AD

AMCMS Code No. 4420.25.0132.2.136
USATECOM Project No. 8-7-0230-04
Report No. DPS-2662 (Addendum)

ADDENDUM TO FINAL REPORT ON PRODUCT IMPROVEMENT TEST OF REDESIGNED BUFFER FOR M16A1 RIFLE (DISPLACEMENT - TIME STUDY)

BY

ALLAN WILSON

MAY 1968

ABERDEEN PROVING GROUND

ABERDEEN PROVING GROUND, MARYLAND

DIGITIZED FOR YOUR REVIEW AT WWW.SMALLARMSOFTHEWORLD.COM

DDC AVAILABILITY NOTICE

This document may be further distributed by any holder only with specific prior approval of Commanding General, US Army Materiel Command, ATTN: AMCPM-RS.

REPRODUCTION LIMITATIONS

Reproduction of this document in whole or in part is prohibited except with the permission of CG, USAMC, ATTN: AMCPM-RS.

DDC is authorized to reproduce this document for United States Government purposes.

DISPOSITION INSTRUCTIONS

Destroy this report in accordance with AR 380-5 when no longer needed. Do not return it to the originator.

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents issued and approved by the Department of the Army.

AMCMS CODE NO. 4420.25.0132.2.136

USATECOM PROJECT NO. 8-7-0230-04

PRODUCT IMPROVEMENT TEST OF REDESIGNED BUFFER FOR M16A1 RIFLE (DISPLACEMENT - TIME STUDY)

ADDENDUM TO FINAL REPORT

BY

ALLAN WILSON

MAY 1968

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND
21005

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

SECTION 2. DETAILS OF TEST

PAGE

FIGURES

PAGE

FIGURES (Cont'd)

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

USATECOM PROJECT NO. 8-7-0230-04

ADDENDUM TO FINAL REPORT ON PRODUCT IMPROVEMENT TEST OF REDESIGNED BUFFER FOR M16A1 RIFLE (DISPLACEMENT - TIME STUDY)

SECTION 1. INTRODUCTION

1.1 BACKGROUND

A product-improved redesigned buffer for the M16A1 rifle was tested at Aberdeen Proving Ground between 7 September 1967 and 15 January 1968. The results of the test were reported in Reference 1.

In addition, a displacement-time study of the M16A1 with both the standard and redesigned buffer was initiated at Aberdeen Proving Ground in December 1967 and completed in March 1968. The objective of the displacement-time study was to evaluate certain dynamic characteristics of the rifle mechanism with the standard and redesigned buffers while firing various types of ammunition. As directed in Reference 4, this study has been prepared as an addendum to the product improvement test report cited in Reference 1.

1.2 RESULTS

Test results are presented in Section 2 and discussed within the context of each of the test phases.

1.3 CONCLUSIONS

It is concluded that:

a. The occurrence of bolt carrier rebound on closure is successfully overcome by the redesigned buffer with all types of ammunition.

b. Lower cyclic rates of fire, and particularly the substantially lower bolt-carrier energies which result from firing tracer cartridges loaded with IMR 8208 propellant in combination with the redesigned buffer, can be expected to degrade weapon performance, particularly under adverse conditions.

c. The urethane end cap on the redesigned buffer is not considered suitable as an energy absorbing material where impacts occur repetitively each 65 to 70 milliseconds as in burst fire. The relatively slow compression-decompression rate of this material results in a progressive round-to-round increase in velocity of the bolt carrier in counterrecoil to the extent that an extremely wide variation in rate of fire occurs within each burst.

d. The current 2-propellant option in ammunition results in widely divergent levels of weapon cycling characteristics and the total weapon system spectrum of performance becomes highly unpredictable in service use. In addition, irregularities within cyclic rates attributable to either of the two propellants appear to be further increased by the sensitivity characteristics of the redesigned buffer.

e. The displacement-time records obtained in this study fail to indicate any inherent design limits in the M16A1 rifle mechanism which make it desirable to maintain the cyclic rate of fire below the current permitted maximum of 850 rounds per minute with the redesigned buffer. On the contrary, the energy level attendant with rates of fire as low as the presently permitted 650 rounds per minute can be expected to degrade weapon performance and such degradation has been and continues to be confirmed in other D&PS tests of the M16A1 rifle.

f. Increasing the basic level of acceptance test cyclic rate criteria, while restricting the cyclic rate range, is supported by displacement-time records of the cycling mechanism as well as records measuring the dynamic characteristics of noncyclic subassemblies in the M16A1 rifle.

1.4 RECOMMENDATIONS

It is recommended that:

a. More extensive studies of the current redesigned buffer be conducted to determine the full extent and the significance of the variation in cyclic performance attributed to the impact characteristics of the urethane end cap on the buffer. These studies should include displacement-time records obtained during extreme temperature environments.

b. Propellant specifications for the family of 5.56-mm cartridges be re-examined and further defined to insure that the cyclic rate spread that now exists between the two current propellants is substantially reduced in the future. Due to the acknowledged technical difficulty involved, this recommendation must be viewed as a relatively long-term goal.

c. During the interim period the advantages of continuing to load IMR 8208 propellant, to preserve the tracer cartridge capability and to avoid single-source procurement, must be weighed against the mounting evidence that this option limits the degree to which the present weapon system may be optimized.

d. Acceptance test specifications be revised to require a cyclic rate range of 750 to 900 rounds per minute instead of the current 650 to 850 rounds per minute range. It is further recommended that the procedures for determining cyclic rate data be precisely identified and that cyclic-rate performance be an independent requirement in both ammunition and weapon acceptance tests.

SECTION 2. DETAILS OF TEST

1. TEST OBJECTIVE

To evaluate and compare displacement-time records for the M16A1 rifle with both the original model buffer (formerly referred to as the standard buffer) and with a redesigned buffer, and to conduct these firings within a limited span of ammunition types.

2. TEST METHODS

An M16A1 rifle, No. 733046, of current configuration (except for flash suppressor and chrome-plated chamber) was employed as the test weapon for the majority of the firings. Reflector viewing ports were cut at the left side of the upper receiver and along a portion of the buttstock extension tube. Small chrome-plated reflector rods were attached to the receiver and buttstock extension as reference points and concave reflecting surfaces were polished on the bolt carrier and on each of the two models of buffers.

An XM177E2 mechanism, the submachine gun version of the M16A1 rifle, was modified to obtain displacement-time records of the magazine follower (cartridge elevator). The right side of the magazine well was cut to provide two vertical and parallel reflector ports and a standard M16A1 magazine was similarily modified with matching vertical ports. Small chrome-plated reflector rods were then attached to each end of the magazine follower.

All displacement-time records were obtained with the test weapon installed in a variable deflection mount. While no attempt was made to simulate the recoil characteristics of shoulder firing, the mount was adjusted to permit a recoil-counterrecoil displacement of approximately 0.175 inch for each shot.

A machinegun-type counter chronograph was employed simultaneously with the firing of some of the displacement-time records to obtain projectile velocities for each record round during burst fire.

3. TEST PHASES

3.1 INITIAL CONTROL PHASE

Firing was first conducted to determine procedural control which would permit valid comparison between the various displacement-time records. The following controls were established and were observed throughout the displacement-time tests:

a. Prior to each test phase, the bolt and bolt carrier mechanism were cleaned and lubricated with MIL-L-46000A.

b. A continuous 20-round burst of ammunition was then fired to "condition" the gun. This burst would typically be 20 to 60 rd/min higher than subsequently fired bursts and the subsequent bursts would then generally stabilize around this lower level, providing that a 15-minute cooling period was observed between all bursts. The initial conditioning burst and the 15-minute cooling interval were rigorously adhered to during all record firings.

c. The interchange of ammunition lots to accomplish the various test phases was held to a minimum and a further conditioning exercise was conducted on initial introduction of each lot, or whenever a lot was changed. This conditioning consisted of firing 100 rounds of the new lot followed by the previously mentioned cleaning operation and then firing a nonrecord 20-round burst.

3.2 SHOULDER-FIRED RATES

One 20-round burst was fired with the test weapon hand-held and shoulder supported with each lot of ammunition and each buffer model, and average cyclic rates of fire were measured. The rates are listed in Table I and are compared to rates obtained in the recent product improvement test of the redesigned buffer (Reference 1) as well as to rates obtained with the test weapon installed in the displacement-time mount.

3.3 CHARACTERISTIC DISPLACEMENT-TIME CURVE

A representative displacement-time curve for a single cycle of the M16A1 rifle was obtained and is shown in Figure 1. The trace indicates the timing and displacement of the bolt carrier at each of the many operational points which occur during a single cycle.

3.4 AMMUNITION LOT SENSITIVITY PHASE

Displacement-time records were obtained with each of five lots of ammunition and with each of the buffer models by firing a continuous 20-round burst in each instance. The individual data for these records are contained in Appendix I and individual cycle times are plotted in Figures 4 through 7.

3.5 ACCELERATED FIRING PHASE

Using five magazines, 100 rounds were fired in 35 seconds and displacement-time record No. 9 was obtained for the final 20 rounds. A 12-second interval elapsed between the firing of the final nonrecord round of the fourth magazine and the firing of the first of the final 20 record rounds. Average cyclic rates of fire were also obtained for each 20-round burst of the 80 nonrecord rounds. The test was conducted with the redesigned buffer and lot LC-12194.

3.6 VARIABLE WEIGHT BUFFER PHASE

This phase of the test was conducted first by obtaining a displacement-time record with lot LC-12194 and the redesigned buffer without alteration or modification to the buffer. Consecutive records were then obtained by exchanging the standard steel inertia weights (0.64 ounce each) for aluminum weights (0.16 ounce each). The exchange of aluminum weights for steel weights progressed by additional single exchanges for each subsequent record until the final record was obtained with five aluminum weights substituted for the five steel weights. The redesigned buffer and the steel inertia weights are shown in Figures 8 and 9.

The entire phase was later repeated by reversing the order of exchange of the inertia weights, i.e., first record with five aluminum weights, second record with four aluminum and one steel weight, etc.

The individual data records, Nos. 29 through 34 and 73 through 77, are contained in Appendix I.

3.7 MAGAZINE COMPLEMENT PHASE

Displacement-time records were obtained firing lot LC-12194 in the burst lengths of 21, 20, 19, 18, 17, 10, and 5 rounds. In each trial, one round was loaded in the weapon chamber and the magazine loaded with the remainder of the respective complement. The intent of the test was to determine if cyclic characteristics of the weapon, both in recoil and counterrecoil, would be measurably affected by firing from a less than fully loaded magazine.

The individual data for these records, Nos. 3 through 8 and 29, are contained in Appendix I.

3.8 SPECIAL INVESTIGATION PHASE WITH ORIGINAL MODEL BUFFER

In previous tests with the original model buffer, it had been observed that the bevel ring springs, which provide the buffing action in this model, would occasionally become jammed together. Displacement-time records were obtained to evaluate this characteristic by employing a set of bevel ring springs which had become firmly jammed together as a result of firings in the product improvement test of the redesigned buffer (Reference 1).

4. TEST RESULTS

4.1 SHOULDER-FIRED RATES

Average cyclic rates of fire were obtained to indicate if the test rifle, No. 733046, was within the population of recently tested M16A1 rifles and to determine if the use of the displacement-time mount would significantly affect cyclic operations. The results are summarized in Table I.

Table I. Average Cyclic Rates of Fire

	Cyclic Rate, rd/min				
	Shoulder-Fired Rate Data from Ref 1			Test Weapon No. 733046 Fired from	
Lot No.[a]	Min[b]	Avg[b]	Max[b]	Shoulder[c]	Displacement-Time Mount[d]
			Redesigned Buffer		
LC-12177	752	810	873	832	873
LC-12194	-	-	-	869	891
LC-12081	580	735	834	804	859
TW-18166	612	680	744	773	744
TW-18001	564	657	744	[e]740	758
			Original Model Buffer		
LC-12177	820	901	972	897	912
LC-12194	-	-	-	908	938
LC-12081	638	800	906	851	925
TW-18166	727	796	863	827	890
TW-18001	637	760	863	-	878

See footnotes on following page.

[a]Lot LC-12177; ball projectile with WC-846 propellant. LC-12194; ball projectile with WC-846 propellant. LC-12081; tracer projectile with WC-846 propellant. TW-18166; ball projectile with IMR-8208 propellant. TW-18001; tracer projectile with IMR-8208 propellant.
[b]Data obtained from first 160 rounds with nine guns (reference 1).
[c]Rate is result of one trial with each lot, each buffer.
[d]Rate is result of one trial each taken from the ten displacement-time records from ammunition sensitivity phase.
[e]A 19-round burst was fired.

During the initial control phase of this test, it became apparent that cyclic characteristics, and cyclic rates of fire between weapons, could be meaningfully compared only if rates were measured at the same number of rounds after a cleaning period and if the comparison guns were approximately of the same "age" at the time of test, i.e., total number of rounds fired. For these reasons, the data extracted from Reference 1 in Table I can only be approximately compared to the rates for the displacement-time weapon (a direct comparison could be in error by an estimated $\pm$ 40 rd/min). Nevertheless, even with this restriction on direct rate comparisons, the displacement-time weapon appeared to be definitely located within the upper rate range of recently tested weapons and was judged to be a suitable mechanism for displacement-time studies.

The effect of the displacement-time mount was also quite evident and, as was expected, provided somewhat higher rates than those obtained during shoulder-fired tests; however, the rates were not unrealistically high and the comparative data obtained from the displacement-time records (original versus redesigned buffer, ammunition lot versus ammunition lot, etc) appear valid and not compromised by the use of a single weapon or by the use of the semirigid test mount.

4.2 CHARACTERISTIC DISPLACEMENT-TIME CURVE

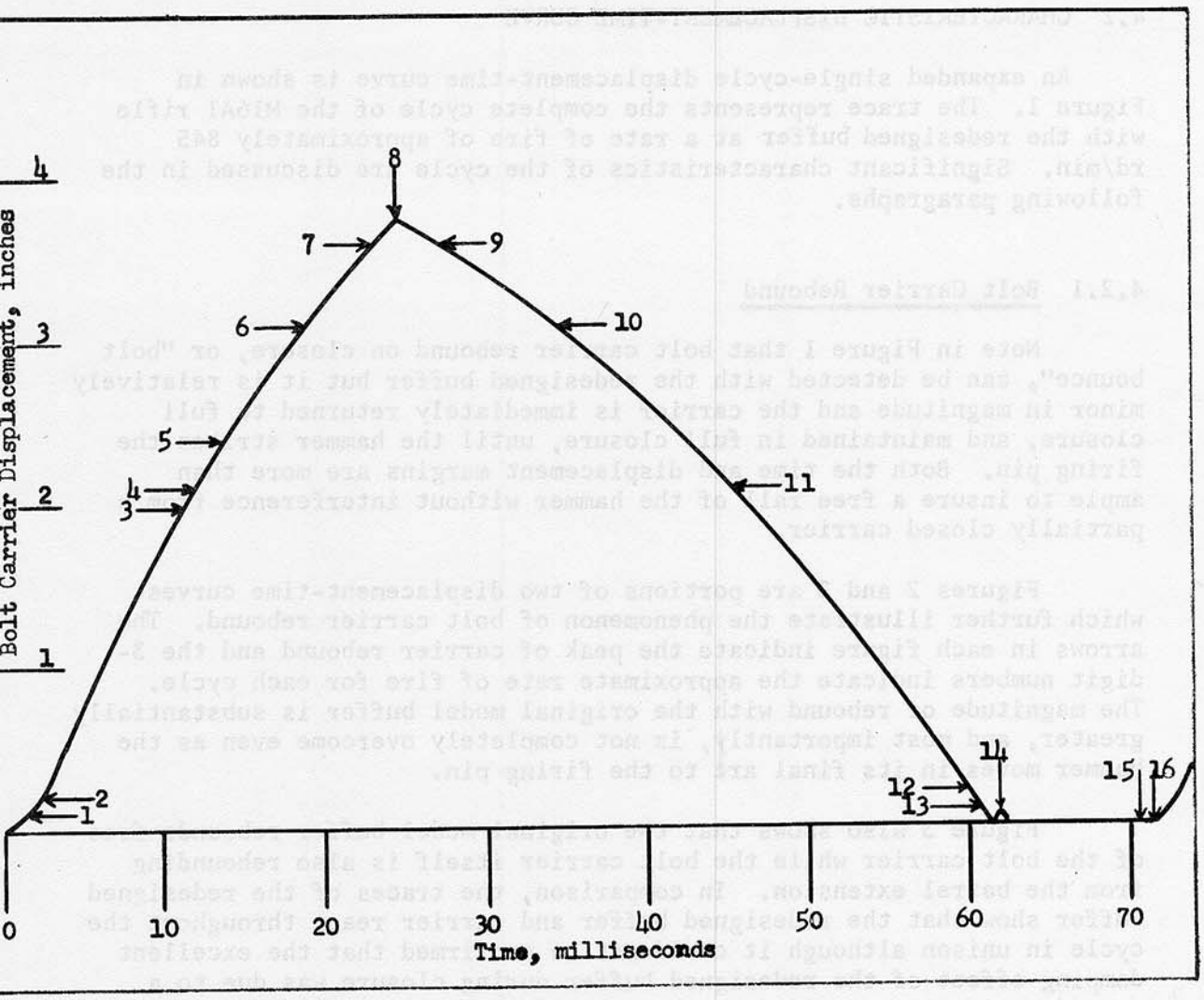
An expanded single-cycle displacement-time curve is shown in Figure 1. The trace represents the complete cycle of the M16A1 rifle with the redesigned buffer at a rate of fire of approximately 845 rd/min. Significant characteristics of the cycle are discussed in the following paragraphs.

4.2.1 Bolt Carrier Rebound

Note in Figure 1 that bolt carrier rebound on closure, or "bolt bounce", can be detected with the redesigned buffer but it is relatively minor in magnitude and the carrier is immediately returned to full closure, and maintained in full closure, until the hammer strikes the firing pin. Both the time and displacement margins are more than ample to insure a free fall of the hammer without interference from a partially closed carrier.

Figures 2 and 3 are portions of two displacement-time curves which further illustrate the phenomenon of bolt carrier rebound. The arrows in each figure indicate the peak of carrier rebound and the 3-digit numbers indicate the approximate rate of fire for each cycle. The magnitude of rebound with the original model buffer is substantially greater, and most importantly, is not completely overcome even as the hammer moves in its final arc to the firing pin.

Figure 3 also shows that the original model buffer rebounds free of the bolt carrier while the bolt carrier itself is also rebounding from the barrel extension. In comparison, the traces of the redesigned buffer show that the redesigned buffer and carrier react throughout the cycle in unison although it could not be confirmed that the excellent damping effect of the redesigned buffer during closure was due to a secondary impulse provided by the inertia weights (Figure 9) as claimed by the manufacture; however, this presumed secondary impulse would be expected to occur within 1 to 3 milliseconds after bolt carrier closure which coincides well with the observed point of recovery of bolt rebound (the downward turn of the small rebound peak).



Legend

1. Carrier travel prior to unlocking.
2. Bolt fully unlocked.
3. Hammer engaged by disconnect in semiautomatic fire.
4. Hammer engaged by automatic sear in automatic fire.
5. Fired case ejected.
6. Bolt face clears base of next live round in magazine.
7. Bolt face clears bolt stop catch position.
8. Buffer impact.
9. Bolt face engaged by bolt stop after last round only.
10. Bolt face contacts base of live round in magazine.
11. Bolt clears cartridge retaining lips in magazine.
12. Bolt face contacts barrel extension.
13. Bolt locked, automatic sear releases hammer in automatic fire.
14. Bolt carrier rebound or "bounce".
15. Hammer impacts the firing pin.
16. Carrier starts rearward in recoil.

Figure 1: Characteristic Displacement-Time Curve for Bolt Carrier of M16A1 Rifle Equipped with Redesigned Buffer.

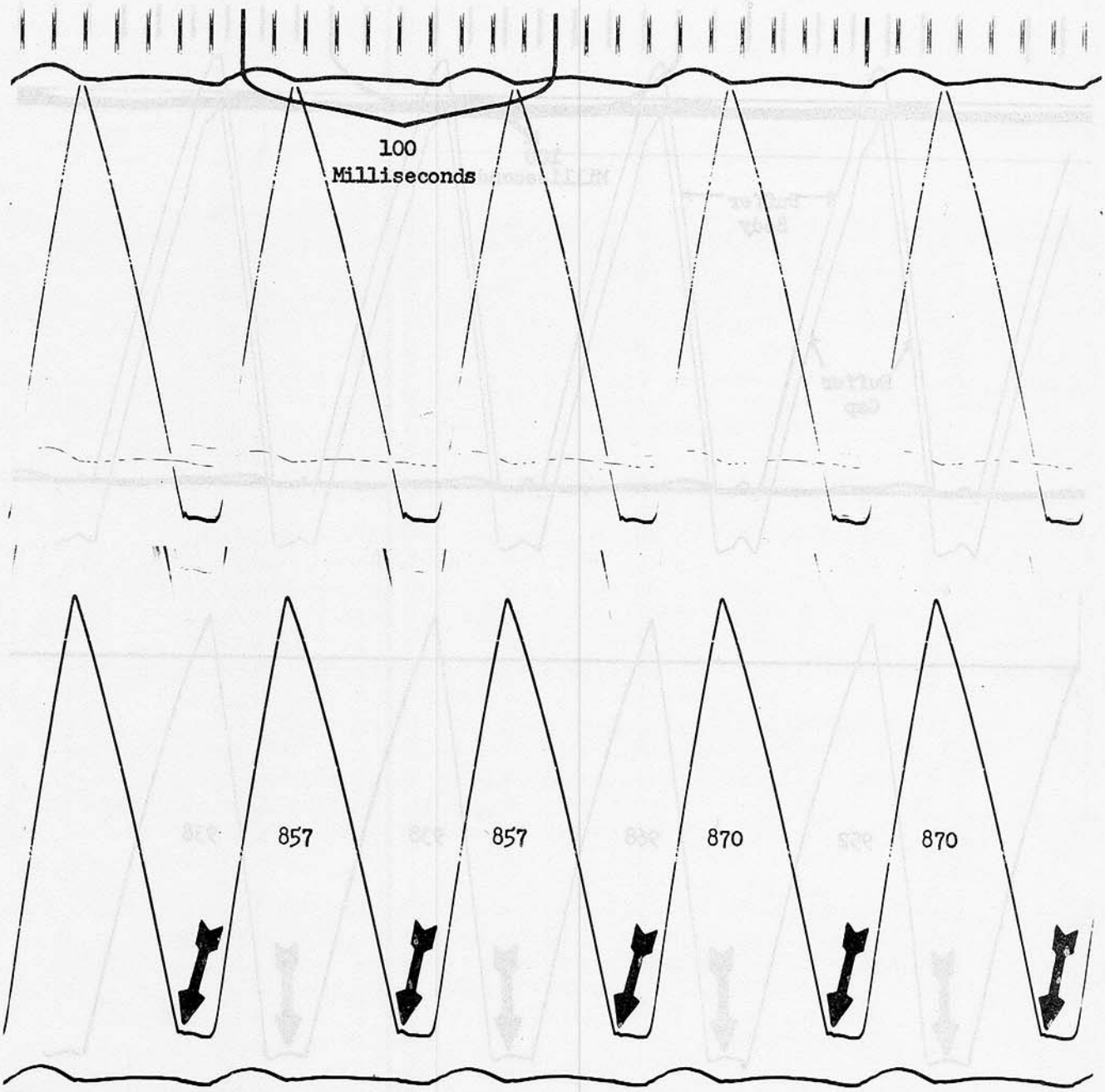


Figure 2: Displacement-Time Record during Burst Fire Showing Redesigned Buffer Trace, Top, and Bolt Carrier Trace, Bottom. Lot LC-12081 was Fired.

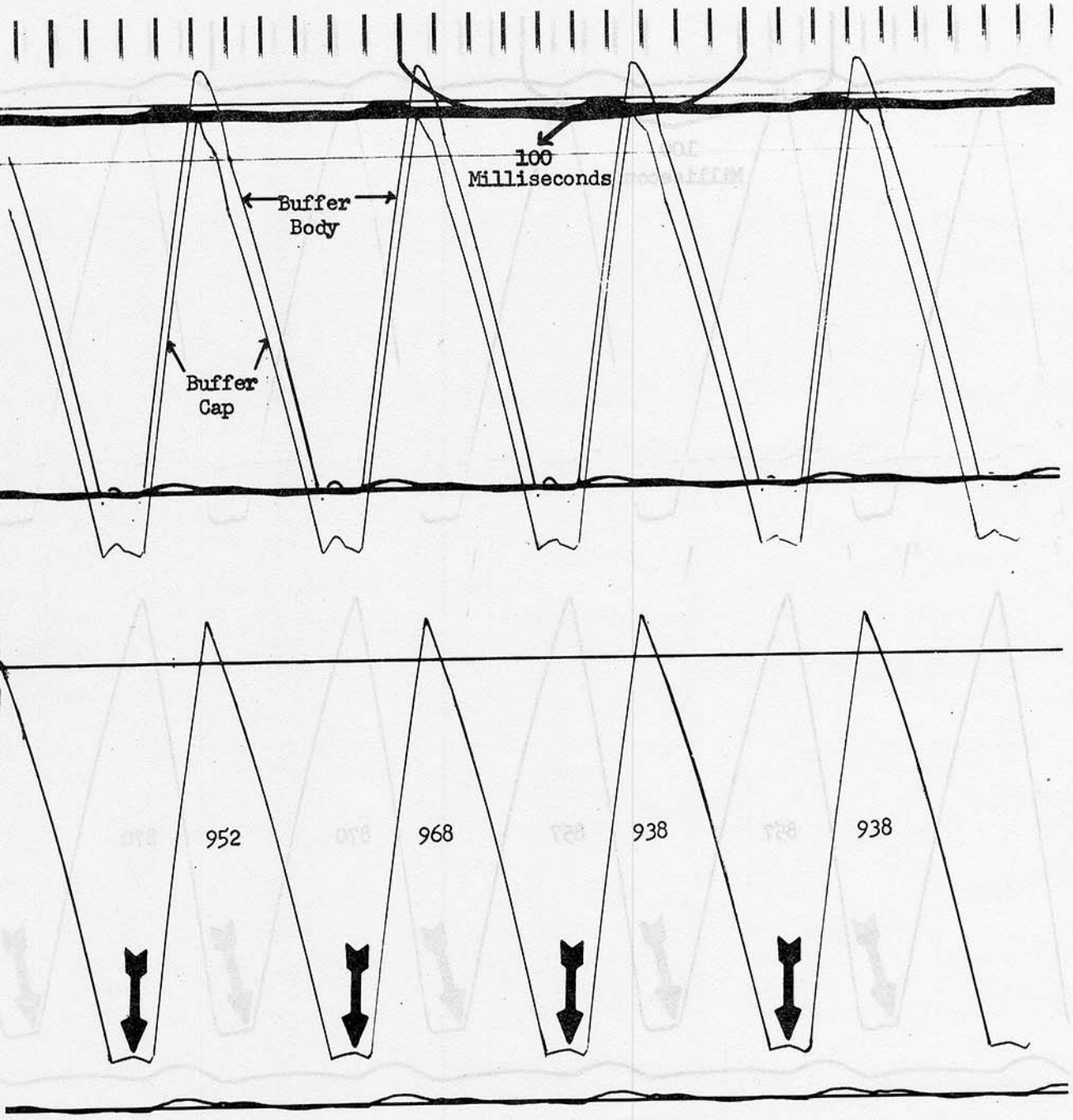


Figure 3: Displacement-Time Record during Burst Fire Showing Original Model Buffer Trace (Top) and Bolt Carrier Trace (Bottom). Lot LC-12194 was Fired.

4.2.2 System Governors

From an inspection of Figure 1, it can be seen that several mechanical operations must take place in a single cycle which are essential to proper functioning but are largely independent of the velocity of the bolt carrier in either recoil or counterrecoil. These functions are the movement of the hammer, the engagement of the bolt by the bolt-stop mechanism, and the proper positioning of each live round by the cartridge follower in the magazine. These functions can be considered as system governors and provide theoretical parameters within which cyclic rates of fire must fall if proper functioning is to occur. The effect of each of these system governors is discussed in the following paragraphs.

4.2.2.1 Hammer Fall. The time required for the hammer to fall after sear release was measured with a displacement-time camera using a cutaway XM177E2 mechanism (identical to the M16A1 in this phase of operation). Hammer fall time, position 13 to position 15 on Figure 1, was between 10 and 11 milliseconds during 20 trials.

In theory, if the cyclic rate of the bolt carrier were sufficiently low, the time required for a very slowly closing carrier could exceed the hammer time of 10 to 11 milliseconds and the hammer would strike the carrier instead of the firing pin, causing a failure to fire. However, as the bolt is locked and the carrier completely at rest in a forward position approximately 3 to 4 milliseconds after hammer release, the dwell margin is more than ample and could not be defeated by any conceivable low rate of fire that would also successfully cycle the mechanism. In fact, as high cyclic rates only add to the already ample dwell period, and with bolt rebound eliminated by the redesigned buffer, functioning of the hammer as a system governor is only theoretical and its potential governing effect has been designed out of the system.

4.2.2.2 Cartridge Follower. From Figure 1, it can be seen that the time permitted for the cartridge follower in the magazine to fully elevate and position the next round to be fired must not exceed approximately 15 milliseconds when the bolt carrier is cycling at approximately 845 rd/min. As lower cyclic rates would permit a longer than 15-millisecond operation (even short recoils, which occur at extreme low rates, provide relatively long "turnaround" times) the cartridge follower becomes a system governor only at some upper rate level.

An examination of all displacement-time records shows that the fastest single cycle with a redesigned buffer was at a rate of 1000 rd/min and occurred during the final cycle on record No. 9 (ref Appendix I). Measurement of this cycle shows that the cartridge follower reaction time must not (and obviously did not) exceed 10 milliseconds. With this value as a standard, actual magazine response times were

measured for a number of 20-round bursts, again employing an XM177E2 mechanism and the M16A1 magazine. The response time appeared to vary between 4.5 and 6.5 milliseconds with shorter times occurring as the magazine emptied.

Due to the technical difficulty in obtaining these measurements and the subsequent interpretation of the records, errors possibly as great as 20% may exist and the true mechanism response time may be as great as 7.5 milliseconds for initial rounds from a full magazine. However, as this would require an estimated cycle time on the order of 1500 rd/min to override the magazine, and as this cycle time would have to occur at the beginning of a fully-loaded magazine (invariably the fastest cycle times for a burst are recorded at the end of a burst), it appears, as in the analysis of the hammer fall, that the cartridge elevator is only a theoretical system governor and imposes no realistic cycling limits, either at high or low rates.

4.2.2.3 Bolt-Stop Mechanism. The bolt-stop mechanism would appear to place the most stringent limits on the cycle time of the gun mechanism. From Figure 1 it can be seen that, from the standpoint of time, the bolt-stop must respond in approximately 7 milliseconds, and in less than that at rates above 845 rd/min. Furthermore, considering bolt carrier displacement, a low-rate short recoil, which might successfully complete all other operations, could easily fail to displace the bolt sufficiently rearward to permit the stop to engage the bolt face as the last round fires. Displacement-time records were therefore evaluated to measure the bolt-stop response time and estimates were also made of low-rate short recoil which would fail to engage the stop but which would complete all other operations.

The bolt-stop response times averaged 5.2 milliseconds with a maximum time of 5.6 milliseconds. It was also noted that partial, but usually successful engagement of the bolt, would occur within 4 milliseconds even without full travel of the bolt-stop mechanism. However, this would represent marginal performance and a safe margin would appear to be 6 milliseconds, i.e., with reference to Figure 1, bolt carrier operations Nos. 7 through 9 should not be completed in a time less than 6 milliseconds to insure sufficient time for bolt-stop response. This would impose an estimated upper rate limit of 975 rd/min for the final round in a magazine.

The lower rate required for a short recoil, but sufficient to complete all operations except bolt-stop engagement, was estimated to occur at approximately 500 rd/min for the final round in a magazine.

4.2.3 System Governor Analysis

The displacement time records so far discussed would indicate that the M16A1 mechanism is well designed to accommodate a wide range in cyclic rate and that the only apparent limits are defined by the response characteristics of the bolt-stop mechanism; namely, 500 to 975 rd/min as a cyclic rate for the firing of the last round in the magazine.

One of the major values of the identification of this performance parameter would be a realistic translation of these individual minimum and maximum cycle times to equivalent average cyclic rates of fire for a 20-round burst against which the initial acceptance of weapons could be established. This possibility is discussed in the following paragraphs.

4.2.3.1 Upper Rate Limit. From an examination of a number of displacement-time records with the redesigned buffer, a relationship between the cycle time of final rounds and the average cyclic rate of fire for a 20-round burst was determined. To evaluate final rounds in the 900 + rs/min range, some of the data were taken from records where a modified (reduced weight) redesigned buffer was tested. However, the relationship between average rate and final individual rates is considered valid even with the reduced weight buffer. These data are summarized in Table II.

Table II. Comparison of 900 + Rd/Min Average Rates of Fire with Final Round Cyclic Rates

Record No.	Cyclic Rate, rd/min: For 20-Rd Burst	Cyclic Rate, rd/min: For Final Cycle in 20-Rd Burst[a]	Rate Difference Between Avg and Final Rate, rd/min
3	908	952	44
9	968	1000	32
31	928	968	40
33	948	968	20
[b]65	907	952	45
[b]74	981	1017	36
[b]75	959	984	25
[b]76	934	968	34
[b]77	923	938	15
[b]78	924	968	44
Avg			34

See footnotes on following page.

Table II (Cont'd)

[a]The final complete cycle in a 20-round burst follows the firing of the 19th round, not the 20th round where the cycle is not completed due to the bolt-stop. However, the velocity of the bolt is usually of nearly the same magnitude for either of the final two rounds and the final cyclic rate can be presumed to be the same.
[b]From modified (reduced weight) redesigned buffer.

From the rate relationship in Table II it would appear that the average cyclic rate for a burst should not exceed 940 rd/min in order to remain below a level of 975 rd/min for final rounds in the burst. However, several other conditions of weapon use should be considered before establishing an upper limit for weapon acceptance tests.

Presumably, acceptance testing would be done by employing some form of a mechanical mount for the gun which would probably reflect a higher rate than would be experienced by the user, and conversely, the user would experience rates higher than acceptance test levels when employing the M16A1 under extreme high temperature conditions. However these two factors, which influence upper rate levels by approximately 40 to 50 rd/min in each case, would appear to be self-cancelling and the maximum acceptance rate could remain at 940 rd/min.

A further consideration would be the effect on rates which the user might experience in sustained fire. From the data obtained on displacement-time record No. 9 (ref Appendix I) it can be seen that sustained firing would undoubtedly produce cycling of final rounds in excess of 975 rd/min, from an initial acceptance level of 940 rd/min, although the only apparent consequence would be a failure of the bolt to remain to the rear at the conclusion of each magazine. The likelihood of this occurrence could be subtantially reduced by lowering the basic acceptance level to approximately 900 rd/min and, although this level is 50 rd/min above the present upper limit of 850 rd/min, it appears entirely justified by the design characteristics of the M16A1 rifle.

The only remaining consideration would be one of weapon durability as a consequence of the higher proposed rate and the resultant increase in energy and impact load on weapon parts. Normally, this effect is difficult to predict but if tests and user reports of the XM177E2 sub-machine gun are consulted, there appears to be little concern in this area. The XM177E2 weapon employs identical M16A1 parts throughout the mechanism, except for the buffer and action spring, and the XM177E2 has generally experienced much higher rates of fire than the M16A1 rifle. Average cyclic rates have often exceeded 1000 rd/min and parts durability has not been a significant problem. In summary, there would appear to be little reason for rejecting a recommended acceptance rate increase to 900 rd/min.

4.2.3.2 Lower Rate Limit. Although the displacement-time records indicate that the M16A1 rifle can accommodate individual cycles as low as 500 rd/min, these cycles could not be successfully completed under any but the least adverse field conditions. While displacement-time records have not been obtained to show the degree to which adverse conditions might be overcome by high rates of fire, and the much higher energies associated with these rates, it is obviously of some advantage to insure the highest energies possible commensurate with the maximum design limit. In terms of average rate of fire, this limit would be reached in acceptance tests at 900 rd/min as previously stated, but obviously a lower limit is required to accommodate variations in weapons as well as ammunition. With the current 2-propellant option available, it is doubtful that the presently permitted 200-rd/min range (650 to 850 rd/min) can be successfully maintained considering the extremes of weapon and ammunition variables recently encountered in the product improvement test of the redesigned buffer (Reference 1). Furthermore, a 200-rd/min range appears almost certain to produce a poorly defined weapon-ammunition system spectrum which may have contributed significantly in the past to widely diverse and often contradictory test results and user performance appraisals. Therefore, even at the cost of foregoing the 2-propellant option, it is recommended that the acceptance test cyclic rate range be set at 750 to 900 rd/min to gain a greater margin of working energy and, hopefully, to further narrow the spectrum of system performance.

It should also be noted that, while this recommendation would probably eliminate one of the two current propellants, it would not necessarily eliminate the lower rate IMR-8208 propellant in favor of the higher rate WC-846. The displacement-time records discussed in paragraph 4.5 indicate that by varying the weight of the redesigned buffer, the cyclic rate level can be adjusted within a range of 750 to 900 rd/min for either of the propellant types, although not for both propellants simultaneously.

4.3 AMMUNITION LOT SENSITIVITY PHASE

Displacement-time records were obtained with each of the five lots of test ammunition and with each of the buffer models. The individual data for each record are contained in Appendix I, records Nos. 16, 18, 23, 29, and 54 for the redesigned buffer and Nos. 62, 68, 71, 81, and 85 for the original model buffer.

The individual cycle times for each record are also plotted and shown in Figures 4 through 7. These figures illustrate several very significant performance characteristics of the M16A1 system and show that the degree of variability in weapon cycling is a function of the design of the buffer model employed and, to a lesser extent, is a function of the type of projectile and propellant. The observed variations in cyclic performance are discussed in the following paragraphs.

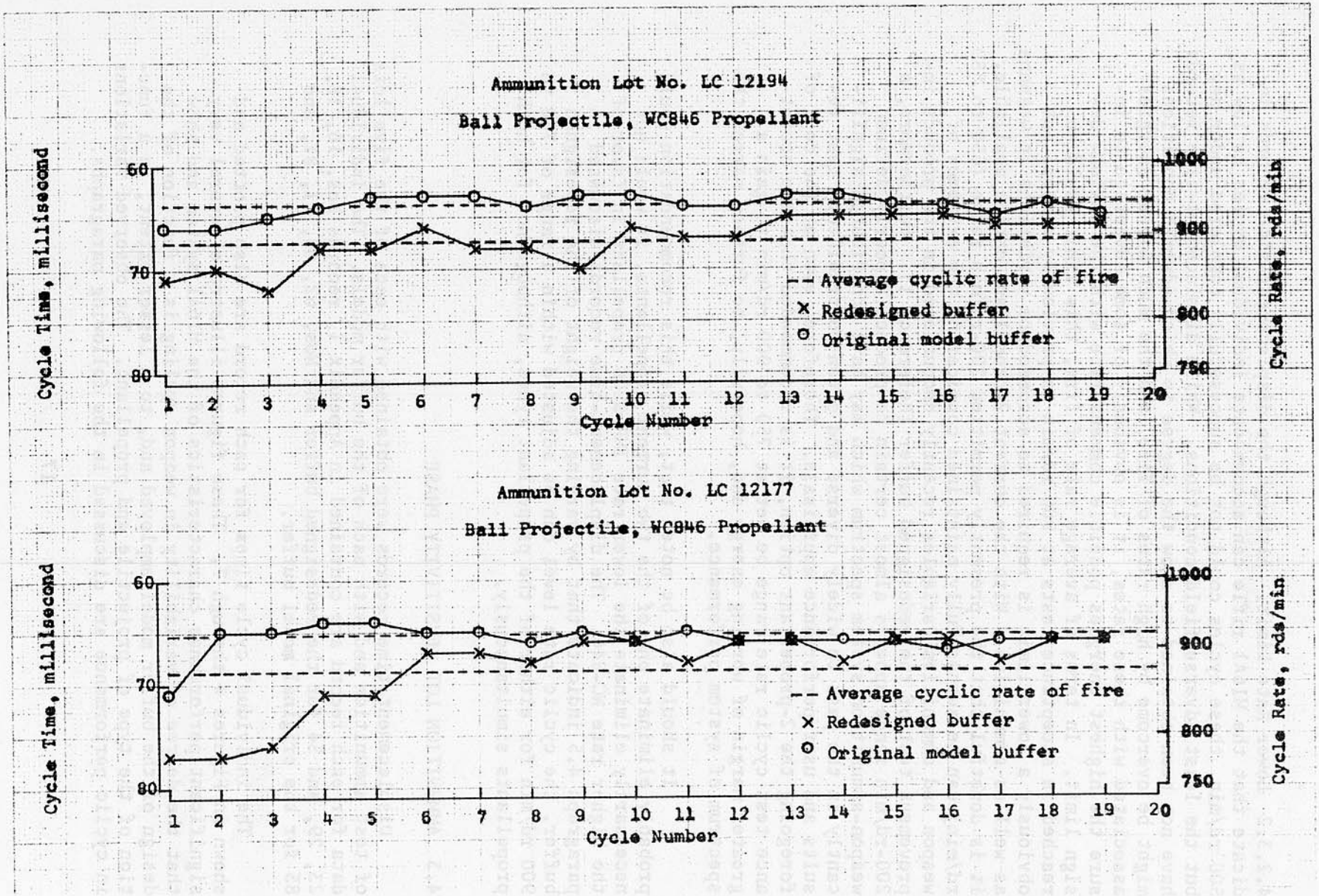


Figure 4: Cycle Times and Rates for Individual Rounds during Burst Fire with WC-846 Propellant-Loaded Ball Projectile Cartridges.

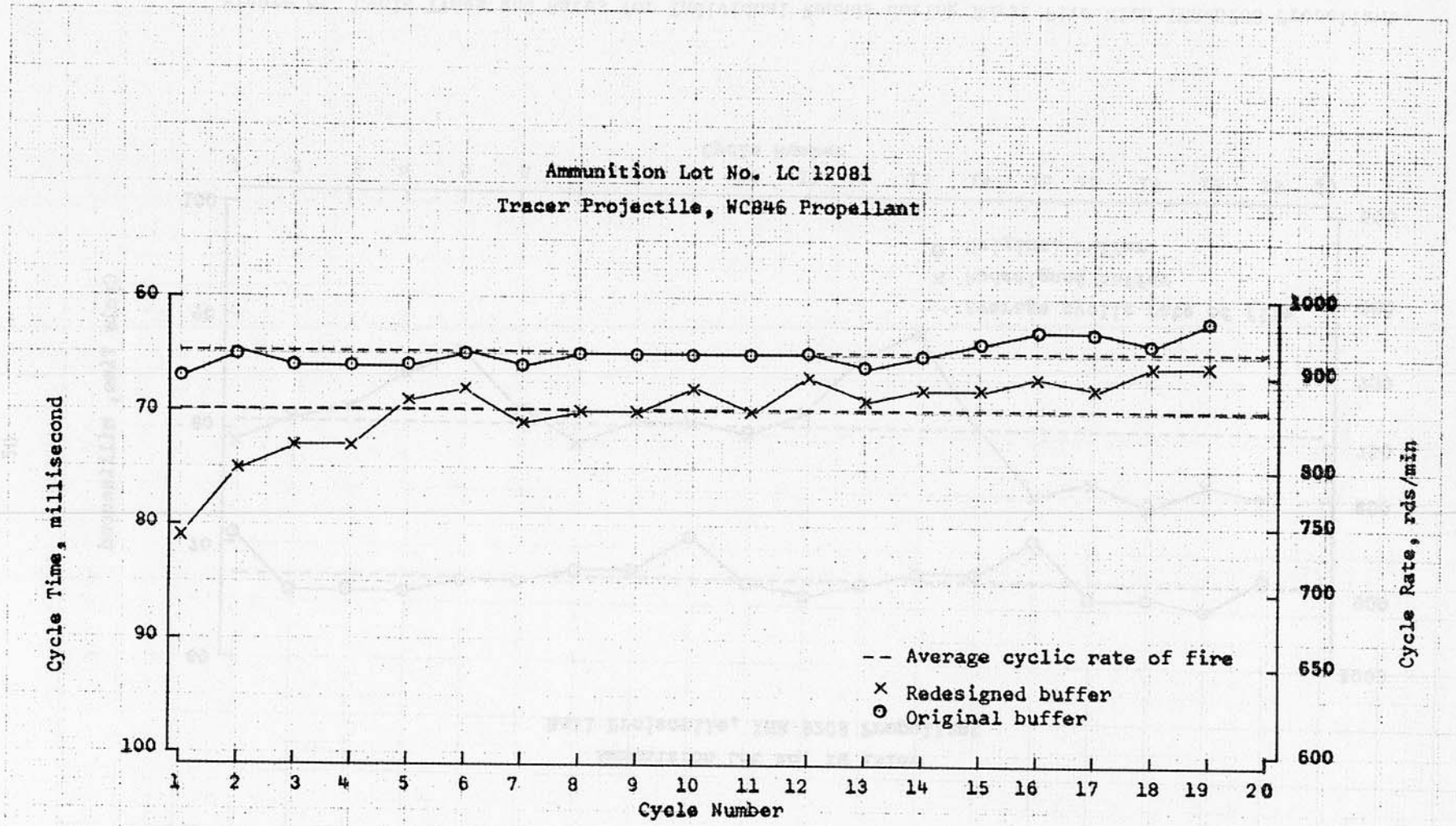


Figure 5: Cycle Times and Rates for Individual Rounds during Burst Fire with WC-846 Propellant-Loaded Tracer Projectile Cartridges.

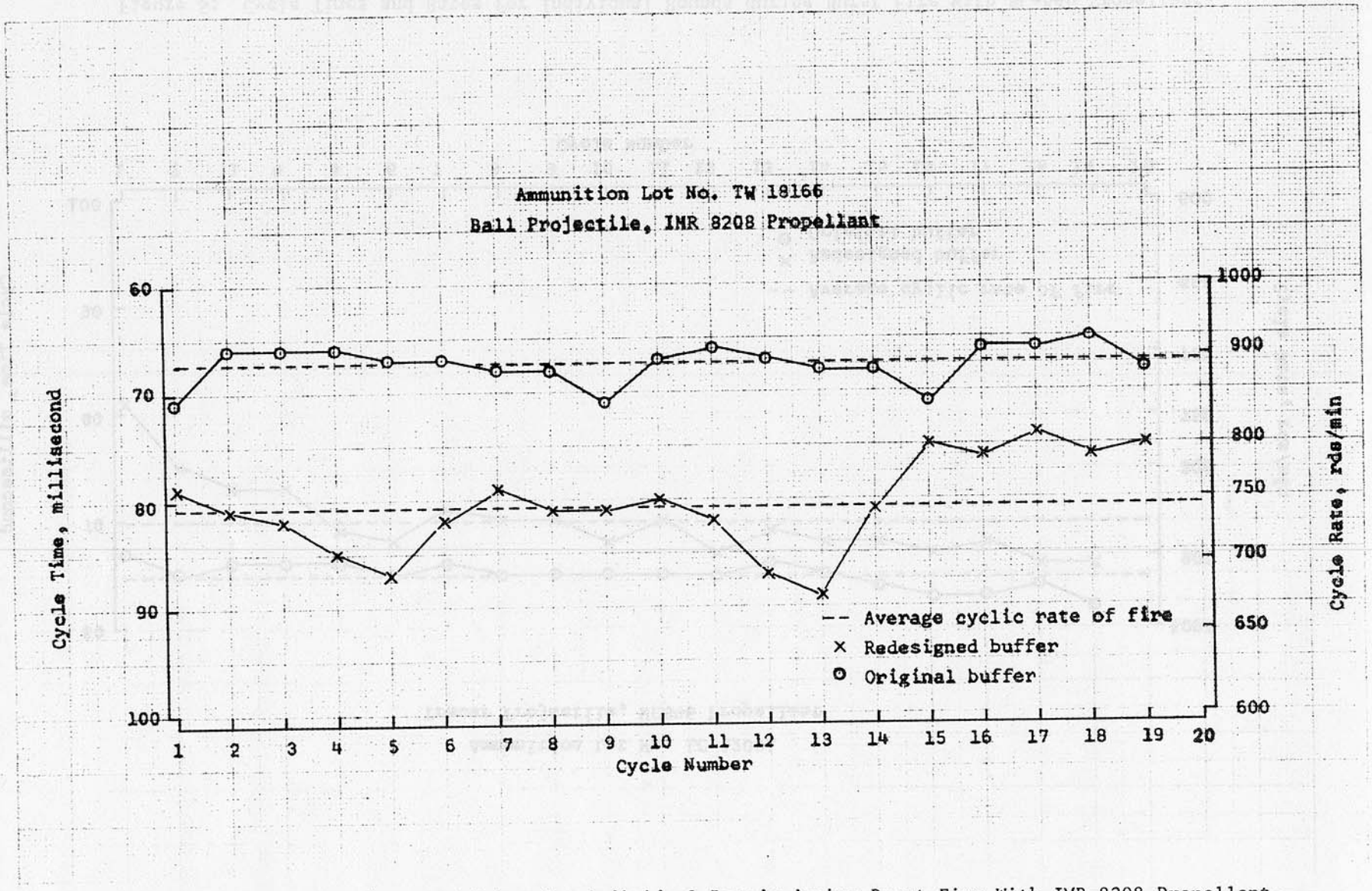


Figure 6: Cycle Times and Rates for Individual Rounds during Burst Fire With IMR-8208 Propellant-Loaded Ball Projectile Cartridges.

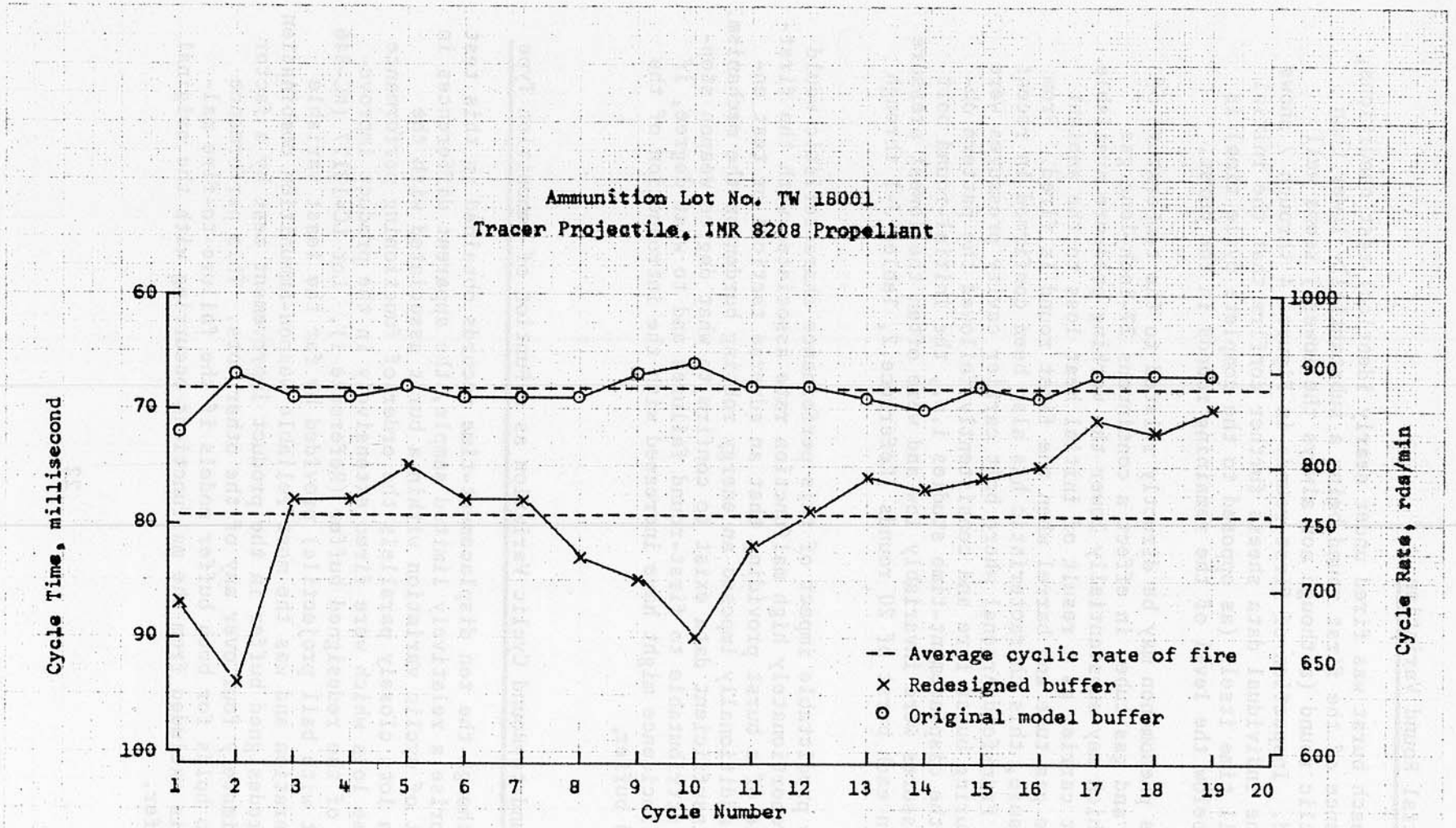


Figure 7: Cycle Times and Rates for Individual Rounds during Burst Fire With IMR-8208 Propellant-Loaded Tracer Cartridges.

4.3.1 Initial Round Variation

As each burst was fired under nearly identical test conditions, the occurrence of the first round being a substantially lower than average cyclic round (although not always the lowest) seems well established. Inspection of first rounds in Figures 4 through 7 shows this and the individual data sheets further confirm that the initial round recoil time itself (as opposed to the complete cycle time) is generally below the level of the remaining rounds in the burst.

This phenomenon may be directly related to the temperature of the barrel and gas tube, in effect a continuous 27-inch-long gas conduit, which may substantially lower the working pressure available to the bolt carrier as a result of initial heat loss to the ambient temperature gas tube and barrel when the first round is fired. From whatever cause, this characteristic has also been confirmed in recent firings at Frankford Arsenal where bolt carrier cavity pressures were measured during burst fire and consistently followed the pattern observed in the displacement-time studies i.e., the initial-round bolt cavity pressures were invariably low and were often the lowest pressure recorded in each burst of 20 rounds (Reference 2, Tables J-1 through J-IV).

The predictable impact of this performance characteristic would be a disproportionately high malfunction rate associated with the first-round cycle of a burst providing that an adverse tactical or test environment additionally imposed an energy robbing burden on the mechanism. To date, insufficient data exist to confirm to what degree weapon stoppages are attributable to first-round failures and to what degree, if any, this incidence might have increased with the introduction of the redesigned buffer.

4.3.2 Round-to-Round Cyclic Variation as a Funtion of Ammunition Type

Although the ten displacement-time records obtained in this test phase comprise a relatively limited sample, the apparent differences in the extent of cyclic variation within a burst associated with the ammunition lots closely parallels the order of functioning performance of the same lots which were fired extensively in the product improvement test of the redesigned buffer (Reference 1). Lot LC-12177 (WC-846 propellant with ball projectile) provided by far the least variable cyclic operation and was the most reliable weapon-ammunition combination with the redesigned buffer in the product improvement test by a factor of approximately four over any of the other lots. This performance ratio also holds for both buffer models if the failure-to-fire malfunction is excluded from the malfunctions occurring with the original model buffer.

4.3.3 Round-to-Round Cyclic Variation as a Function of Buffer Model

The most pronounced variation in cyclic performance appears primarily to be a function of the type of buffer model. Gross variation in cyclic operation appears characteristic of the redesigned buffer, in comparison to the original model buffer, and perhaps most importantly, the redesigned buffer required more rounds of firing to approach a steady-state rate of fire than does the original buffer. In fact, the redesigned buffer tends to progressively elevate the round-to-round cycle time from beginning to end of burst and the latter half of each burst is at an average level much closer to the level of the original model buffer than would be indicated by comparing only average cyclic rates of fire measurements for complete bursts.

Again, as all test conditions were nearly identical for the firings in this phase, the progressive rate increased noted with the redesigned buffer would indicate that the energy-absorbing qualities, or the buffing characteristics of the redesigned buffer, were constantly changing during continuous firing. As buffing is accomplished through compression and decompression of the urethane end cap on the redesigned buffer, inquiries were made concerning the characteristics of this materiel from the subcontractor supplying the end caps[a]. The subcontractor advised that he did not have immediately available the data regarding the compression/decompression characteristics for small increments of time between impacts but that his opinion would be that if the cap were compressed as much as 0.08 inch it would be doubtful if it could decompress more than 25% in a 60-70 millisecond period and full decompression would require much longer (Note: the amount of compression of the redesigned buffer was measured for selected rounds on nearly all redesigned buffer displacement-time records and the maximum compression measured was approximately 0.08 inch; ref individual data sheets in Appendix I.)

To gain some further insight concerning the characteristics of the urethane cap, a new redesigned buffer was compressed 0.08 inch and an attempt was made to measure the decompression rate. While it was not possible to measure very short-term decompression rates without a sophisticated and somewhat costly test technique, it was observed that 2 to 3 seconds after release from compression, decompression was only 85% completed and that 100% decompression was not achieved even after 5 minutes.

[a]Some degree of buffing also occurs when the five buna rubber disks separating the weights inside the buffer are compressed during cycling (see Figures 8 and 9). As these disks are impacted possibly three times in each cycle, as opposed to once for the urethane end cap, and as their total thickness is greater than the exposed portion of the end cap, the interior "buffing" characteristics may be significant.

From this information, it became apparent that a fully decompressed urethane cap would have excellent buffing characteristics as a result of the first impact but would become progressively more "live" and less inert with each repeated impact. This characteristic and its influence on rate can be seen in Figures 4 through 7 and is demonstrated even more conclusively if the counterrecoil times are consulted on the individual data sheets in Appendix I and compared to the relatively consistent counterrecoil times for the original model buffer.

This characteristic also appears to explain the very pronounced increase in average cyclic rates of fire from magazine to magazine as shown in the cyclic rate of fire figures in paragraph 2.10 of Reference 1 and where, conversely, the same rapid-fire exercise (140 rounds fired in an average time of 44 seconds) did not materially increase average rates when the original model buffer was employed.

It should be kept in mind that steadily increasing the round-to-round rate within a burst is not, per se, an undesirable condition. Automatic fire is not a continuous cycling function but 20 (or less) individual and separate stop-and-start cycles and the duration of one successful cycle has little effect on the likelihood that the next cycle will be successful. What is important is that none of the cycles within a burst exceed the desired maximum or minimum cyclic time. If the state of the art of weapon and ammunition production dictates a range of 150 or perhaps 200 rd/min in 20-round average cyclic rates then, even when lots of ammunition very near to the mean impulse characteristics are fired in guns similarly close to their respective mean, some of the individual cycles within a burst are still likely to be outside the limits. If cyclic rate performance is to be controlled, and considering the known sensitivity of the M16A1 system this appears essential, it can not be done with what appears to be an extremely variable buffer.

4.4 ACCELERATED FIRING TEST

Displacement-time record No. 9 (Appendix I) was obtained to evaluate the effects on cyclic performance of 100 rounds of accelerated firing. The details of the test are described on the data sheet.

Of particular significance were the cyclic rates noted for the final two rounds fired; 1017 and 1000 rd/min respectively. On the basis of the average cyclic rate of fire for the first burst in the 100-round test, 829 rd/min, it is estimated that initial rounds cycled at a rate of 750 rd/min which resulted in a total variation of 250 rd/min in the 35 seconds of firing. As was previously discussed in paragraph 4.3, the major cause of the steadily increasing rate, both round-to-round and magazine-to-magazine, appears to be the constantly changing characteristics of the redesigned buffer although heating and momentary cooling of the gas system between brief magazine change periods undoubtedly has some effect, particularly on the initial round of each burst.

4.5 VARIABLE WEIGHT BUFFER PHASE

Displacement-time records were obtained to evaluate the effect of changing the weight of the redesigned buffer by substituting aluminum weights for steel weights within the buffer body. Two trials were conducted at each of six weight levels with lot LC-12194. Figures 8 and 9 illustrate each of the buffer models and the standard steel inertia weights, which were exchanged for aluminum weights, are shown. The individual data records, Nos. 29 through 34 and 73 through 77, are contained in Appendix I.

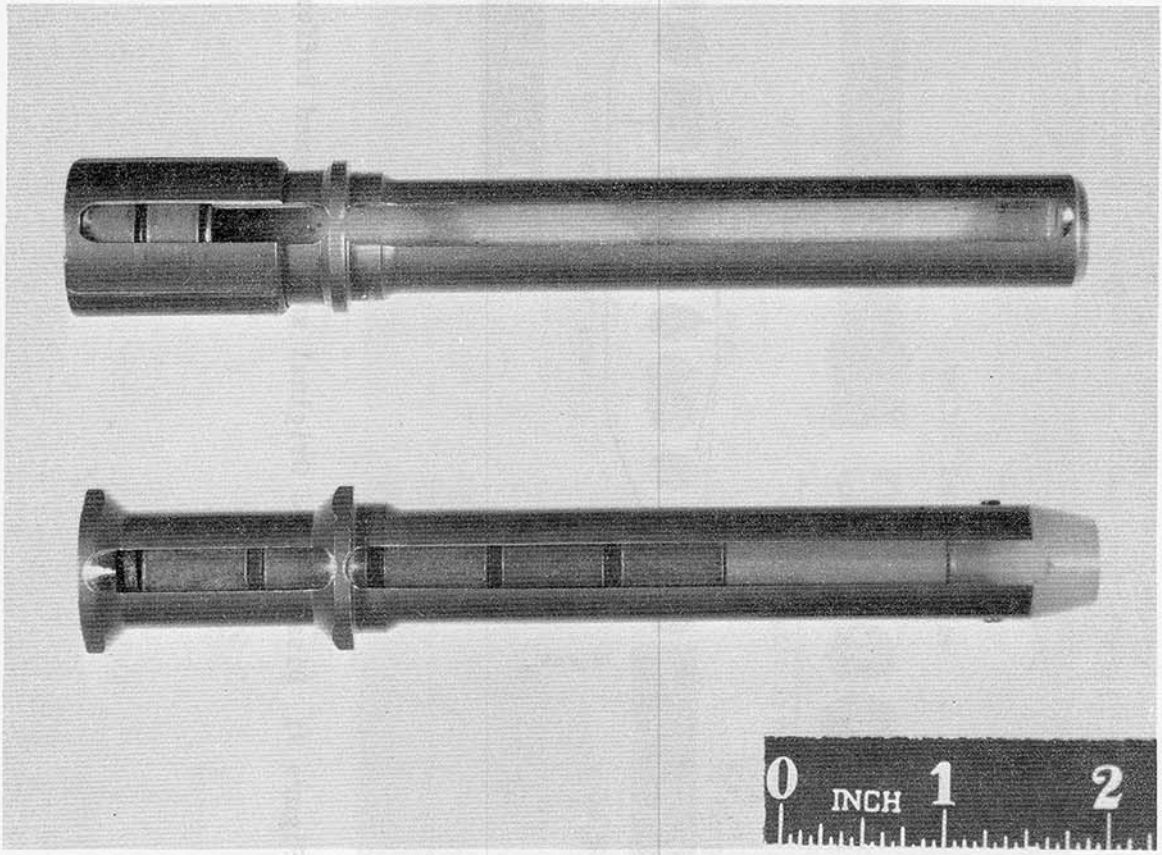


Figure 8: Cutaway Views of Original (Top) and Redesigned Buffers.

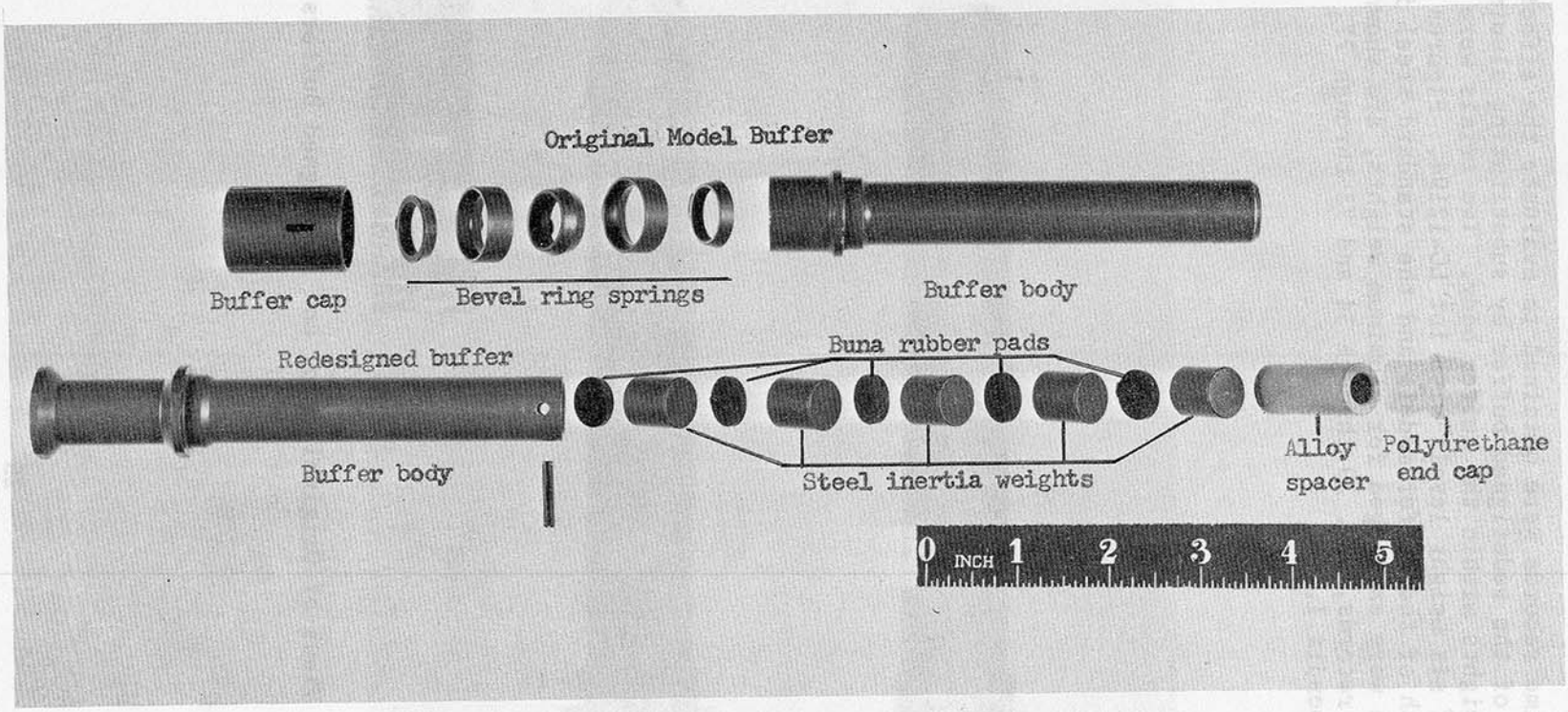


Figure 9: Disassembled Original and Redesigned Buffers.

The bolt carrier assembly, action spring, original model buffer, and redesigned buffer were carefully weighed and the various weights of the lightened redesigned buffer were noted. The weights are shown in Table III.

Table III. Weight of Components Comprising the Cycling Group of M16A1 Displacement-Time Rifle

	Wt, oz
Complete bolt carrier assembly	[a]11.57
Original model buffer	2.01
Redesigned buffer	[a] 5.20
Action spring	[a] 2.17
Cycling group[b]:	
With original model buffer	14.30
With redesigned buffer	17.49
With redesigned buffer, 1 aluminum, 4 steel weights	17.01
With redesigned buffer, 2 aluminum, 3 steel weights	16.53
With redesigned buffer, 3 aluminum, 2 steel weights	16.05
With redesigned buffer, 4 aluminum, 1 steel weights	15.57
With redesigned buffer, 5 aluminum, 0 steel weights	15.09

[a]The average weight and standard deviation for the same components from 150 different rifles as reported in Reference 2 are as follows:
Bolt carrier assembly, 11.53, std dev 0.2037.
Redesigned buffer, 5.18, std dev 0.0172.
Action spring, 2.11, std dev 0.0192.
[b]Cycling group weights include 1/3 the weight of the action spring.

Figures 10 through 15 illustrate that the incidence of bolt carrier rebound on closure (bolt "bounce") becomes progressively less controlled as the weight of the redesigned buffer is lightened and the cyclic rate increases. Note in Figures 14 and 15 how the arrows designating the peak of rebound shift from the left to right side of the dwell periods as the burst is fired. In Figure 15, the peak of rebound finally occurs sufficiently late in the dwell period after round 13 that the hammer strikes the partially rearward carrier and a failure to fire results.

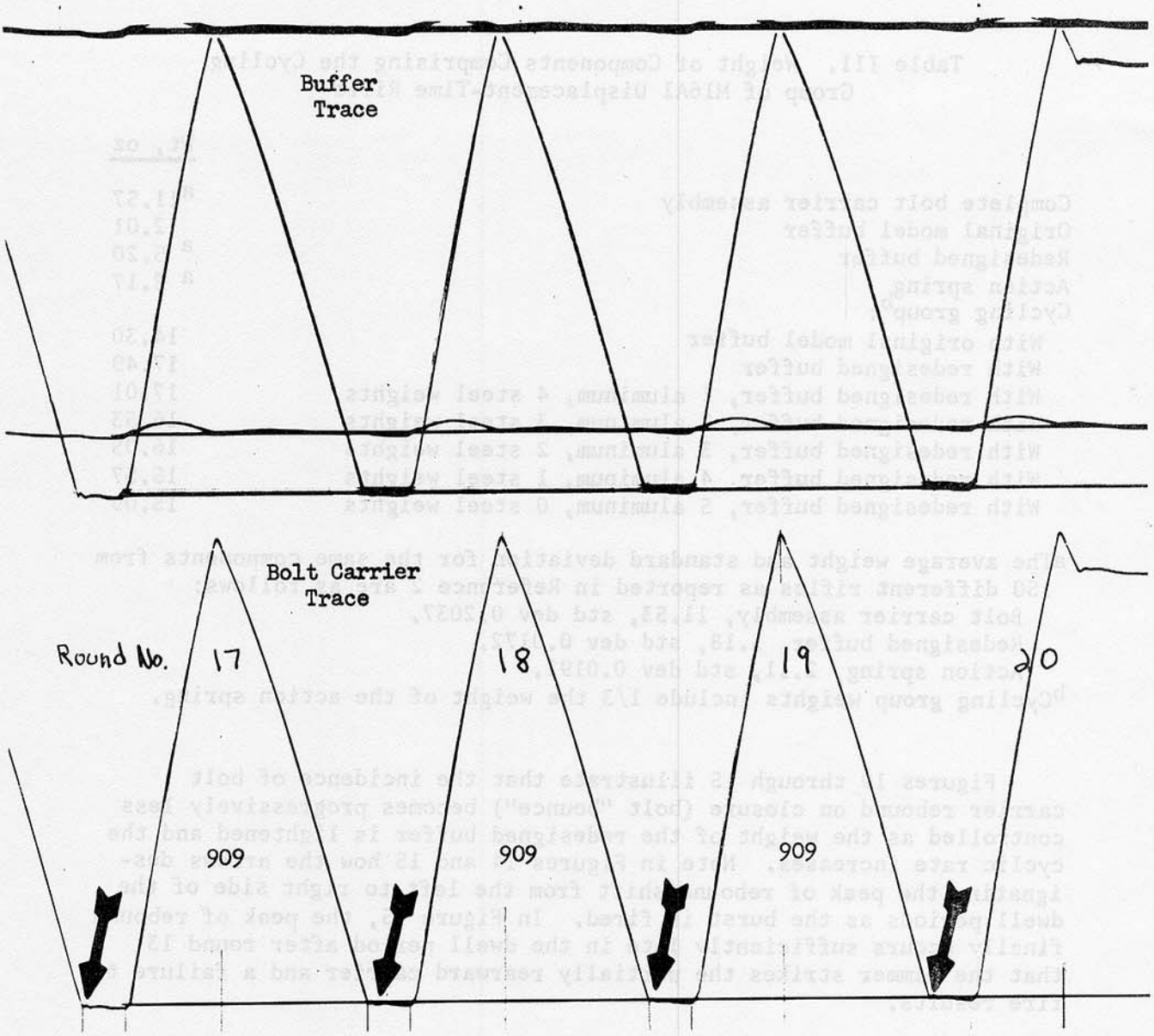


Figure 10: Displacement-Time Record No. 29 Showing Final Rounds in a Burst Fired with Redesigned Buffer Weighing 5.20 Ounces. Arrows Indicate Peak of Carrier Rebound; 3-Digit Numbers Indicate Rate of Fire.

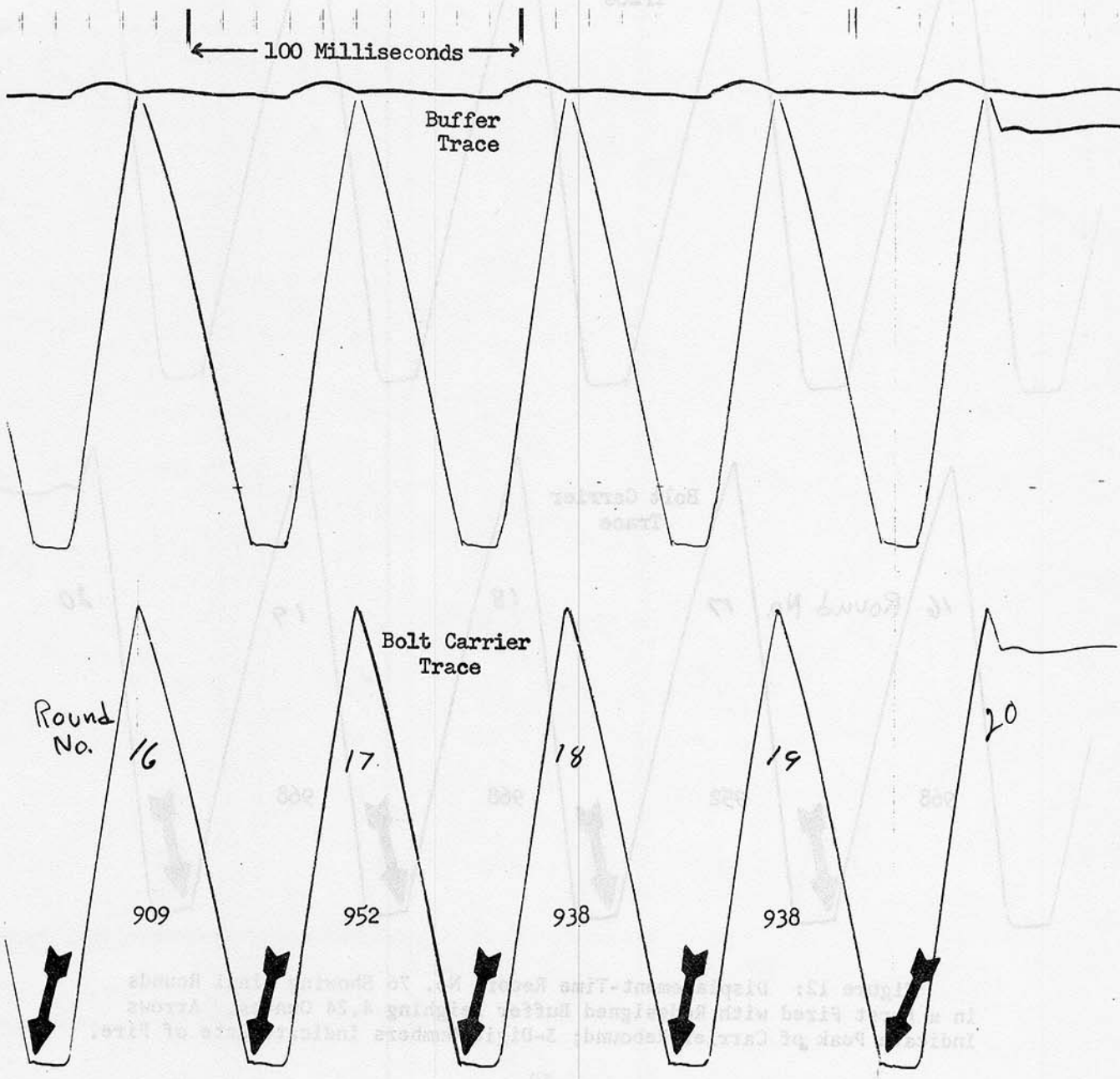


Figure 11: Displacement-Time Record No. 77 Showing Final Rounds in a Burst Fired with Redesigned Buffer Weighing 4.72 Ounces. Arrows Indicate Peak of Carrier Rebound; 3-Digit Numbers Indicate Rate of Fire.

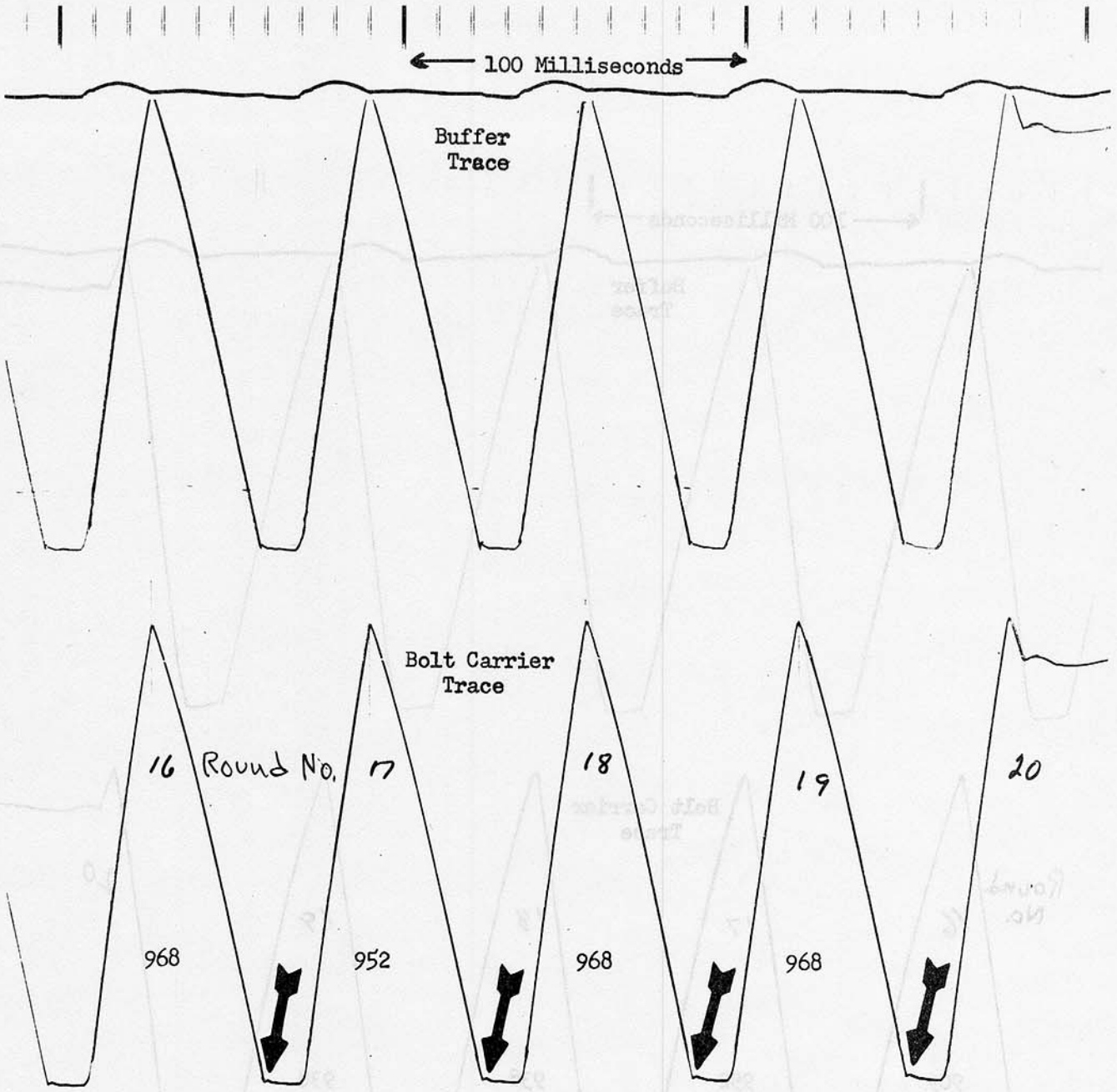


Figure 12: Displacement-Time Record No. 76 Showing Final Rounds in a Burst Fired with Redesigned Buffer Weighing 4.24 Ounces. Arrows Indicate Peak of Carrier Rebound; 3-Digit Numbers Indicate Rate of Fire.

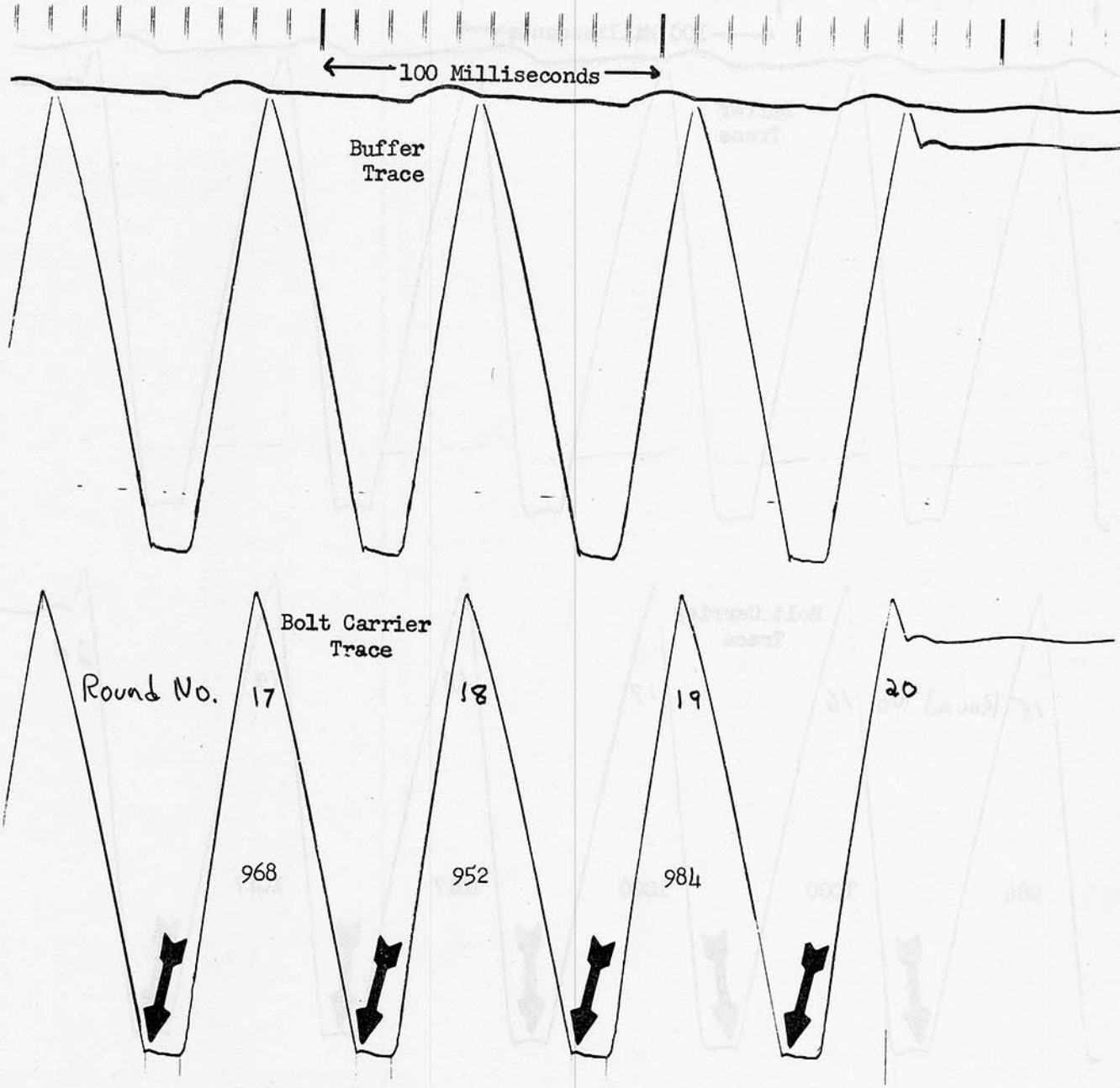


Figure 13: Displacement-Time Record No. 75 Showing Final Rounds in a Burst Fired with Redesigned Buffer Weighing 3.76 Ounces. Arrows Indicate Peak of Carrier Rebound; 3-Digit Numbers Indicate Rate of Fire.

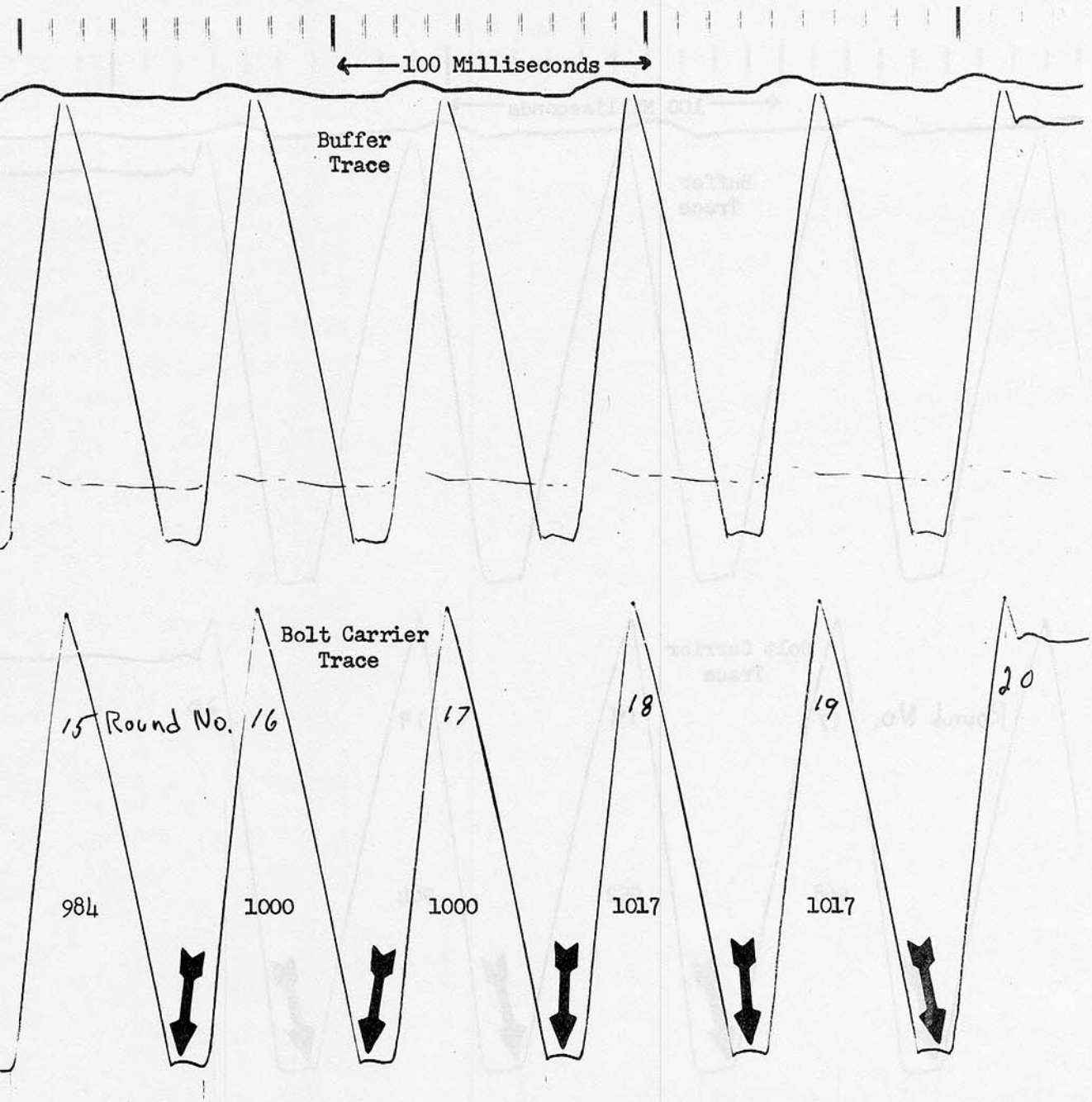


Figure 14: Displacement-Time Record No. 74 Showing Final Rounds in a Burst Fired with Redesigned Buffer Weighing 3.28 Ounces. Arrows Indicate Peak of Carrier Rebound; 3- and 4-Digit Numbers Indicate Rate of Fire.

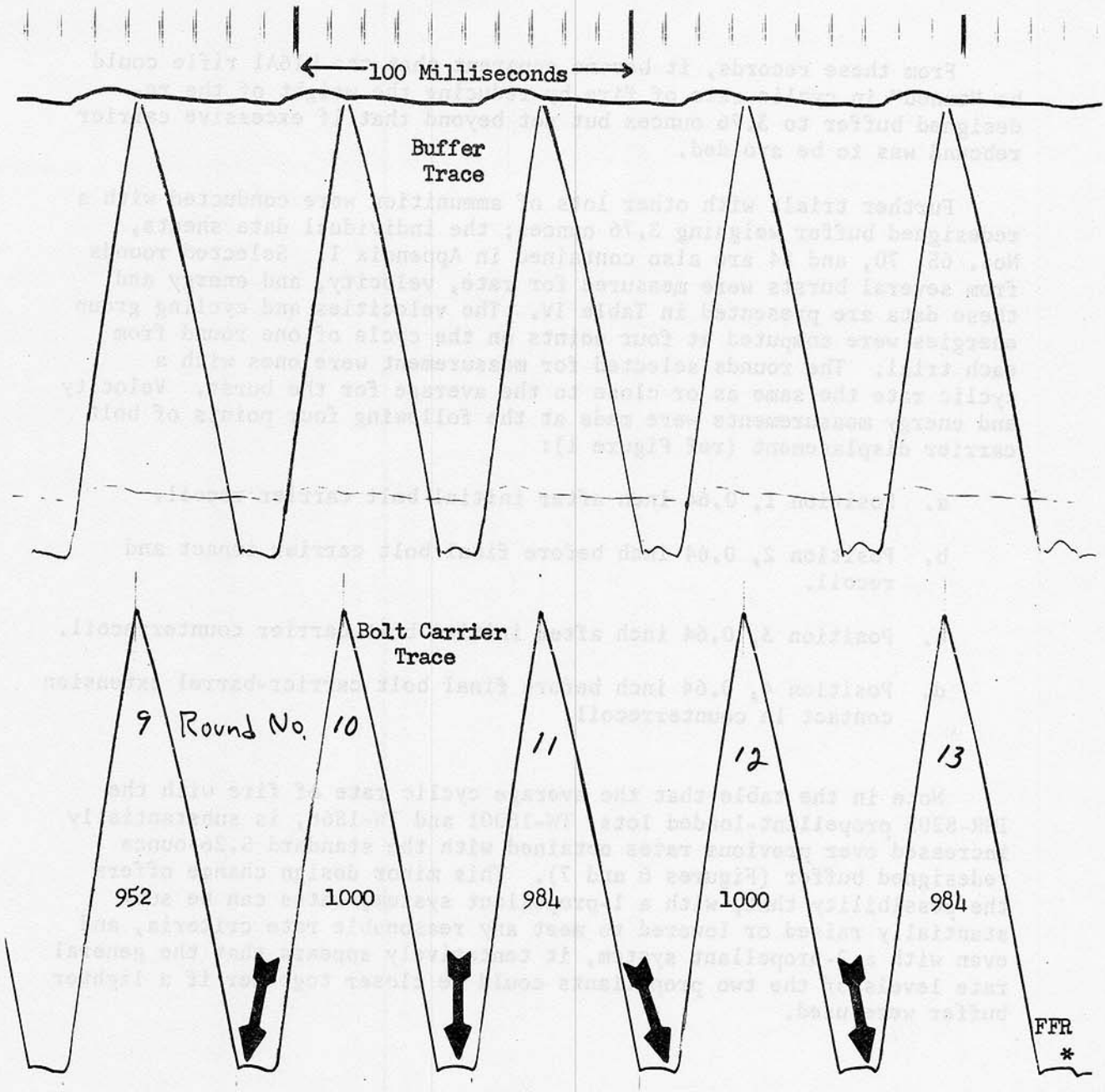


Figure 15: Displacement-Time Record No. 73 Showing Final Rounds in a Burst Fired with the Redesigned Buffer Weighing 2.80 Ounces, Arrows Indicate Peak of Carrier Rebound; 3- and 4-Digit Numbers Indicate Rate of Fire. Note Failure to Fire (*) at Peak of Rebound Following Round 13.

From these records, it became apparent that the M16A1 rifle could be "tuned" in cyclic rate of fire by reducing the weight of the redesigned buffer to 3.76 ounces but not beyond that if excessive carrier rebound was to be avoided.

Further trials with other lots of ammunition were conducted with a redesigned buffer weighing 3.76 ounces; the individual data sheets, Nos. 65, 70, and 84 are also contained in Appendix I. Selected rounds from several bursts were measured for rate, velocity, and energy and these data are presented in Table IV. The velocities and cycling group energies were computed at four points on the cycle of one round from each trial. The rounds selected for measurement were ones with a cyclic rate the same as or close to the average for the burst. Velocity and energy measurements were made at the following four points of bolt carrier displacement (ref Figure 1):

a. Position 1, 0.64 inch after initial bolt carrier recoil.

b. Position 2, 0.64 inch before final bolt carrier impact and recoil.

c. Position 3, 0.64 inch after initial bolt carrier counterrecoil.

d. Position 4, 0.64 inch before final bolt carrier-barrel extension contact in counterrecoil.

Note in the table that the average cyclic rate of fire with the IMR-8208 propellant-loaded lots, TW-18001 and TW-1866, is substantially increased over previous rates obtained with the standard 5.26-ounce redesigned buffer (Figures 6 and 7). This minor design change offers the possibility that, with a 1-propellant system, rates can be substantially raised or lowered to meet any reasonable rate criteria, and even with a 2-propellant system, it tentatively appears that the general rate levels of the two propellants could be closer together if a lighter buffer were used.

Table IV. Velocity and Energy Data for Variable Weight Buffer Phase

Record No.	Buffer Wt, oz	Cyclic Rate, rd/min: Avg for 20-Rd Burst	Selected Round	Rd No.	Velocity[a], fps: Position No. 1	2	3	4	Energy[a], ft-lb: Position No. 1	2	3	4
Ammunition Lot: LC-12194.												
29	5.20	908	896	12	18.4	15.2	7.9	10.8	5.8	3.9	1.1	2.0
30	4.72	908										
31	4.24	928										
33	3.28	948										
34	2.80	954										
73	2.80	978										
74	3.28	981	984	15	19.6	14.9	9.4	11.6	5.8	3.3	1.3	2.0
75	3.76	959										
76	4.24	935										
77	4.72	923										
23	OMB [b]	938	909	2	19.0	15.2	[c] -	11.1	4.9	3.4	[c] -	1.7
23	OMB [b]	938	952	13	23.0	15.9	[c] -	11.1	7.3	3.5	[c] -	1.7
Ammunition Lot: LC-12081.												
65	3.76	907	909	12	18.5	13.1	8.6	11.2	5.3	2.7	1.2	1.9
Ammunition Lot: TW-18001.												
70	3.76	836	845	10	16.3	11.1	8.1	10.8	4.1	1.9	1.0	1.8
Ammunition Lot: TW-18166.												
84	3.76	870	870	9	16.2	12.7	8.6	11.2	4.1	2.5	1.2	1.9

[a]The degree of accuracy in measuring velocity and bolt carrier energy at precise points on the condensed 20-round burst records is estimated to be ±10% for velocity and approximately twice that for energy measurements. Until further work is done in this area, these measurements can only be used to indicate the approximate general level and relationship between the velocities and energies reported.

[b]Original model buffer.

[c]The traces were indistinct at this point and the data were not obtained.

4.6 PROJECTILE VELOCITY VERSUS BOLT CARRIER VELOCITY

During burst-fire exercises, an attempt was made to determine if a relationship could be found between occasional low projectile velocities and low bolt carrier velocities; however, it soon became apparent that the investigation was beyond the scope of the basic study as much higher displacement-time camera drum speeds would be required than were suitable for completion of the programmed test phases. The burst-fire projectile velocity data that were obtained are included in Appendix I for possible future reference as burst fire projectile velocities for the M16A1 rifle have not often been tabulated.

4.7 SPECIAL INVESTIGATION WITH ORIGINAL MODEL BUFFER

During the product improvement test of the redesigned buffer, it was noted that occasionally the bevel ring springs contained in the buffer cap of the original model buffer (Figure 9) would become firmly jammed together and would then usually produce higher than normal rates of fire. A set of such jammed rings was removed from an original model buffer from the product improvement test and installed in the buffer used in the displacement-time studies. Attempts were then made to fire a burst of 20 rounds but each attempt terminated in a failure to fire.

Subsequently, displacement-time record No. 66 was similarly terminated by a failure to fire after the 19th round. This record was obtained with the original model buffer and the bevel ring springs in relatively new and in presumably undamaged condition. Careful disassembly of the buffer after the stoppage showed that two of the five bevel ring springs were jammed together.

From these records, it appears entirely possible that a substantial amount of past M16A1, and particularly XM16E1 test data, may have reflected this bevel ring spring malfunction which could be expected to result in a high number of both failures to fire and failures of the bolt to remain to the rear after the last round. The most outstanding example of this occurrence may be the data reported in Reference 3 where nearly 50% of all XM16E1 malfunctions (approximately 940 of 2020 malfunctions) were either failures of the bolt to remain to the rear or failures to fire. All XM16E1 rifles in the reference test were equipped with the original model buffer.

The displacement-time data showing the failure-to-fire malfunctions with the original model buffer are contained in record No. 24 and 66 in Appendix I.

4.8 MAGAZINE COMPLEMENT PHASE

The individual data sheets for the displacement-time records which were obtained by firing a 21-, 20-, 19-, 18-, 17-, 10-, and 5-round burst are contained in Appendix I (records Nos. 3 through 8 and 29). From an examination of the records it can be seen that it requires approximately six to seven rounds of firing before a reasonably "steady state" of fire is reached. This compares well with the data shown in Figure 4 and indicates again that the most significant factor in cyclic rate change within any single burst appears to be due to the characteristics of the redesigned buffer and that a less than fully-loaded magazine does not materially aid in overcoming initial low rates.

In Figure 16, bolt carrier velocities and energies are computed for a 20-round burst of lot LC-12194 and compared to similar velocities and energies for lot TS-18001. The data presented in Figure 16 are from the same records illustrated earlier in Figures 4 and 7. The energy levels tabulated assume a cycling group weight of 17.49 ounces. Note by reference to Figure 1 that the velocity and energy points in each counterrecoil stroke have been measured at approximately the point of cartridge feeding.

The data presented in Figure 16 show the potential energy advantage available to the rifle mechanism when firing a WC-846 propellant-loaded, ball projectile lot as opposed to an IMR-8208 propellant-loaded tracer lot TW-18001. While displacement-time records have not been obtained during adverse firing conditions, where certain energy levels may be found to be successful in overcoming some types of gun failures, the data nevertheless appear to provide a logical reason for the higher weapon reliability levels associated in recent tests with WC-846 ball projectile lots.

With reference to the product-improvement test of the redesigned buffer, 70% more failures to feed (a low energy, counterrecoil malfunction) and eight times as many incidents of the bolt closing on an empty chamber (usually a low energy, short recoil malfunction) occurred with lot TW-18001 as with LC-12177. The displacement-time data, in conjunction with the malfunction rates reported in the product-improvement test, would appear to warrant extending the present restriction on loading ball projectile cartridges with IMR-8208 propellant to include tracer cartridges.

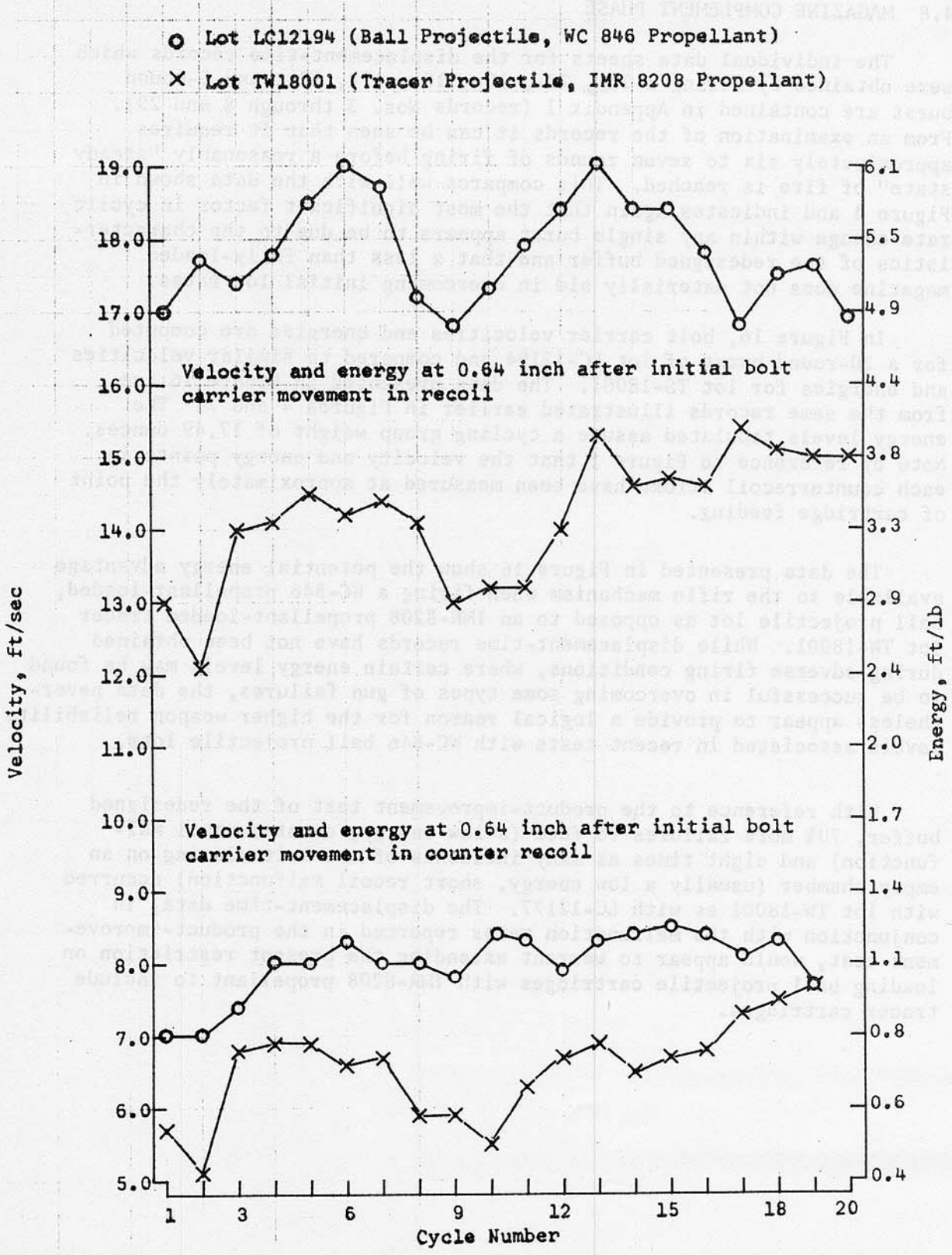


Figure 16: Bolt Carrier Velocity and Energy with Redesigned Buffer for Two Lots of Ammunition.

APPENDIX I - TEST DATA

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 3.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 20 rounds plus one round in the chamber and a 21-round burst fired; gun cleaned and lubricated prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	23	38	11	72	833	0.05
2	23	37	11	71	845	0.05
3	22	35	12	69	870	0.06
4	22	35		69	870	
5	22	33		67	896	
6	22	33	11	66	909	0.06
7	22	33		66	909	
8	22	35		68	882	
9	22	33		65	923	
10	22	35		68	882	
11	22	33	11	66	909	0.05
12	22	33		66	909	
13	22	32		64	938	
14	22	32		63	952	
15	22	32		63	952	
16	22	32	11	65	923	0.06
17	22	32		64	938	
18	22	32		64	938	
19	21	31	10	62	968	0.06
20	21	31	11	63	952	0.06
21	21					

Total cycle time, 1321 ms. Average cyclic rate of fire, 908 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 4.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 18 rounds plus one round in the chamber and a 19-round burst fired; gun cleaned and lubricated at 21 rounds prior to record No. 4.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	24	39	11	74	811	0.04
2	25	40	11	76	789	0.03
3	24	38	12	74	811	0.04
4	23	37		72	833	
5	24	37		72	833	
6	23	36	11	70	857	0.05
7	23	36		69	870	
8	22	35		67	896	
9	22	33		66	909	
10	22	33		67	896	
11	22	33	10	65	923	0.06
12	22	32		65	923	
13	22	32		64	938	
14	22	33		66	909	
15	22	32		65	923	
16	23	32	10	65	923	0.05
17	22	31	10	63	952	0.06
18	22	32	11	65	923	0.06
19	22					

Total cycle time, 1225 ms. Average cyclic rate of fire, 882 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 5.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 17 rounds plus one round in the chamber and an 18-round burst fired; gun cleaned and lubricated at 40 rounds prior to record No. 5.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	24	38	11	73	822	0.04
2	24	38	11	73	822	0.05
3	24	38	11	73	822	0.05
4	24	40		76	789	
5	25	41		77	779	
6	25	41	11	77	779	0.04
7	24	39		74	811	
8	24	38		74	811	
9	23	36		70	857	
10	23	36		70	857	
11	23	36	11	70	857	0.04
12	22	35		68	882	
13	22	33		66	909	
14	22	34		66	909	
15	22	33		65	923	
16	22	31	11	64	938	0.07
17	22	32	10	64	938	0.05
18	22					

Total cycle time, 1200 ms. Average cyclic rate of fire, 850 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 6.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 16 rounds plus one round in the chamber and a 17-round burst fired; gun cleaned and lubricated at 58 rounds prior to record No. 6.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	25	39	11	75	800	0.06
2	25	37	11	73	822	0.03
3	24	37	11	72	833	0.04
4	25	38		74	811	
5	24	38		73	822	
6	25	39	11	75	800	0.04
7	24	38		74	811	
8	25	41	11	77	779	0.02
9	23	38		73	822	
10	24	36		71	845	
11	24	37	11	72	833	0.05
12	24	36		71	845	
13	23	36		71	845	
14	24	37		72	833	
15	22	35	11	68	882	0.04
16	23	36	11	70	857	0.04
17	22					

Total cycle time, 1161 ms. Average cyclic rate of fire, 827 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 7.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 9 rounds plus one round in the chamber and a 10-round burst fired; gun cleaned and lubricated at 75 rounds prior to record No. 7.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	25	37	11	73	822	0.05
2	25	36	11	72	833	0.04
3	24	36	11	71	845	0.04
4	23	35		69	870	
5	23	35		69	870	
6	22	32	11	65	923	0.05
7	22	32		65	923	
8	22	32		65	923	
9	23	34	11	68	882	0.05
10	22					

Total cycle time, 617 ms. Average cyclic rate of fire, 875 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 8.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 4 rounds plus one round in the chamber and a 5-round burst fired; gun cleaned and lubricated at 85 rounds prior to record No. 8.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	24	38	11	73	822	0.05
2	24	36	11	71	845	0.05
3	23	36	11	70	857	0.04
4	22	35	10	67	896	0.05
5	22					

Total cycle time, 281 ms. Average cyclic rate of fire, 854 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 28 February 1968. **Record No.:** 9.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: One hundred rounds were fired in 35 seconds and record No. 9 obtained for the final 20-round burst (12 seconds elapsed from the firing of the 80th round to the firing of the 1st round of record No. 9). The gun had been cleaned and lubricated at 170 rounds prior to the record. The average cyclic rates of fire for the initial four bursts were 829, 847, 893, and 904 rds/min in order as fired.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	22	35	11	68	882	0.06
2	22	32	10	64	938	0.06
3	21	32	11	64	938	0.07
4	21	31		62	968	
5	21	32		64	938	
6	21	30	10	61	984	0.08
7	21	30		62	968	
8	21	30		61	984	
9	21	30		61	984	
10	21	31		63	952	
11	20	31	10	61	984	0.08
12	20	31		62	968	
13	20	30		61	984	
14	20	30		61	984	
15	21	30		61	984	
16	20	30		61	984	0.08
17	21	29		61	984	
18	20	29	10	59	1017	0.09
19	20	30	10	60	1000	0.09
20	20					

Total cycle time, 1177 ms. Average cyclic rate of fire, 968 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 29 February 1968. **Record No.:** 16.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12177.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated at 40 rounds prior to record No. 16.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	26	41	10	77	779	0.03
2	25	42	10	77	779	0.03
3	25	41	10	76	789	0.03
4	23	38		71	845	
5	22	37		71	845	
6	22	35	10	67	896	0.06
7	22	34		67	896	
8	22	35		68	882	
9	22	34		66	909	
10	22	34		66	909	
11	23	35	10	68	882	0.05
12	22	33		66	909	
13	22	33		66	909	
14	23	35		68	882	
15	23	33		66	909	
16	23	33	10	66	909	0.06
17	24	33		68	882	
18	23	33	10	66	909	0.05
19	23	33	10	66	909	0.06
20	23					

Total cycle time, 1306 ms. Average cyclic rate of fire, 873 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 29 February 1968. **Record No.:** 18.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12177.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated at 20 rounds prior to record No. 18.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	21	40	10	71	845
2	20	35	10	65	923
3	21	33	11	65	923
4	20	33		64	938
5	21	33		64	938
6	21	34	10	65	923
7	20	34		65	923
8	21	34		66	909
9	20	35		65	923
10	20	36		66	909
11	20	35	10	65	923
12	20	36		66	909
13	20	36		66	909
14	20	36		66	909
15	20	36		66	909
16	21	36	10	67	896
17	20	36		66	909
18	20	36	10	66	909
19	19	37	10	66	909
20	20				

Total cycle time, 1250 ms. Average cyclic rate of fire, 912 rd/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c]Individual total cycle time converted to a rate of fire in rd/min.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 23.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated at 25 rounds prior to record No. 23.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	21	35	10	66	909
2	21	35	10	66	909
3	20	35	10	65	923
4	19	34		64	938
5	19	34		63	952
6	18	34	10	63	952
7	19	34		63	952
8	19	35		64	938
9	19	34		63	952
10	18	34		63	952
11	19	35	10	64	938
12	19	35		64	938
13	19	34		63	952
14	19	35		63	952
15	19	35		64	938
16	19	35	10	64	938
17	19	35		65	923
18	18	36	10	64	938
19	18	35	10	65	923
20	18				

Total cycle time, 1216 ms. Average cyclic rate of fire, 938 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 24.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber for each of three trials. A set of jammed bevel ring springs, which were removed from a buffer which had been previously fired in another M16A1 rifle, were installed in the test buffer. All three trials resulted in a failure-to-fire due to extreme carrier rebound. The gun was cleaned and lubricated at 45 rounds prior to record No. 24.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	19	41	10	70	857
2	19	32	[d]10	[d]61	984
1	19	32	[d]10	[d]61	984
1	20	32	[d]10	[d]62	968

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires.

[c]Individual total cycle time converted to a rate of fire in rd/min.
[d]Estimated.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 29.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated at 20 rounds prior to record No. 29.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	23	38	10	71	845	0.04
2	24	36	10	70	857	0.04
3	24	38	10	72	833	0.04
4	23	35		68	882	
5	23	34		68	882	
6	22	34	10	66	909	0.04
7	22	36		68	882	
8	22	36		68	882	
9	22	37		70	857	
10	22	34		66	909	
11	22	34	10	67	896	0.07
12	22	35		67	896	
13	22	34		65	923	
14	22	33		65	923	
15	22	33		65	923	
16	22	33	10	65	923	0.06
17	22	33		66	909	
18	22	34	10	66	909	0.06
19	22	34	10	66	909	0.06
20	22					

Total cycle time, 1279 ms. Average cyclic rate of fire, 891 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 30.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Buffer: Redesigned; with one aluminum and four steel weights.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 40 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	22	39	10	72	833	0.04
2	22	34	9	66	909	0.06
3	22	35	10	67	896	0.05
4	22	34		66	909	
5	22	34		66	909	
6	22	34	10	67	896	0.06
7	23	34		68	882	
8	22	34		66	909	
9	22	35		67	896	
10	21	34		66	909	
11	21	34	10	66	909	0.06
12	21	34		65	923	
13	21	34		66	909	
14	20	33		63	952	
15	21	34		66	909	
16	21	32	10	64	938	0.06
17	21	32		64	938	
18	21	32	10	64	938	0.06
19	22	33	10	66	909	0.06
20	22					

Total cycle time, 1255 ms. Average cyclic rate of fire, 908 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 31.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with two aluminum and three steel weights.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 60 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	22	38	9	70	857	0.04
2	22	34	10	66	909	0.04
3	22	34	10	66	909	0.05
4	22	33		65	923	
5	22	32		64	938	
6	22	32	10	65	923	0.06
7	22	33		66	909	
8	22	33		66	909	
9	22	34		66	909	
10	21	32		64	938	
11	21	32	10	64	938	0.06
12	21	32		64	938	
13	22	32		65	923	
14	21	32		63	952	
15	22	33		66	909	
16	20	32	10	62	968	0.07
17	21	32		63	952	
18	21	32	10	62	968	0.07
19	21	31	10	62	968	0.08
20	21					

Total cycle time, 1229 ms. Average cyclic rate of fire, 928 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 1 March 1968. **Record No.:** 33.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733086.
Buffer: Redesigned; with four aluminum and one steel weight.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 100 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	21	37	10	68	882	0.02
2	21	32	10	63	952	0.05
3	22	33	10	65	923	0.05
4	22	33		64	938	
5	23	32		64	938	
6	20	32	11	63	952	0.07
7	20	32		63	952	
8	21	33		63	952	
9	20	34	10	65	923	
10	18	34		63	952	
11	18	35		63	952	
12	20	33		63	952	
13	20	33		63	952	
14	19	33		62	968	
15	18	34		62	968	
16	20	32	11	63	952	0.08
17	20	32		62	968	
18	19	32	11	62	968	0.07
19	19	32	11	62	968	0.07
20	19					

Total cycle time, 1203 ms. Average cyclic rate of fire, 948 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rd/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 6 March 1968. **Record No.:** 54.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model.

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: WC-846.
Lot No.: LC-12081.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 120 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	22	35	11	67	896
2	22	32	11	65	923
3	22	34	11	66	909
4	22	33		66	909
5	22	34		66	909
6	21	33	11	65	923
7	22	34		66	909
8	22	32		65	923
9	22	32		65	923
10	21	33		65	923
11	20	34	10	65	923
12	22	33		65	923
13	22	34		66	909
14	21	33		65	923
15	20	33		64	938
16	21	32	11	63	952
17	21	32		63	952
18	21	32	11	64	938
19	20	32	10	62	968
20	20				

Total cycle time, 1233 ms. Average cyclic rate of fire, 925 rd/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c]Individual total cycle time converted to a rate of fire in rds/min.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 62.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: WC-846.
Lot No.: LC-12081.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 20 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	28	43	10	81	741	0.03
2	25	39	10	75	800	0.04
3	24	38	11	73	822	
4	25	38		73	822	
5	24	35		69	870	
6	25	32	10	68	882	0.05
7	26	34		71	845	
8	26	34		70	857	
9	25	34		70	857	
10	25	33		68	882	
11	25	34	10	70	857	0.04
12	24	33		67	896	
13	24	34		69	870	
14	24	34		68	882	
15	24	34		68	882	
16	23	33	10	67	896	0.04
17	24	33		68	882	
18	23	33	10	66	909	0.03
19	23	32	10	66	909	0.03
20	23					

Total cycle time, 1327 ms. Average cyclic rate of fire, 859 rd/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 65.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with three aluminum and one steel weight.

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: WC-846.
Lot No.: LC-12081.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 80 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	25	38	10	74	811	0.04
2	24	36	10	70	857	0.04
3	23	32	10	66	909	0.04
4	23	34		67	896	
5	24	33		67	896	
6	24	33	10	67	896	0.04
7	24	33		67	896	
8	23	33		66	909	
9	24	34	10	68	882	0.05
10	23	33		66	909	
11	23	33		66	909	
12	23	33		66	909	
13	22	32		64	938	
14	22	32		65	923	
15	22	32		65	923	
16	22	31	10	63	952	0.06
17	22	32		64	938	
18	22	31	10	63	952	0.06
19	22	31	10	63	952	0.07
20	22					

Total cycle time, 1257 ms. Average cyclic rate of fire, 907 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 66.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Old model (standard).

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: WC-846.
Lot No.: LC-12081.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 100 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	23	36	10	70	857
2	23	33	10	67	896
3	23	33	10	67	896
4	23	34		67	896
5	23	33		67	896
6	22	33	10	66	909
7	22	33		67	896
8	22	33		67	896
9	22	34		66	909
10	22	33		66	909
11	22	34	10	67	896
12	22	35		67	896
13	22	33		66	909
14	21	32		64	938
15	20	31		61	984
16	20	32	10	62	968
17	22	31		63	952
18	21	32	10	62	968
19	21	31	d -		
20	d -				

Total cycle time, 1180 ms. Average cyclic rate of fire, 915 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] The final rounds failed to fire.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 68.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: IMR-8208.
Lot No.: TW18001.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 40 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	31	46	10	87	690	0.03
2	36	49	10	94	638	0.02
3	28	40	9	78	769	0.04
4	28	40		78	769	
5	27	38		75	800	
6	28	40	10	78	769	0.03
7	27	40		78	769	
8	29	44		83	723	
9	31	44		85	706	
10	32	47		90	667	
11	30	43	10	82	732	0.03
12	26	42		79	759	
13	26	40		76	789	
14	27	39		77	779	
15	26	39		76	789	
16	26	39	10	75	800	0.04
17	24	36		71	845	
18	26	36	11	72	833	0.04
19	25	34	11	70	857	0.04
20	26					

Total cycle time, 1504 ms. Average cyclic rate of fire, 758 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 70.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with three aluminum and one steel weight.

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: IMR-8208.
Lot No.: TW-18001.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 80 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	29	44	10	83	723	0.03
2	28	42	10	80	750	0.03
3	27	40	10	78	769	0.03
4	27	39		76	789	
5	27	39		76	789	
6	26	38	10	75	800	0.03
7	25	36		71	845	
8	25	35		70	857	
9	25	35	10	70	857	0.05
10	25	35		71	845	
11	25	34		69	870	
12	25	35		70	857	
13	25	33		68	882	
14	25	35		70	857	
15	24	34		69	870	
16	24	32	10	67	896	0.05
17	24	33		67	896	
18	23	33	10	67	896	0.06
19	23	32	10	66	909	0.04
20	23					

Total cycle time, 1363 ms. Average cyclic rate of fire, 836 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c]Individual total cycle time converted to a rate of fire in rds/min.
[d]Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds in a burst are measured.

Displacement-Time Data

Date: 7 March 1968. **Record No.:** 71.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model (standard).

Ammunition
Projectile Type: M196 (tracer).
Propellant Type: IMR-8208.
Lot No.: TW-18001.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 100 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	24	38	10	72	833
2	23	35	09	67	896
3	24	36	10	69	870
4	24	36		69	870
5	23	35		68	882
6	24	35	11	69	870
7	23	36		69	870
8	23	36		69	870
9	23	34		67	896
10	22	34		66	909
11	23	35		68	882
12	22	36		68	882
13	22	36		69	870
14	22	37		70	857
15	22	34		68	882
16	23	35	11	69	870
17	22	33		67	896
18	22	34	11	67	896
19	22	34	11	67	896

Total cycle time, 1298 ms. Average cyclic rate of fire, 878 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds in a burst are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.

Displacement-Time Data

Date: 8 March 1968. **Record No.:** 73.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with five aluminum weights.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 37 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	21	32	10	63	952	0.06
2	22	29	10	62	968	0.07
3	21	28	11	61	984	0.06
4	22	28	11	61	984	
5	21	30	10	61	984	
6	20	28	11	60	1000	0.06
7	22	32	10	63	952	
8	22	29	10	62	968	
9	21	31	11	63	952	
10	20	29	11	60	1000	
11	19	32	10	61	984	0.06
12	19	29	11	60	1000	0.07
13	18	30	e -	e -	e -	0.08

Total cycle time, 737 ms. Average cyclic rate of fire, 978 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds are measured.
[c]Individual total cycle time converted to rate of fire in rds/min.
[d]Minus values, if listed, indicate buffer failed to impact rear of extension tube.
[e]The 14th round failed to fire.

Displacement-Time Data

Date: 8 March 1968. **Record No.:** 74.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with four aluminum weights and one steel weight.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 57 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	22	33	10	65	923	0.04
2	22	30	10	62	968	0.05
3	22	31	10	63	952	0.05
4	21	30		61	984	
5	21	32		63	952	
6	21	30	11	62	968	0.06
7	20	30		61	984	
8	21	30		61	984	
9	21	31	10	62	968	
10	20	28		60	1000	
11	20	31		62	968	
12	20	30		60	1000	
13	21	30		62	968	
14	20	29		59	1017	
15	20	30		61	984	
16	19	30	10	60	1000	0.07
17	20	29		60	1000	
18	19	29	10	59	1017	0.07
19	19	29	10	59	1017	0.07
20	20					

Total cycle time, 1162 ms. Average cyclic rate of fire, 981 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds are measured.

Displacement-Time Data

Date: 8 March 1968. **Record No.:** 75.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Buffer: Redesigned; with three aluminum weights and two steel weights.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 77 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	22	34	10	66	909	0.05
2	22	32	9	63	952	0.06
3	22	31	10	63	952	0.05
4	22	30		62	968	
5	22	32		64	952	
6	22	31	10	62	968	0.07
7	21	32		62	968	
8	22	30		62	968	
9	22	31		64	952	
10	22	29		61	984	
11	22	29	10	62	968	0.07
12	22	30		62	968	
13	22	30		63	952	
14	22	30		63	968	
15	22	30		62	968	
16	21	32	10	62	968	0.07
17	20	32		62	968	
18	20	32	10	63	952	0.07
19	20	32	10	61	984	0.08
20	20					

Total cycle time, 1189 ms. Average cyclic rate of fire, 959 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds are measured.
[c]Individual total cycle time converted to a rate of fire in rds/min.
[d]Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds are measured.

Displacement-Time Data

Date: 8 March 1968. **Record No.:** 76.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Buffer: Redesigned; with two aluminum weights and three steel weights.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 97 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	23	37	9	70	857	0.05
2	22	32	10	64	938	0.06
3	23	32	10	65	923	0.06
4	23	32		66	909	
5	22	32		64	938	
6	23	31	11	65	923	0.05
7	22	32		64	938	
8	22	32		64	938	
9	22	32	10	64	938	
10	22	33		65	923	
11	22	32		64	938	
12	21	32		63	952	
13	22	32		65	923	
14	21	33		64	938	
15	21	32		63	952	
16	20	32	10	62	968	0.08
17	21	32		63	952	
18	20	30	11	62	968	0.07
19	22	30	10	62	968	0.08
20	20					

Total cycle time, 1219 ms. Average cyclic rate of fire, 935 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds are measured.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds are measured.

Displacement-Time Data

Date: 8 March 1968. **Record No.:** 77.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with one aluminum and four steel weights.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: WC-846.
Lot No.: LC-12194.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 117 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	23	38	10	71	845	0.04
2	22	32	10	64	938	0.06
3	23	33	10	66	909	0.06
4	23	33		67	896	
5	22	33		65	923	
6	22	32	10	64	938	0.06
7	22	32		64	938	
8	22	34		66	909	
9	22	33	10	66	909	0.06
10	22	33		65	923	
11	22	33		66	909	
12	22	32		64	938	
13	22	32		65	923	
14	21	30	10	62	968	
15	21	32		63	952	
16	21	33	11	66	909	0.06
17	21	31		63	952	
18	22	32	10	64	938	0.07
19	22	32	10	64	938	0.05
20	22					

Total cycle time, 1235 ms. Average cyclic rate of fire, 923 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires; only selected rounds are measured.
[c]Individual total cycle time converted to a rate of fire in rds/min.
[d]Minus values, if listed, indicate buffer failed to impact rear of extension tube; only selected rounds are measured.

Displacement-Time Data

Date: 11 March 1968. **Record No.:** 81.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: IMR-8208.
Lot No.: TW-18166.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst fired; gun cleaned and lubricated 20 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	28	41	9	79	759	
2	28	42	10	81	741	
3	28	43	10	82	732	
4	30	45		85	706	
5	32	46		87	690	
6	31	40	10	82	732	
7	28	40		79	759	
8	29	41		81	741	
9	29	42		81	741	
10	29	41		80	750	
11	30	42	10	82	732	
12	30	46		87	690	
13	32	47		89	674	
14	29	42		81	741	
15	26	39		75	800	
16	26	40	9	76	789	
17	25	38		74	811	
18	27	38	10	76	789	
19	26	38	10	75	800	
20	25					

Total cycle time, 1532 ms. Average cyclic rate of fire, 744 rds/min.

[a] Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b] Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires.
[c] Individual total cycle time converted to a rate of fire in rds/min.
[d] Measurements were not obtained.

Displacement-Time Data

Date: 11 March 1968. **Record No.:** 84.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Redesigned; with three aluminum and two steel weights.

Ammunition
Projectile Type: M193 (ball).
Propellant Type: IMR-8208.
Lot No.: TW-18166.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst was fired; the gun was cleaned and lubricated 80 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min	Buffer Compression[d], in.
	Recoil	Counter-recoil	Dwell[b]	Total Cycle		
1	28	41	10	79	759	
2	28	40	10	78	769	
3	26	38	10	75	800	
4	24	35		70	857	
5	23	31		65	923	
6	26	34	10	71	845	
7	23	33		67	896	
8	25	32		68	882	
9	25	34	10	69	870	
10	25	35		70	857	
11	24	33		68	882	
12	24	33		67	896	
13	23	35		68	882	
14	23	33		67	896	
15	23	33		67	896	
16	23	33	10	66	909	
17	23	31		65	923	
18	24	33	10	67	896	
19	24	30	10	64	938	
20	24					

Total cycle time, 1311 ms. Average cyclic rate of fire, 870 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires.
[c]Individual total cycle time converted to a rate of fire in rds/min.
[d]Measurements were not obtained.

Displacement-Time Data

Date: 11 March 1968. **Record No.:** 85.

Weapon
Model: M16A1.
Caliber: 5.56-mm.
Serial No.: 733046.
Buffer: Original model (standard).

Ammunition
Projectile Type: M193 (ball).
Propellant Type: IMR-8208.
Lot No.: TW-18166.

Test Condition: Magazine loaded with 19 rounds plus one round in the chamber and a 20-round burst was fired; the gun was cleaned and lubricated 100 rounds prior to record.

Cycle No.[a]	Time, ms				Cyclic Rate of Fire[c], rd/min
	Recoil	Counter-recoil	Dwell[b]	Total Cycle	
1	24	37	10	71	845
2	23	33	10	66	909
3	23	32	10	66	909
4	23	33		66	909
5	23	34		67	896
6	23	34	10	67	896
7	23	35		68	882
8	24	34		68	882
9	25	36		71	845
10	23	35		67	896
11	22	34	9	66	909
12	22	34		67	896
13	22	36		68	882
14	22	36		68	882
15	23	37		71	845
16	21	36	10	66	909
17	22	34		66	909
18	22	32	9	65	923
19	22	35	10	68	882
20	22				

Total cycle time, 1282 ms. Average cyclic rate of fire, 890 rds/min.

[a]Each cycle begins at the point of initial rearward movement of the bolt carrier and ends at the final moment of bolt carrier dwell.
[b]Measured from point of initial bolt carrier contact with the barrel extension, at conclusion of counterrecoil, to initial rearward movement of the carrier as next round fires.
[c]Individual total cycle time converted to a rate of fire in rds/min.

Projectile Velocities During Burst Fire, M16A1 Rifle

	Velocity 15 Ft from Muzzle, fps						
	Ammunition Lot						
	LC-12194	LC-12194	LC-12194	LC-12194	LC-12194	TW-18166	TW-18166
Rd	Record No.						
No.	38	39	40	42	43	47	48
1	3135	3175	Lost	3175	3195	Lost	3195
2	3155	3175	Lost	3096	3135	3125	3126
3	3125	3115	Lost	3125	3135	3125	3145
4	3096	3145	Lost	3125	3145	3115	3175
5	3135	3205	Lost	3096	3096	3115	3125
6	3135	3145	Lost	3086	3135	3185	3155
7	3155	3125	3125	3125	3135	3125	3115
8	3135	3145	3125	Lost	3155	3125	3106
9	3115	3165	3145	3125	3125	3125	3135
10	3086	Lost	3135	3086	3165	3145	3155
11		3096	3067	3067	3086	3135	3096
12		3106	3115	3106	Lost	3106	Lost
13		3125	3125	3115	3145	3096	3115
14		3145	3125	3125	3106	Lost	3185
15		Lost	3135	3086	3125	3145	3155
16		Lost	3115	3086	3106	3145	3096
17		3125	3125	3125	Lost	3165	3165
18		3096	Lost	3155	Lost	3125	3145
19		3067	3115	Lost	3145	3115	3145
20		3106	Lost	Lost	3125	3040	3135

	Velocity 15 Ft from Muzzle, fps						
	Ammunition Lot						
	LC-12081	LC-12081	LC-12081	LC-12081	LC-12081	LC-12081	TW-18001
Rd	Record No.						
No.	49	50	51	52	53	54	55
1	3030	3012	3096	3049	3086	2890	3077
2	3012	2959	2941	3003	3021	2933	3077
3	3067	2959	2967	2985	2933	2985	3030
4	3030	2994	3003	3021	3040	3195	3058
5	3003	3012	2924	2994	3067	2959	3049
6	3125	3012	3030	2941	3003	2967	3115
7	2985	2959	3021	3012	3030	2941	3115
8	3021	2950	Lost	3021	3012	2985	3096
9	3003	3030	2967	3021	2985	2976	3096
10	2985	3030	3003	2985	3067	2967	3106
11	3058	3021	3030	3049	3049	2976	3106
12	3012	3003	2959	3040	2994	3003	3106
13	2959	2985	3021	2941	3021	2959	3058
14	2985	3021	3067	3021	3086	2941	3125
15	3077	3012	3012	3058	3021	2950	3077

Velocity 15 Ft from Muzzle, fps

Rd No.	Ammunition Lot: LC-12081 (Record No. 49)	LC-12081 (50)	LC-12081 (51)	LC-12081 (52)	LC-12081 (53)	LC-12081 (54)	TW-18001 (55)
16	3012	2941	3012	3012	3030	3003	3096
17	3012	3030	3021	3003	3012	2985	3077
18	3030	3106	3030	3077	2976	2967	3115
19	3021	3012	3012	3086	2959	2985	3096
20	3125	3030	3012	3003	2967	-	3125

Velocity 15 Ft from Muzzle, fps

Rd No.	Ammunition Lot: TW-18001 (Record No. 56)	TW-18001 (57)	TW-18001 (58)	TW-18001 (59)	TW-18001 (60)	LC-12081 (61)
1	3106	3086	3125	3115	3096	3012
2	3115	3067	3077	Lost	3135	2950
3	3115	3115	3155	3049	3077	2959
4	3125	3106	3125	3106	3106	3021
5	3125	3106	3125	3086	3125	3021
6	3077	3165	3086	3125	3106	2976
7	3106	3145	3175	3086	3125	2976
8	3155	3125	3125	3086	3077	3012
9	3040	3106	3175	3058	3125	Lost
10	3115	3115	3175	3125	3058	3086
11	3077	3205	3125	3145	3077	3021
12	3125	3040	3125	3058	3030	3021
13	3145	3058	3125	3125	3086	2994
14	3067	3058	3077	3106	3096	3003
15	3125	2959	3125	3145	3125	2994
16	3096	3096	3115	3106	3135	3003
17	Lost	3125	3077	3030	3106	2994
18	3115	3155	3049	3106	3115	2950
19	3135	3165	3096	3135	3115	2967
20	3175	Lost	3125	3086	3145	3012

Velocity 15 Ft from Muzzle, fps

Rd No.	Ammunition Lot: LC-12081 (Record No. 62)	LC-12081 (63)	LC-12081 (64)	TW-18001 (68)	TW-18001 (69)	TW-18001 (70)
1	2976	3012	3021	3106	3135	3106
2	2994	3021	2994	3115	3096	3106
3	3030	2976	3021	3106	3106	3086
4	3049	3003	2967	3115	3115	3115
5	2941	2985	2967	3125	3145	3145
6	3040	3030	2924	3165	3067	3145

Rd No.	Velocity 15 Ft from Muzzle, fps					
	Ammunition Lot					
	LC-12081	LC-12081	LC-12081	TW-18001	TW-18001	TW-18001
	Record No.					
	62	63	64	68	69	70
7	3049	3012	2967	3125	3115	3125
8	3030	3067	2959	3125	3115	3086
9	3012	3040	3003	3106	3115	Lost
10	3012	3003	3030	3125	3125	3155
11	3012	3003	2967	3115	3115	3135
12	3040	3040	2985	3135	3077	3096
13	3003	3040	3030	3086	3030	3145
14	3012	2994	2959	Lost	3155	3096
15	3040	3040	Lost	3077	Lost	3155
16	Lost	3003	2941	3155	3106	3096
17	3012	3067	2976	3096	3115	3135
18	3012	3021	3049	Lost	3125	3155
19	3040	3021	3021	3125	3155	3106
20	3021	3030	3012	3077	3096	Lost

APPENDIX II - REFERENCES

1. Staley, L., Final Report on Product Improvement Test of Redesigned Buffer. USATECOM Project No. 8-7-0230-04. Aberdeen Proving Ground. Report No. DPS-2662, January 1968. (Distribution Controlled by AMCPM-RS. AD 826 676L.)

2. Fulton, C., Shindler, C., Shinaly, F., Special Tests of 5.56-mm Ammunition. Report No. R-1883, Frankford Arsenal, February 1968.

3. Wilson, A., Partial and Final Reports on Small Arms Weapons Systems (SAWS). USATECOM Project No. 8-5-0400-03. Aberdeen Proving Ground. Report No. DPS-1851 and -1970, January 1966 and May 1966. (Distribution Controlled by AMCPM-RS.)

4. Teletype No. 0420, 21 December 1967, AMSTE-BC to AMCPMSO-RS, Subject: Product Improvement Test Report of M16A1 Buffer.

APPENDIX III - DISTRIBUTION LIST

USATECOM Project No. 8-7-0230-04

Addressee	Final Report
Commanding General US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005 ATTN: AMSTE-BC	30
Commanding General US Army Materiel Command Washington, D. C. 20315 ATTN: AMCRD-WI	2*
AMCAD-S	1*
AMCPP	1*
AMCQA	1*
AMCMA-R	1*
AMCSU	1*
AMCMI	1*
Commanding General US Army Combat Developments Command Aberdeen Proving Ground, Maryland 21005 ATTN: CDC Liaison Officer, USATECOM	10*
Commanding General US Army Materiel Command Rock Island, Illinois 61200 ATTN: AMCPM-RS	3*
Commanding General US Army Weapons Command Rock Island, Illinois 61200 ATTN: AMSWE-RDS	5*
Commanding General US Army Munitions Command Dover, New Jersey 07801 ATTN: AMSMU-RE	3
Commanding General US Army Ammunition Procurement and Supply Agency Joliet, Illinois 60431 ATTN: SMUAP-A	3

*Distribution denoted by an asterisk (*) will be furnished from those copies forwarded to Headquarters, USATECOM.

Addressee	Final Report
Commandant US Army Ordnance Center and School Aberdeen Proving Ground, Maryland 21005	1
Commandant US Army Infantry School Fort Benning, Georgia 31905 ATTN: AJIIS-M	1
Commandant US Marine Corps Washington, D. C. 20380	1
Commanding Officer US Army Springfield Armory Springfield, Massachusetts 01101 ATTN: SWESP-RET	3
Commanding Officer US Army Frankford Arsenal Philadelphia, Pennsylvania 19137 ATTN: SMUFA-C2500	1
Commanding Officer US Army Arctic Test Center APO Seattle 98733	1
Commanding Officer US Army Ballistics Research Laboratories Aberdeen Proving Ground, Maryland 21005 ATTN: AMXBR-ID AMXBR-WD	1 1
Commanding Officer US Army Human Engineering Laboratories Aberdeen Proving Ground, Maryland 21005 ATTN: AMXHE-SYS	1
President US Army Infantry Board Fort Benning, Georgia 31905	1
President US Army Maintenance Board Fort Knox, Kentucky 40121	1

Addressee	Final Report
Director Marine Corps Landing Force Development Center Quantico, Virginia 22134	1
Marine Corps Liaison Officer US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005	1*
AFSC STLO Building 390 Aberdeen Proving Ground, Maryland 21005	1
Commanding Officer Aberdeen Proving Ground Aberdeen Proving Ground, Maryland 21005	
ATTN: STEAP-DS	1
STEAP-DS-TA	1
Commander Defense Documentation Center for Scientific and Technical Information Cameron Station Alexandria, Virginia 22313	
ATTN: Document Service Center	20

Secondary distribution is controlled by US Army Materiel Command, ATTN: AMCPM-RS.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
Development and Proof Services
Aberdeen Proving Ground, Maryland 21005

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
ADDENDUM TO FINAL REPORT ON PRODUCT IMPROVEMENT TEST OF REDESIGNED BUFFER FOR M16A1 RIFLE (DISPLACEMENT - TIME STUDY)

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Final Report

5. AUTHOR(S) *(Last name, first name, initial)*
Wilson, Allan

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1968	81	3

8a. CONTRACT OR GRANT NO.
AMCMS Code No. 4420.25.0132.2.136

b. PROJECT NO.
USATECOM Project No. 8-7-0230-04

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
DPS-2662 (Addendum)

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES
This document may be further distributed by any holder only with specific prior approval of Commanding General, US Army Materiel Command, ATTN: AMCPM-RS.

11. SUPPLEMENTARY NOTES
None

12. SPONSORING MILITARY ACTIVITY
USAMC

13. ABSTRACT

A displacement-time study of the M16A1 rifle and the redesigned buffer demonstrated that the occurrence of bolt carrier rebound has been successfully overcome and failures to fire due to carrier rebound have been eliminated. However, the urethane end cap on the redesigned buffer was not considered suitable as an energy-absorbing material where impacts occur repetitively each 60 to 75 milliseconds as in burst fire.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
M16A1 rifle Redesigned buffer Displacement-time studies						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS), (S), (C), or (U).*

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

6 JUN 1968

AMSTE-BC

SUBJECT: Addendum to Final Report on Product Improvement Test of Redesigned Buffer for M16A1 Rifle (Displacement-Time Study), USATECOM Project No. 8-7-0230-04

Commanding General
US Army Materiel Command
ATTN: AMCPM-RS
Rock Island, Illinois 61200

1. References:

a. Letter, AMSTE-BC, dated 31 January 1968, Subject: Transmittal of Final Report on Product Improvement Test of Redesigned Buffer for M16A1 Rifle, USATECOM Project No. 8-7-0230-04, DPS Report No. 2662, dated January 1968.

b. Addendum to Final Report on Product Improvement Test of Redesigned Buffer for M16A1 Rifle (Displacement-Time Study) dated May 1968, USATECOM Project No. 8-7-0230-04, DPS Report No. 2662 (Addendum), inclosed.

2. Forwarded herewith are approved copies of subject report except that for clarity the recommendation cited in paragraph 1.4d, page 3 is reworded as follows:

The procedures for determining cyclic rate data be precisely identified, and that cyclic rate performance be independently required in both ammunition and weapons acceptance tests, at a level of 750 to 900 rounds per minute. Furthermore, this is to be immediately implemented relative to determining suitability for field issuance, regardless of isolation of causes and actions to change cyclic rate level and variability, or contractual obligations.

3. Test results and pertinent analysis are presented within each subtest in section 2 of the report. For clarity and understanding, considering relative complexity and implications for potential improvement of subject

AMSTE-BC 6 JUN 68

SUBJECT: Addendum to Final Report on Product Improvement Test of Redesigned Buffer for M16A1 Rifle (Displacement-Time Study), USATECOM Project No. 8-7-0230-04

weapon, it is desirable that the report be read in its entirety. For example, additional insights or findings in the following areas are provided:

a. The absence of realistic cyclic rate limitations associated with the magazine follower.

b. The cause of low initial cyclic rates in beginning rounds, and variability of a firing sequence as related to the physical characteristics of the urethance end cap in the redesigned buffer.

c. Limitations in achieving kinematic uniformity and functional suitability with current propellant systems having widely divergent impulse characteristics by practical "tuning" techniques such as by varying the mass and distribution of buffer weights.

d. Sensitivity of cyclic rate levels to rigidity of mounting.

e. The desirability and implications of increased cyclic rates.

FOR THE COMMANDER:

Goodwin Morrow

GOODWIN MORROW
Act Dir,
Inf Mat Test Dir

1 Incl
as (5 cys)

Copies furnished:
CG AMC ATTN: AMCRD-WI (2 cys)
AMCAD-S (1 cy)
AMCPP (1 cy)
AMCQA (1 cy)
AMCMA-R (1 cy)
AMCSU (1 cy)
AMCMI (1 cy)
AMCPMSO-RS (20 cys)
CG WECOM ATTN: AMSWE-RDS (3 cys)
CDC LO, USATECOM (10 cys)
USMC LO, USATECOM (1 cy)