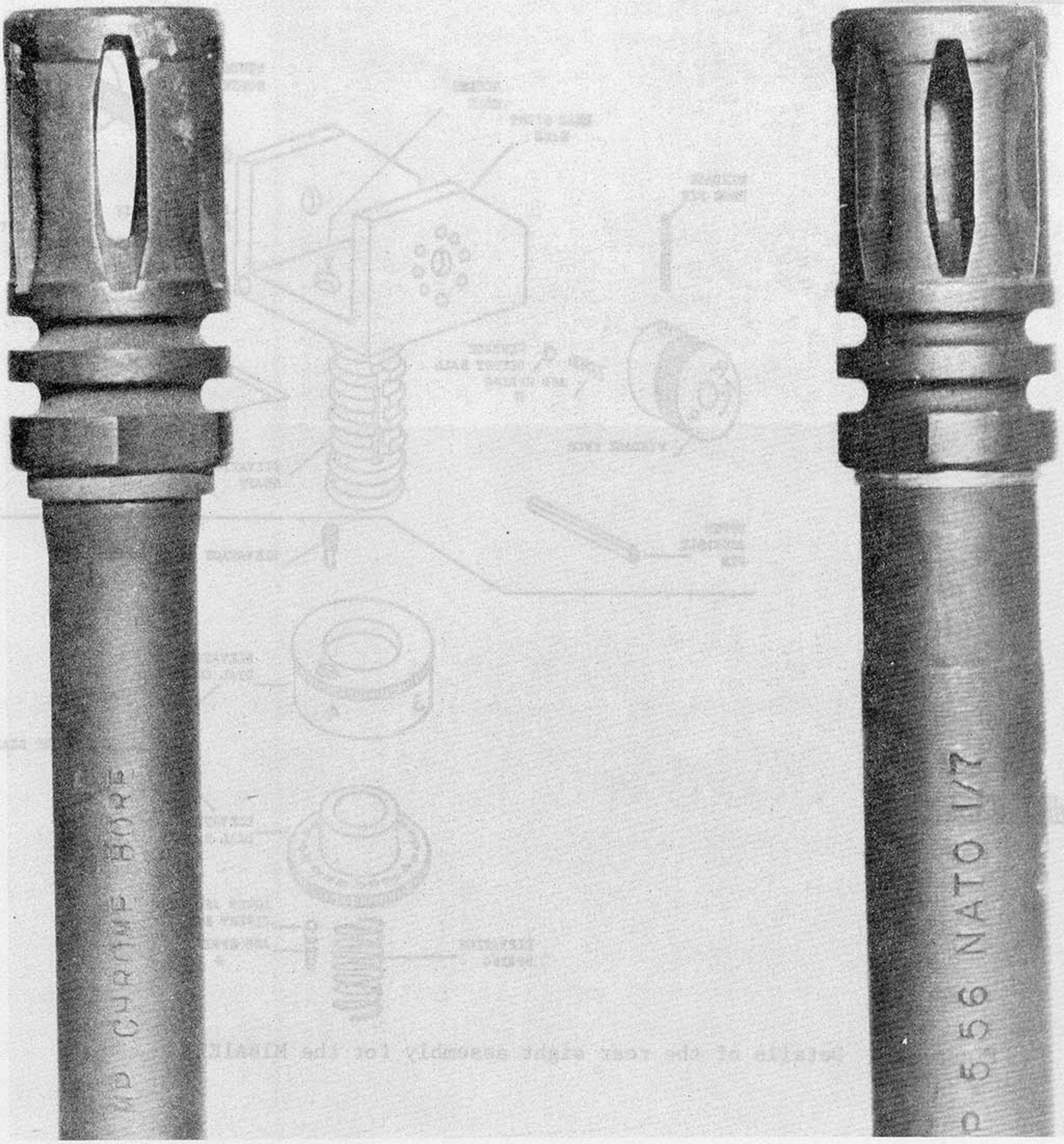


Figure 18. M16A1 flash suppressor (left) and M16A1E1 muzzle brake compensator, top view.

UPPER ASSEMBLY

LOWER ASSEMBLY

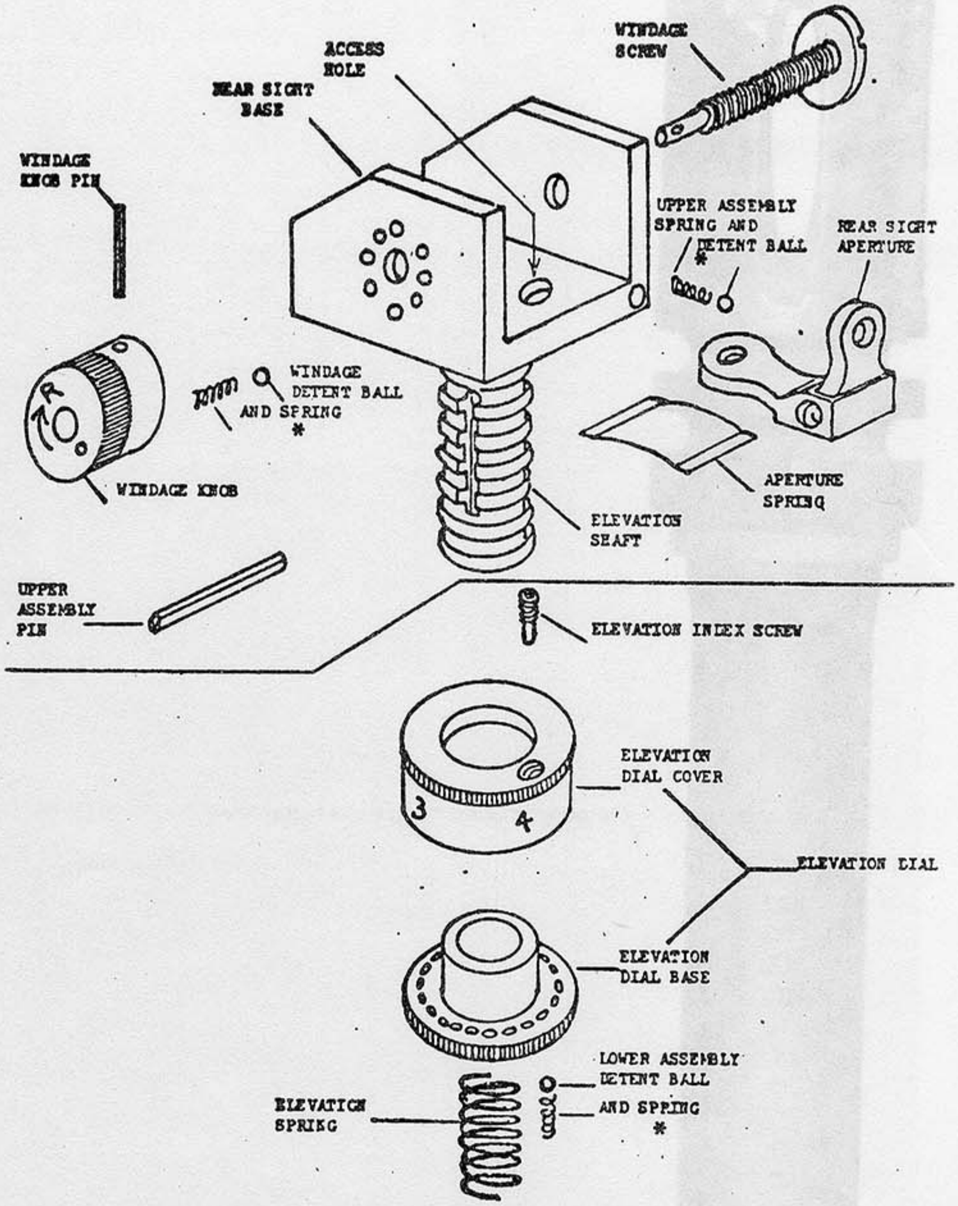


Figure 19. Details of the rear sight assembly for the M16A1E1.

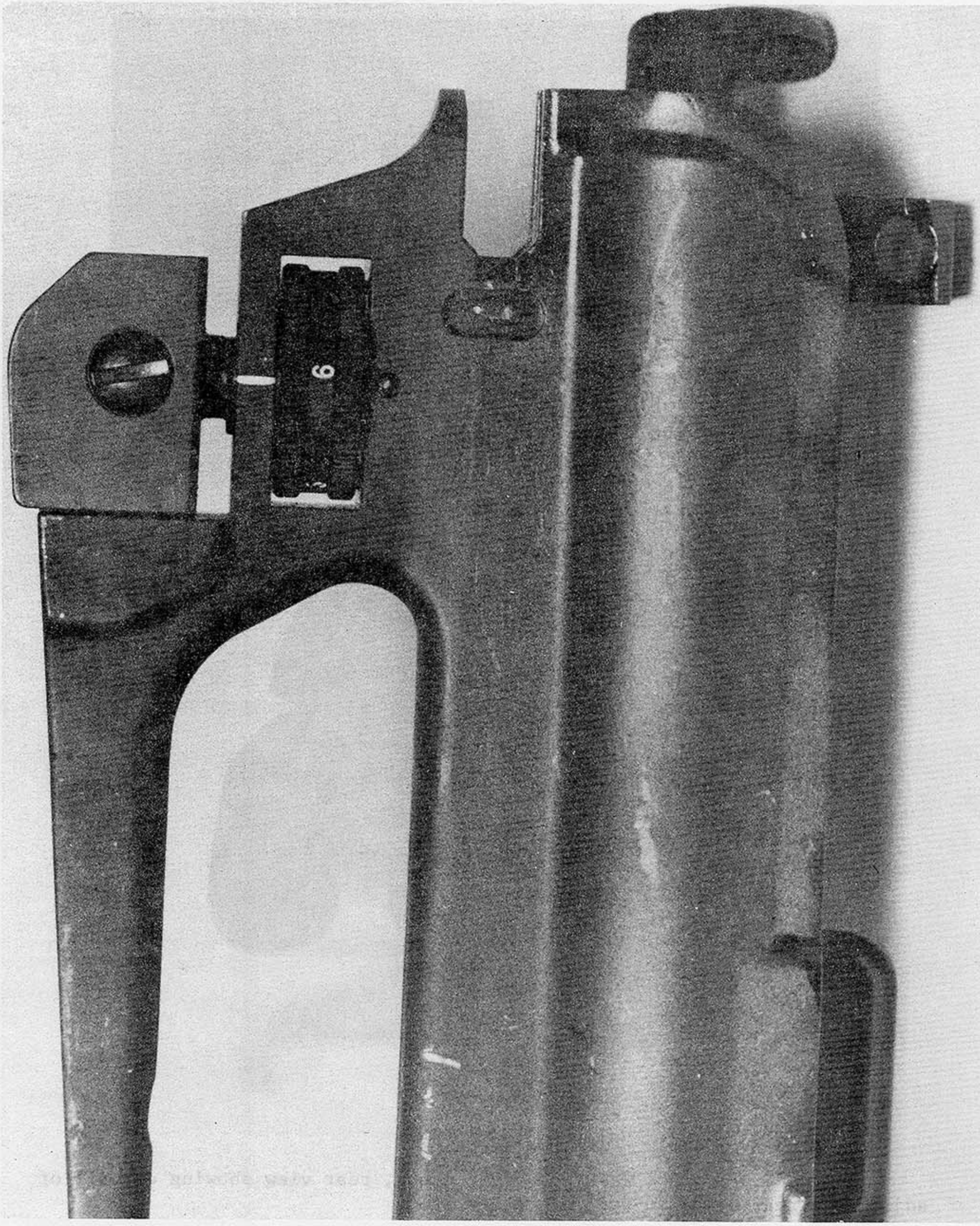


Figure 20. M16A1E1 upper receiver group, left side view showing details of adjustable rear sight at full elevation.

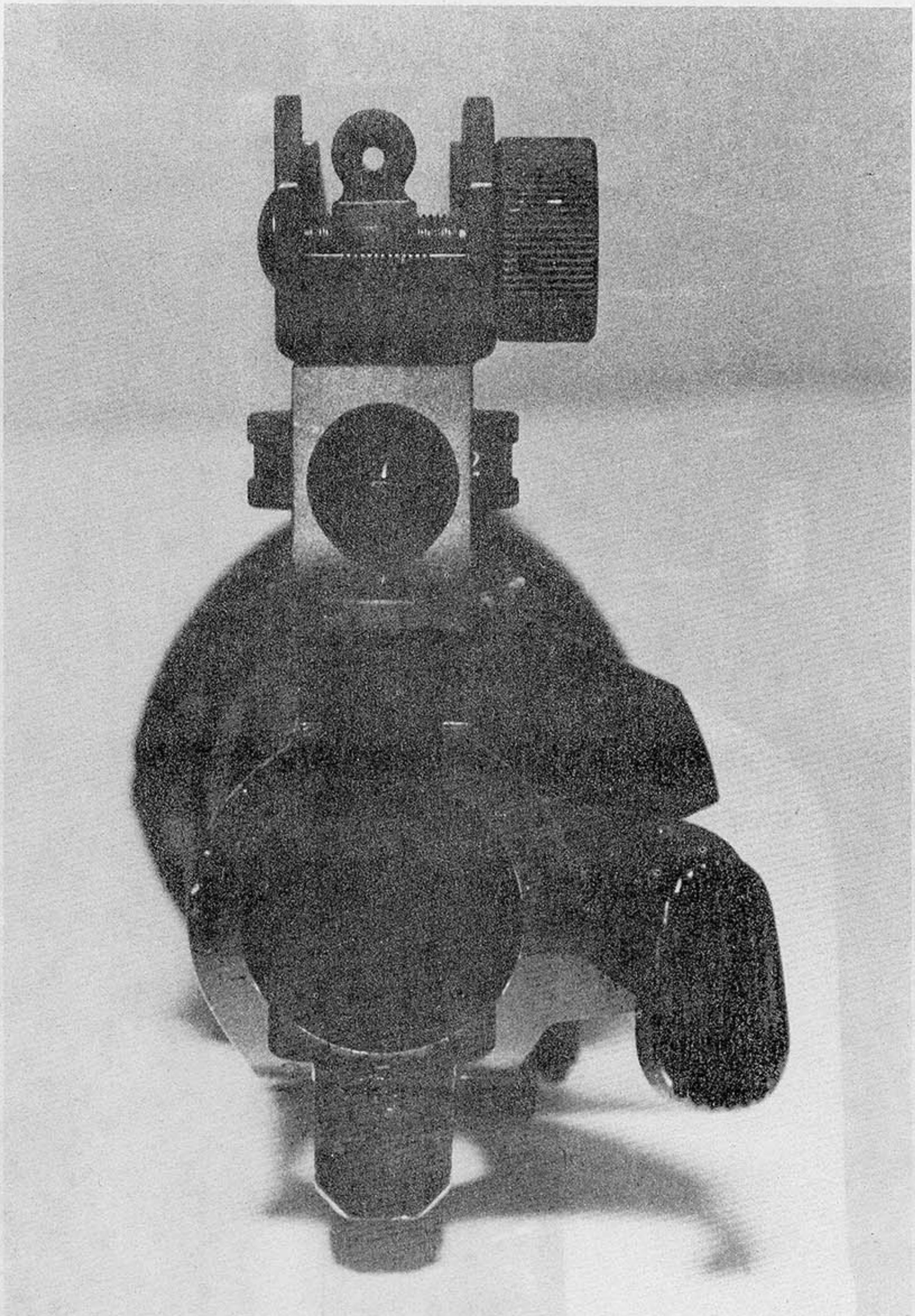


Figure 21. M16A1E1 upper receiver group, rear view showing details of adjustable rear sight at full elevation.

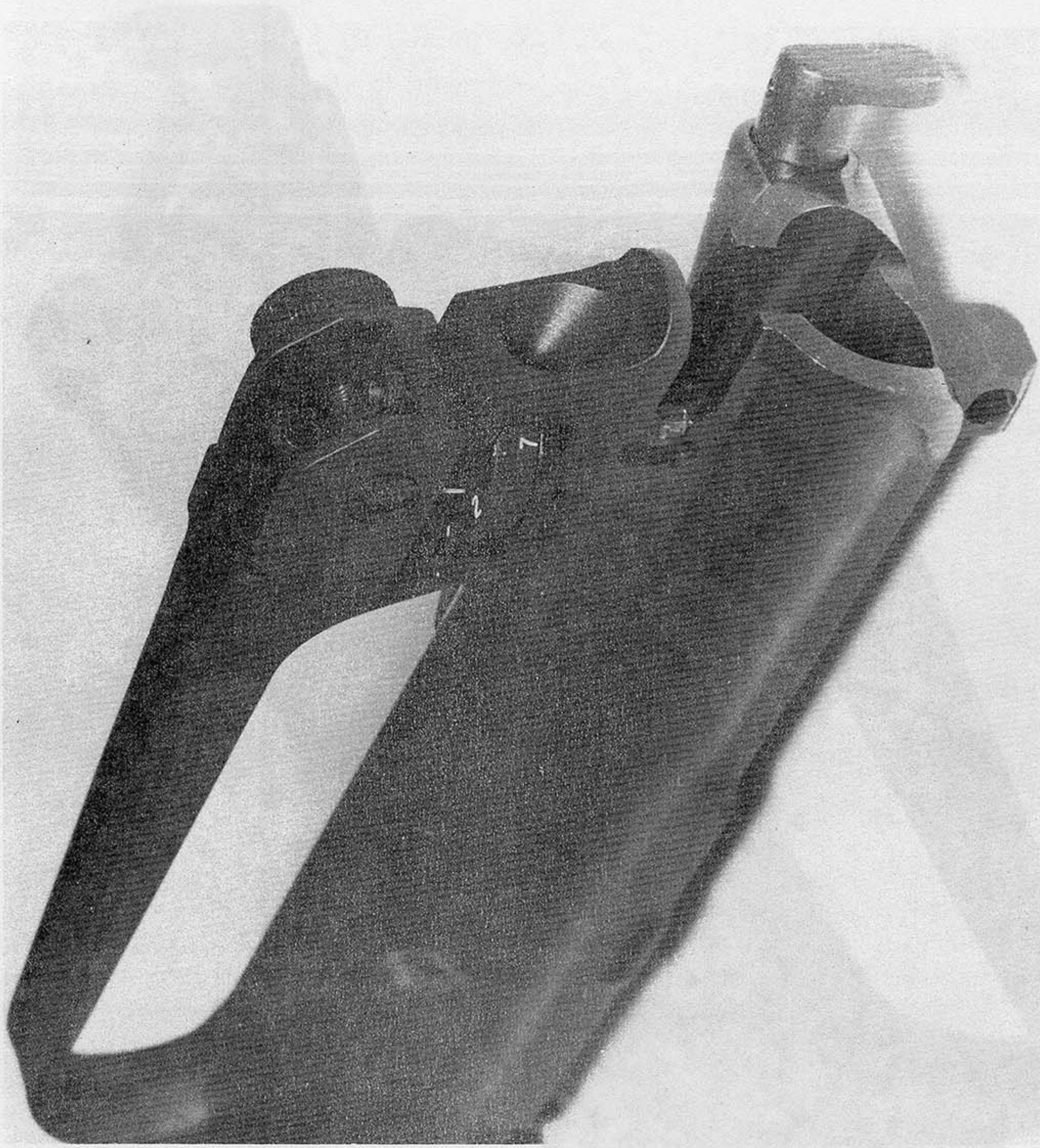


Figure 22. M16A1E1 upper receiver group left-top-rear view of adjustable rear sight in lowest position.

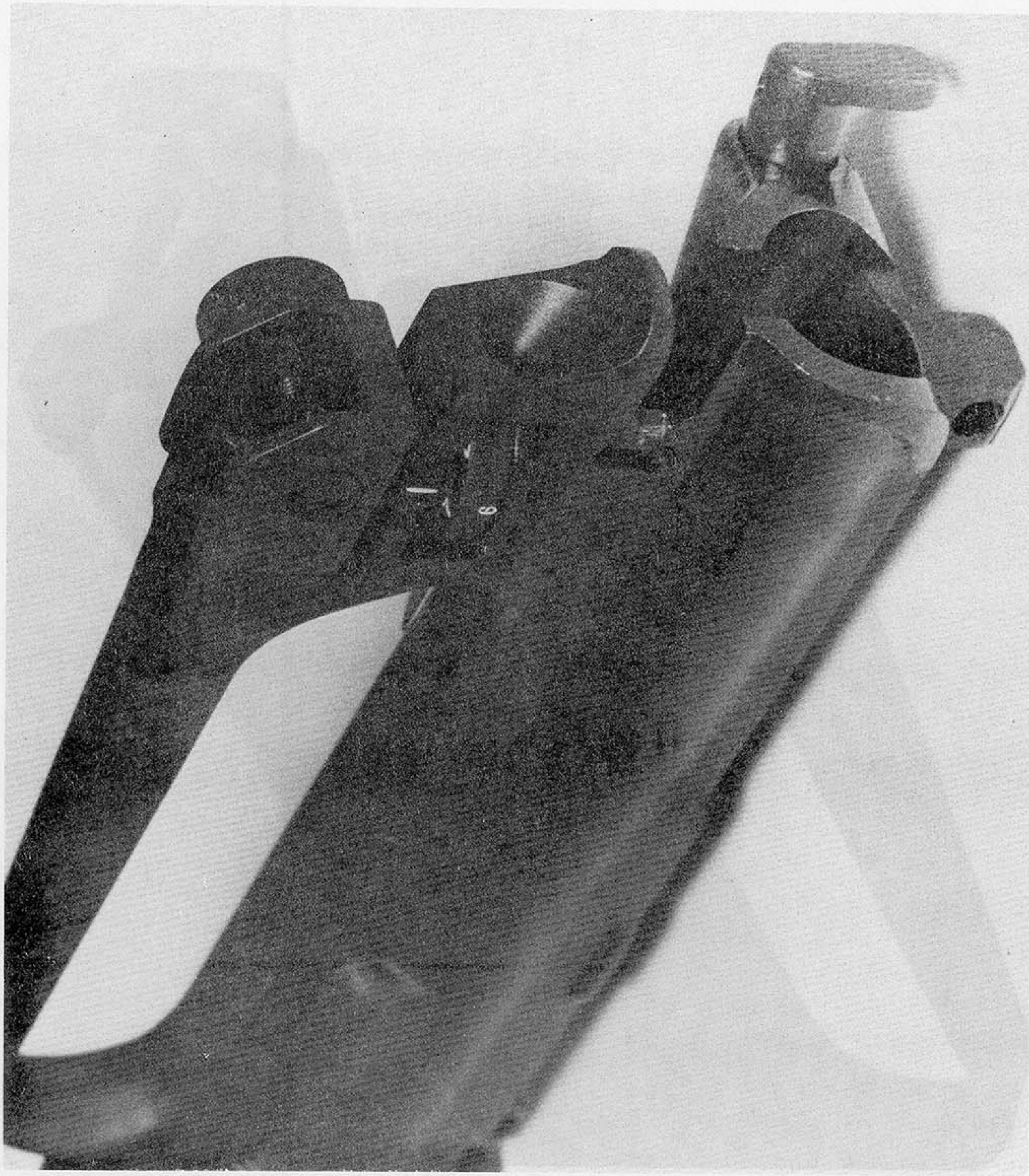


Figure 23. M16A1E1 upper receiver group, left rear view showing details of adjustable rear sight at full elevation.

Figure 24. M16A1E1 upper receiver group, right frontal view showing details of spent case deflector and adjustable rear sight.

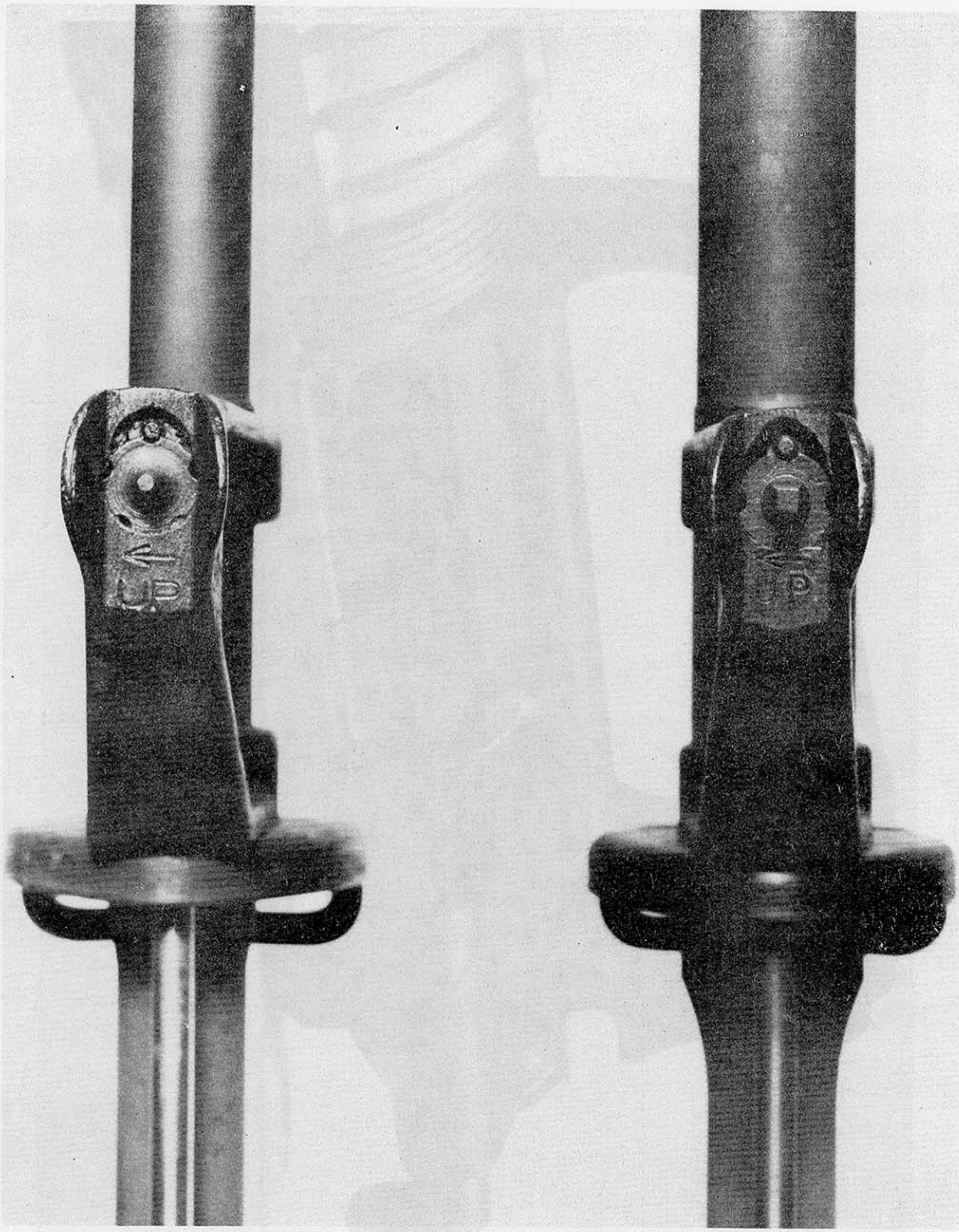


Figure 25. M16A1 (left) and M16A1E1 front sight details, top view.

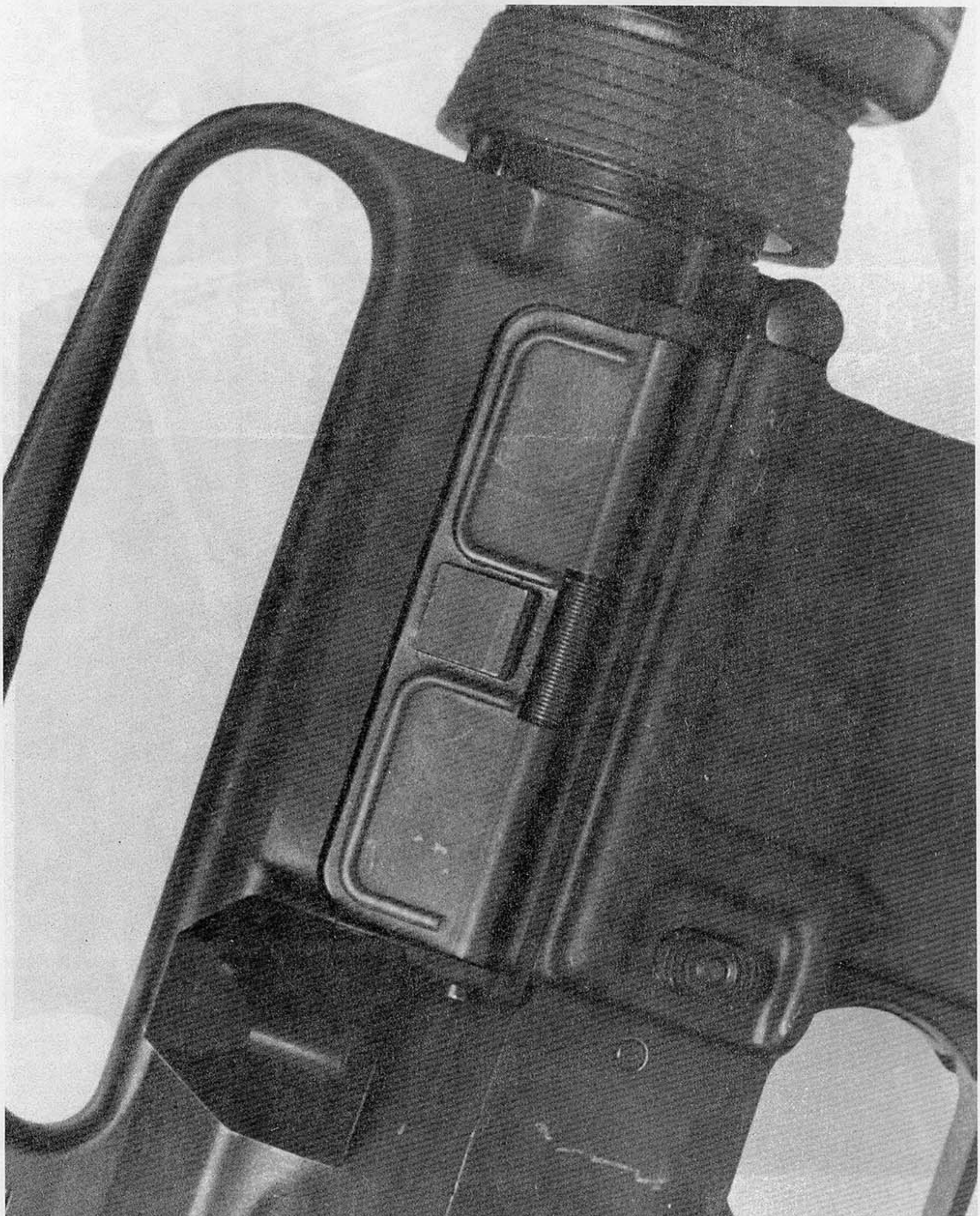


Figure 26. M16A1E1 right-side view of spent case deflector, dust cover closed.

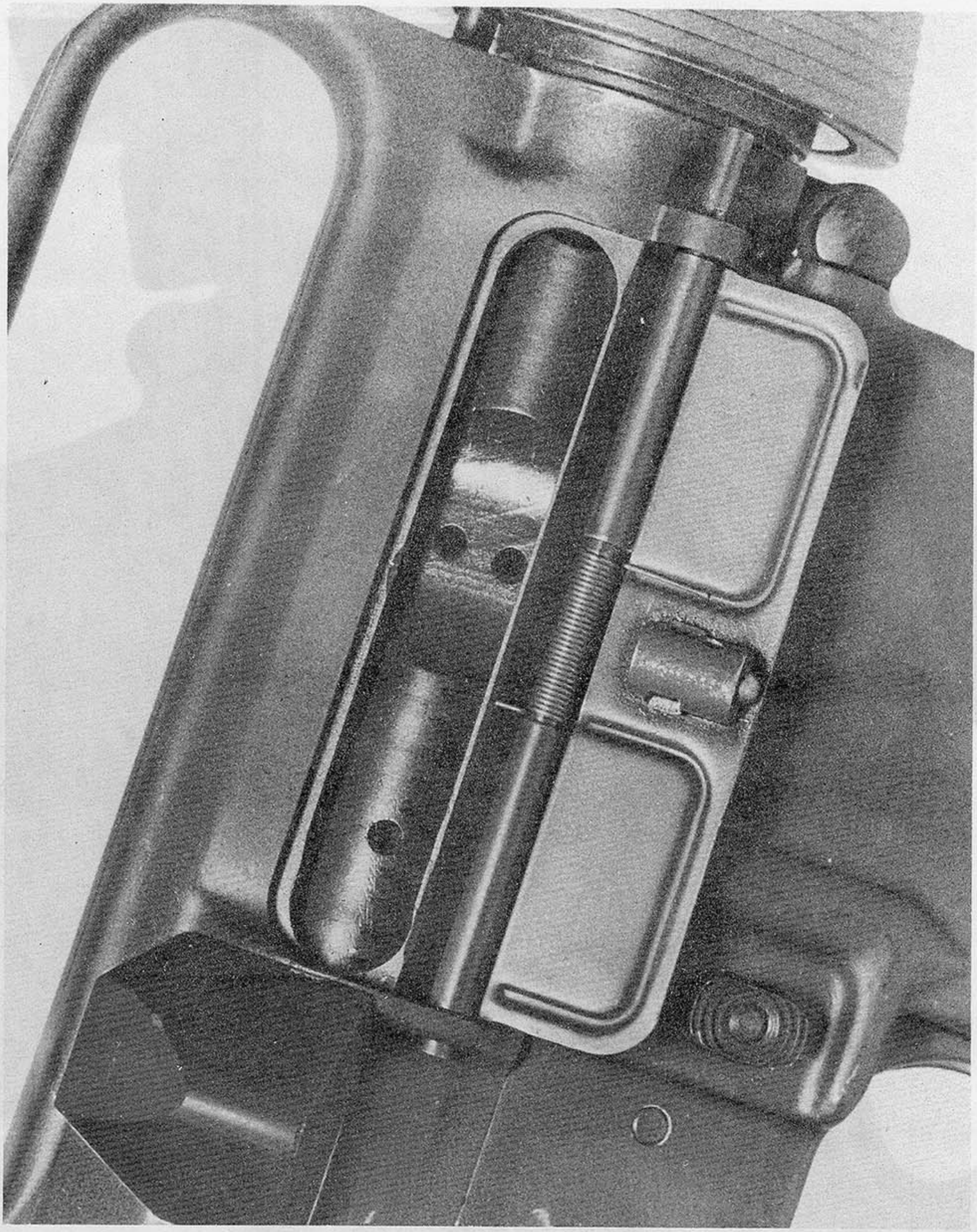
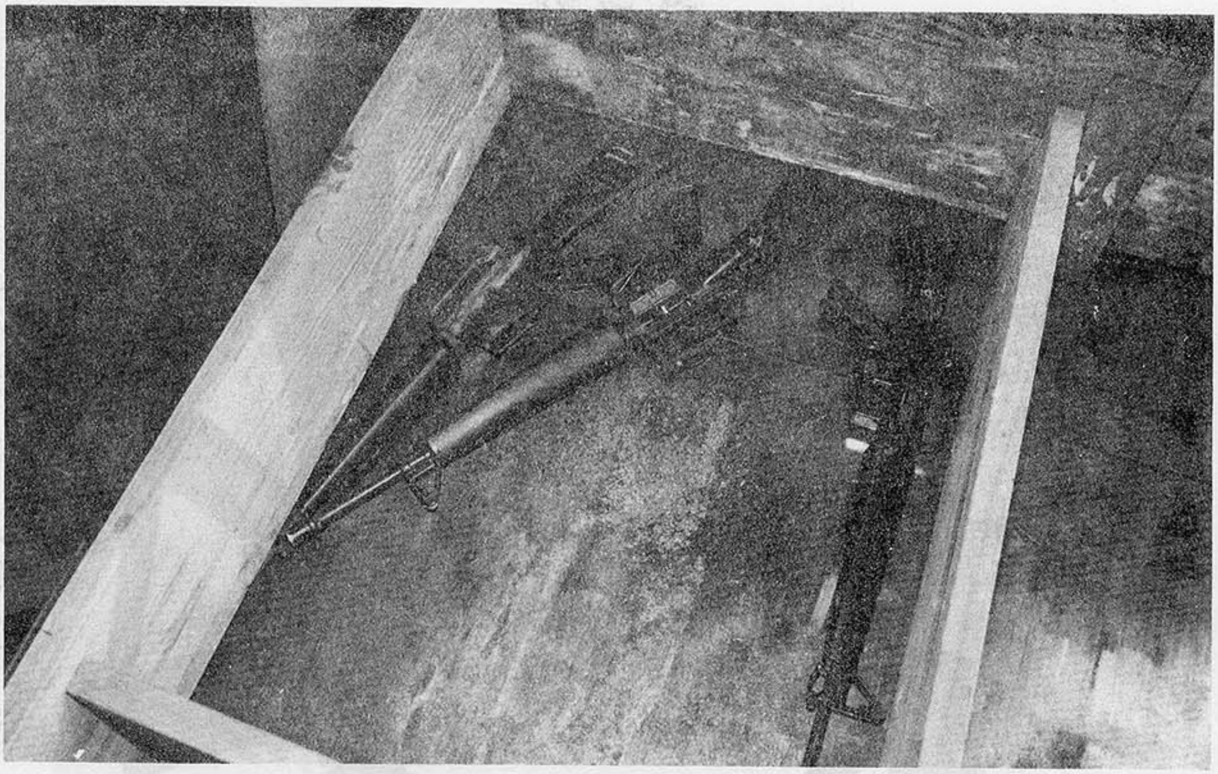


Figure 27. M16A1E1 right-side view of ejection port showing details of spent case deflector, dust cover open

Figure 28. Right- and left-side views of M16A1E1 rifle with M7 bayonet attached.



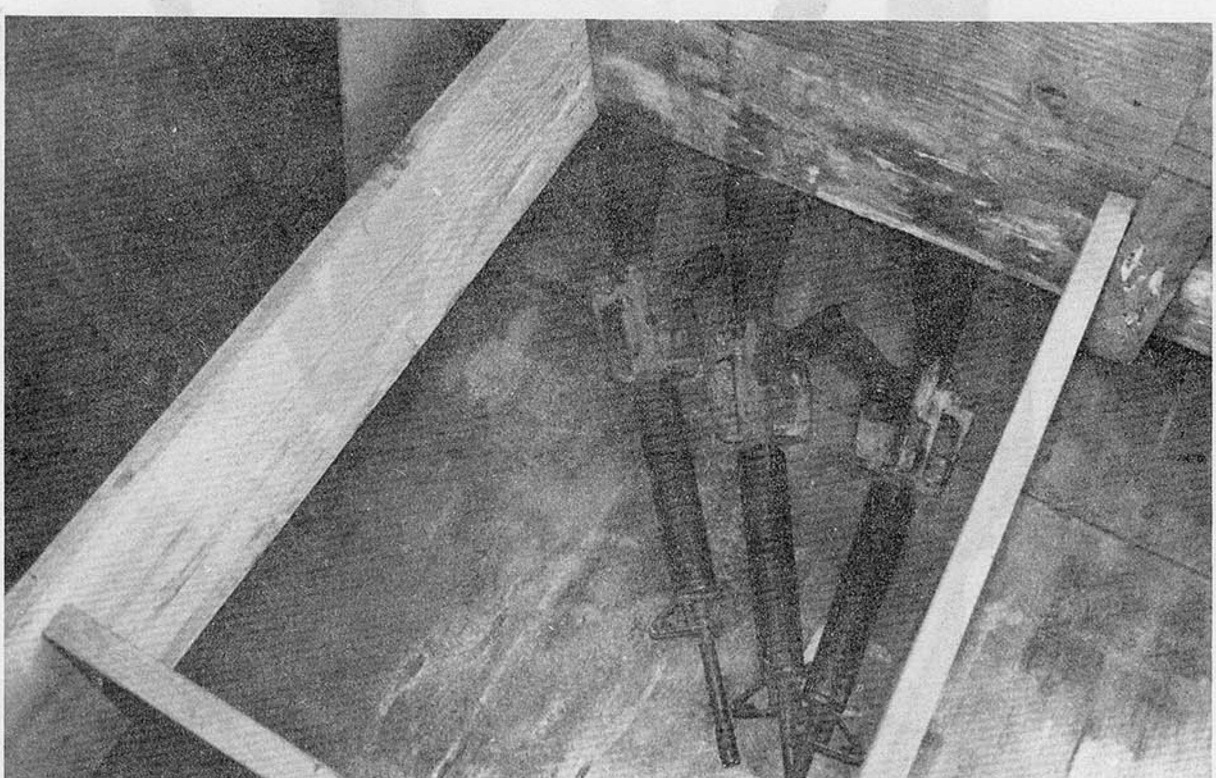
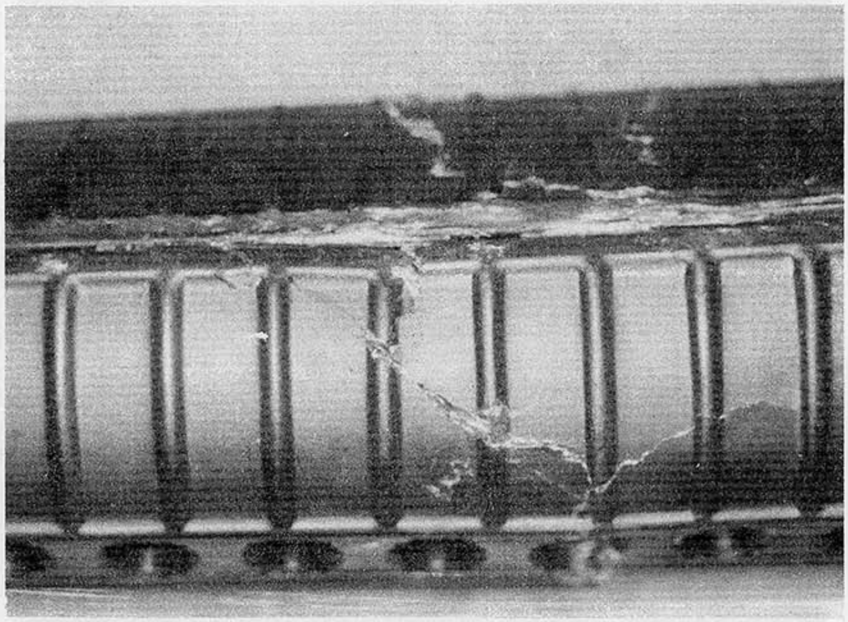


Figure 29. Overhead view of loose cargo test setup for M16A1 (top) and M16A1E1 rifles.



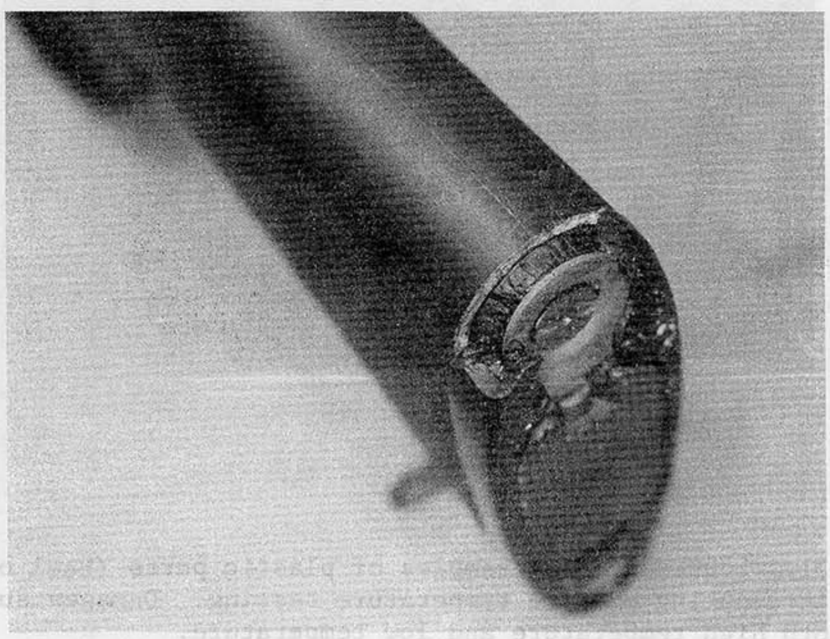


Figure 30. Representative samples of plastic parts damage sustained during extreme temperature testing. Handguard (top) and heel of buttstock (bottom).

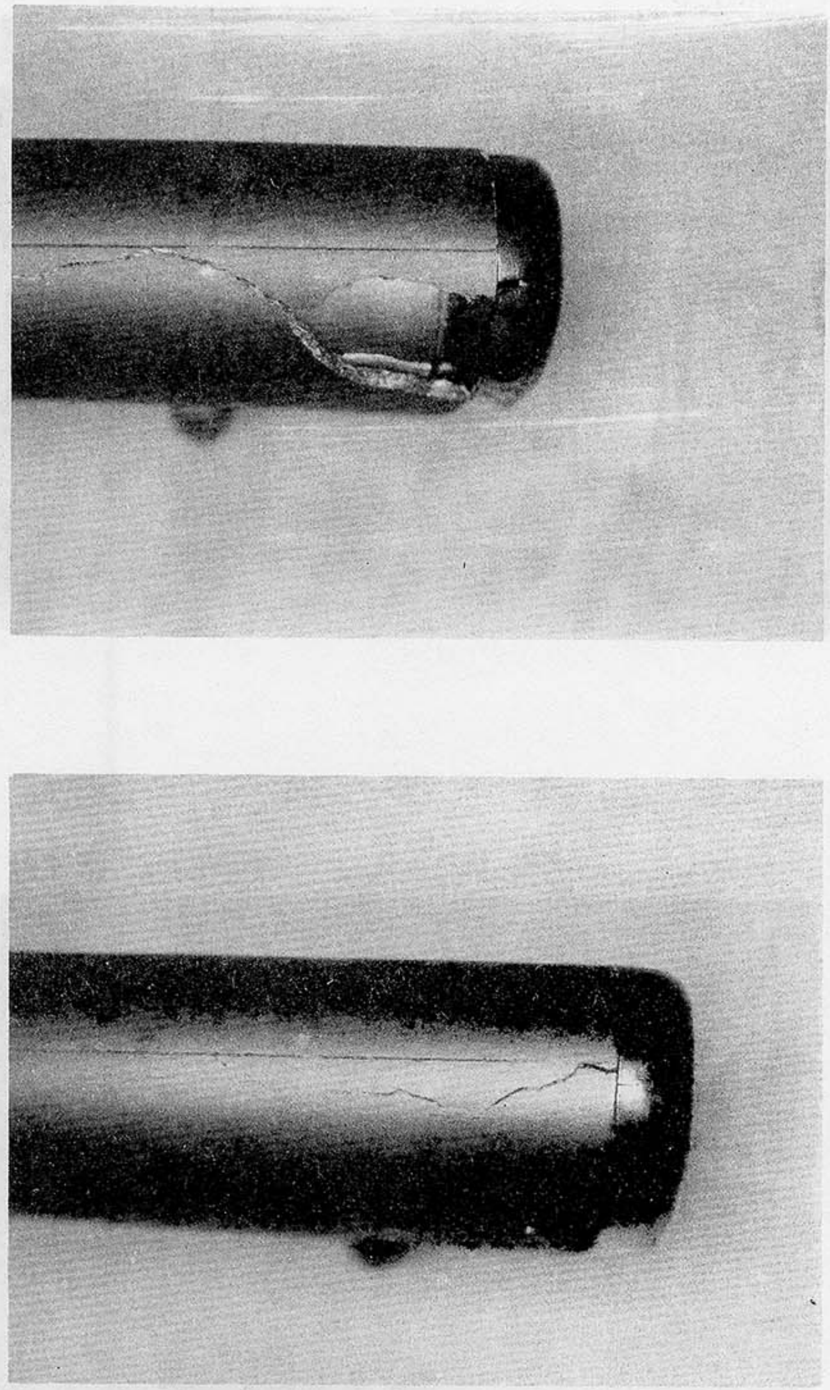


Figure 31. Representative samples of plastic parts (heel of buttstock) damage sustained during extreme temperature testing. Damages sustained were similar in both high temperature and low temperature.

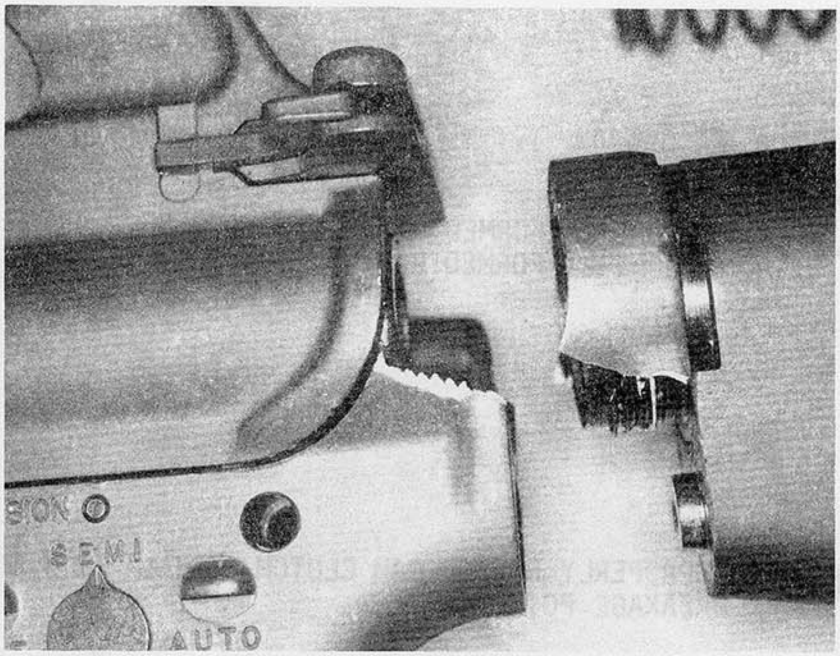


Figure 32. Details of lower receiver failure during low temperature drop test (M16A1).

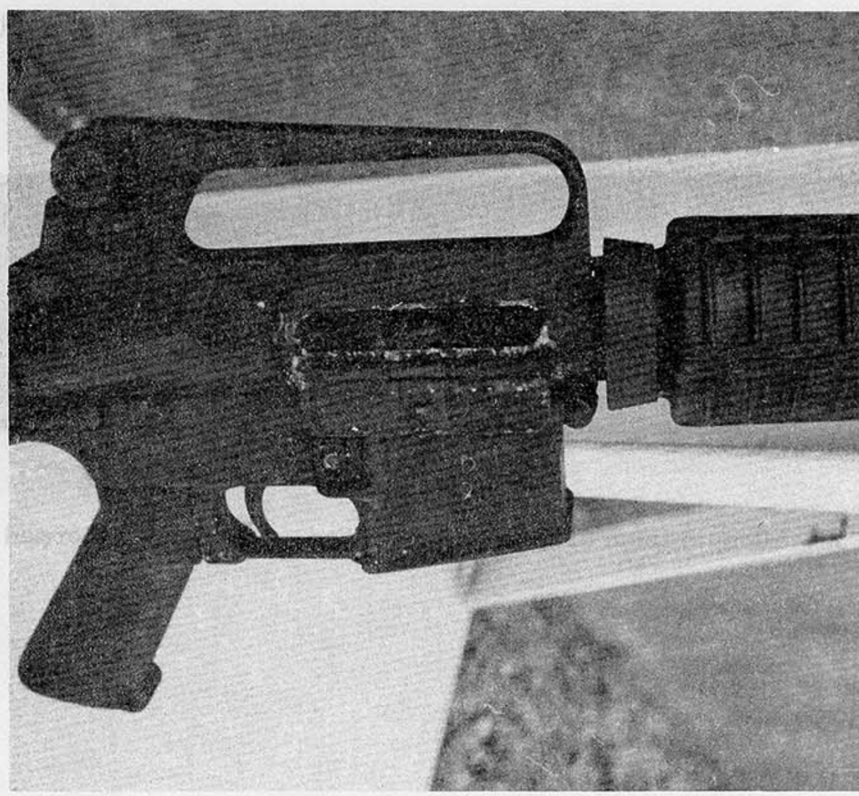


Figure 33. Representative sample of corrosion accumulation after salt water immersion test. Both rifle types showed equal amount of corrosion.

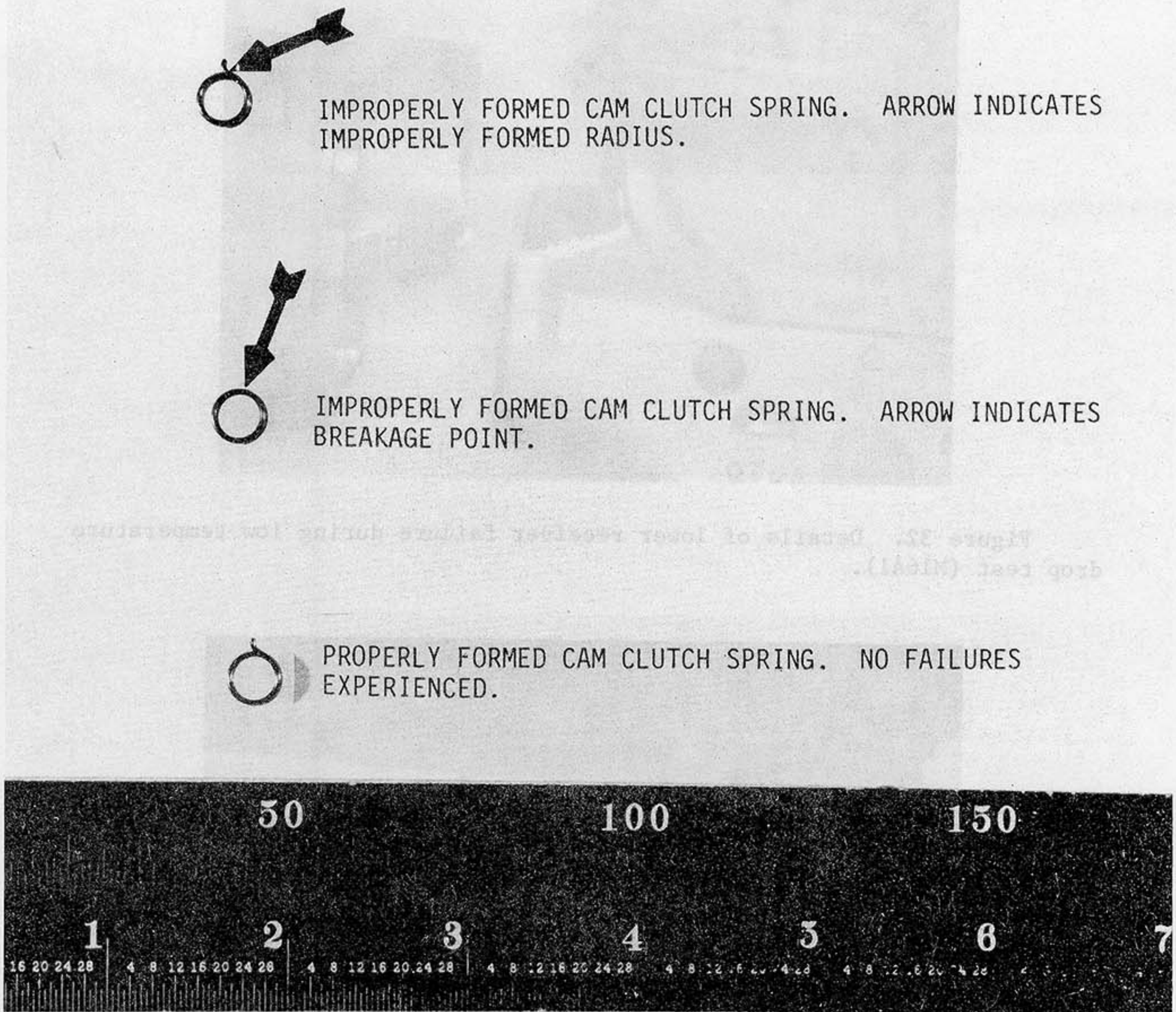


Figure 34. Comparison of properly formed, improperly formed, and broken cam clutch springs.

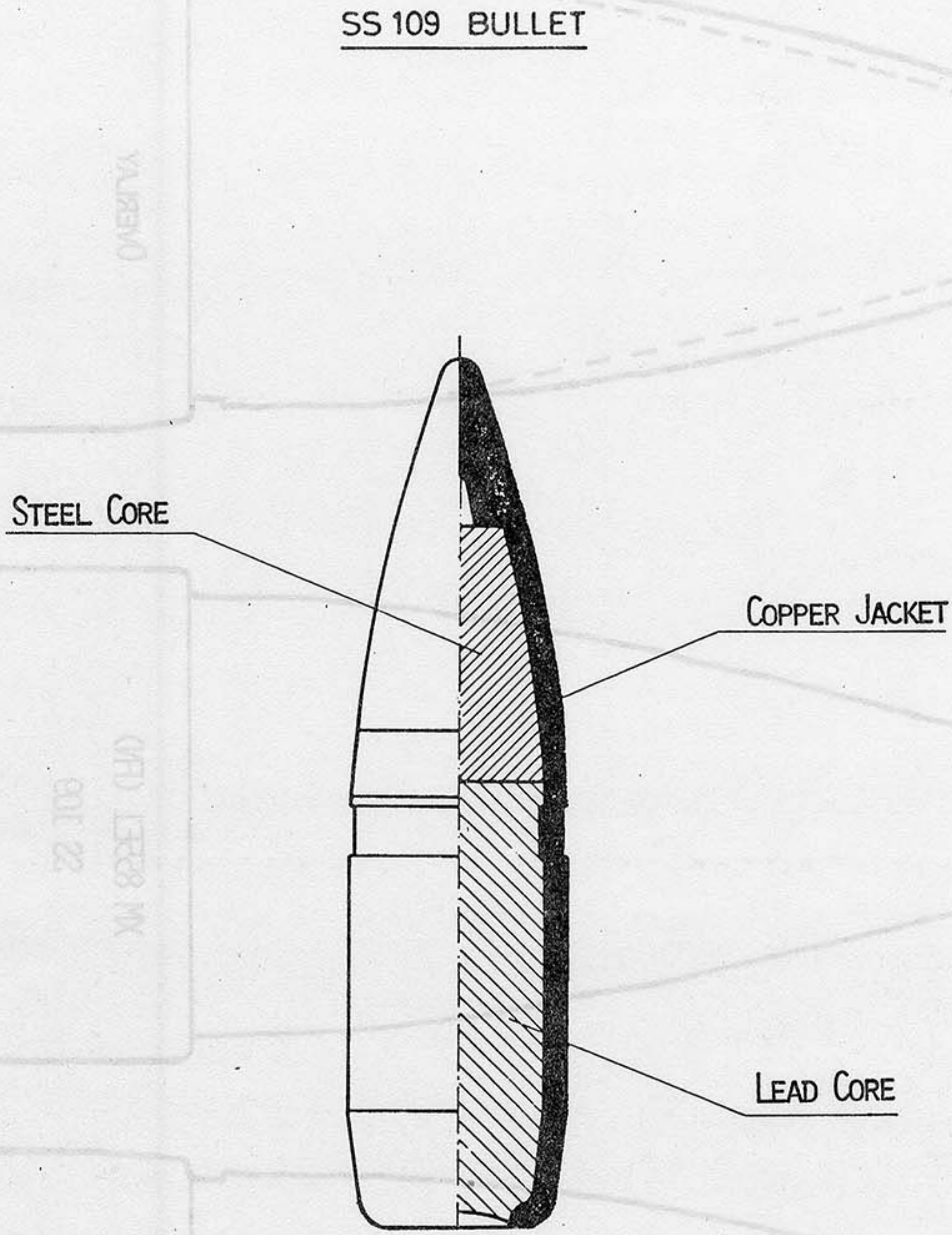


Figure 35. Cutaway view of the SS109 bullet, common to both the SS109 and XM855E1(FN) cartridges.

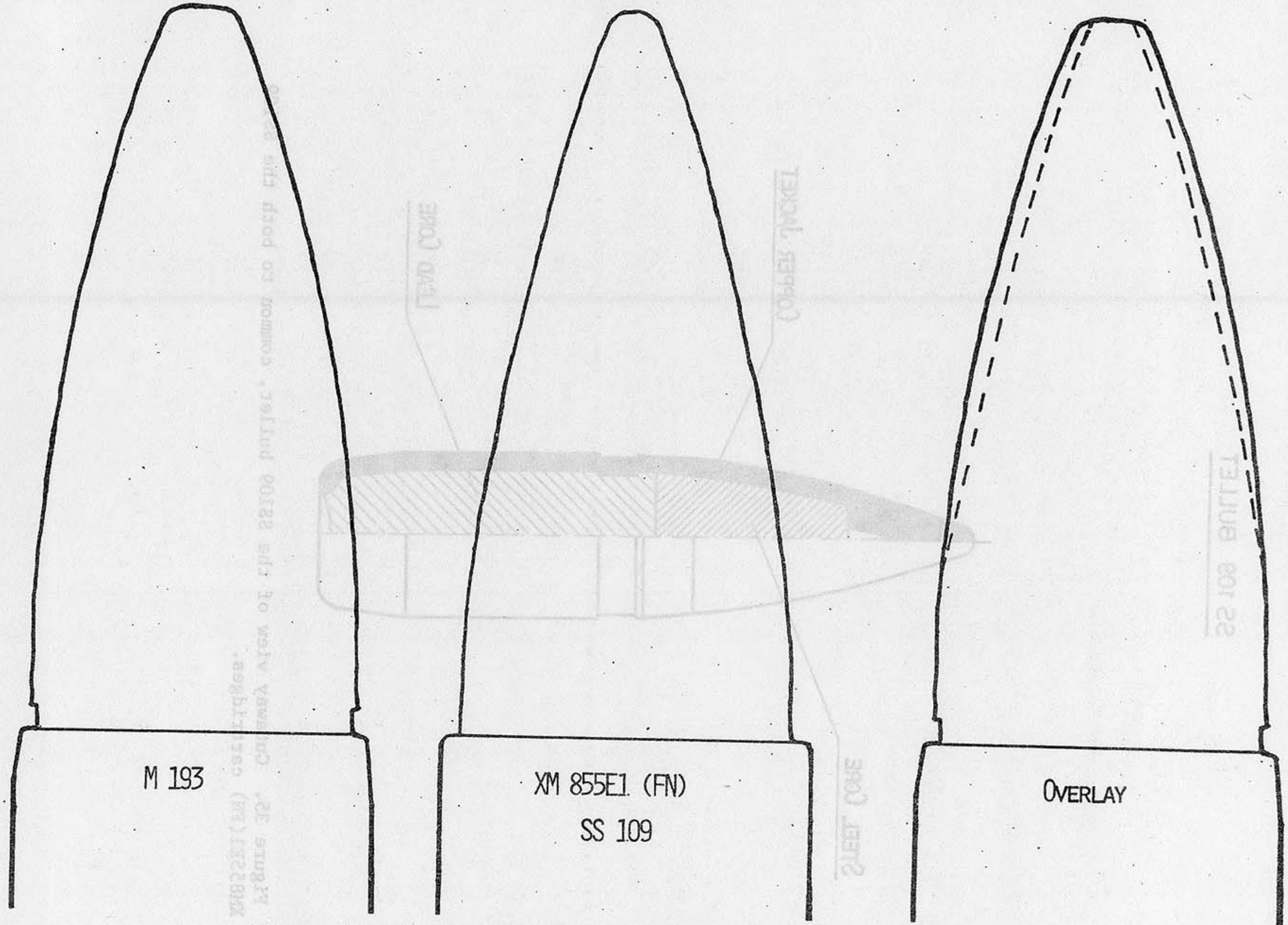


Figure 36. Outlines of the 5.56-mm projectiles magnified 10X.

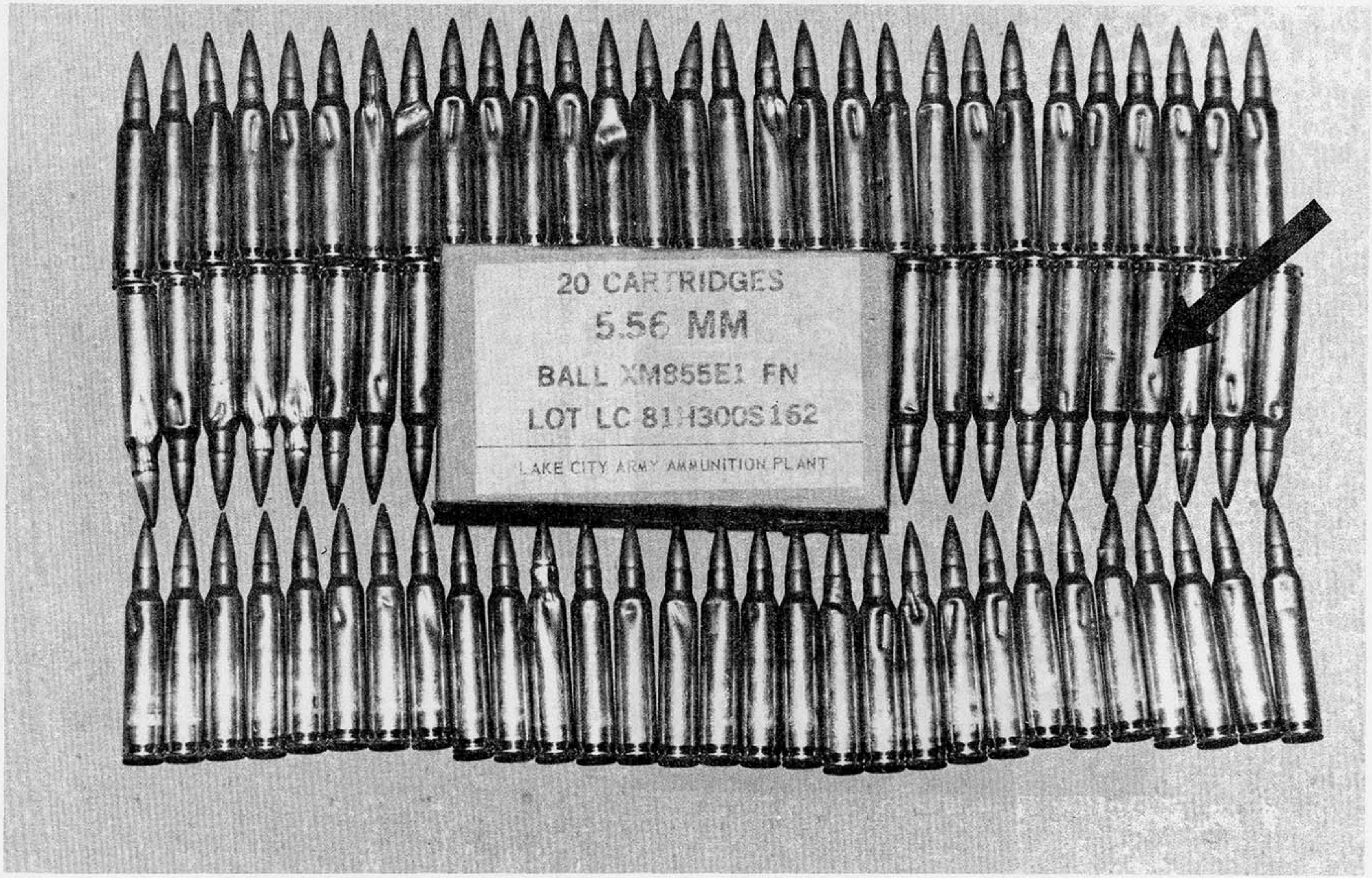


Figure 37. Small representative sample of defective cartridges received. This resulted in individual cartridge inspection prior to loading. M193 cartridge (arrow) was inadvertently packaged with XM855E1(FN) cartridges.

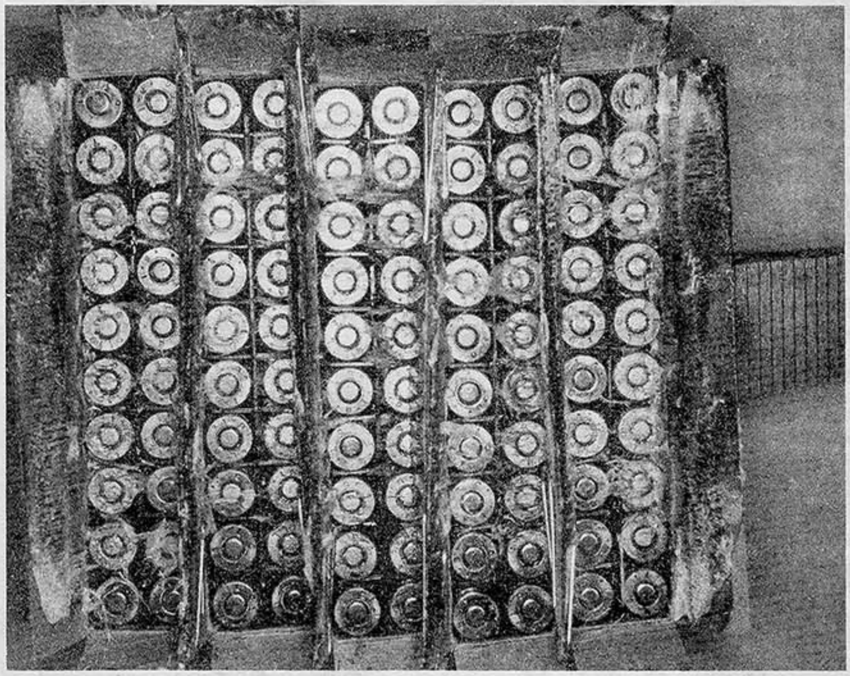


Figure 38. Examples of XM855E1(FN) cartridge packaging with excessive sealing glue, as opened after high temperature conditioning.

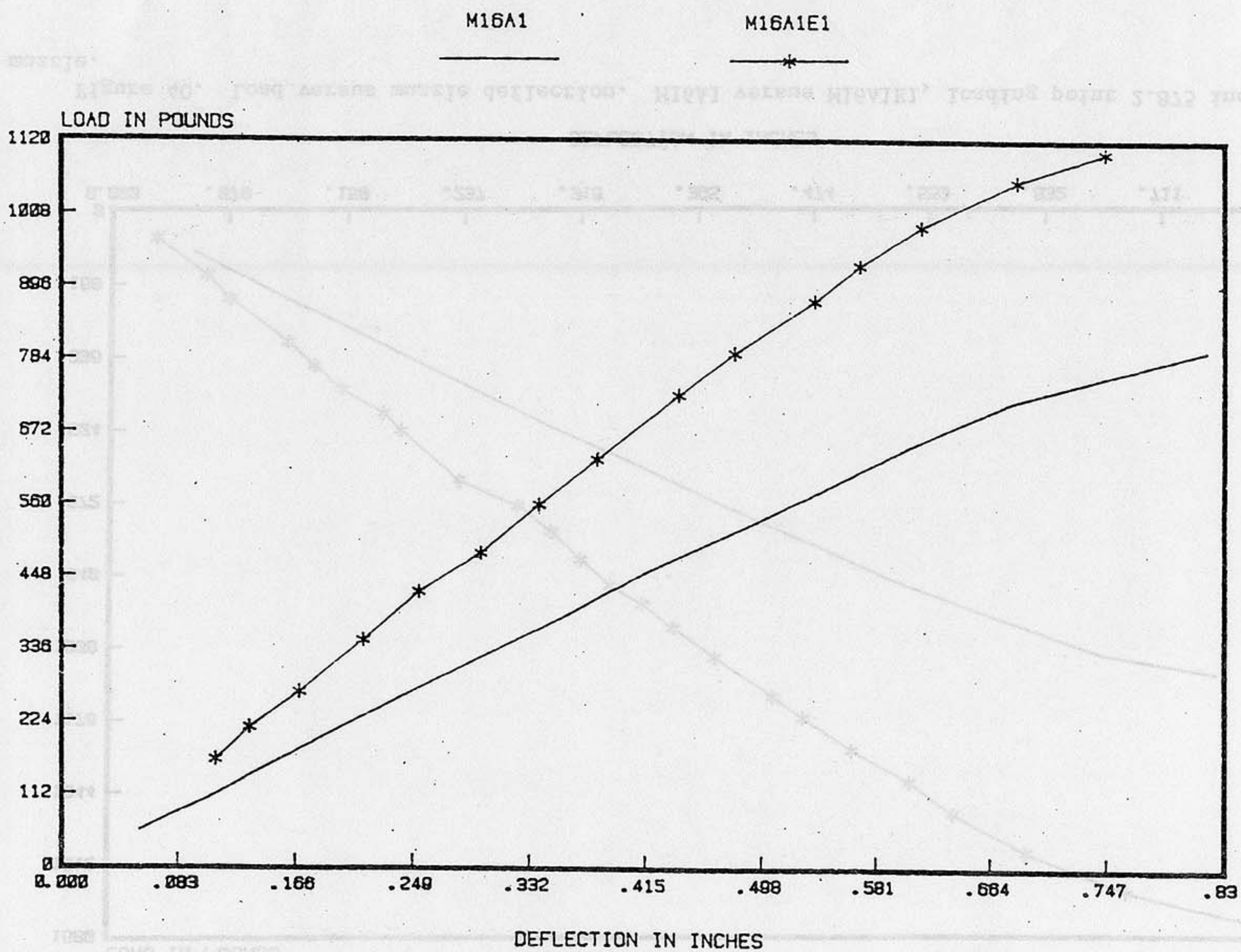


Figure 39. Load versus muzzle deflection. M16A1 versus M16A1E1, loading point 1.625 inches from muzzle.

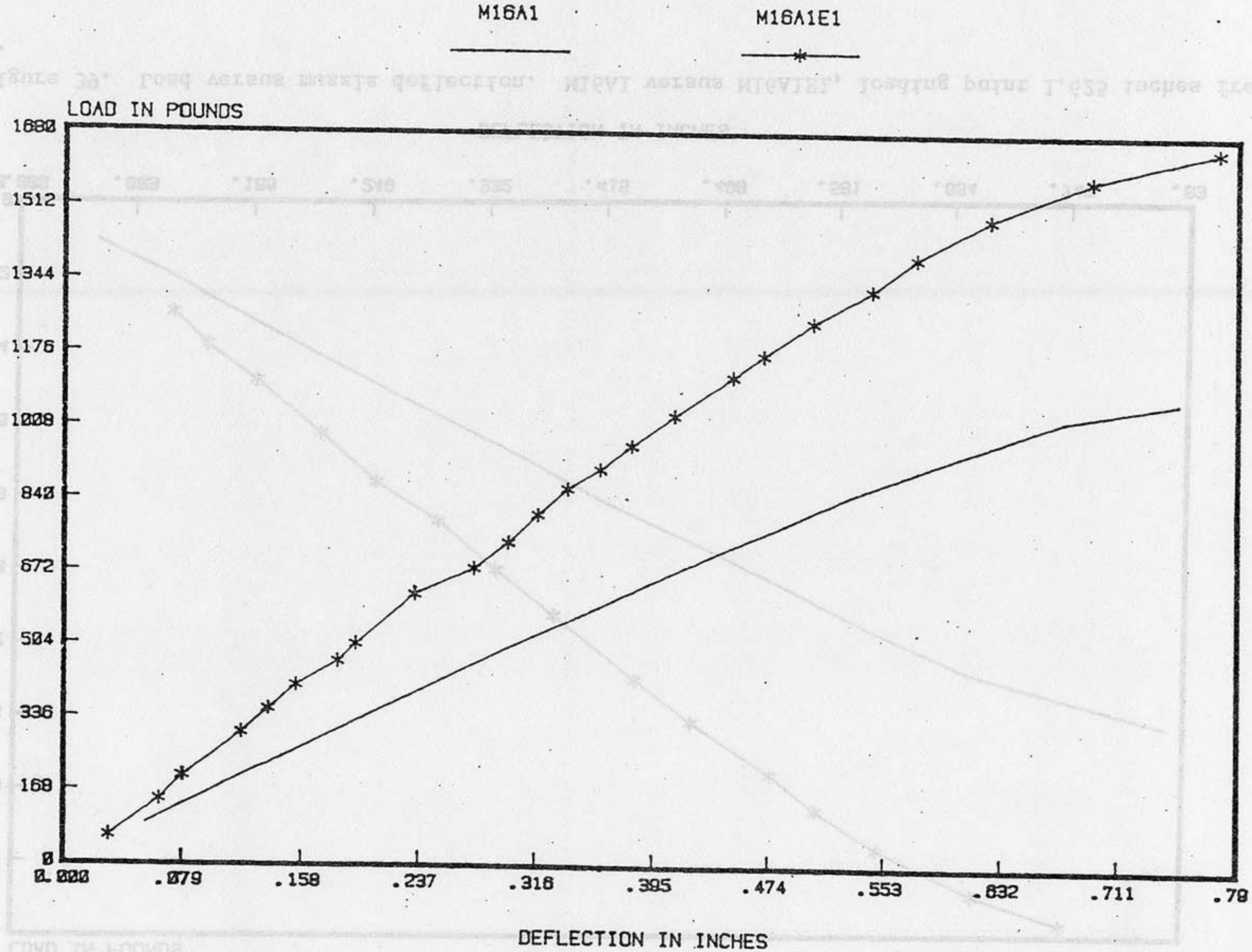


Figure 40. Load versus muzzle deflection. M16A1 versus M16A1E1, loading point 2.875 inches from muzzle.

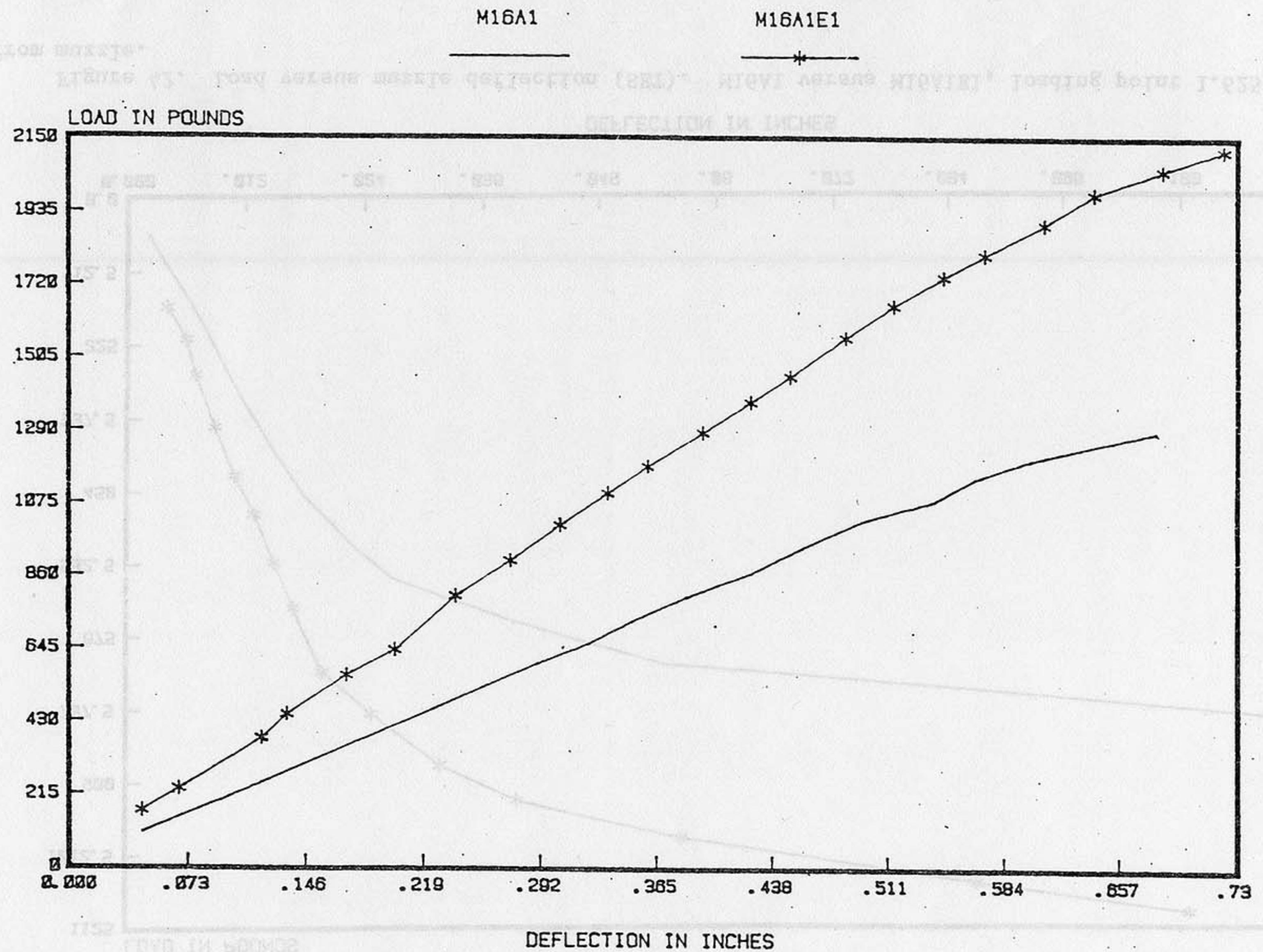


Figure 41. Load versus muzzle deflection. M16A1 versus M16A1E1, loading point 3.625 inches from muzzle.

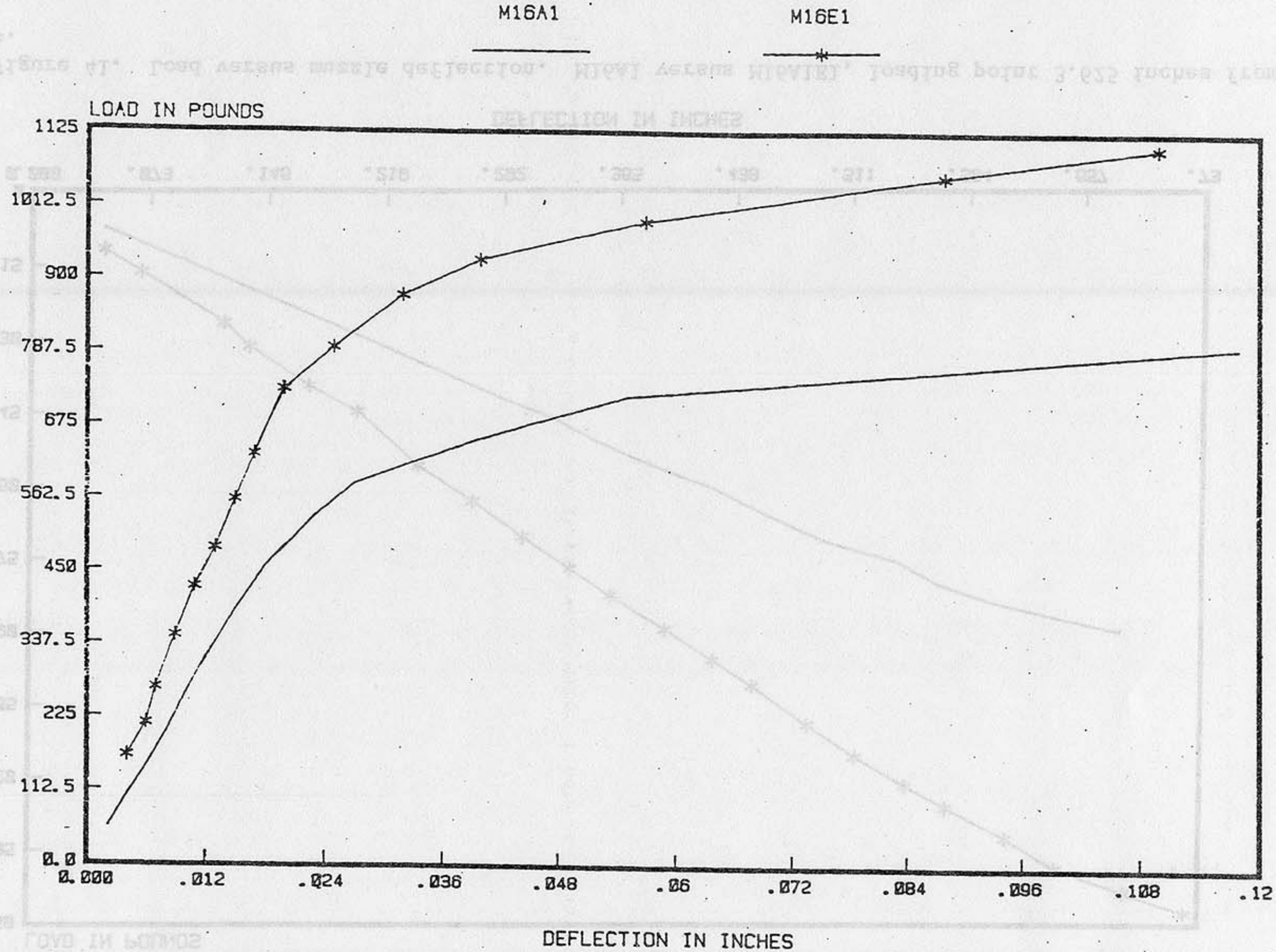


Figure 42. Load versus muzzle deflection (SET). M16A1 versus M16A1E1, loading point 1.625 inches from muzzle.

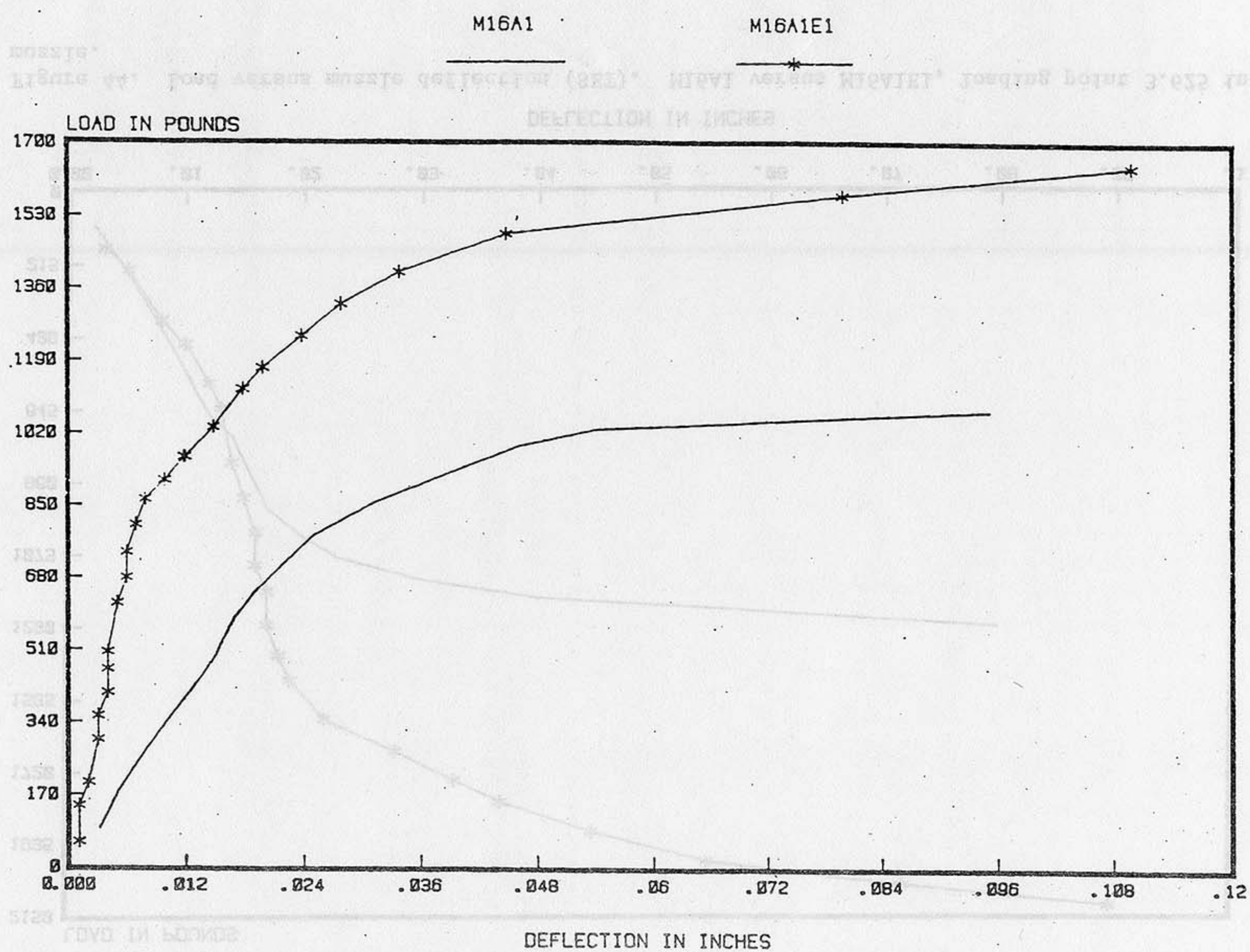


Figure 43. Load versus muzzle deflection (SET). M16A1 versus M16A1E1, loading point 2.875 inches from muzzle.

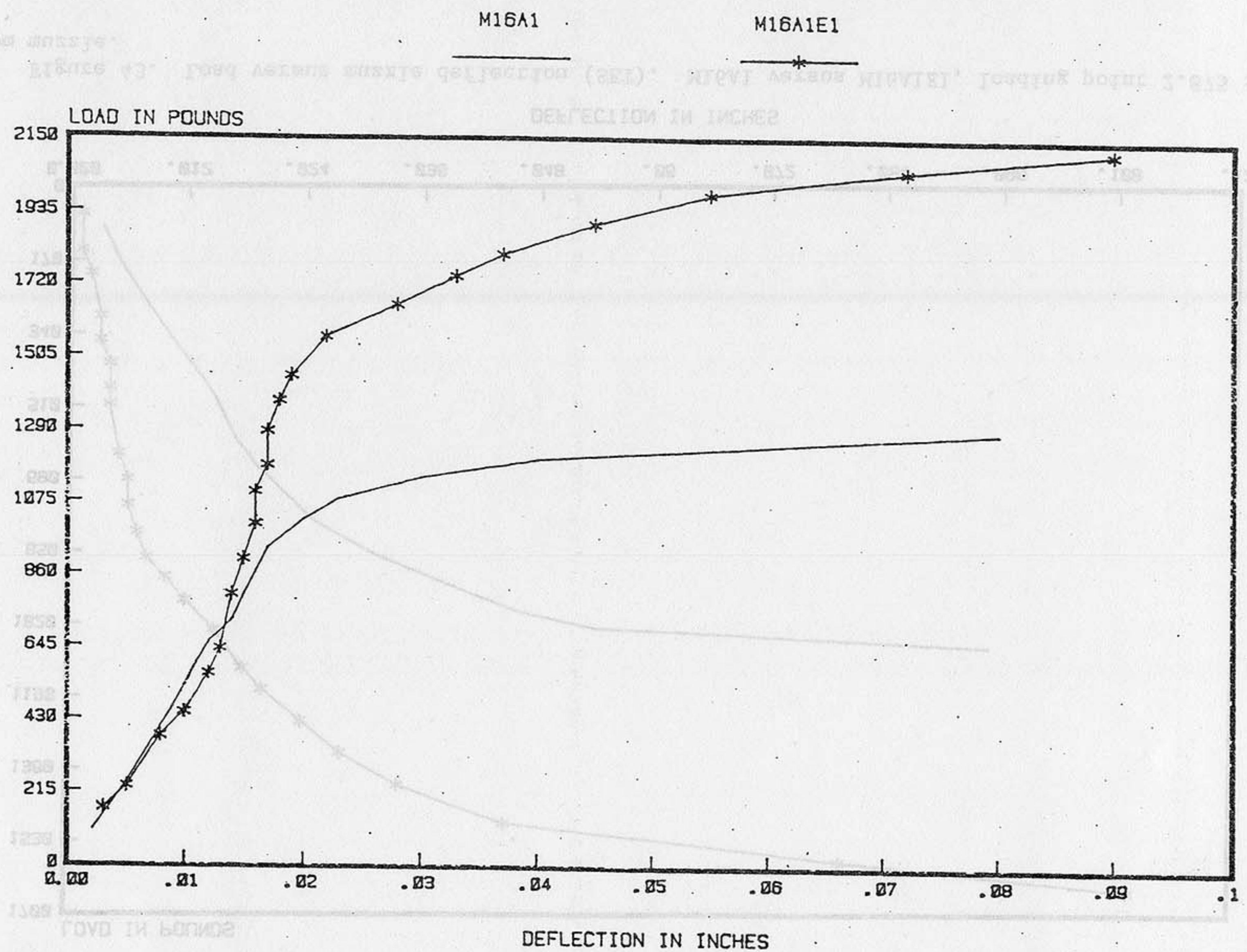


Figure 44. Load versus muzzle deflection (SET). M16A1 versus M16A1E1, loading point 3.625 inches from muzzle.

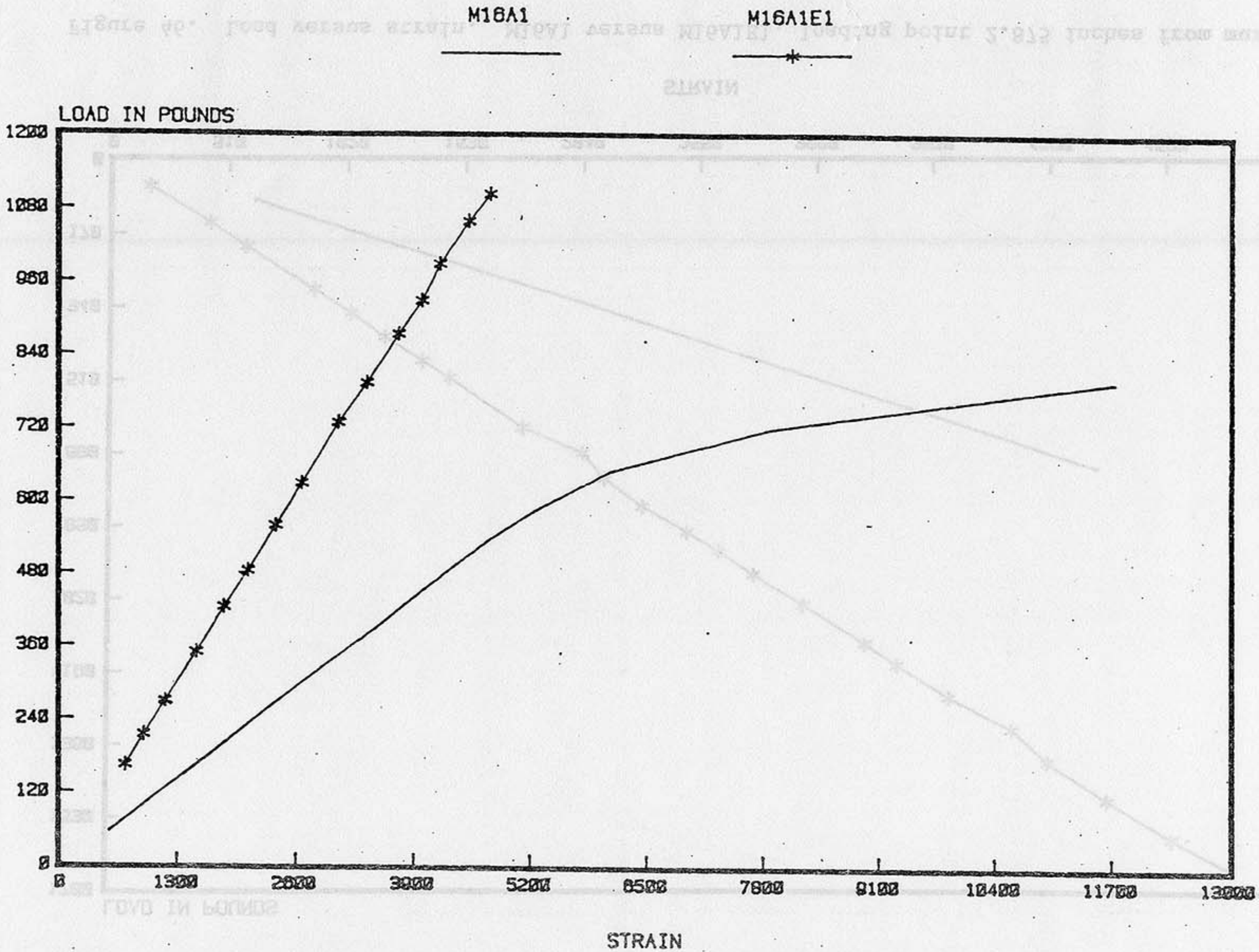


Figure 45. Load versus strain. M16A1 versus M16A1E1, loading point 1.625 inches from muzzle.

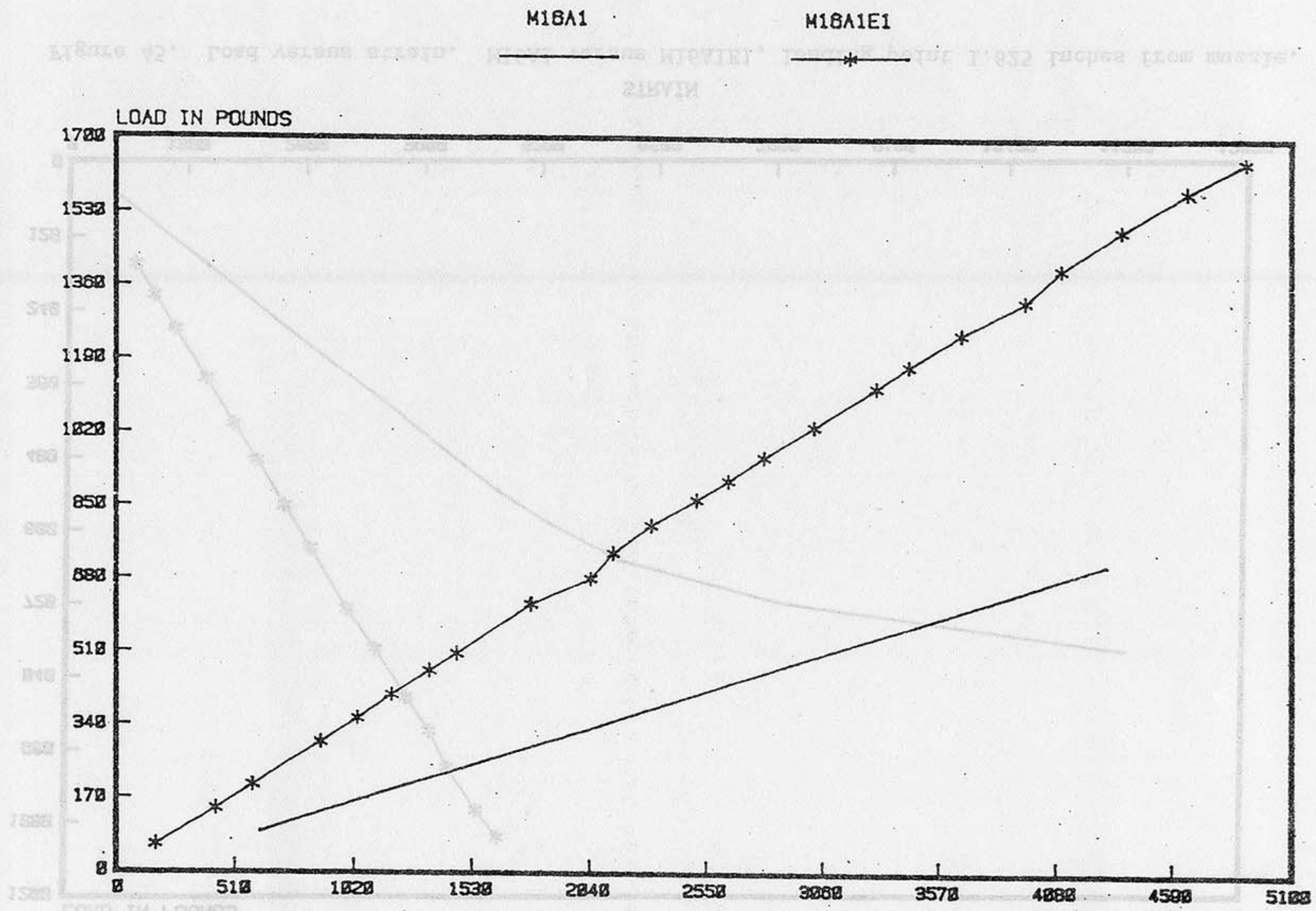


Figure 46. Load versus strain. M16A1 versus M16A1E1, loading point 2.875 inches from muzzle.

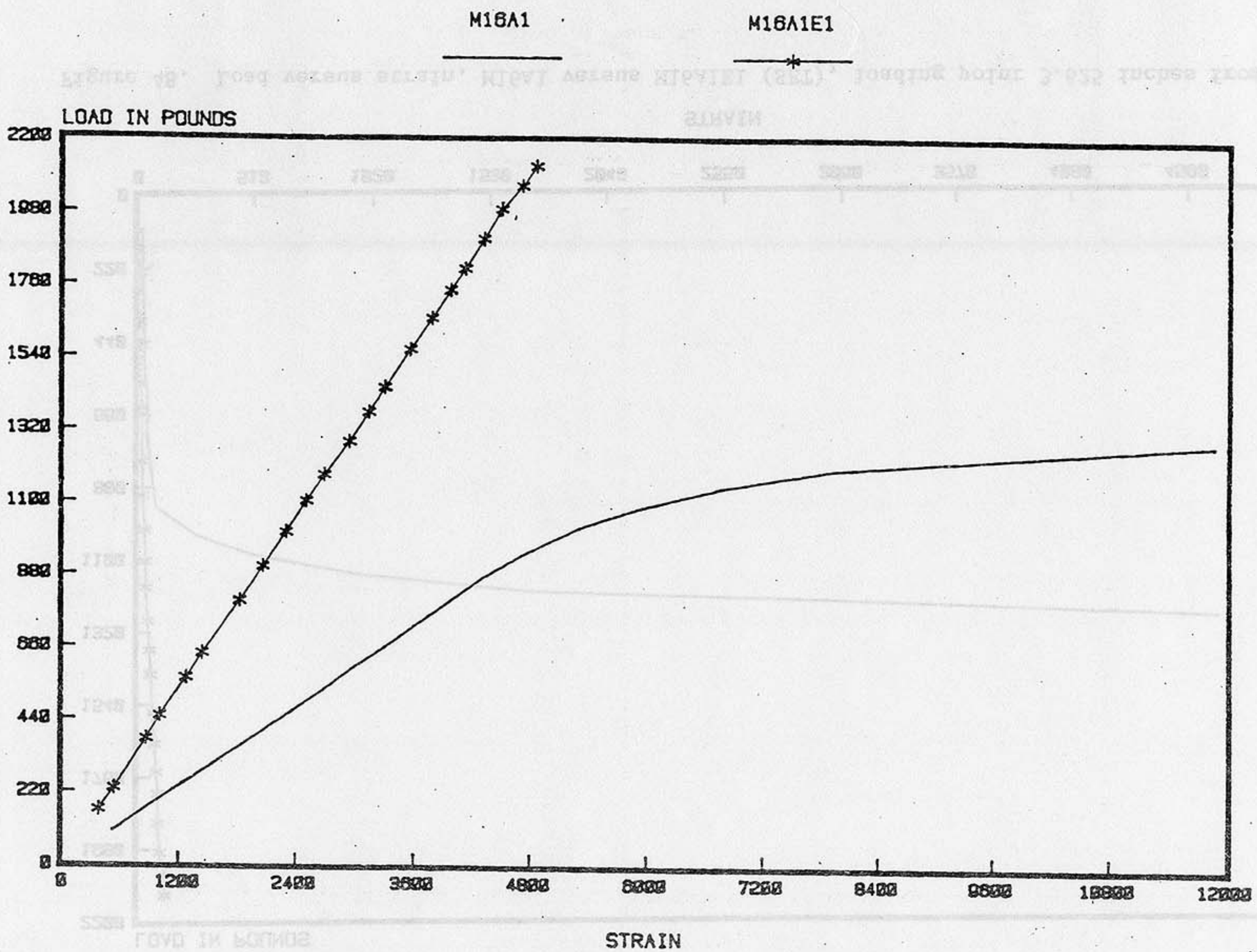


Figure 47. Load versus strain. M16A1 versus M16A1E1, loading point 3.625 inches from muzzle.

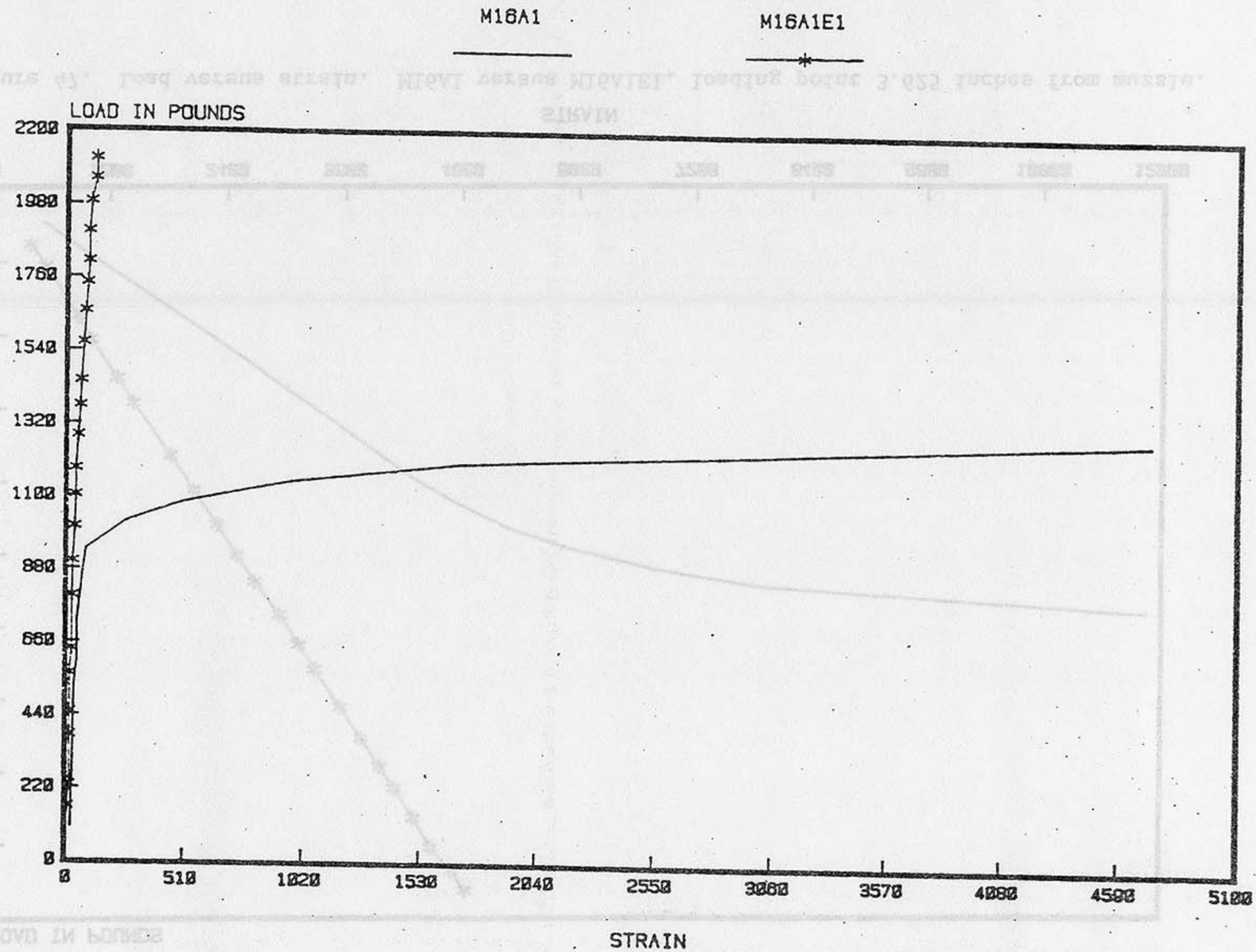


Figure 48. Load versus strain, M16A1 versus M16A1E1 (SET), loading point 3.625 inches from muzzle.

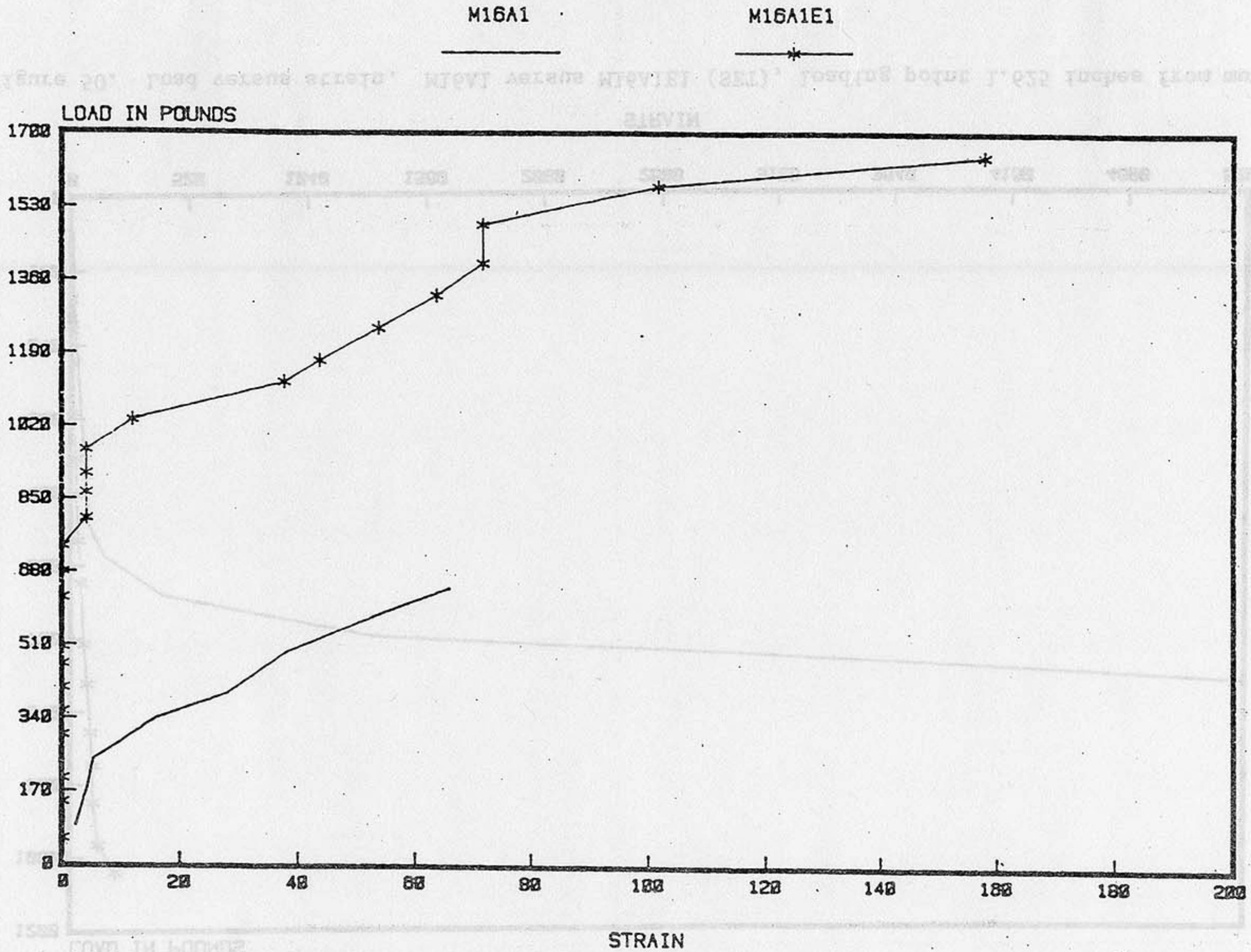


Figure 49. Load versus strain. M16A1 versus M16A1E1 (SET), loading point 2.875 inches from muzzle.

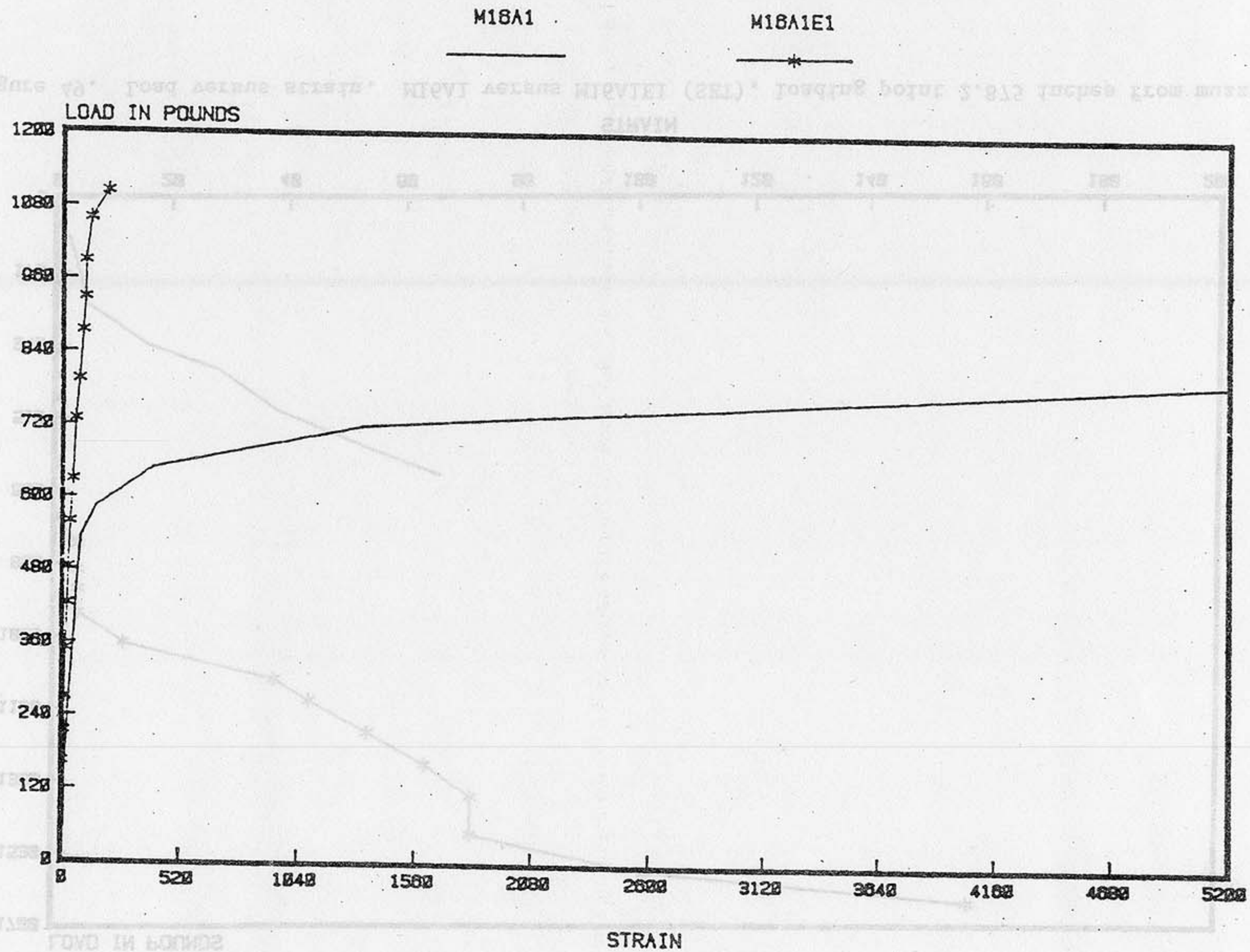


Figure 50. Load versus strain. M16A1 versus M16A1E1 (SET), loading point 1.625 inches from muzzle.

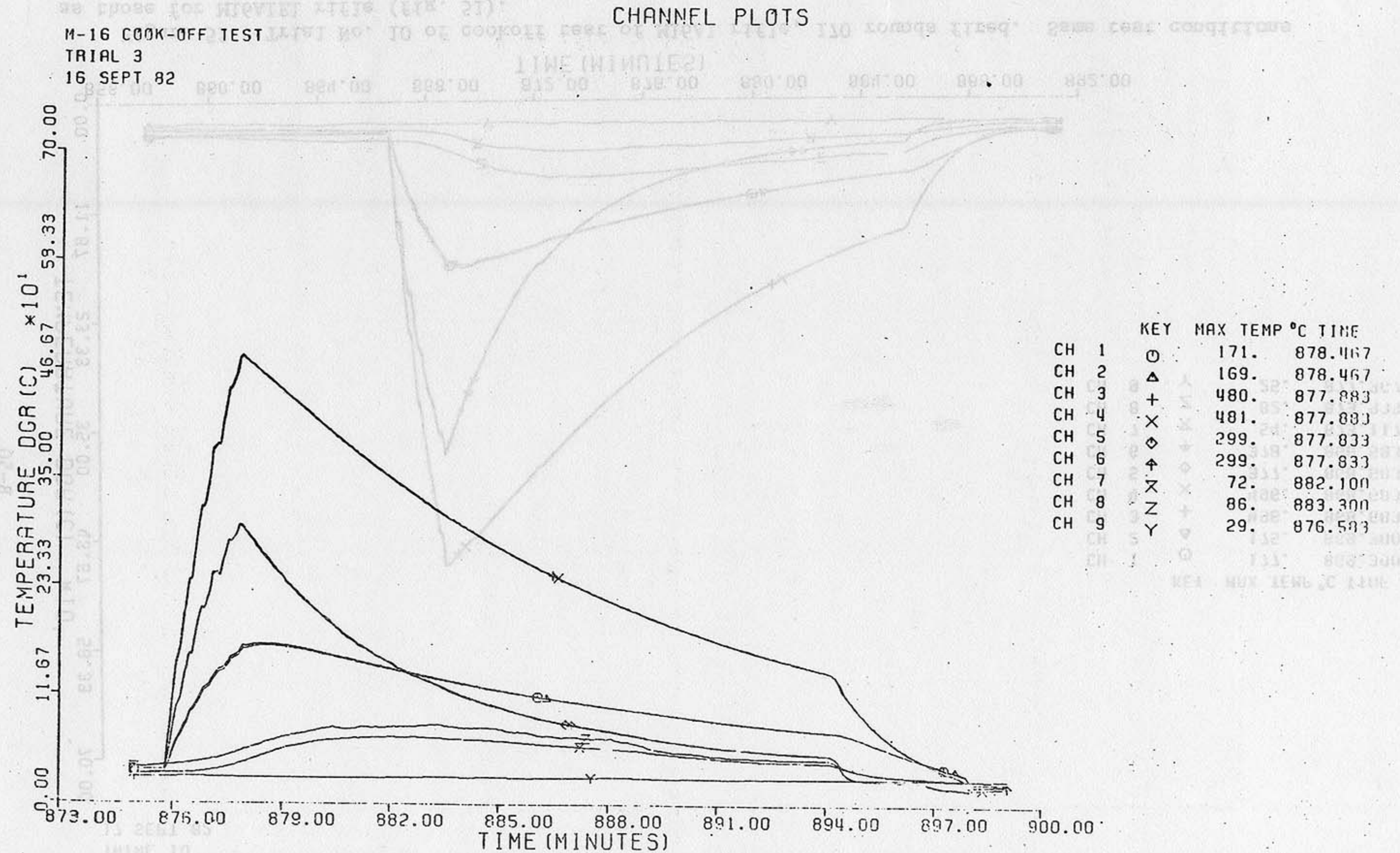


Figure 51. Trial No. 3 of cookoff test of M16A1E1 rifle, 170 rounds fired.

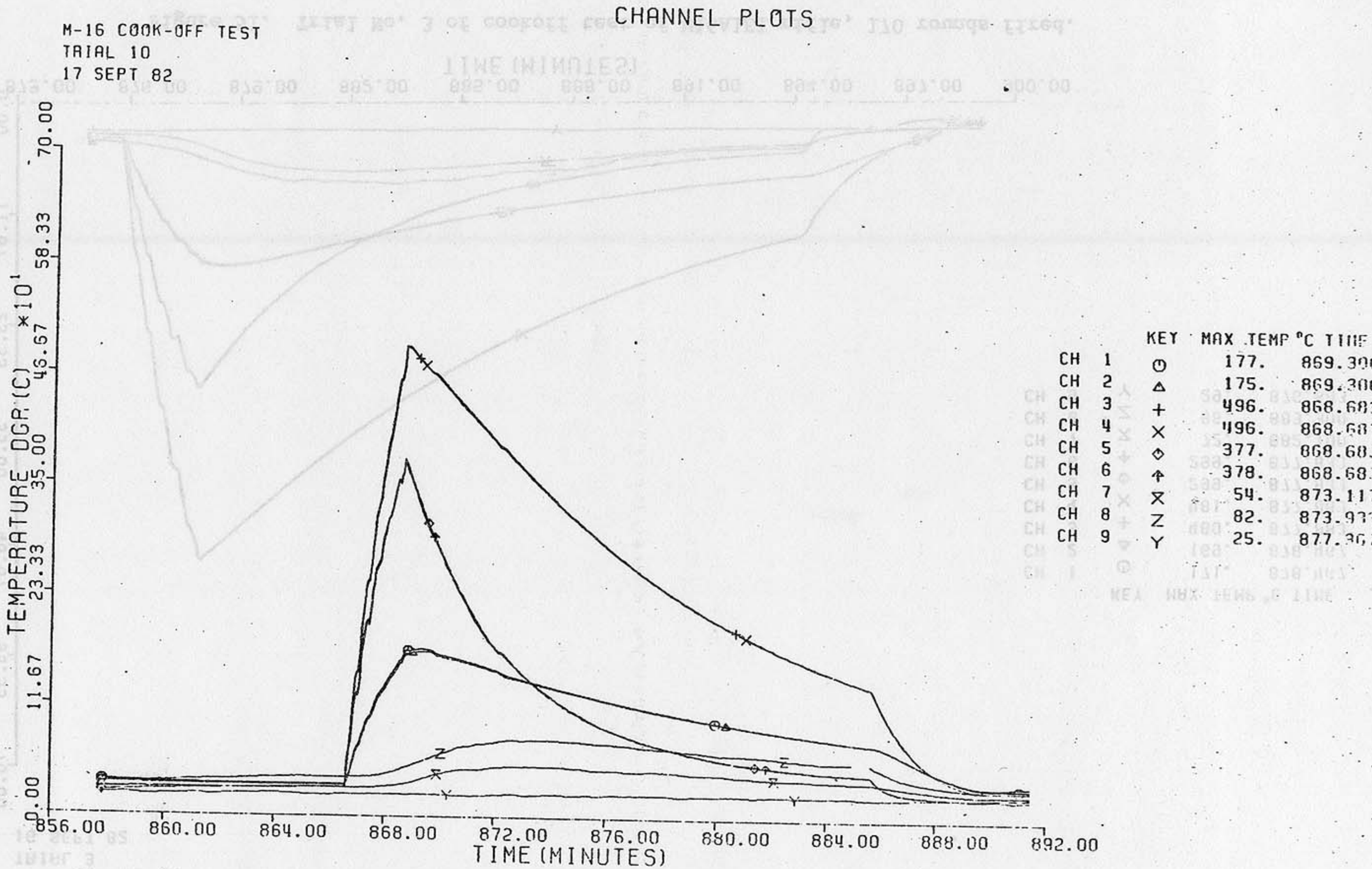


Figure 52. Trial No. 10 of cookoff test of M16A1 rifle, 170 rounds fired. Same test conditions as those for M16A1E1 rifle (fig. 51).

TABLE 1. GROUPS OF NONMATING PARTS FOR PARTS INTERCHANGE TEST

Group I

Take down pin detent (8448585) (2).
Receiver - upper (8448603) for M16 or (8448524) for M16A1.
Rear sight windage drum pin** (MS9047-003).
Magazine catch spring (8448637).
Trigger (8448592).
Front sight post (8448572).

Group II

Lower receiver (8448580).
Rear sight detent spring (8448538).
Barrel and front sight assembly
barrel (8448549).
Barrel extension (8448550).
Barrel indexing pin (8448551).
Front sight (8448566).
Taper pin (8448564).
Nut barrel (8448553).
Handguard cap (8448564).
Extractor pin (8448513).
Butt cap screw (8448627).
Lock washer**(MS35335-61).
Ejection port cover assembly (8448525).

Group III

Receiver extension (8448581).
Bolt (8448510) with bolt rings (8448511) (3).
Ejection port cover pin (8448533) and snap ring**(8448664).
Front sight detent (8448573).
Trigger guard pivot pin**(MS9047-102).
Trigger spring (8448593).
Take down pin (8448584).
Magazine catch button (8448636).

Group IV

Key and bolt carrier assembly (8448505).
Take down pin detent spring (8448586) (2).
Handguard slip ring (8448554).
Ejector and safety detent spring (8448516).
Retainer buffer (8448582).
Trigger and hammer pin (8448609) (2).
Front sight detent spring (8448574).

Group V

Spring buffer retainer (8448583).
Buttstock sssembly stowage (8448650).
Ejection port cover spring (8448532).
Handguard slip ring assembly (8448555).
Ejector pin**(MS9047-005).
Magazine catch (8448638).
Disconnect (8448635).
Plunger assembly (8448545) M16A1 only.

Group VI

Rear sight (8448539).
Spring disconnect (8448594).
Bolt cam pin (8448502).
Bolt catch (8448628).
Pistol grip (8448632).
Buffer assembly (8448615).
Pawl spring pin**(8448521-2) M16A1 only.

TABLE 1 (CONT'D)

Group VII	Group VIII
Ejector (8448515). Rear sight spring (8448536). Gas tube assembly (8448567). Hammer assembly (8448612). Flash suppressor (8448576). Firing pin retaining pin (8448504). Bolt catch plunger (8448634). Pawl (8448543) M16A1 only. Roll pin** (MS9047-071) M16A1 only.	Receiver pivot pin (8448621). Firing pin (8448503). Rear sight windage screw (8448534). Gas tube pin** (MS9047-035). Handguard assembly, LH (8448557). Flash suppressor, lock washer (8448577). Bolt catch spring (8448633). Automatic sear pin (8448599). Pawl detent (8448544) M16A1 only.

Group IX	Group X
Rear sight windage drum (8448535). Charging handle assembly (8448517). Bolt catch pin** (MS9047-069). Hammer spring (8448611). Safety (8448630). Bolt spring (8448542) M16A1 only.	Extractor (8448512) with spring assembly (8448755). Rear sight detent (8448537). Handguard assembly, RH (8448561). Trigger guard assembly (8448587). Automatic sear assembly (8448595). Action spring (8448629). Safety detent (8448631). Plunger spring (8448540) M16A1 only.

Note: All items followed by a double asterisk (**) shall be replaced during interchangeability test. Parts inadvertently damaged during interchange may be replaced without penalty when authorized and verified by the Government representative witnessing the test.

TABLE 2. DETAILED DESPERSION DATA, INITIAL 6000 ROUNDS, ENDURANCE TEST

Range (m)	Rifle No. (APG)	Extreme Spread (cm) Target 1	2	3	4	5	6	Avg
		Initial Accuracy						
200	1A	15.5	20.1	17.5	15.8	21.1	16.4	17.7
	2A	18.6	29.7	26.3	25.3	25.0	11.0	22.6
	3A	24.5	19.9	18.0	20.3	24.2	22.2	21.5
	4A	18.8	24.5	9.9	18.4	18.7	16.9	17.9
	5A	24.0	23.6	18.4	17.4	16.5	9.5	18.2
	All							19.6
	1D	32.4	22.2	27.5	32.0	20.0	39.4	28.9
	2D	32.1	25.1	25.1	19.2	19.9	31.5	25.5
	3D	32.0	17.8	30.1	18.6	25.7	26.4	25.1
	4D	24.1	28.9	20.2	25.9	36.7	30.6	27.7
	5D	24.9	24.6	31.7	34.9	27.4	26.6	28.4
	All							27.1
300	1A	32.1	33.6	46.1	43.6	23.6	33.7	35.4
	2A	50.6	44.1	40.1	38.2	35.3	30.8	39.8
	3A	36.5	29.3	29.9	23.1	33.6	23.8	29.4
	4A	25.3	28.4	36.9	45.3	42.6	23.5	33.7
	5A	36.1	24.5	28.3	22.8	30.9	46.1	31.4
	All							33.9
	1D	22.4	56.9	39.4	50.9	51.8	37.8	43.2
	2D	38.7	48.5	31.7	49.0	38.7	53.7	43.4
	3D	59.6	36.9	35.2	36.3	49.6	47.5	44.2
	4D	46.2	49.2	35.5	41.2	38.0	30.6	40.1
	5D	48.1	29.0	45.2	49.4	45.4	50.2	44.6
	All							43.1
400	1D	57.4	84.9	83.5	40.5	37.3	57.0	60.1
	2D	39.6	35.9	49.3	80.3	95.0	79.3	63.2
	3D	60.0	42.1	50.2	61.0	64.4	28.9	51.1
	4D	66.2	55.6	63.8	43.3	61.2	54.9	57.5
	5D	65.7	40.4	44.0	40.1	53.1	64.1	51.2
	All							56.6

Range (m)	Rifle No. (APG)	Extreme Spread (cm) Target 1	2	3	4	5	6	Avg
500	1A	68.5	47.4	79.4	79.7	56.8	56.4	64.7
	2A	80.0	54.8	112.6	53.9	49.9	88.4	73.3
	3A	52.0	62.5	37.1	85.4	63.5	43.2	57.3
	4A	63.2	37.2	97.0	76.0	58.3	53.1	64.1
	5A	61.0	49.7	66.6	68.0	64.1	61.3	61.8
	All							64.2
	1D	55.7	57.6	82.1	69.4	69.2	55.2	64.9
	2D	57.7	56.4	63.5	102.7	45.5	129.8	76.0
	3D	92.9	64.4	62.3	76.9	49.7	53.0	66.5
	4D	65.5	64.9	76.4	52.3	76.4	112.4	74.7
	5D	63.6	49.6	65.1	98.2	61.6	88.5	71.1
	All							70.6
600	1A	50.9	62.7	54.3	138.7	55.6	108.3	78.4
	2A	84.6	79.4	66.8	102.7	99.7	65.5	83.1
	3A	68.9	66.8	83.0	67.8	54.1	52.3	65.5
	4A	74.0	87.8	148.7	84.9	90.3	88.1	95.6
	5A	46.8	72.3	59.3	76.4	76.8	89.1	70.1
	All							78.5
	1D	55.1	148.5	109.0	98.8	100.8	76.7	98.1
	2D	88.1	74.8	60.7	59.0	83.3	134.5	83.4
	3D	89.4	125.1	72.0	70.1	89.1	103.9	91.6
	4D	106.3	79.0	128.3	100.6	188.7	114.3	119.5
	5D	80.5	124.3	69.2	115.4	108.0	83.3	96.8
	All							97.9
700	1D	113.8	97.6	74.1	149.1	85.7	107.4	104.6
	2D	102.6	70.8	92.2	131.4	91.6	132.5	103.5
	3D	72.7	76.1	116.6	107.5	141.8	69.0	97.3
	4D	68.5	78.6	148.6	182.8	147.8	103.1	121.6
	5D	120.2	58.9	114.4	160.0	69.9	116.8	106.7
	All							106.7
800	1A	122.1	132.4	93.3	164.9	140.7	180.9	139.1
	2A	153.2	159.6	174.7	151.0	200.0	128.2	161.1
	3A	134.4	153.1	110.1	147.5	123.5	140.9	134.9
	4A	138.6	187.3	210.2	155.0	174.4	142.5	168.8
	5A	180.6	180.2	175.3	103.7	192.2	117.8	158.3
	All							152.4

Range (m)	Rifle No. (APG)	Extreme Spread (cm) Target 1	2	3	4	5	6	Avg
	1D	89.2	139.1	138.0	133.6	137.0	153.2	131.7
	2D	132.3	132.0	128.0	140.7	125.5	137.4	132.7
	3D	97.5	168.6	175.9	107.2	171.7	99.4	136.7
	4D	89.0	159.2	104.1	148.1	137.4	170.6	134.7
	5D	92.2	105.3	112.1	153.9	138.9	151.0	125.6
	All							132.3
				After 3600 Rounds				
200	1A	20.0	14.1	13.0	27.4	25.5	20.1	20.0
	3A	15.6	14.5	15.6	17.3	17.6	15.4	16.0
	4A	25.4	19.4	18.3	21.1	17.9	19.0	20.2
	All							18.7
	1D	16.5	27.5	20.3	29.0	24.6	45.7	27.3
	3D	28.8	21.2	22.4	18.4	19.5	29.7	23.3
	5D	46.2	34.7	57.8	29.5	65.6	24.9	43.1
	All							31.2
300	1A	27.0	23.7	28.9	21.7	17.7	28.8	24.6
	3A	27.8	28.6	19.6	22.7	37.4	23.2	26.6
	4A	23.6	28.4	27.5	38.3	35.7	28.6	30.3
	All							27.2
	1D	65.6	29.1	38.1	29.8	35.4	64.5	43.7
	3D	39.3	44.3	34.9	51.6	27.8	46.5	40.7
	5D	49.9	49.4	78.7	70.5	55.5	86.7	65.1
	All							49.8
500	1A	34.5	45.9	44.7	47.3	46.0	47.9	44.4
	3A	41.3	34.6	52.5	35.7	41.3	123.2	54.8
	4A	84.7	46.7	52.0	54.8	48.5	45.1	55.3
	All							51.5
	1D	95.1	71.3	109.2	58.4	55.7	59.6	74.9
	3D	76.6	70.4	65.5	63.4	95.0	40.9	68.6
	5D	103.1	93.1	129.2	113.4	77.0	218.6	122.4
	All							88.6

Range (m)	Rifle No. (APG)	Extreme Spread (cm)						
		Target						
		1	2	3	4	5	6	Avg
		After 6000 Rounds						
200	1A	18.7	19.4	18.4	18.6	13.7	14.8	17.3
	3A	16.1	13.4	15.4	15.7	14.1	16.1	15.1
	4A	33.3	15.0	18.6	24.0	22.0	11.9	20.8
	All							17.7
	1D	56.8	39.1	43.8	52.3	33.6	47.1	45.4
	3D	73.6	73.4	56.2	56.1	60.9	56.8	62.8
	5D	93.8	69.4	82.1	78.6	64.9	82.4	78.5
	All							62.2
300	1A	19.3	22.4	26.2	21.7	24.9	25.5	23.3
	3A	25.8	70.0	24.1	29.8	34.4	24.0	34.7
	4A	24.4	27.2	27.1	25.3	41.8	36.2	30.3
	All							29.4
	1D	55.6	34.6	78.8	70.6	55.9	79.7	62.5
	3D	99.8	97.8	73.6	86.3	100.3	94.0	92.0
	5D	101.3	108.9	97.2	95.7	96.0	110.1	101.5
	All							85.3
500	1A	45.5	57.0	52.8	38.4	123.0	39.4	59.4
	3A	48.9	51.2	35.4	142.3	59.8	35.0	62.1
	4A	54.3	66.1	68.8	597.2	47.4	45.2	230.0
	All							117.2
	1D	118.8	129.9	116.3	198.7	150.0	144.6	143.0
	3D	154.6	183.4	174.4	143.7	185.1	158.4	166.6
	5D	220.1	168.7	181.2	208.2	251.8	202.5	205.4
	All							171.7
600	1D	144.3	154.4	163.9	163.1	204.9	154.3	164.2
	3D	181.4	188.5	201.6	130.2	166.1	151.8	169.9
	5D	230.8	230.8	225.0	186.5	133.2	178.9	197.5
	All							177.2
800	1D	183.9	144.1	251.9	265.9	267.7	196.4	218.3
	3D	231.4	219.0	235.5	201.4	216.6	283.4	231.2
	5D	198.6	164.3	221.7	224.5	215.9	224.3	208.1
	All							219.2

APPENDIX C - DEFICIENCIES, SHORTCOMINGS, AND SUGGESTED IMPROVEMENTS

1. Deficiency

Deficiency	Suggested Corrective Action	Remarks
The case ejection pattern places personnel to the right of any firer in danger of being struck by hot spent cases. Paragraph 2.15 identifies areas for improvement of the M16A1E1 from the safety and health viewpoint.	Redesign of the spent case deflector to cause the spent case ejection pattern to fall between the 1 and 2 o'clock positions. Retest for endurance on first article acceptance to insure safe ejection pattern and reliability.	This will help eliminate the hot case ejection problem as presently encountered on the M16 designs.

2. Shortcomings

Shortcomings	Suggested Corrective Action	Remarks
2.1 Marginal firing pin energy. Paragraphs 2.2 and 2.4 identify and expand the associated problems encountered.	Retest for energy and extreme cold operation in first article inspection.	Design of hammer spring is the suspected cause of the marginal to insufficient firing pin energy.
2.2 Buffer failure in cold weather operation.	Redesign buffer assembly procedures so retaining plug will not fail in extreme cold.	Buffer failures are hard to clear and completely stop rifle operation.

3. Suggested Improvements

None specified. Paragraph 2.13 identifies areas for improvement of the M16A1E1 rifle from the human factors viewpoint.

APPENDIX D - LOGISTIC SUPPORTABILITY DATA

Summary of Part Life Data

Part Name	Subtest	Part Life (Rd)	Rifle Type
Carrier key screws (2)	High Temperature	1456	M16A1[a]
Buffer assembly	Endurance	6600	M16A1[a]
Buffer assembly	Low Temperature	1828	M16A1E1[a]
Buffer assembly	Low Temperature	2323	M16A1[a]
Buffer assembly	Low Temperature	2286	M16A1E1[a]
Buffer assembly	Low Temperature	2043	M16A1E1[a]
Low receiver	Low Temperature	Drop test	M16A1[a]
Bolt ring	Endurance	4800	M16A1[a]
Bolt assembly	Endurance	6000	M16A1E1[a]
Cam clutch spring	Low Temperature	1803	M16A1E1[b,c]
Cam clutch spring	Endurance	5760	M16A1E1[b,c]
1:7 twist barrels	Endurance	6000	M16A1E1[b]

[a]Parts that are common to M16A1 amd M16A1E1.
[b]Part that is peculiar to M16A1E1 only.
[c]Cam clutch springs were examined and found to be improperly formed. New springs were obtained within tolerance with no failures experienced.

Note: Buffers were examined in an effort to determine causes of failures. Apparently the nylon material in the nose plug shrinks in extreme cold which allows disengagement from the tube. More testing is needed to confirm this theory.

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APPENDIX F - ABBREVIATIONS

ARS = adjustable range sight
ARRADCOM = US Army Armament Research and Development Command
ASTM = American Society for Testing and Materials.
ATS = ARRADCOM Test Site
BCD = burst control device
BFA = blank firing attachment or adapter
CIL = clean, inspect, and lubricate
CLP = cleaner, lubricant, and preservative
DARCOM = US Army Materiel Development and Readiness Command
HFE = human-factors evaluation
JSSAP = joint services small arms program
MBC = muzzle brake compensator
MILES = multiple integrated laser engagement system
MPI = magnetic particle inspection
MRBS = mean rounds between stoppages
SD = standard deviation
SPL = sound pressure level
spm = shots per minute
TFT = Technical Feasibility Test

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