



DEPARTMENT OF THE ARMY
UNITED STATES ARMY MATERIEL COMMAND
PRODUCT MANAGER, M16 SERIES RIFLES
ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61201

JA
25-10

21 JAN 1971

AMCPM - RS

SUBJECT: M16 Steering Group Meeting, 7 January 1971

Commanding General, U. S. Army Test & Evaluation Command, ATTN: AMSTE-BC,
Mr. G. Morrow, Aberdeen Proving Ground, Maryland 21005
Commanding General, U. S. Army Munitions Command, ATTN: AMSMU-RE-M, Mr.
S. Spaulding, Dover, New Jersey 07801
Commanding General, U. S. Army Weapons Command, ATTN: AMSWE-RES-P, Mr.
R. Henry, Rock Island, Illinois 61201
Commanding Officer, U. S. Army Aberdeen Research & Development Center,
ATTN: AMXRD-SR, Mr. O. P. Bruno, Aberdeen Proving Ground, Maryland 21005
Commanding Officer, Frankford Arsenal, ATTN: SMUFA-J1000, Dr. Manning,
Philadelphia, Pennsylvania 19137
Commanding Officer, U. S. Army Small Arms Systems Agency, ATTN: AMXAA-WS,
Mr. Regan, Aberdeen Proving Ground, Maryland 21005
Commandant of the Marine Corps "Code AO4F", Headquarters, U. S. Marine
Corps, Washington, D. C. 20380

Attached is a copy of the minutes of the last M16 Steering Group Meeting
held at Rock Island Arsenal on 7 January 1971.

Rex D. Wing
REX D. WING
Colonel, OrdC
Product Manager
M16 Series Rifles

1 Incl
as

CF:
CG, MC Supply Activity "Code
P820", Philadelphia, PA 19100
CMC "Code CSY7", HQ, USMC,
Washington, D. C. 20380

MINUTES
M16 STEERING GROUP MEETING
7 JAN 1971
ROCK ISLAND, ILLINOIS

1. The 12th meeting of the AMC M16 Steering Group was held at Rock Island on 7 Jan 71 for the purpose of providing a Technical Review of the Chrome Bore and remaining tasks assigned to the Steering Group. The agenda followed at the meeting is attached as Incl 1. A list of attendees is attached as Incl 2. A summary of the tasks held on each of the various topics is included in the following paragraphs. Detailed publications in support of each of the topics are attached as Incls 3 through 11.
2. Opening Remarks: COL R. D. Wing, Product Manager, M16 Series Rifles, and chairman of the meeting welcomed attendees. Administrative announcements and a brief introduction to the meeting were provided by Mr. J. R. Gallagher, AMCPM-RS.
3. Muzzle Erosion/Chrome Bore Review: Mr. A. Cole, WECOM, presented details on the muzzle erosion problem and possible corrective actions in process (see Incl 3). Dr. Manning, FA, presented a report on possible ammunition corrective actions (see Incl 4). A detailed status report on the Chrome Bore Program as a solution to the erosion problem was jointly presented by Mr. Robert Hasset, GE; Mr. Earl Cusac, GM; and Mr. C. Bradley, AMCPM-RS. The entire presentation including viewgraphs is attached as Incl 5. After the briefing and the departure of GE and GM personnel the discussion included the following comments and conclusions:
 - a. WECOM will determine rifle accuracy comparison and environmental testing of chrome vs a standard 5.56 bore.
 - b. COL R. D. Wing stated that the chrome bore process could increase barrel life by as much as 10 times (E.G. 2,000 to 20,000 rounds) in an aggressive climate such as SEA with a possibility of adding as little as \$1.20 unit cost for chrome plating rifle bores.
 - c. LTC Butler stated that the current Marine Corps requirements start at 6,000 barrels, needed at a rate of approximately 1,500 a month.

d. Members of the Steering Group unanimously agreed that they had no reservations on proceeding with the chrome bore in future production of barrels, if this product included an Initial Production Test by TECOM.

4. Frankford Arsenal Task Assignments: Dr. Manning presented a status report on each of the following Frankford Arsenal task assignments. A copy of these presentations is attached as Incl 6.

a. Development of Math Model Simulating Internal Weapon System Functioning.

b. Investigation of Design Approaches to Minimize Ammunition Variability.

c. Tracer Product Improvement Program.

d. Development of Improved Instrumentation and Techniques.

e. Profile and Alignment Acceptance Criteria - WECOM will provide estimated test cost to Frankford Arsenal by the end of January 71 with a Frankford Arsenal estimate of the possibility of successful evaluation of the proposed change to the Product Manager shortly thereafter.

5. WECOM Task Assignments: Mr. A. Cole, WECOM, presented his status report on the three WECOM task assignments as follows:

a. Extractor Spring Life

b. Ejection Pattern Study

c. 30 rd Magazine

A copy of the presentation of each is attached as Incl 7. COL Wing stated that because of potential significant cost savings the WECOM evaluation of the 30-round straight line magazine and appropriate tech data package were urgently needed. A completion date for the evaluation was not available.

6. ARDC Task Assignments: Mr. T. L. Brosseau, ARDC, presented a status report on Interior Ballistics/Kinematic Studies (Incl 8). Mr. Brosseau also reported on the status of a negator spring study done at BRL on the 20-round magazine. This effort was undertaken to preclude the excessive force necessary to strip the first 2 or 3 rounds from the magazine. Comparison charts of the current magazine vs the negator spring magazine are attached as Incls 9 and 10. The final report will be completed soon and provided to WECOM for use in their current evaluation of 30-round magazines.

AMCPM-RS

Minutes, M16 Steering Group Meeting, 7 Jan 1971, Rock Island, Illinois

7. Product Improvement Tasks: M16 Rifle Product Improvement tasks were presented by LTC C. E. West, AMCPM-RS, on the following items:

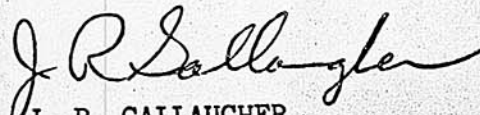
- a. Arms Rack
- b. Blank Firing Attachment
- c. Top Sling Adaptor
- d. Modified Buttstock
- e. Toothbrush

Product Improved tasks on the M203 Grenade Launcher were presented by MAJ Huggin, AMCPM-RS. All product improvement task presentations are attached as Incl 11.

8. Mr. C. Fagg, AMCPM-RS, made a brief presentation on proposed alternative methods of eliminating the full automatic feature on the M16 Rifle including a relatively simple and inexpensive (3 to 5 cents) design feature consisting of the addition of a very small part to the rifle.

9. COL Wing gave a resume on the bids just recently received on the M203 mass production contract and on the FY71 M16 Rifle contract. The meeting adjourned with the tentative conclusions that one additional meeting of the Steering Group would be held prior to 30 June with the possibility of terminating the Steering Group immediately thereafter.

11 Incls
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J. R. GALLAUGHER
Recorder

AGENDA
AMC M16 STEERING GROUP MEETING
7 JANUARY 1971

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|-------|--|------|
| I. | Opening Remarks by Chairman | 0900 |
| II. | Muzzle Erosion/Chrome Bore Review | |
| | A. Presentation of the Problem Including Rejection
Criteria and Possible Corrective Actions (WECOM) | 0915 |
| | B. Possible Ammunition Corrective Actions (FA)
(COFFEE BREAK) | 0945 |
| | C. Chrome Bore Status (PM, Rifles) | 1000 |
| | 1. GM Contract | |
| | 2. GE Testing | |
| | 3. Gov't Review | |
| III. | Frankford Arsenal Task Assignments (FA) | 1100 |
| | A. Development of Math Model Simulating Internal
Weapon System Functioning | |
| | B. Investigation of Design Approaches to Minimize
Ammunition Variability | |
| | C. Tracer Product Improvement Program | |
| | D. Development of Improved Instrumentation and Techniques | |
| | E. Profile and Alignment Acceptance Criteria
(LUNCH) | |
| IV. | WECOM Task Assignments (WECOM) | 1300 |
| | A. Extractor Spring Life | |
| | B. Ejection Pattern Study | |
| | C. 30 Rd Magazine | |
| V. | ARDC Task Assignment (ARDC)
Interior Ballistics/Kinematic Studies | 1330 |
| VI. | Product Improvement Tasks (PM, Rifles) | 1340 |
| | A. Arms Rack | |
| | B. Blank Firing Attachment | |
| | C. Top Sling Adaptor | |
| | D. Modified Buttstock | |
| | E. Toothbrush | |
| | F. Plastic-cased Blank Ammunition | |
| | G. M203 Grenade Launcher Attachment | |
| | 1. Die Cast Receiver | |
| | 2. Quadrant Sight | |
| VII. | Closing of Product Manager's Office and Future of
M16 Steering Group | 1400 |
| VIII. | Summary and Conclusions | 1415 |
| IX. | Adjourn | 1500 |

Encl 1

ML6 STEERING GROUP

LIST OF ATTENDEES

<u>NAME</u>	<u>ORGANIZATION</u>
COL R. D. Wing	Product Manager, M16 Series Rifles
Dr. H. Manning	Frankford Arsenal (MUCOM)
Mr. A. A. Cole	WECOM
Mr. C. L. Crider	TECOM
Mr. T. L. Brosseau	ARDC - BRL
Mr. W. F. Willoughby	ARDC - BRL
LTC W. O. Butler (MC)	HQ, U. S. Marine Corps, Code AO4F
MAJ D. W. Johnston (MC)	HQ, U. S. Marine Corps, Code CSY7
CPT J. E. McCall (MC)	HQ, U. S. Marine Corps, Code P820
CPT E. T. Krieger (MC)	AMSWE-LMC
MAJ R. A. Gravett	AMSWE-LCD
Mr. J. Regan	USASASA
Mr. R. Hasset	General Electric
Mr. E. Cusac	General Motors
Mr. J. Meir	General Motors
Mr. J. R. Gallagher	AMCPM-RS
LTC C. E. West	AMCPM-RS
MAJ H. C. Shiery	AMCPM-RS
MAJ B. A. Huggin	AMCPM-RS
Mr. C. E. Bradley	AMCPM-RS
Mr. C. R. Fagg	AMCPM-RS
Mr. L. F. Brunton	AMCPM-RS
Mr. H. D. Martin	AMCPM-RS
Mr. J. Hendrin	AMSWE-SM
CPT A. D. Pearn	AMSWE-CM

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AMC M16 STEERING GROUP MEETING
7 January 1971

II. Muzzle Erosion/Chrome Bore Review

A. Muzzle erosion problem and possible corrective action.

1. Field reported inaccuracies of the M16 Rifle led to an investigation of rejection criteria and erosion gage feasibility. Standard bore erosion gage evaluation stated that a barrel is satisfactory for U.S. Continental use provided the bore erosion gage does not enter the barrel bore more than 6.625 from the rear surface of the barrel extension, and that a barrel is satisfactory for overseas use provided the bore erosion gage does not enter the bore more than 3.625 inches measuring from the rear surface of the barrel extension. Since most of the sample barrels fulfilled both CONUS and overseas bore gage specifications, but would not meet accuracy requirements, it appeared that an improved measuring device was necessary. Erosion gage penetration into the muzzle was introduced in an effort to determine barrel condition resulting from factors not directly associated with number of rounds fired, and to utilize a simple tool already in existence.

2. In resolving the problem, 150 sample barrels were received from SEA, of which 86 were selected for evaluation and testing. Visual classification of the barrels as to general condition and pitting of the bores was followed by gaging and test firing. An assigned pitting factor, erosion gage penetration of both the breech and muzzle end, bore and groove diameter readings, and test firing accuracy results were recorded for each selected test barrel.

3. An additional operation of machine shortening certain barrels to the erosion gage muzzle penetration depth was conducted in order to correlate effect of muzzle erosion on accuracy.

4. Forty-five barrels were selected from distinguishable groups for purpose of control. Complete testing and gaging results were recorded for comparison with the supplied sample barrels. All information was then supplied to the Systems Analysis Directorate to develop through a statistical analysis, a discriminating procedure suitable for use by field troops.

5. Associated tasks conducted simultaneously were chemically induced pitting of new barrels and the effect of cleaning rod wear on barrel bores.

(a) Nine (9) new barrels were chemically etched at the muzzle to approximate the pitting observed in the SEA barrels in this area. Comparisons of accuracy of the barrels in new condition with those artificially pitted for 1/4 inch of the muzzle showed a general loss of accuracy.

Incl 3

(b) An assessment was made of the affects of the present M13E1 cleaning rod on barrel damage and thus loss of accuracy. Four (4) new barrels were progressively abused by accelerated cleaning from the muzzle. Four thousand strokes were logged on the barrels using excessive side rubbing action. No appreciable increase in bore diameter or loss of accuracy was observed. Two barrels that had been artificially pitted were also given cleaning rod test. No loss of accuracy was observed in subsequent firing.

6. In the final analysis; bore and groove variation, pitting, and muzzle enlargement were found to be variables highly correlated with round dispersion. An interim rejection criteria was released specifying 5/16 of an inch as the maximum acceptable limit of erosion gage penetration into the muzzle.

7. Corrective action:

(a) First on the list of suspected causes of the difficulty is lack of field care of barrels. The recommended corrective action is more vigilance in field care of weapons.

(b) Although the tests indicated that cleaning rod wear was, at most, a small contributing factor to inaccuracy, it is intended that the cleaning rod design be reviewed to reduce or remove sharp or abrasive edges.

(c) Currently, R&D prototypes of barrels with chrome plated bores are undergoing evaluation. All indications to date are that barrels of this configuration when supplied will substantially reduce the pitting observed.

II. MUZZLE EROSION/CHROME BORE REVIEW

A. --- (WECOM)

B. Possible Ammunition Corrective Actions

1. Frankford Arsenal has considered the possibility that special ammunition might be devised to obtain a serviceable degree of accuracy in some M16A1 rifles which have badly deteriorated barrels, and do not give serviceable accuracy with ordinary M193 ball ammunition. There is some evidence, in general, which suggests that barrels in poor condition might give improved accuracy with bullets designed to have a higher stability factor, and perhaps to have greater resistance to deformation in the barrel. However, the changes which would be required in bullet design would very probably degrade the performance of the ammunition for use in normal barrels. Efforts to explore the possibility of designing special bullets to accommodate badly deteriorated barrels could not be recommended, unless the gravity of the "muzzle-erosion" problem warrants the inevitable compromises in normal performance, cost, and the obvious logistic complications of developing and producing a different type of 5.56mm ammunition.

2. With the object of aiding in prevention of corrosion-damage to M16A1 barrels, Frankford Arsenal has been engaged in some investigations of the problem. A detailed analytical study of barrel fouling is being pursued, as an extension of the effort which identified and corrected the problem of gas-tube fouling in the M16A1. That study has not yet produced any result which sheds light on the immediate barrel-corrosion problem, but will continue toward that objective, among others.

3. Since being advised of the "muzzle-erosion" problem, Frankford Arsenal has also initiated a test program to learn more about the causes of bore corrosion, particularly as they may relate to ammunition. In this program, twelve M16A1 rifles and four M14 rifles have been placed in an environmental chamber which is maintained at 95 percent relative humidity and 100°F. These weapons are being subjected to various schedules of firing and maintenance, employing ball and tracer ammunition of standard types. The test has been in progress for approximately seven weeks, and is still continuing. Some tentative observations to date, based on results obtained under these rigorous temperature/humidity conditions, include the following:

a. M16A1 rifles which are fired periodically with either ball or tracer ammunition, and completely neglected as to cleaning or protection of the bore, develop bore corrosion-damage within approximately two weeks, which progresses so as to impair accuracy significantly within approximately three weeks.

b. M14 rifles, which have chrome-plated bores, do not suffer any discernible bore corrosion, at least up to six weeks of exposure under the same aforementioned conditions. The wooden stock is attacked by "mold",

but the plastic stock is not affected.

c. M16A1 rifles which are fired with M193 ball ammunition, and are subjected to the operator's normal care and cleaning procedures prescribed in DAPAM 750-30 dated 28 June 1968 develop some visible signs of bore corrosion, but this does not progress sufficiently to cause a perceptible degradation of accuracy within at least six weeks.

d. M16A1 rifles which are fired with M193 tracer ammunition, and subjected to normal care and cleaning procedures, do not develop perceptible bore corrosion at least up to six weeks, and suffer no impairment of accuracy.

e. M16A1 rifles which are thoroughly cleaned, and are not fired, but are not protected by application of a preservative material (MIL-L-46000A), develop visible signs of bore corrosion within approximately three days of exposure to the environmental conditions described. However, the corrosion is less extensive than that which occurs in weapons which have been fired and left uncleaned and unprotected by preservative.

4. The tentative conclusions which can be drawn from Frankford Arsenal's investigation of bore-corrosion under extremely adverse temperature/humidity conditions, subject to confirmation as the test proceeds to completion, include the following:

a. Chrome-plating of the bore, such as that employed in M14 rifles, is highly effective in preventing bore-corrosion, even when care and maintenance are completely neglected after firing.

b. Performance of the prescribed cleaning and maintenance procedures for the M16A1 rifle does not entirely prevent bore corrosion under the rigorous environmental conditions of this test, but does afford sufficient protection that accuracy of the weapon is not impaired after at least six weeks of continuous exposure.

c. Neglect of cleaning and maintenance procedures after firing of the M16A1 rifle causes extensive corrosion damage in the bore, which is sufficient to affect accuracy adversely after approximately three weeks of continuous exposure to the adverse environmental conditions of this test.

d. The residue of firing, followed by neglect of cleaning and maintenance procedures, causes bore corrosion to progress more rapidly than that which occurs if the rifle is cleaned but untreated with any corrosion-inhibitor such as MIL-L-46000A. It is not clear that the firing residue produces any actively corrosive chemical action, however, since the effect might be due only to the hygroscopicity of the combustion products in the very humid environment.

e. There is some evidence that the residue from firing M193 ball ammunition is more conducive to corrosion than that which results from firing M196 tracer ammunition. It is not clear whether this difference might be due to the less effective removal of the ball-ammunition fouling by the normal cleaning procedures, and/or to the different character of propellant fouling produced by the ball propellant of the ball round (unlike the tracer round which contains extruded propellant), and/or to some effect of the pyrotechnic igniter in the tracer round on the properties of the residue.

5. It appears, at present, that some limited alleviation of the M16A1 bore-corrosion problem might be achieved by modifications of the ammunition, but the effectiveness of chrome-plating the bore promises much greater gains in this respect, especially if weapons may be subjected to a rigorous temperature/humidity environment and may sometimes not receive the prescribed cleaning and maintenance by the operator in the field.

CHROME BORE

1. The requirement for a chrome bore is not new - it originated with OTCM 36486 dated 14 March 1957, which requires all rifles be chrome plated. The fact that the M16 was not previously chrome plated was not because the requirement was ignored - it was because previous efforts have not been successful. All previous feasibility studies for chrome plating the bore were conducted by Colt's Inc., who controlled the technical data package. Because of the other problems facing us at the early stages of this program, no real urgency for chrome plate existed and it took a back seat to the then very pressing problems of cartridge case extraction, cyclic rate, congressional inquiries, starting up two new producers, etc.

2. When GMC was awarded a contract in 1968 to produce the M16 Rifle, the PM, Rifles appraised GMC of the programs then in being to product improve the weapon. One of those areas discussed was the chrome bore. Providing the Government had no objection, GMC offered to investigate the feasibility of the program at no cost to the Government and agreed to make available to the Government any new techniques or processes developed, also without cost or obligation to the Government.

3. Because of the new manufacturing techniques introduced by GMC, that is, the intro-form (cold form) process and electro chemical machining (ECM), it was fairly obvious that GMC probably had an excellent opportunity to succeed. The reason for this is because of the extremely fine finish GMC obtains throughout the length of the barrel from chamber to muzzle. The drawing presently requires a 32 rms finish throughout the interior of the barrel whereas GMC is producing barrels with a 10 rms or better. The fact that the M16 Barrel has only 2 thousandths of land definition, as compared to 4 thousandths for the M14 Rifle, requires that the surface be relatively free of irregularities and burrs. This is because any subsequent operations to remove the surface roughness, as well as the chrome plating operation, tend to distort definition of the lands and grooves. Plating over a rough surface will normally result in early deterioration of the chrome plate and poor accuracy. Colt's experienced both of these results during their investigative efforts to develop process controls.

4. The guidelines given to GMC were that the chrome process should be a one-step operation for the full length of the barrel including the chamber. Insofar as thickness of the chrome is concerned, a minimum of .4 mil was specified for the bore. No upper limit was specified, provided that performance and reliability were not degraded. Actually, the performance requirement for accuracy and the economics of applying the chrome will dictate the upper limit. The present drawing requirements specify a lower limit of .2 mil for the chamber, and by using a straight, unshaped anode,

Incl 5

AMCPM-RS
Chrome Bore

this theoretically would deposit .4 mil in the bore.

5. A brief description of the data to be presented is provided by this viewgraph (Viewgraph #1). Mr. Earl Cusac and Mr. John Meir of GMC will describe GMC's early development efforts on this program.

Earl Cusac (GMC)

Knowing the requirements for a chrome plated bore, Hydra-matic started a two phase program. Phase I was to use our standard production barrel, made by the cold form process, electro-polish and chrome plate in the conventional manner. Phase II was to electro-chemically machine the gun drilled barrel blanks to improve the surface finish, cold form the blanks over a special oversized mandrel to produce the required finished bore and rifling dimensions. The special mandrel would be developed so that no subsequent machining or sizing operations of the bore or rifling would be required before plating. While the special mandrel was being made, work on Phase I was started with a commercial plater. The first six conventionally plated barrels tested for accuracy had an extreme spread of 5 to 18 inches at 50 yds. The plating thickness was found to vary considerably along the length of the barrel as well as circumferentially. No other plated barrels were submitted to GMC by the plater and this phase was discontinued. Phase II was pursued at the General Motors Technical Center. A total of 29 barrels were plated experimentally. Twelve of these barrels were submitted to Weapons Command for test.

Clyde Bradley (AMCPM-RS)

The in-house effort by GMC laboratories resulted in 12 barrels being delivered to USAWECOM for test in February 1969. The barrels were run through the RIA laboratories to check uniformity of the plating, its adherence and corrosion protection. The results were very favorable. The barrels had good uniform plating thickness, adherence was good, and the sought after corrosion protection was obtained. Concurrently, USAWECOM entered into a contract with General Electric Corp. at Springfield Armory for performance of a product improvement test under Government supervision.

The purpose of the General Electric tests was to ensure good adherence of the chrome plate under severe firing schedule, and also to ascertain whether addition of chrome plate in any way degraded performance or reliability. The results of the General Electric product improvement tests are presented by Mr. Robert Hasset, General Electric Corp.

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GE Presentation to Steering Committee
1/7/71

Mr. Robert Hasset

Eight barrels were furnished for this test. One phase is described as a High Rate Test, where two standard barrels and two chrome plated barrels were fired 2,000 rds ea with a firing schedule of 60 rounds per minute with forced air cooling to ambient temperature after each 200 rds with no cleaning until the end of the test.

The second phase was to fire four chrome plated barrels in an Endurance Test of 20,000 rds each. Two barrels were to be fired with M193 ball ammunition only, and the other two with mix of 4 ball to one tracer. In each case, the firing sequence was in accordance with the purchase description; i.e.:

1. 1st 20 rds automatic in bursts of 3 to 5 rds ea
2. 20 rds automatic in one burst
3. 20 rds semiautomatic
4. 20 rds automatic in bursts of 3 to 5 rd
5. 20 rds automatic in one burst.

This test also required trapping projectiles at the outset, at 10,000 and 20,000 rds as well as inspection, velocity reading and accuracy at 2,000 rd increments.

The velocity readings were taken over a 20 ft base with screens set up at 5 and 25 ft from the muzzle. Accuracy firing was performed at 100 yds using a bench rest w/muzzle and elbow support.

The test was stopped after less than 1,000 rds were fired on chrome plated barrels in the High Rate Test due to excessive pressure build-up in the chamber resulting in blown primers, severe case setback and rear end case failures caused by minimum bore size just forward and adjacent to bullet seat. All barrels were returned to the Army Weapons Command for examination.

Earl Cusac

Examination by the Weapons Command and GMC determined that: (Slide 2)

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Chrome Bore

(1) No allowance had been made for chrome build-up in the bullet seat area; (2) No polishing or burr removal operations had been performed on the bullet seat area before plating; (3) Erosion had started in the forcing cone area extending into the bore and (4) There was considerable coppering in the forcing cone and adjoining bore. It was concluded items 1 and 2 (no allowance for chrome build-up and no polishing or burr removal operation in the bullet seat area) were the major causes of the blown primers. Additional development and testing supported these conclusions.

At this point, Phase IIA was initiated. This phase incorporated the additional operation of electro-chemically machining this critical bullet seat area. This operation accomplished the two major objectives. It removed adequate material for chrome build-up and also polished the surfaces and removed any burrs. Six Phase IIA barrels were resubmitted to Weapons Command for resumption of testing by General Electric Corp.

Mr. Hasset

The reworked barrels were tested with the following results:

a. The tests were conducted without malfunctions or stoppages that were attributable to the addition of chrome plate. Examination of fired cases throughout the tests revealed no evidence of setback or increased chamber pressures.

b. Examination of the trapped projectiles shows that rifling marks changed during the tests. What were clear, sharp engravings ended up as ragged spiral edges.

c. Some decrease in velocity was noted for each rifle as the test progressed. The largest was for barrel #7 which dropped an avg of 112 ft/sec.

d. The average ES changed. For most barrels the extreme limits were reached between 12,000 and 16,000 rds. The spread for #7 at 16,000 rds was such that 2 of 10 shots were off the target; however, at 20,000 rds this barrel produced the best target. No evidence of yaw was detected on any target for any of the barrels. After 20,000 rds, barrels #6 and #7 were chemically cleaned and again measured and targeted.

e. Erosion was greatest in the bullet seat area, with most of it occurring after 6,000 rds.

f. The difference, if any, between use of straight ball or combat load was not noticeable.

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It is recommended that:

1. The High Rate Test be continued until a failure occurs on one type of barrel.
2. Std barrels be subjected to a similar endurance test and the resultant findings be compared.

The results of the General Electric Testing are described on viewgraphs #2 through #12.

Clyde Bradley

As soon as it was evident that the product improvement test was favorable, it was decided to enter the final and most difficult phase - to determine whether GMC's laboratory techniques could be adopted to a mass production process at an economical cost. This Headquarters entered into a contract with GMC to establish a pilot line chrome plating process. This was the first time GMC received any remuneration for their efforts. It was a firm fixed price contract for slightly over \$40,000. It was also about this time that the first problems of corrosion of the bore and degradation of accuracy came to the attention of this Headquarters.

We were not completely satisfied with the erosion conditions obtained in the Product Improvement tests, and we continued to concurrently investigate and test other types of chrome. One of these was extremely promising and is the type of chrome being used on the pilot line quantity being run by GMC. It is a high chrome concentration, is slightly softer than the standard hard chrome, and showed improved resistance to erosion.

It is also important to note that the actual chrome plating line is not at GMC. One of the contract requirements was that the plating line be established at a commercial plating source. Mr. Cusac will cover the results of the program phase.

Mr. Earl Cusac

On October 7, 1970 a contract was awarded to Hydramatic to determine the production feasibility of applying chrome plate to the bore of the M16A1 Rifle Barrel on a production pilot line using the General Motor developed process. Concurrently with the tests at General Electric, Hydramatic investigated various types of crack-free chrome for the purpose of reducing erosion of the bullet seat area. Limited tests on this type of plating appeared to significantly reduce bullet seat erosion. Based on these observations, four barrels were plated with crack-free chrome and tested under the technical supervision of the U. S. Army Weapons Command. The test program consisted of two chrome

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plated barrels fired 2,000 rounds at high rate of fire (60 rd/min), and two chrome plated barrels fired 20,000 rounds at standard rate of fire (20 rpm) and two nonchrome plated standard production barrels fired 20,000 rounds as a base line. An ammunition mix of 4 to 1 ball to tracer was used. Six targets were fired at fifty yards on each weapon at 0, 6,000, 12,000 16,000 and 20,000 rounds. (Slide #13) This chart shows the average extreme spread at 50 yards for the 20,000 round tests. The standard barrels are represented by the solid lines and the chrome plated barrels by the broken lines. (Slides #14 and #15) This chart shows the average major and minor diameters of the standard barrels taken in one inch increments from the muzzle end at zero and 20,000 rounds. (Slide #16) This chart is the same as the previous one except it is for the chrome barrels.

The barrel erosion gage was not used until the end of the test. At that time, the gage entered the standard barrels $2 \frac{3}{4}$ and $3 \frac{3}{4}$ inches beyond the second mark. (CONUS Rejection) In the chrome barrels, the first mark was still visible by $\frac{3}{8}$ inch. (Demonstrate erosion gage.) It is interesting to note the difference in the targets of the test barrels at 20,000 rounds and at 50 yds, particularly the large number of yaws on the standard barrels. To date, over 300 barrels have been plated with a nonproprietary, crack-free chrome, by a commercial plater, and on a pilot production line. The pilot line consists of five production fixtures which have been producing 40 barrels a day. (Slide #17) Sixty-eight barrels have been fired for accuracy and no degradation in accuracy has been observed.

Technical data recommendations for the process have been submitted to the Rifles Office. (Slide #18) This last chart indicates the plating thickness on each land and groove as shown.

In conclusion, with only three manufacturing operations (two electro-chemical machining operations and one grind operation) added to the standard production barrel, a chrome plated M16A1 barrel is a production practicality.

Clyde Bradley

The objective was to comply with a stated requirement that the barrel be chrome plated to obtain corrosion protection and ease of maintenance. We strived to accomplish this without degrading performance or reliability. We believe we have accomplished our objective and in fact may have added some additional benefits:

1. We have improved the accuracy life of the barrel.
2. We have substantially reduced erosion in the breach.
3. We have reduced yawing.

AMCPM-RS
Chrome Bore

Chrome plate can be added at a reasonable cost - three additional machining operations are required by the contractor in addition to the chrome plating. The additional machining operations should not increase the cost more than \$.75. The chrome plating of the bore and chamber is estimated at \$2.25; however, you have to deduct approximately \$.52 that we now pay for chroming the chamber. Approximately \$2.50 per barrel increase is estimated for in quantities of 50,000 for spare barrel assemblies.

- I. Introduction (PM)
 - A. History of Program
 - B. Outline of Data to be Presented

- II. GM - Initial Chrome Work
 - A. Phase I
 - B. Phase II
 - C. Phase IIA

- III. GE - Results of Phase II, IIA

- IV. GM - Continued Chrome Work
 - A. Decision on Type of Chrome
 - B. Pilot Line Production
 - C. Results of Pilot Line Production

- V. Summary & Conclusion (PM)

RIFLE NO. 5

VELOCITY READINGS
FEET PER SECOND

SHOT	START	ROUNDS FIRED				
		4000	8000	12000	16000	20000
1	3133.3	3152.0	3131.8	3076.9	3078.3	3092.6
2	3168.0	3194.3	3137.7	3106.0	3114.2	3092.9
3	3139.2	3117.6	3090.2	3105.2	3111.8	3067.4
4	3174.6	3149.6	3150.5	3137.2	3118.1	3114.2
5	3153.0	3196.4	3068.8	3116.2	3105.6	3101.2
6	3158.5	3147.1	3137.2	3106.5	3084.5	3105.5
7	3173.0	3120.6	3119.6	3091.6	3097.8	3112.3
8	3197.9	3146.1	3094.0	3121.5	3140.7	3121.0
9	3185.7	3178.1	3126.9	3098.8	3095.0	3191.8
10	3198.9	3184.2	3153.6	3107.0	3180.6	3112.8
AVG	3168.2	3158.6	3120.9	3106.7	3112.6	3111.2

TABLE 1-15

7

VELOCITY READINGS
FEET PER SECOND

RIFLE NO. 6

SHOT	START	ROUNDS FIRED				
		4000	8000	12000	16000	20000
1	3146.1	3158.0	3071.2	3130.8	3067.9	3101.7
2	3156.5	3137.2	3096.9	3122.5	3117.6	3135.2
3	3171.5	3131.3	3127.4	3110.4	3106.5	3079.7
4	3133.3	3136.7	3132.8	3138.2	3124.0	3088.3
5	3163.5	3136.7	3125.4	3105.5	3127.9	3143.1
6	3139.2	3154.5	3109.9	3111.3	3110.9	3128.9
7	3171.2	3123.5	3077.3	3111.8	3134.3	3069.3
8	3146.6	3131.3	3144.1	3125.9	3165.0	3108.0
9	3168.0	3116.2	3101.2	3126.9	3148.6	3146.6
10	3158.5	3155.0	3159.0	3096.4	3144.1	3160.5
AVG	3155.4	3138.0	3114.5	3098.0	3124.6	3116.1

TABLE 1-15 (Continued)

VELOCITY READINGS
FEET PER SECOND

RIFLE NO. 7

ROUNDS FIRED

SHOT	START	4000	8000	12000	16000	20000
1	3163.0	3181.1	3116.7	3194.3	3134.7	3085.9
2	3183.6	3142.1	3163.5	3141.1	3085.4	3074.0
3	3173.5	3164.5	3112.3	3095.4	3091.1	3115.2
4	3205.1	3179.1	3174.5	3101.2	3104.1	3055.3
5	3152.5	3231.0	3119.1	3072.2	3050.1	3052.5
6	3167.0	3183.1	3151.5	3102.2	3149.6	3037.6
7	3189.7	3108.0	3127.9	3133.3	3097.8	3060.4
8	3179.6	3132.3	3121.5	3147.6	3088.5	3054.8
9	3198.9	3147.6	3182.1	3128.9	3104.1	3128.4
10	3248.3	3202.5	3169.5	3125.4	3148.6	3073.6
AVG	3186.1	3167.1	3143.9	3124.2	3105.4	3073.8

TABLE 1-15 (Continued)

VELOCITY READINGS
FEET PER SECOND

RIFLE NO. 8

ROUNDS FIRED

SHOT	START	4000	8000	12000	16000	20000
1	3107.0	3121.0	3061.3	3035.3	3110.9	3087.8
2	3134.7	3102.6	3069.3	3105.1	3093.5	3045.9
3	3165.5	3124.5	3059.9	3148.6	3084.9	3092.1
4	3158.0	3144.6	3118.6	3100.7	3132.8	3112.8
5	3156.5	3139.7	3085.4	3090.2	3084.0	3095.9
6	3152.0	3121.5	3096.4	3118.1	3129.4	3083.0
7	3167.5	3103.6	3145.1	3011.3	3087.8	3115.2
8	3191.8	3114.7	3129.4	3131.3	3138.2	3099.9
9	3185.2	3127.4	3110.4	3154.5	3120.1	3114.2
10	3135.7	3139.2	3061.3	3174.6	3115.7	3097.4
AVG	3155.3	3123.8	3093.7	3107.0	3109.7	3094.0

TABLE 1-15 (Continued)

AVERAGE VELOCITIES

RIFLE	START	ROUNDS FIRED				
		4000	8000	12000	16000	20000
5	3168.2	3158.6	3120.9	3106.7	3112.6	3111.2
6	3155.4	3138.0	3114.5	3098.0	3124.7	3116.1
7	3186.1	3167.1	3143.9	3124.2	3105.4	3073.8
8	3155.3	3123.8	3093.7	3107.0	3109.7	3094.0
AVG	3166.0	3146.8	3118.3	3109.0	3113.1	3098.7

OVERALL AVERAGE: 3125.3 FPS

RIFLE NO. 5

ACCURACY RESULTS

ROUNDS	1				2				3				4				5				AVG ES	AVG MR
	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES		
TART	1.44	1.30	1.07	3.9	1.67	1.46	1.13	3.9	1.01	2.17	1.26	4.5	2.22	2.24	1.46	4.2	1.19	2.68	1.40	4.5	4.2	1.26
4000	1.20	3.50	1.54	6.3	1.55	2.93	1.45	4.9	1.07	3.35	1.50	6.4	1.68	1.55	1.40	4.3	.93	3.53	1.38	1.38	5.6	1.45
8000	3.04	3.52	1.14	3.6	2.84	3.92	1.03	4.0	2.26	3.76	1.39	3.8	2.52	1.92	.86	3.1	3.00	3.20	1.09	3.6	4.3	1.10
2000	4.38	4.04	1.59	5.4	3.50	4.86	1.63	5.3	3.60	3.54	1.38	4.0	3.46	4.54	1.31	4.6	2.82	4.74	1.55	5.5	5.8	1.49
6000	4.22	4.35	1.81	4.4	3.73	5.02	1.76	5.1	2.16	5.88	1.58	5.9	5.57	5.07	1.91	6.0	3.22	3.92	1.49	4.0	5.1	1.71
0000	3.50	4.44	1.40	4.8	3.60	4.36	1.58	4.4	3.22	6.80	1.62	6.8	3.60	4.78	1.62	5.4	4.42	3.40	1.75	4.5	5.2	1.59

EH-EXTREME HORIZONTAL
 EV-EXTREME VERTICAL
 MR-MEAN RADIUS
 ES-EXTREME SPREAD

VI 11/24/74 #2

TABLE 1-17

RIFLE NO. 6

ACCURACY RESULTS

ROUNDS	TARGET																				AVG ES	AVG MR
	1				2				3				4				5					
	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES		
TART	2.68	1.97	1.49	4.2	.93	3.9	1.34	2.6	1.82	2.22	1.52	4.2	1.12	1.63	1.55	4.8	2.53	1.31	1.48	4.2	4.0	1.47
4000	1.75	1.78	1.46	4.0	1.26	2.47	1.28	4.2	1.29	2.96	1.54	5.4	.78	1.83	1.38	4.4	1.19	1.35	1.28	4.5	4.4	1.39
3000	3.04	3.52	1.67	4.0	2.84	3.92	1.12	5.4	2.26	3.76	1.42	5.2	2.52	1.92	.97	4.6	3.00	3.20	1.06	5.1	4.9	1.25
2000	4.38	4.04	1.59	5.4	3.50	4.86	1.63	6.7	3.60	3.54	1.38	10.0	3.46	4.54	1.31	6.1	2.82	4.74	1.55	5.3	6.7	1.49
5000	6.98	3.00	1.66	7.0	3.33	4.93	1.44	5.0	4.76	3.40	1.75	5.3	3.60	3.98	1.49	4.3	4.02	7.40	1.84	7.7	5.9	1.64
0000	5.24	6.20	1.71	5.7	5.50	9.15	2.45	9.4	5.34	6.16	2.36	7.5	2.38	5.82	1.79	5.8	3.87	3.32	1.41	4.7	6.6	1.94

EH-EXTREME HORIZONTAL
 EV-EXTREME VERTICAL
 MR-MEAN RADIUS
 ES-EXTREME SPREAD

TABLE 1-17 (Continued)

VIEWGRAPH # 2

ACCURACY RESULTS

RIFLE NO. 7

ROUNDS	TARGET																				AVG ES	AVG MR
	1				2				3				4				5					
	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES		
TART	2.64	2.02	.91	3.2	2.90	3.21	1.47	4.0	2.43	3.34	1.09	4.0	2.68	5.34	1.47	5.3	2.48	3.30	1.34	4.1	4.1	1.26
4000	3.90	4.06	1.57	4.5	2.64	4.10	1.30	4.4	1.72	5.50	1.41	5.4	3.03	2.34	1.11	3.3	3.32	6.60	1.73	6.9	4.9	1.42
8000	5.46	5.32	2.11	5.9	2.84	2.90	1.36	3.9	2.88	6.26	2.06	6.8	4.16	6.26	1.85	6.4	4.16	5.08	1.89	5.4	5.7	1.85
2000	5.50	7.52	2.55	9.1	8.60	8.40	3.84	9.4	7.50	7.86	2.69	9.0	6.70	7.60	3.14	7.6	9.70	9.33	3.90	12.5	9.5	3.22
6000	2 RDS OFF TARGET				5.10	13.24	2.96	13.2	5.0	7.3	2.61	8.3	3.00	9.24	2.49	9.3	5.75	9.93	2.69	11.2	10.5	2.69
0000	2.64	2.54	.75	3.0	3.06	4.03	1.45	4.8	3.90	3.55	1.30	4.2	3.80	4.00	1.51	4.0	2.56	5.42	1.57	5.7	4.3	1.31

EH-EXTREME HORIZONTAL
 EV-EXTREME VERTICAL
 MR-MEAN RADIUS
 ES-EXTREME SPREAD

TABLE 1-17 (Continued)

 VIEW @ 1000 YD 4

RIFLE NO. 8

ACCURACY RESULTS

ROUNDS	TARGET																				AVG ES	AVG MR
	1				2				3				4				5					
	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES	EH	EV	MR	ES		
PART	4.76	2.82	1.45	4.8	3.04	2.20	1.18	4.0	2.87	5.19	1.43	5.0	3.50	2.75	1.17	3.8	3.10	3.90	1.41	3.9	4.3	1.33
000	4.50	2.84	1.37	4.0	2.77	4.38	1.03	3.9	1.60	4.67	1.12	4.9	3.70	3.90	1.24	4.1	3.13	4.35	1.78	4.4	4.3	1.31
000	3.16	3.70	1.66	3.8	2.34	2.84	.92	3.0	2.72	2.92	1.39	3.6	2.92	3.76	1.29	3.9	2.64	4.30	1.18	4.3	3.9	1.29
000	2.30	4.52	1.42	4.5	3.88	2.90	1.38	4.5	3.22	3.36	1.21	3.6	2.32	4.66	1.36	4.8	3.94	2.22	1.44	4.3	4.3	1.36
000	2.6	5.40	1.33	5.4	6.00	5.93	2.08	6.3	2.56	6.08	1.79	6.1	4.70	4.70	1.69	4.9	4.22	6.85	1.85	7.7	6.1	1.75
000	6.64	4.00	2.04	6.8	2.44	2.36	.91	2.7	4.56	3.56	1.53	5.1	2.16	4.72	1.63	4.7	3.78	3.32	1.46	4.1	4.6	1.51

EH-EXTREME HORIZONTAL
 EV-EXTREME VERTICAL
 MR-MEAN RADIUS
 ES-EXTREME SPREAD

TABLE 1-17 (Continued)

ACCURACY RESULTS

20000 ROUNDS - COPPER REMOVED

LE NO. 6

TARGET

T	1				2				3			
	H	V	MR	ES	H	V	MR	ES	H	V	MR	ES
	0	.54	2.63		1.64	0	3.75		.14	0	4.96	
	1.25	.90	1.30		.44	.44	2.05		.62	3.50	1.48	
	2.92	0	1.60		.14	3.12	2.04		1.00	3.58	1.27	
	4.66	.42	2.52		0	4.64	2.28		.80	3.80	1.14	
	3.53	.95	1.28		3.10	2.96	1.25		0	5.00	1.38	
	2.15	1.38	.30		3.20	3.73	1.10		.80	4.90	.58	
	2.20	1.84	.35		2.10	4.30	.54		2.68	5.68	1.58	
	1.82	2.12	.81		4.78	4.60	2.80		4.14	6.00	3.00	
	1.43	2.90	1.65		2.24	5.10	1.33		2.50	7.66	3.05	
	4.14	4.42	3.30		3.50	7.07	3.58		1.47	7.84	3.10	
	<u>2.41</u>	<u>1.55</u>	<u>1.57</u>	<u>5.8</u>	<u>2.11</u>	<u>3.76</u>	<u>2.10</u>	<u>7.3</u>	<u>1.41</u>	<u>4.79</u>	<u>2.15</u>	<u>8</u>

LE NO. 7

	2.80	0	3.32		2.16	0	2.00		0	0	4.60	
	3.52	.40	3.27		0	.40	2.97		1.66	.66	3.33	
	0	1.10	2.72		.60	.64	2.32		1.68	2.44	1.65	
	1.44	2.00	1.22		3.77	1.54	1.30		3.42	3.00	1.06	
	1.80	3.55	.38		2.76	2.44	.53		8.30	3.40	5.53	
	2.53	3.93	1.06		1.77	2.70	1.07		2.55	4.62	.81	
	2.64	4.02	1.20		4.06	2.63	1.67		3.21	4.77	1.04	
	.80	4.94	2.00		4.30	2.74	1.90		3.02	5.06	1.26	
	.78	5.20	2.20		2.50	3.40	1.44		.80	6.12	3.04	
	1.36	6.75	3.57		3.46	3.46	1.77		2.93	8.12	4.28	
	<u>1.77</u>	<u>3.90</u>	<u>2.09</u>	<u>6.8</u>	<u>2.54</u>	<u>1.99</u>	<u>1.70</u>	<u>4.9</u>	<u>2.76</u>	<u>3.82</u>	<u>2.66</u>	

ACCURACY RESULTS

20000 ROUNDS - COPPER REMOVED

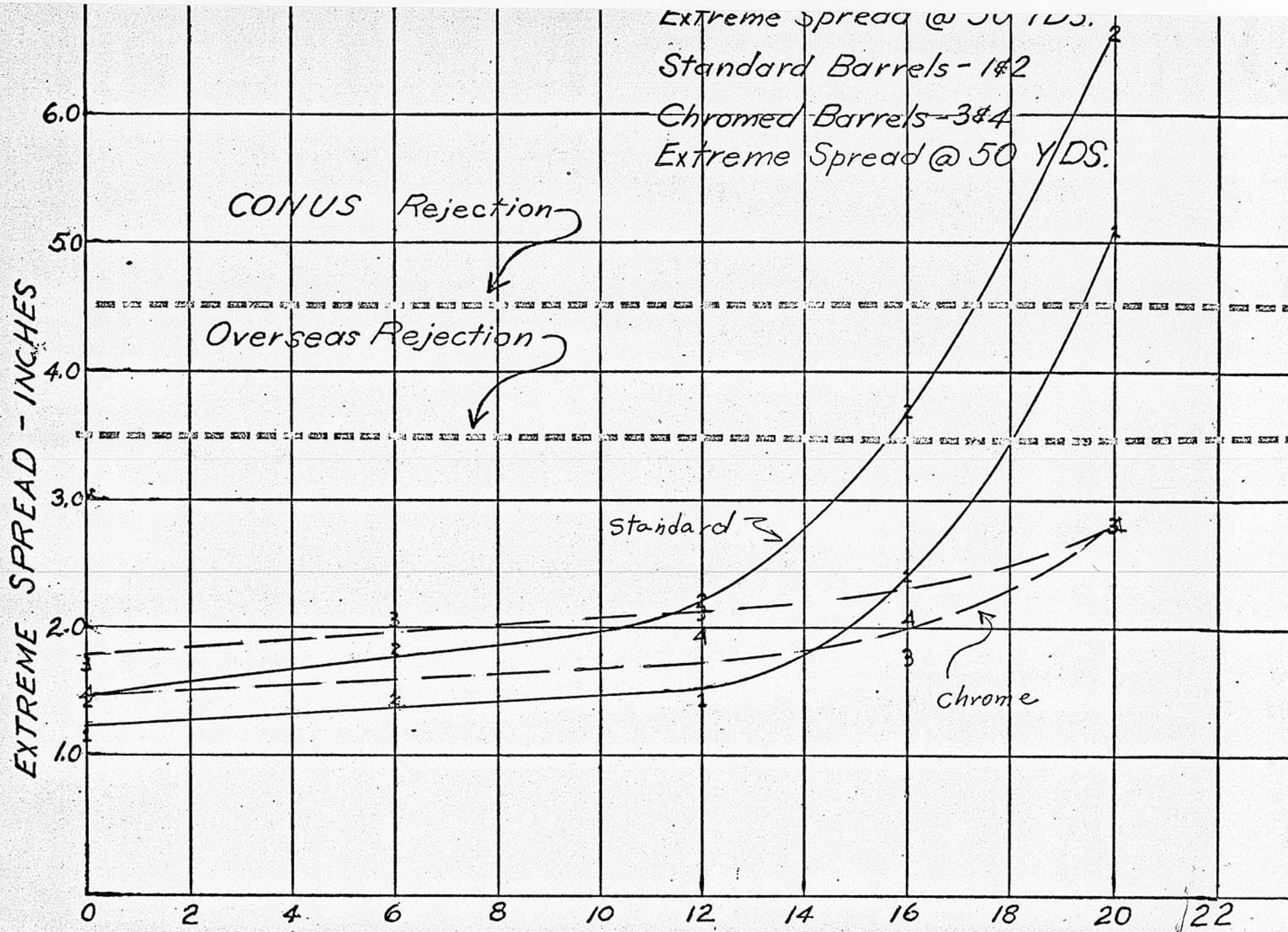
FILE NO. 6

TARGET

	1				2				3		
PT	H	V	MR	ES	H	V	MR	ES	H	V	MR
	0	.54	2.63		1.64	0	3.75		.14	0	4.96
	1.25	.90	1.30		.44	.44	2.05		.62	3.50	1.48
	2.92	0	1.60		.14	3.12	2.04		1.00	3.58	1.27
	4.66	.42	2.52		0	4.64	2.28		.80	3.80	1.14
	3.53	.95	1.28		3.10	2.96	1.25		0	5.00	1.38
	2.15	1.38	.30		3.20	3.73	1.10		.80	4.90	.58
	2.20	1.84	.35		2.10	4.30	.54		2.68	5.68	1.58
	1.82	2.12	.81		4.78	4.60	2.80		4.14	6.00	3.00
	1.43	2.90	1.65		2.24	5.10	1.33		2.50	7.66	3.05
	4.14	4.42	3.30		3.50	7.07	3.58		1.47	7.84	3.10
	<u>2.41</u>	<u>1.55</u>	<u>1.57</u>	<u>5.8</u>	<u>2.11</u>	<u>3.76</u>	<u>2.10</u>	<u>7.3</u>	<u>1.41</u>	<u>4.79</u>	<u>2.15</u>

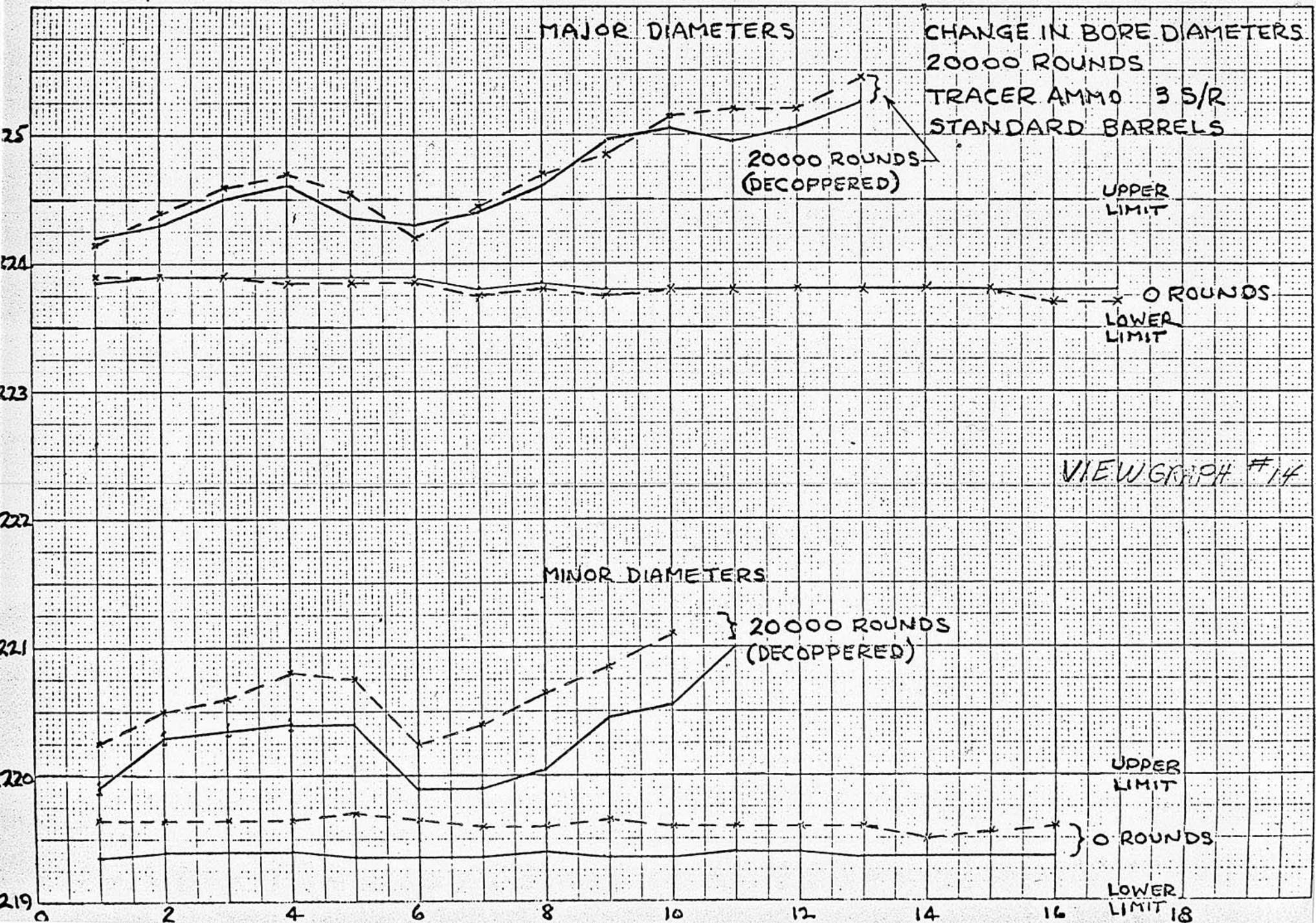
FILE NO. 7

	2.80	0	3.32		2.16	0	2.00		0	0	4.60
	3.52	.40	3.27		0	.40	2.97		1.66	.66	3.33
	0	1.10	2.72		.60	.64	2.32		1.68	2.44	1.65
	1.44	2.00	1.22		3.77	1.54	1.30		3.42	3.00	1.06
	1.80	3.55	.38		2.76	2.44	.53		8.30	3.40	5.53
	2.53	3.93	1.06		1.77	2.70	1.07		2.55	4.62	.81
	2.64	4.02	1.20		4.06	2.63	1.67		3.21	4.77	1.04
	.80	4.94	2.00		4.30	2.74	1.90		3.02	5.06	1.26
	.78	5.20	2.20		2.50	3.40	1.44		.80	6.12	3.04
	1.36	6.75	3.57		3.46	3.46	1.77		2.93	8.2	4.28
	<u>1.77</u>	<u>3.90</u>	<u>2.09</u>	<u>6.8</u>	2.54	1.99	<u>1.70</u>	<u>4.9</u>	<u>2.76</u>	<u>3.82</u>	<u>2.66</u>



Viewgraph #13

ROUNDS (Thousands)
 (4:1 Mix - Ball to Tracer)



CHANGE IN BORE MINOR DIAMETER
 TRACER AMMO 3 S/R
 STANDARD BARREL

5

14

23

22

21

20

19

VIEWGRAPH # 15

20000 RDS
(DECOPPERED)

16000 RDS

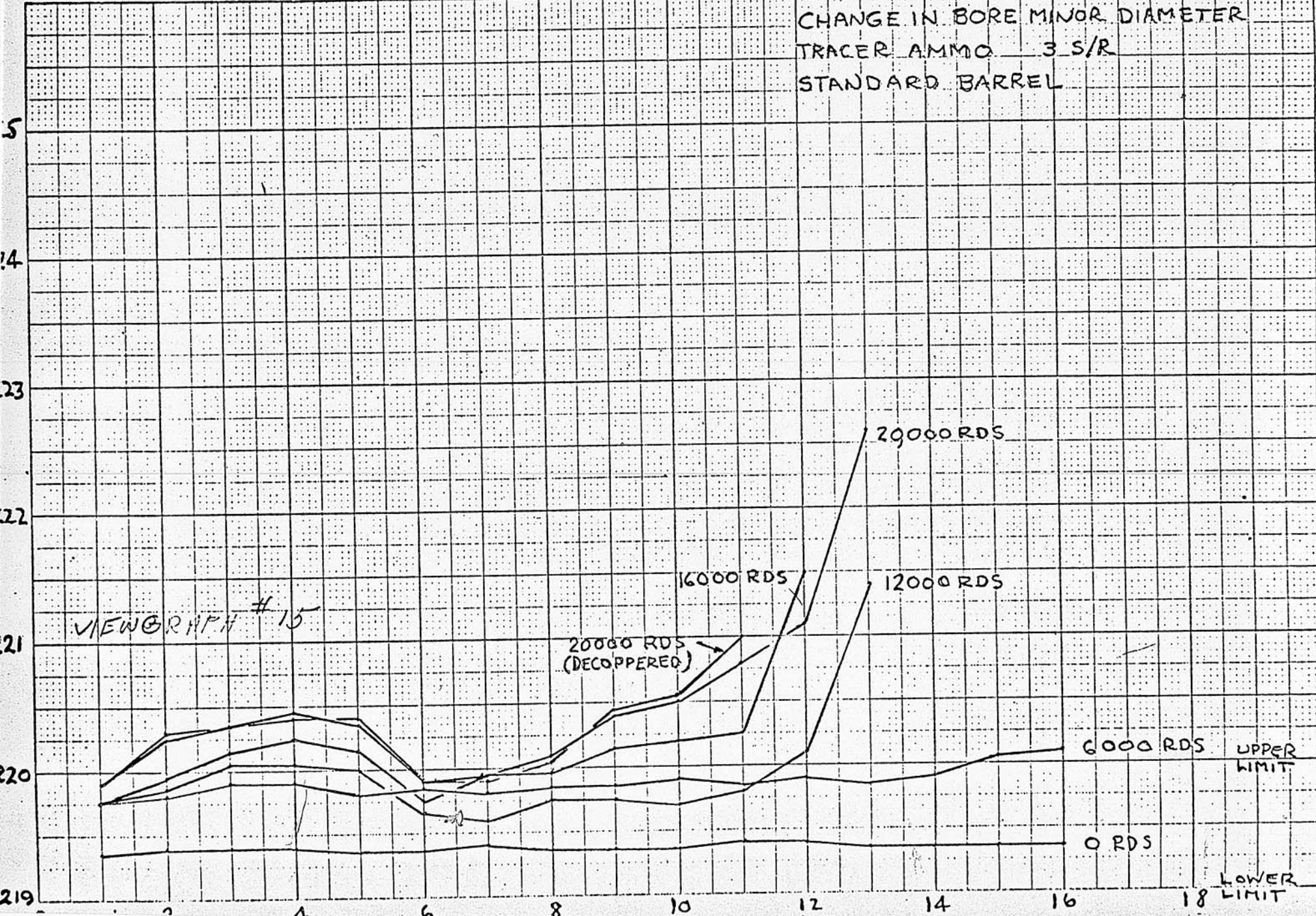
20000 RDS

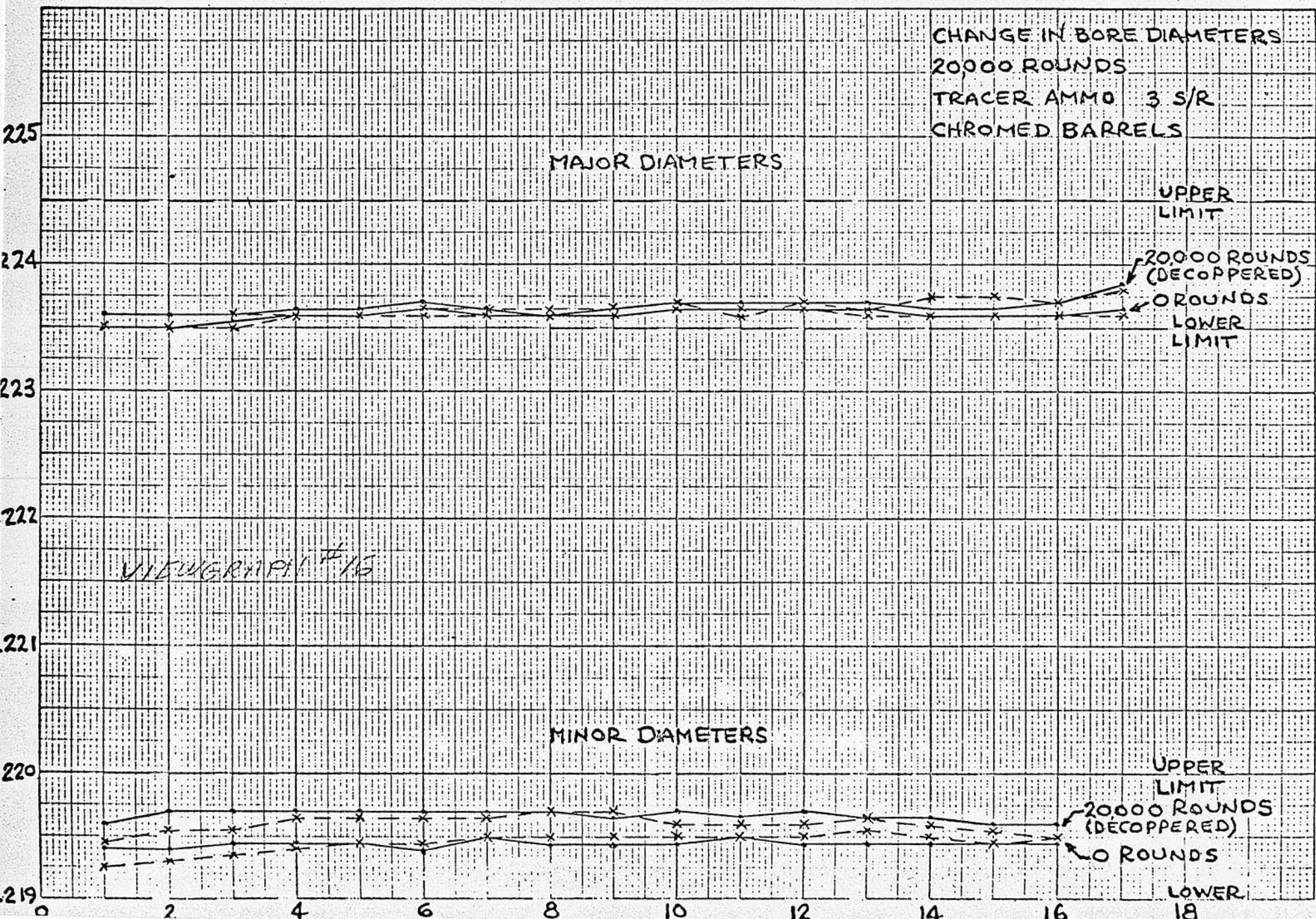
12000 RDS

6000 RDS

UPPER
LIMIT

0 RDS

LOWER
LIMIT



EXTREME SPREAD (50 YDS)

STANDARD BORE

1.4		
1.6	2.1	
1.5	2.1	1.6
1.4	2.1	2.1
2.1	2.2	2.1
1.8	2.0	1.1
1.6	2.1	2.0
1.8	2.1	2.1
1.1	1.4	1.4
2.0	1.4	1.7
1.6	2.1	2.0
2.1	1.7	1.6
2.3	1.7	1.4
1.6	1.4	1.4
2.1	1.6	2.0
2.1	2.0	1.4
1.1	2.0	2.0
2.1	1.1	2.4
1.4	1.5	1.4
1.3	1.7	2.1
1.8	1.5	1.6
2.1	1.7	2.3
1.5	2.1	1.6
	1.6	1.6

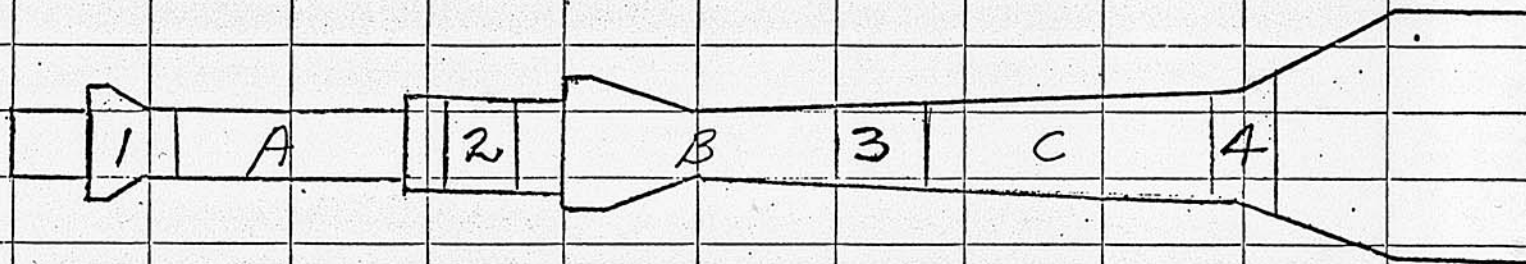
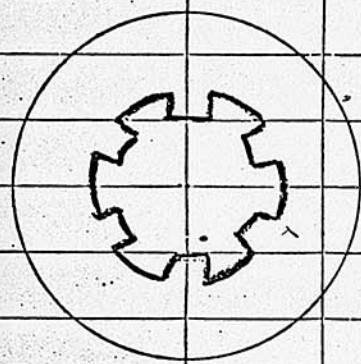
AVERAGE 1.765

CHROME BORE

1.4	0.3	1.8
1.4	1.6	1.4
1.4	1.5	2.4
1.1	1.4	1.0
2.2	1.9	1.8
1.2	3.8	1.4
1.9	1.4	2.0
2.4	1.2	1.3
2.3	2.2	1.2
2.0	2.0	1.6
1.4	1.2	2.0
1.4	1.8	1.8
1.4	1.4	1.9
1.8	1.6	1.4
2.2	2.2	1.4
1.2	2.0	1.4
1.4	2.0	1.8
1.2	1.5	1.6
1.4	1.8	2.4
1.2	1.2	1.6
1.4	1.3	1.4
1.4	2.4	0.9
1.2	1.6	

AVERAGE 1.627

VIEWGRAPH # 17



CHROME PLATED THICKNESS CHECKED IN EACH LAND AND GROOVE, AT SECTIONS AS ILLUSTRATED

	L.	G.	L.	G.	L.	G.	L.	G.	L.	G.	L.	G.
# 1	.00068	.00068	.00068	.00068	.00068	.00068	.00068	.00065	.00065	.00065	.00065	.00065
2	.00065	.00060	.00065	.00060	.00068	.00065	.00068	.00068	.00068	.00065	.00060	.00060
3	.00068	.00064	.00068	.00065	.00068	.00065	.00065	.00062	.00065	.00062	.00065	.00062
4	.00065	.00068	.00068	.00068	.00068	.00065	.00068	.00068	.00068	.00068	.00070	.00068

VIEWGRAPH #18

AMC M16 Steering Group
Development of Mathematical Model Simulating
Internal Weapon System Functioning
7 Jan 1971

Frankford Arsenal plans to publish two reports on this task. This will complete the effort. Additional analyses, models, and data accumulated during the course of the work and not included in either of these two reports will appear in reports supported by the RDT&E program when resources become available.

M16 Rifle/Ammunition Malfunction Model - This report consists of three parts: analysis, computer program description, and computer program operation instructions. Minor refinements are now being incorporated into the computer program to improve mechanical simulations and to reduce cost of operation. Compilation of material for the report is in progress..

Small Arms Diagnostic System - This report will cover the effort of the Technik, Inc. The next several months will see accumulation of data for computing a significant sample size of characteristic curves so that a more reliable base exists for evaluating the diagnostic concept.

Additional Analyses, Models, and Data in Frankford Arsenal Files - Coupled mass spring model for simulating driving spring surge and computing dynamic spring force; Empty cartridge case ejection path model; Optimization routine based upon a modified box method; Propellant gas transmission and pressure gradients using method of characteristics; M16 interior ballistics model; Automatic fire randomization model; Barrel vibration program; Component stress analysis; Case extraction analysis; Spectral analysis of force displacement records; and Pressure time characteristics. In some case computer programs exist, have been debugged and are operable. In other cases computer programs have been designed but require debugging. Data, test description, and analyses exists in various stages of processing (compilations for reports, rough drafts of writeups, or initiated but incomplete mathematical analyses).

All computer programs are written in FORTRAN IV except for CSMP programs. All FORTRAN IV programs are operable on the CDC 6500 Computer at Picatinny Arsenal and IBM 360 at Johnsville. Small subroutines are operable on IBM 1410 at Frankford Arsenal.

M-16

January 1971
C. E. Shindler - J8700

Title: Approaches to Minimize Ammunition Variability

The only open item on the agenda is that of "Standardization of the 5.56mm Primer." However, again as a matter of interest, the GOCO plants were surveyed with regard to the number of propellant lots which were loaded into a single cartridge lot. This survey revealed the following for the period of 1 June through 14 December 1970.

<u>GOCO Plant</u>	<u>M193 Ctg. Lots Produced</u>		<u>M196 Ctg. Lots Produced</u>	
	<u>w/one pwd lot</u>	<u>w/two pwd lots</u>	<u>w/one pwd lot</u>	<u>w/two pwd lots</u>
LCAAP	222	8	19	1
TCAAP	72	20	(none produced)	

Note: This survey reveals a marked improvement in controlling the number of propellant lots loaded into a single cartridge lot. This aspect will continue to be monitored, however, it is suggested that future reporting be limited to problem areas should they develop.

Item: Standardization of the 5.56mm Primer

In view of the curtailment of 7.62mm ammunition production at TCAAP, the effort to produce the 7.62mm #34 primer was diverted to the production of the 5.56mm #41 type primer. It is now anticipated that TCAAP will initiate production of the #41 primer during March 1971 and be in full production by July 1971 so that all 5.56mm ammunition (including the M200 blank) produced at TCAAP will be primed with the #41 primer after July 1971.

The effort to completely standardize the #41 primer whereby all 5.56mm ammunition producers will be fabricating this primer to precisely the same drawings and specifications will be completed prior to the start-up of production at TCAAP. It is to be noted that all producers manufacturing the #41 type primer are doing so to their own drawings. These contractor drawings are similar to, but not identical to, those depicting the FA #41 primer. The actual standardization will constitute the incorporation of the best attributes of each and the reaching of agreement of each producer to a common set of requirements. Since only subtle differences presently exist among all the producers, relatively little difficulty is anticipated in reaching agreement.

AMC M16 RIFLE STEERING GROUP

7 January 1971

Agenda Item IIIC - Tracer Product Improvement Program

In accordance with agreements reached at the last meeting of this group, Frankford Arsenal directed Lake City Army Ammunition Plant to convert its production of Ctg., 5.56mm, Tracer, M196 to an educational order of the GMCS version (loaded with IMR-8208M propellant) tested and conditionally approved by USATECOM. LCAAP has been instructed to develop and incorporate, with the assistance of Frankford Arsenal, whatever process and tool improvements are required to improve the accuracy of this design, thereby removing the one condition cited by USATECOM.

Because of the absence of qualified suppliers of GMCS cups in 5.56mm and of the partial diversion of process engineering capability at LCAAP to the 7.62X39mm program, initiation of the educational order has proceeded more slowly than anticipated. At this writing, two suppliers of cups have been qualified and production will begin in February.

It was also agreed at the last meeting of this group, that USATECOM would be furnished additional test cartridges for an attitudes-test comparison of WC-846 and IMR-8208M propellants in cartridges assembled with the GMCS bullet and for sustained-fire testing of WC-846 loaded tracer cartridge in a 1-4 mix with ball cartridges. Both of these tests are designed to support the resumption of loading WC-846 propellant into tracer cartridges.

For the reasons cited above, these test samples have only just recently been supplied to USATECOM. Testing by that Command should begin early this year.

AMC-M16 STEERING GROUP
INSTRUMENTATION & TEST TECHNIQUES
STATUS REPORT FOR PERIOD ENDING 31 DEC 70

Transient Stress Measurements:

The 5.56mm barrels with the strain gages mounted have been received from the contractor. Comparison tests of pressure-time measurements and strain gage information will be conducted during the upcoming months.

Cyclic Time Measurements:

The tests conducted with the Electro Optical Displacement Meter were completed. The results indicate that the components of cycle time in the M16 can be measured successfully with present instrumentation.

Heat Transfer:

The RFQ for the initial development of instrumentation for measuring heat transfer was issued in September, 1970. Eight proposals in response to the RFQ were evaluated, and the results were returned to Contracting and Purchasing. To date, no contract has been awarded.

Internal Weapon Component Motion:

The program to evaluate the Electro Optical Displacement Measuring Unit has been completed and the results were most satisfactory. The feasibility of using the unit to measure bolt displacement on an M16 or any other weapon has been established. A report on the tests is currently being written.

Pressure Measuring Equipment:

The Lifetime Endurance Tests for the selected pressure transducers has been started. Tests on the first transducer Kistler, Model 6203, are currently being completed. Tests on the BRL-minihat will begin 11 Jan 71. Several more months will be required to complete the endurance tests. Following the endurance tests, efforts will be made to develop new pressure acceptance levels using electronic transducers.

Standard Rifle Mount:

The exoskeleton and anthropomorphic mount have been delivered to Frankford Arsenal. The contract was closed out and a small amount of testing was conducted. The results of these tests were inconclusive, but showed a certain potential. The Human Engineering Laboratory has expressed interest in continuing the project in 1971.

AMC M16 RIFLE STEERING GROUP

7 January 1971

Agenda Item IIIIE - Profile and Alignment Acceptance Criteria

At the last meeting of this group, the Product Manager requested that Hq., USAWECOM design and estimate the cost of a program to assess the effect on system reliability of ammunition which deviates from current profile-gaging requirements in the following manner:

- a. Twenty pound gaging force applied in lieu of ten pounds.
- b. Protrusion from the gage not to exceed .003" allowed in lieu of flush or below.

In the meantime, Frankford Arsenal would attempt to obtain meaningful estimates from the various producers of the potential for saving by changing the gaging requirements to accommodate the above deviations and provide the Product Manager with a cost-effectiveness analysis by combining the above two estimates.

In June 1970, the Commanding Officer of Frankford Arsenal requested, from each active producer, an estimate of the savings that could be realized at his respective plant by adoption of the above changes to the gaging requirements. To date, three responses have been received estimating the potential savings at \$50, \$80 and \$525 per million cartridges. It is the opinion of Frankford Arsenal that the \$525 estimate could not be supported in practice and that the real saving is no higher than the other two figures.

The cost-effectiveness analyses will be performed upon receipt of estimated test costs from USAWECOM.

IV. WECOM Task Assignments

A. Extractor Spring Life

A product improvement effort to reduce breakage and increase service life of the M16 Rifle Extractor Spring has been undertaken by WECOM.

Normal Extractor Spring life should be 6,000 rounds; however, premature breakage is the rule rather than the exception. A three phase program has been developed by WECOM to attack this problem.

Phase I was intended to verify the average number of rounds fired before extractor spring breakage and has been completed. The results of the tests have shown the mean-rounds-to failure of the spring to be 2,000 rounds.

Phase II was intended to test several types of springs and elastomeric combinations and has been completed. Efforts to induce early failures in the standard spring have been applied to testing of several types of substitute springs and spring combinations. The most promising solution seems to be the use of an elastomeric spring or an elastomeric insert in a coil steel spring.

Phase III of the program is currently active. Final configuration and designs are being selected based on the results and criteria established in Phase II for acceptance testing. Completion is expected by July 1971.

B. Ejection Pattern Study

The erratic pattern of ejection characteristic of the M16 Rifle has occasionally resulted in spent cartridge cases being ejected into the faces of left hand firers. Our task at WECOM has been to minimize or eliminate this erratic ejection.

Extensive examination of ejection patterns and high speed movies of test firings has resulted in the observation that ejection spring force and weapon cyclic rate are the major factors in establishing ejection patterns. Weapons with high cyclic rates have a rearward slamming action of the carrier which, when combined with ejector spring action impact the cartridge on the Upper Receiver. This results in a favorable forward ejection of the cartridge. Slower rate weapons, however, depend entirely on the ejector. These weapons exhibit a spinning out of the cartridge which does not impact on the Receiver but rather flies rearward into a left handed firers face.

The resulting solution has been to reduce the force of the ejector spring to minimize the spinning out of the cartridge case. Preliminary tests have shown favorable ejection patterns. Currently, 200 springs of a final design criteria are being made for extensive testing. It is expected that complete testing and recommendations for configuration change will be completed by May 1971.

C. 30 Round Magazine

1. The following tests are currently being conducted:

(a) Test to evaluate removal of dry film lubricant which would result in a substantial cost savings if successful. This test is expected to be completed about 22 January 1971, with a final report by the end of January 1971.

(b) Test to determine the effect of the 30 Round Magazine on the cyclic rate of the Rifle. The resultant information will be used to evaluate current acceptance criteria (SAPD and MIL-R-45587) the expected completion date is the middle of January 1971, with a final report by March 1971.

2. The Technical Data Package is being updated for forthcoming procurement, this entails:

(a) Evaluation of current manufactured magazines for compatibility with current technical data.

(b) Review of CDI studies that reported interference conditions, verify these findings, perform studies to provide solutions to minimize interference problems.

STATUS OF ARDC TASK ASSIGNMENT IN INTERIOR

BALLISTICS/KINEMATIC STUDIES

1. INTERIOR BALLISTICS

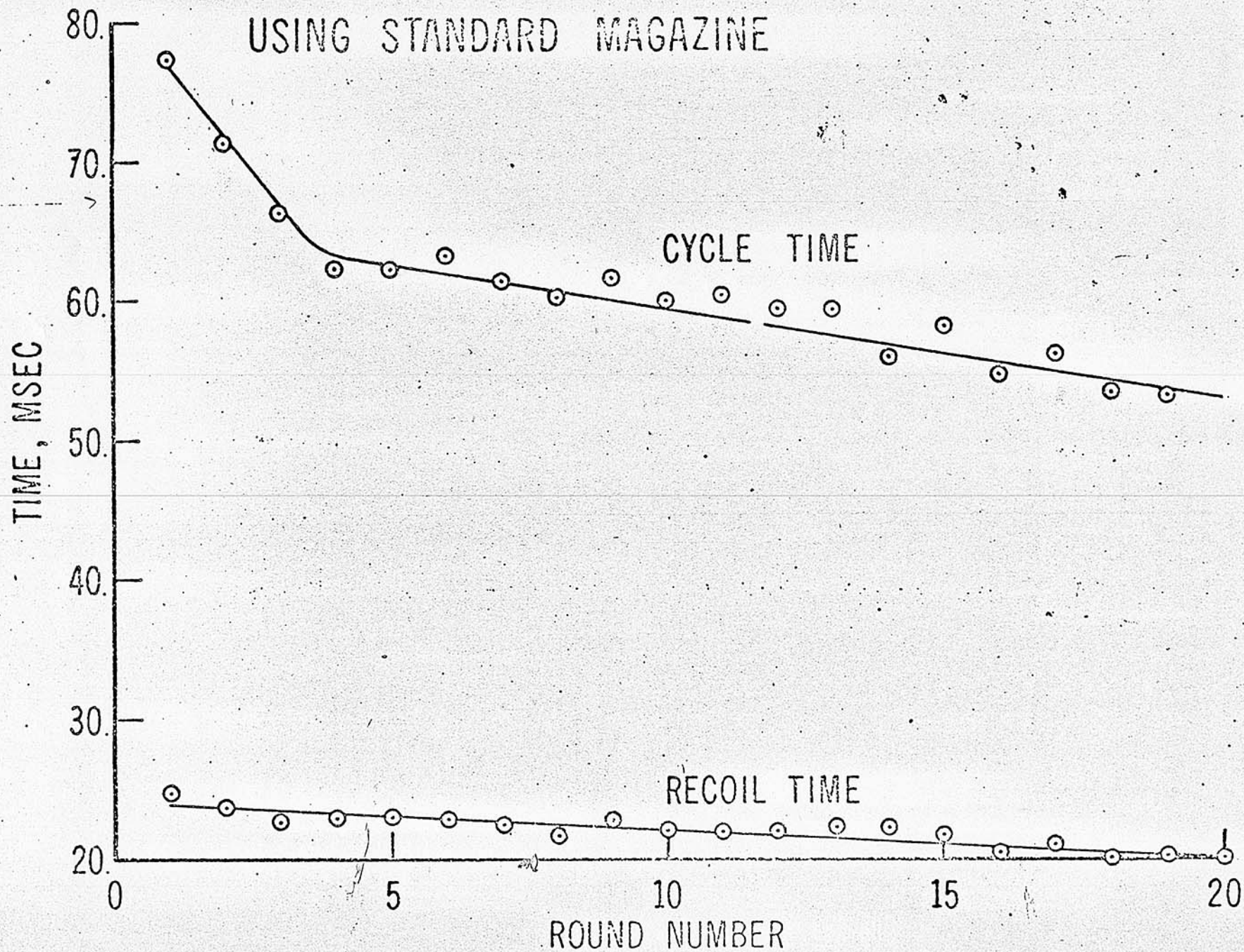
All work has been completed and reports are either completed or are in process of being prepared. One report is BRL Memorandum Report 2072 by myself on the development of the Mini-hat Pressure gage for use in the 5.56mm, and a second report by myself on the interior ballistics of 5.56mm ammunition is nearly finished.

2. KINEMATIC STUDIES

All work has been completed and reports are either completed or in process of preparation. One report on the kinematics of the M16 Rifle is being prepared by myself and is in final stages of preparation. Two reports on studies of the gas system on the M16 have been completed by Dr. Spurk and Meade Werner. One report on the complete analog simulation for the M16 is being started by Mr. Gay. All work for the analog simulator has been completed.

Final 8

VARIATIONS IN CYCLE TIMES IN 5.56 MM WEAPON USING STANDARD MAGAZINE



VARIATIONS IN CYCLE TIMES IN 5.56 MM WEAPON
USING CONSTANT FORCE LOW DRAG MAGAZINE

