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FINAL LETTER REPORT ON
ANALYSIS
OF
CONSOLIDATED CYCLIC RATE DATA
FOR M16A1 RIFLE
BY
ALLAN WILSON
JANUARY 1969

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND

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ABSTRACT

At the request of US Army Ballistic Research Laboratories, the Materiel Test Directorate at Aberdeen Proving Ground (APG) collected and presented M16A1 rifle data from tests recently completed as well as from tests in progress at APG. The data were collected in September 1968 and presented in the form of relative frequency histograms by which weapon reliability and durability were plotted as a function of the cyclic rate-of-fire of the M16A1 rifle.

FOREWORD

The Materiel Test Directorate was responsible for compiling data and reporting on the subject study.

1. BACKGROUND

From information obtained in a laboratory-type kinematic analysis¹ of the M16A1 rifle it was recommended by USATECOM that acceptance criteria for the M16A1 rifle be changed from the existing range of 650-850 rds/min to 750-900 rds/min. In consideration of this recommendation, concern has been expressed that implementation of the higher rate range could result in an increase in both malfunctions and in failure or breakage of weapon parts, particularly at the upper level of cyclic rates.

As a result of this concern, the US Army Ballistic Research Laboratories requested that the Materiel Test Directorate (MTD) of USATECOM summarize and analyze current M16A1 rifle test data to establish the degree to which reliability and durability are related to cyclic rate-of-fire levels in USATECOM tests.

2. PROCEDURE

a. Test Conditions

The firing of 224,000 rounds of M193 ammunition in M16A1 rifles at MTD between January and August 1968 was analyzed. The sources of the test data, the conditions of test and the frequency of cyclic rate measurements are identified as follows:

(1) Test: Quality Assurance Test

No. of Rifles: 22

Rds Fired per Rifle: 6000

Test Condition: All firing conducted from the standard, quality-assurance mount (spring-loaded) at normal ambient temperature.

Frequency of Maintenance: Each 1000 rounds.

¹ Addendum to Final Report on Product Improvement Test of Redesigned Buffer for M16A1 Rifle (Displacement-Time Study), May 1968, DPS Report 2662.

Mode of Fire: 100-rd cycles followed by complete cooling; each cycle was composed of 60 rounds fired semiautomatically, 20 rounds in short bursts and 20 rounds in a continuous burst.¹

Frequency of Cyclic Rate Measurement: 100-round intervals (every 20-rd continuous burst is measured).

Ammunition Lot Identification: FC1921, LC12366, LC12369, TW18301, WCC6166, LC12379, TW18299, LC12385, WCC6171, FC1938, WCC6176, TW18329, LC12414, FA1; all lots were loaded with WC846 (ball) propellant.

(2) Test: Inspection Comparison Test

No. of Rifles: 10

Rds Fired per Rifle: 10,000 for 6 rifles (reliability phase), and 5000 each for the remaining four rifles (3000 at -65°F, 1000 at +155°F and 1000 with weapons unlubricated; dust, mud, and rain test results excluded from this study).

Test Condition: The reliability test was conducted at normal ambient; other conditions as identified above. All rifles were shoulder fired.

Frequency of Maintenance: Same as QA Test.

Mode of Fire: Same as QA Test.

Frequency of Cyclic Rate Measurement: Same as QA Test.

Ammunition Lot Identification: TW18209, loaded with Ball propellant, and TW18149, loaded with IMR8208M propellant; five rifles were fired with each lot.

¹A new schedule of 20 rounds in short bursts, 20 rounds automatically, 20 rounds semiautomatically, 20 rounds in short bursts and 20 rounds semiautomatically has recently been imposed and was followed in the firing of the final 3 of the 22 test rifles.

(3) Test: Product Improvement Test of Electrolized Bolt Carrier Group

No. of Rifles: 6; only sustained fire test data were considered in this study.

Rds. fired per Rifle: Approximately 2000. As no cyclic rate data are obtained during the 650-round semiautomatic phases, only automatically fired phases are considered in this study.

Test Condition: a. 450 rds fired automatically in 30 minutes
b. 200 rds fired automatically in 5 minutes
c. 450 rds fired automatically in 15 minutes
d. 200 rds fired automatically in 2.5 minutes
e. 450 rds fired automatically in 7.5 minutes
f. 200 rds fired automatically in 75 seconds

Weapons are completely cooled between each of the above conditions; firing was conducted with the rifles mounted in a rigid rest.

Frequency of Maintenance: Each 650 rounds.

Mode of Fire: All rounds considered in this study were fired automatically in continuous bursts of either 15 or 20 rounds.

Frequency of Cyclic Rate Measurement: Taken on every burst fired.

Ammunition Lot Identification: RA5318, loaded with ball propellant.

b. Data Selection

A total of 680 malfunctions and 2805 cyclic rates of fire were analyzed from the tests described above. Other than the exceptions listed below, no malfunctions were excluded from the study. The exceptions are as follows:

(1) All failures that occurred in attempts to load a first round by manually releasing the bolt catch.

(2) One failure to fire and several failures of the trigger to return were charged to a defective trigger pin.

(3) Four feeding failures charged to a defective (bent) magazine and 8 failures charged to improper loading of magazines were excluded.

c. Identification of Cyclic Rates with Malfunctions

In order to relate, as closely as possible, the occurrence of a malfunction with a definite rate-of-fire level, each malfunction was scored as occurring at whatever cyclic rate was recorded nearest to the occurrence of the malfunction. In the Quality Assurance and Inspection Comparison Tests this placed a malfunction no further from a cyclic rate measurement than approximately ± 50 rounds; in the sustained fire test the interval was 20 rounds (in some instances, if the malfunction occurred as a nearly final round in a magazine, the rate of fire was obtained for the rounds in the interrupted burst immediately prior to the malfunction).

3. DATA ANALYSIS

The test data are summarized in the following relative frequency histograms. The typed number appearing at the top of each cyclic rate column is the malfunction total associated with the particular column rate range; e.g., in Figure 1 approximately 6% of the 1298 individual rates recorded were between 787 and 800 rds/min and 15 malfunctions were recorded at this column rate range. Figure 7 is a relative frequency histogram that summarizes all the test data individually displayed in Figures 1 through 6, and Figure 8 shows the relative frequency of all of the malfunctions. As a final analysis, Figure 9 presents in a split column, relative frequency histogram an overall display of both cyclic rate and malfunction incidence.

Note that in Figures 2 through 5 equal amounts of ball propellant and IMR propellant-loaded cartridges were fired but with the exception of the +155°F test (Figure 4) the cyclic rate data appear to be from a single, reasonably normal population. However, the IMR firings produced the majority of lower rates and the ball firings produced the higher rate levels and only in the +155°F test are the two distinct and separate ammunition populations apparent.

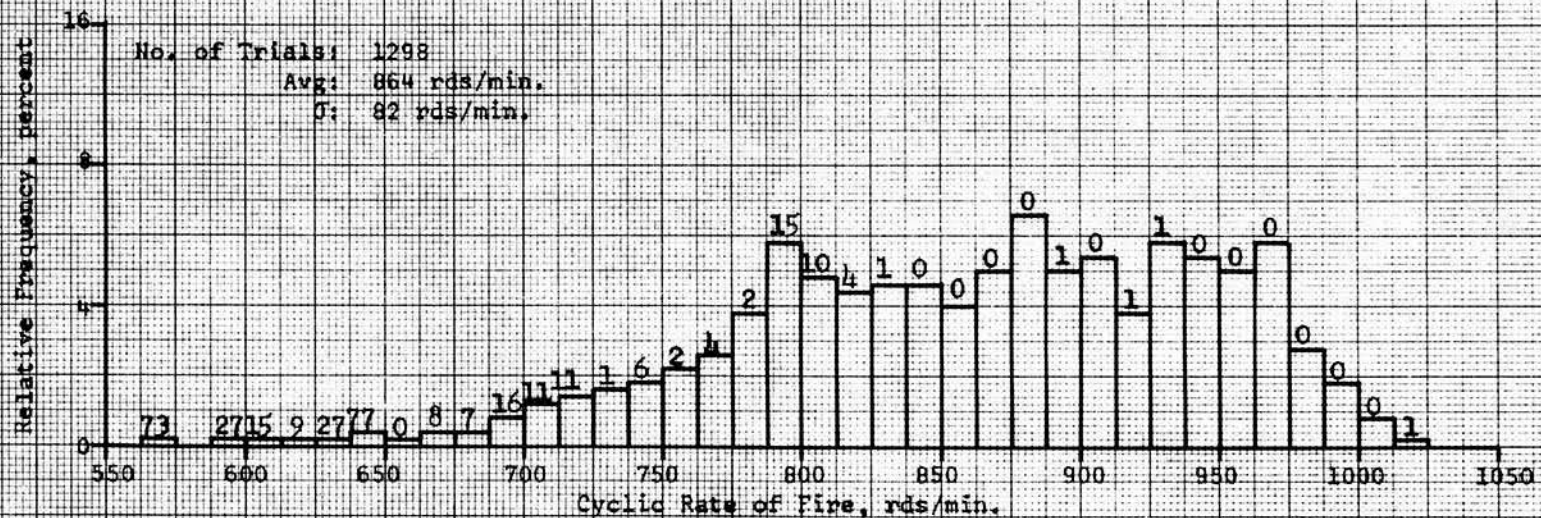


Figure 1. Frequency Distribution of Cyclic Rate of Fire for 22 M16A1 Rifles Fired in Quality Assurance Tests (Numbers at top of each column are total malfunctions that occurred within the cyclic rate range of each column).

No. of Trials: 695
 Avg: 821 rds/min.
 0: 83 rds/min.

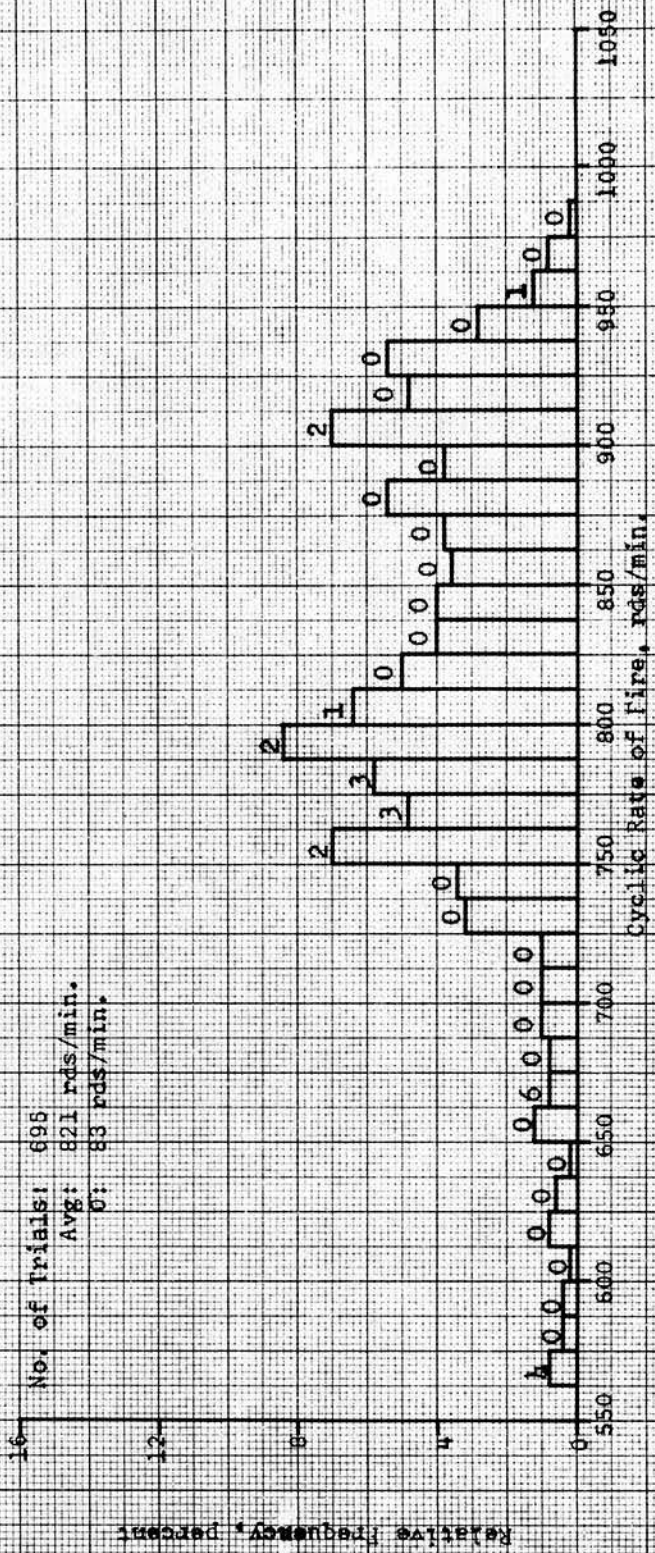


Figure 2. Frequency Distribution of Cyclic Rate of Fire for 6 M16A1 Rifles Fired in the Reliability Phase of an Inspection Comparison Test (Numbers at the top of each column are total malfunctions that occurred within the cyclic rate range of each column).

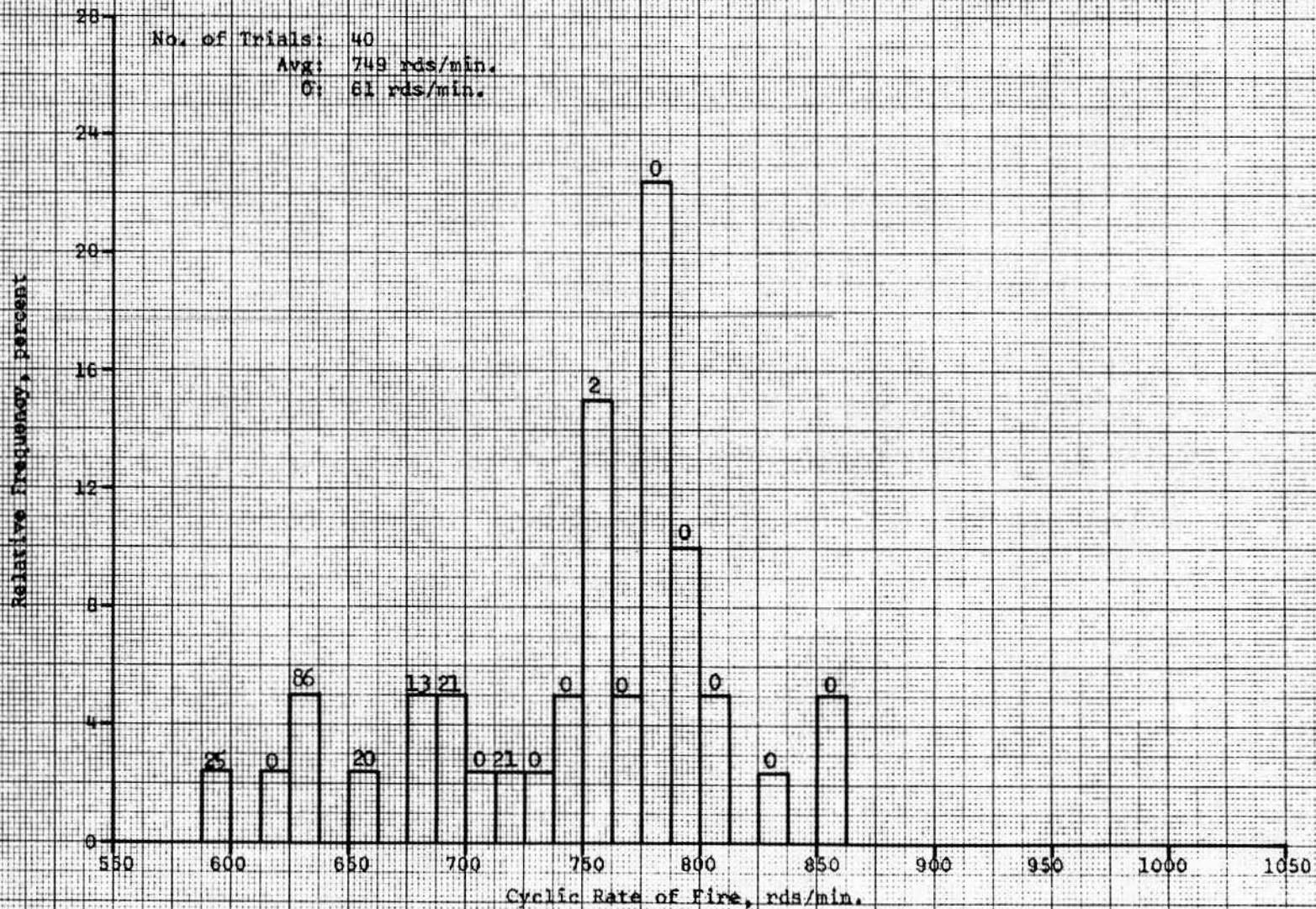


Figure 3. Frequency Distribution of Cyclic Rate of Fire for 4 M16A1 Rifles Fired in the Unlubricated Phase of an Inspection Comparison Test (Numbers at top of each column are total malfunctions that occurred within the cyclic rate range of each column).

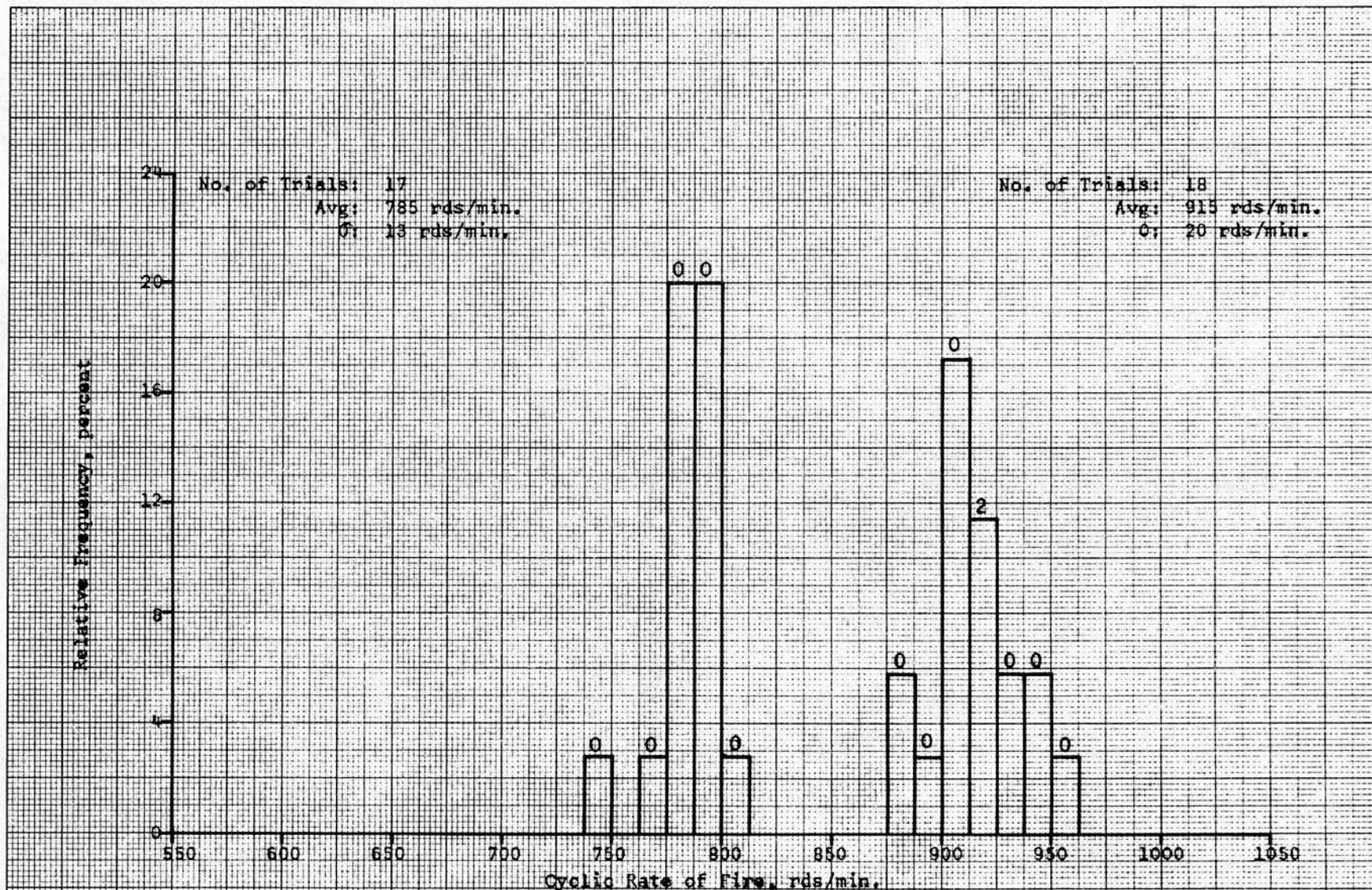


Figure 4. Frequency Distribution of Cyclic Rate of Fire for 4 M16A1 Rifles Fired in the +155°F Test Phase of an Inspection Comparison Test (Numbers at top of each column are total malfunctions that occurred within the cyclic rate range of each column).

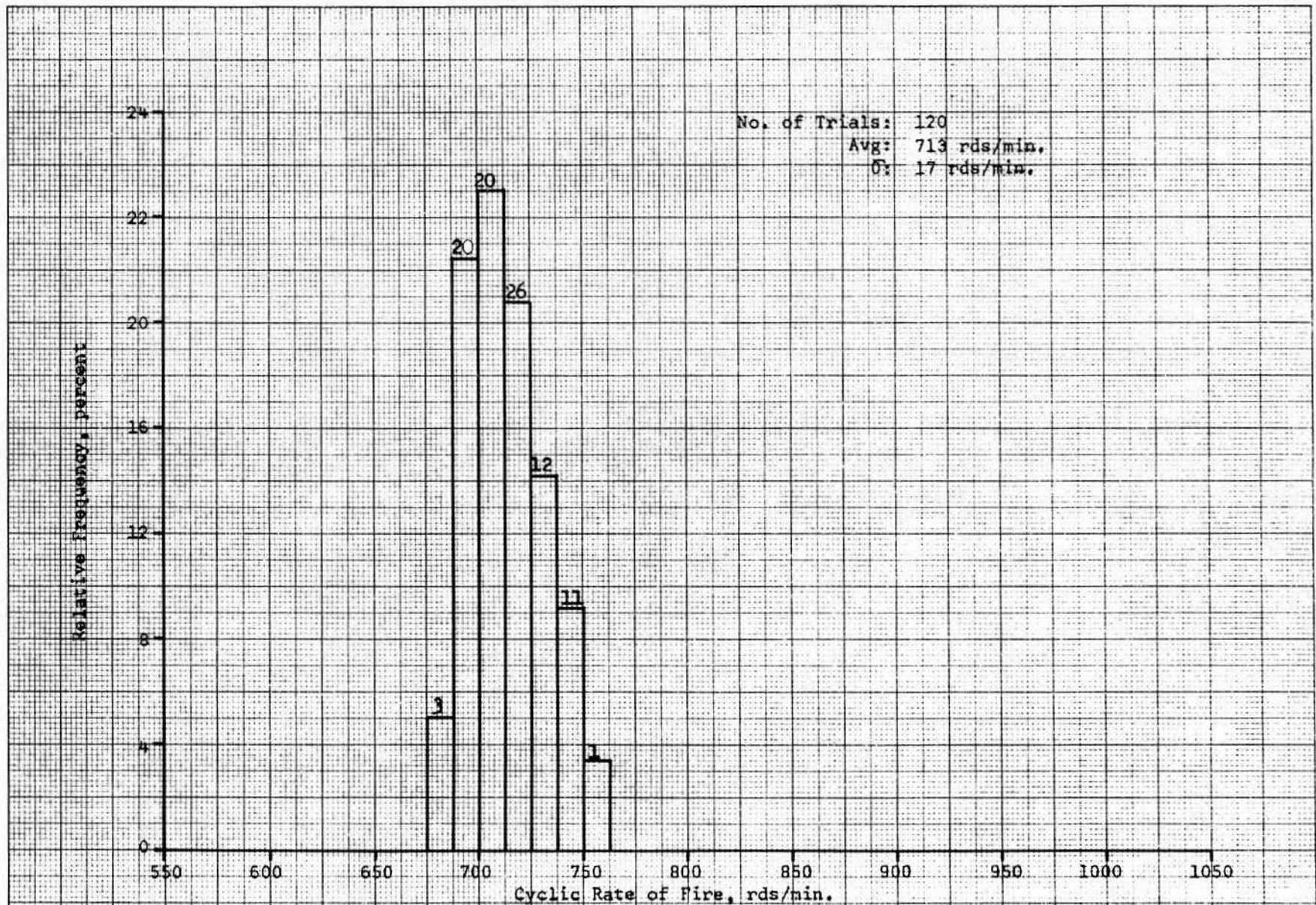


Figure 5. Frequency Distribution of Cyclic Rate of Fire for 4 M16A1 Rifles Fired in the -65°F Test Phase of an Inspection Comparison Test (Numbers at top of each column are total malfunctions that occurred within the cyclic rate range of each column).

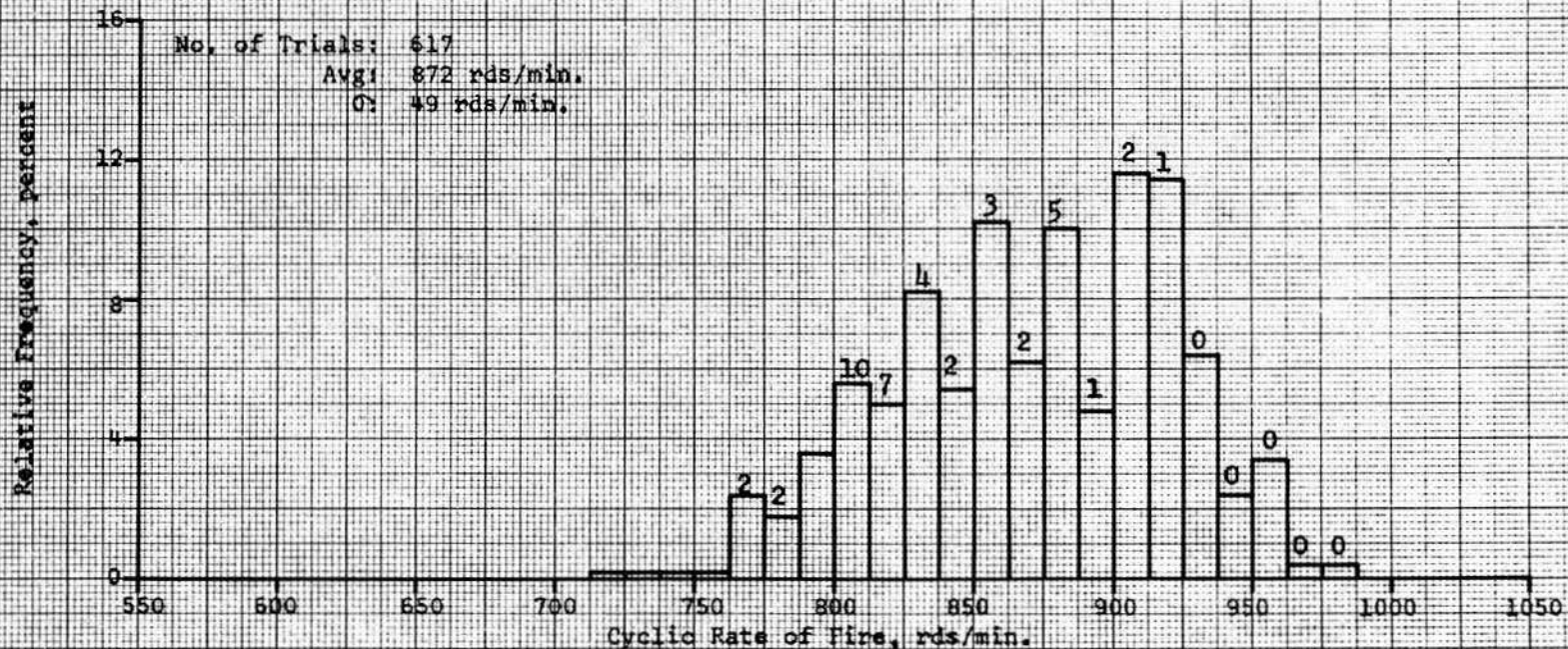


Figure 6. Frequency Distribution of Cyclic Rate of Fire for 6 M16A1 Rifles Fired in the Sustained Fire Test Phase of a Product Improvement Test of Electrolyzed Bolt Carrier Groups for the M16A1 Rifle (Numbers at top of each column are total malfunctions that occurred within the cyclic rate range of each column).

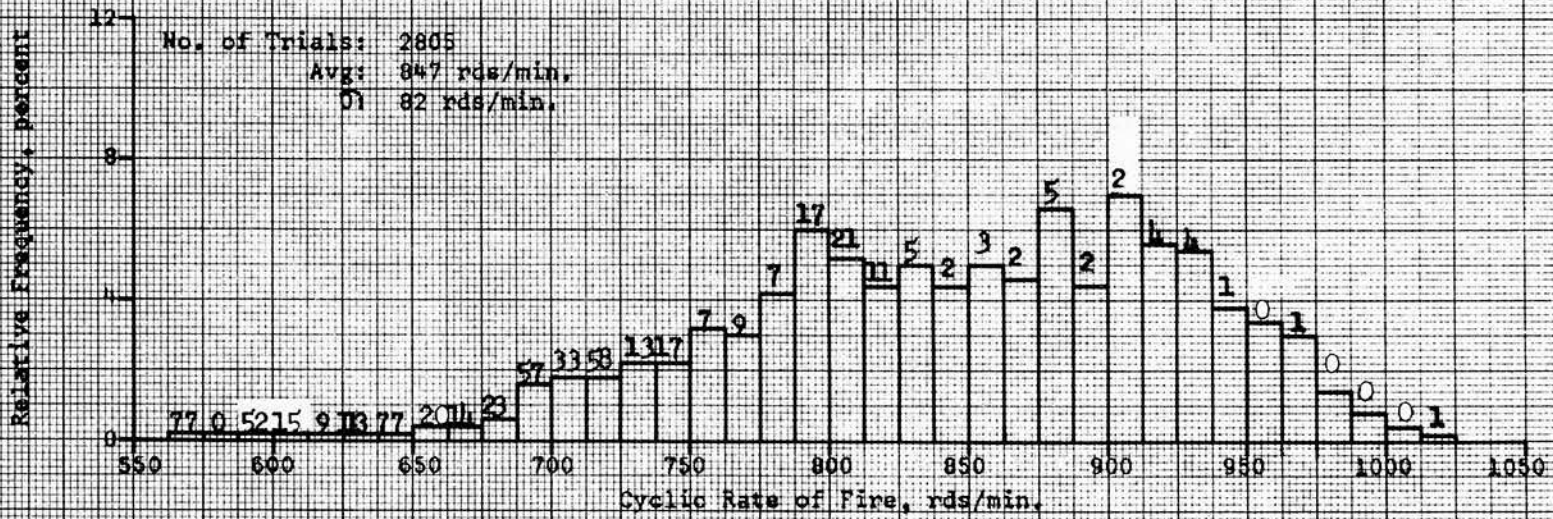


Figure 7. A Summary of the Frequency Distribution of All Cyclic Rates of Fire From the Data Presented in Figure 1 through Figure 6. Numbers at Top of Each Column Are Total Malfunctions that Occurred Within the Cyclic Rate Range of Each Column.

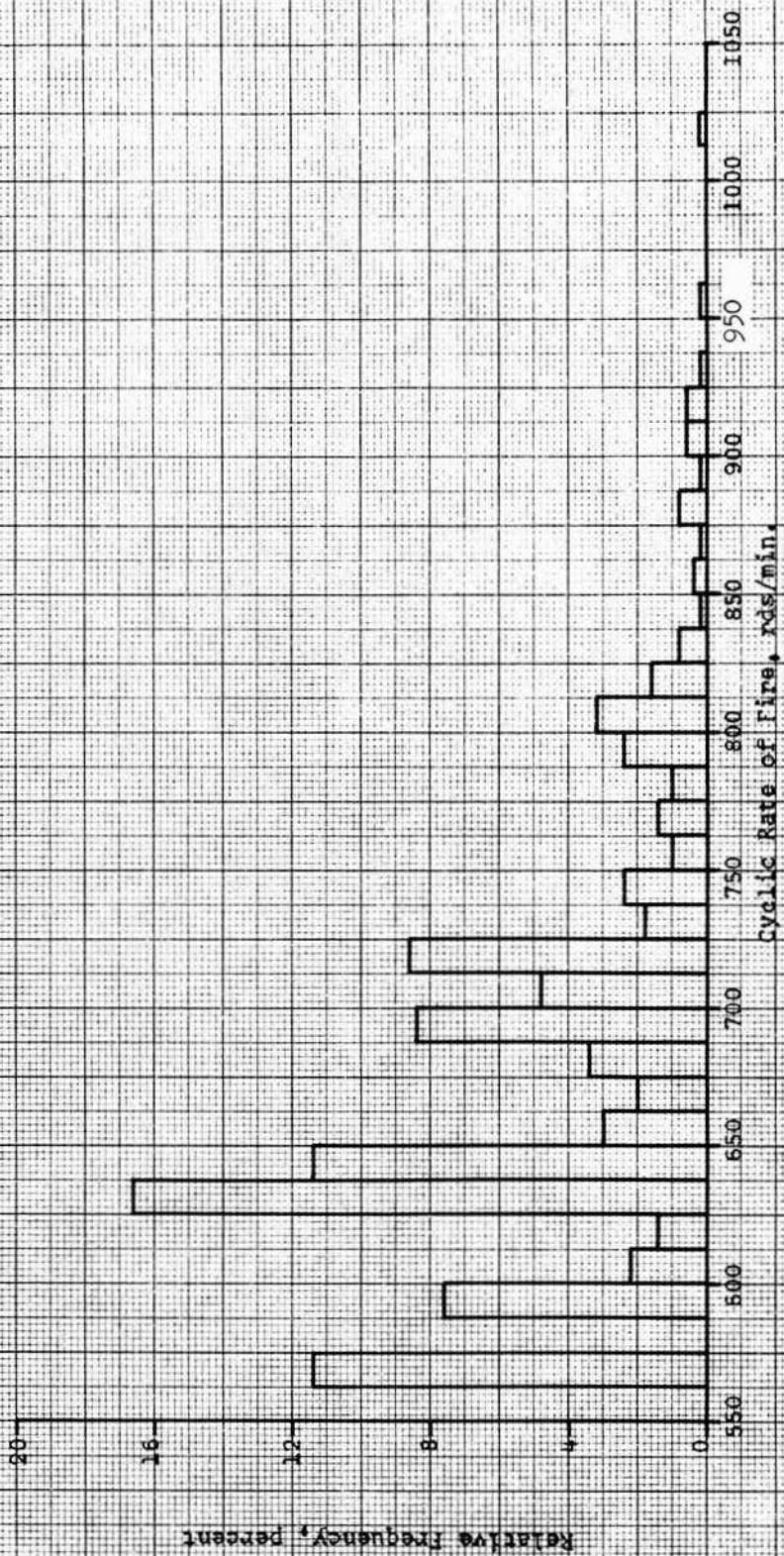


Figure 6. A Summary of the Frequency Distribution of All Malfunctions from the Data Presented in Figure 1 through Figure 6.

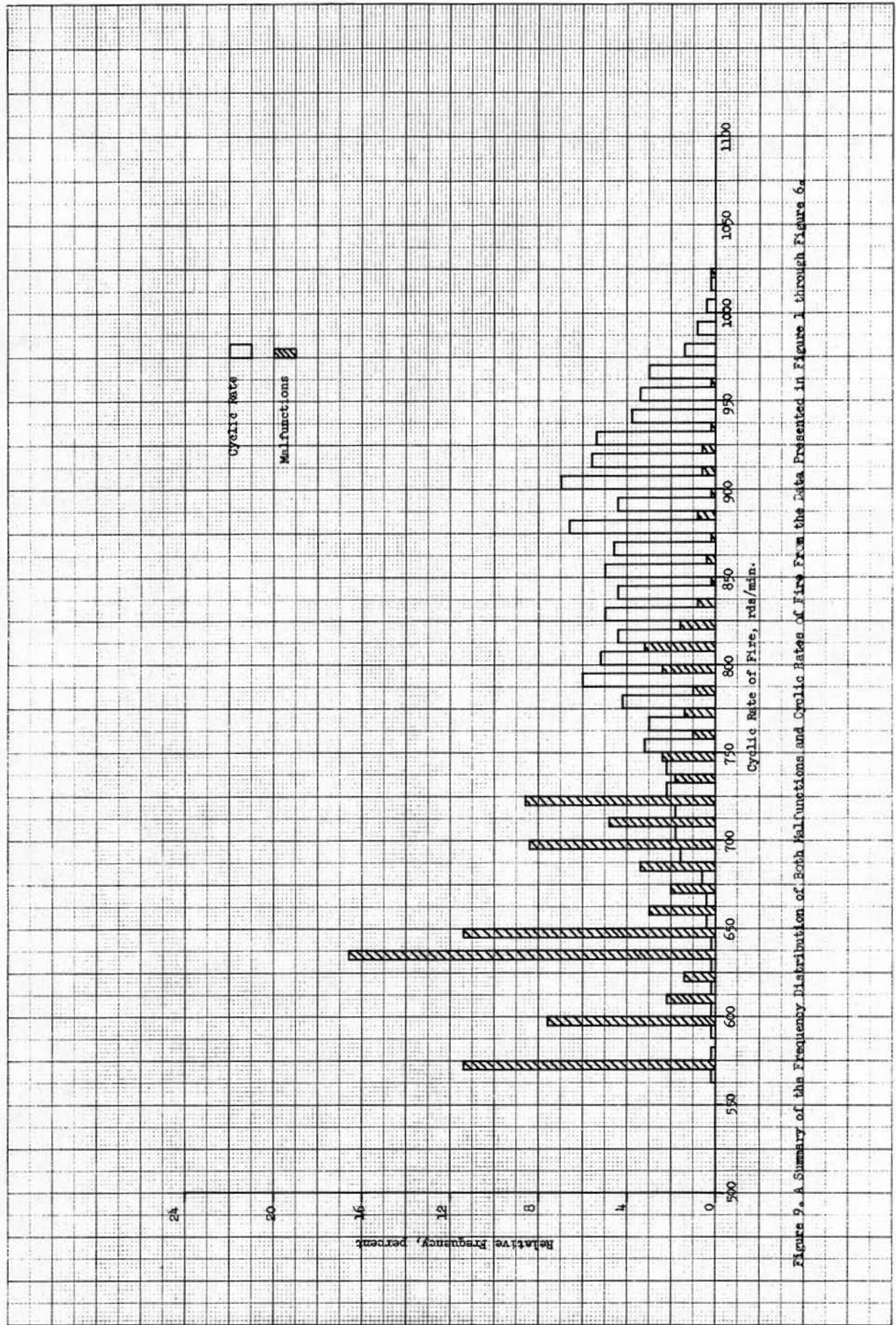


Figure 9. A Summary of the Frequency Distribution of Both Malfunctions and Cyclic Rates of Fire From the Data Presented in Figure 1 through Figure 6.

4. DURABILITY ANALYSIS

A tally of broken parts was also made for the same 224,000 rounds of firing with the following results:

- 6 broken extractor springs
- 2 broken bolt piston rings
- 1 damaged extractor spring
- 2 carrier key screws loosened
- 1 bolt cam pin showed excessive wear
- 1 rifle showed roughness on the bolt carrier guideways in the upper receiver

Excluded from the above count were handguards with loosened or missing rivets and one buffer pad damaged apparently by contact with the butt stock screw or the edges of the butt stock screw hole.

The broken or damaged parts were often not detected until the end of testing and were too few in number to be associated with specific rate levels.

5. SPECIAL MAGAZINE STUDY

Information was also requested concerning modifications made to the magazine springs of M16A1 rifles during a recently conducted phase of the Operational Reliability Study of M16A1 Rifles now in progress at MTD. The purpose of the modifications was to induce certain malfunctions in the M16A1 rifle and the magazine spring modifications demonstrated a marked insensitivity of the rifle system.

It was found that in order to insure a first-round failure to feed from a fully-loaded magazine, where the bolt moves forward from the compressed action spring after manual release, it was necessary to place three magazine springs in the magazine in contrast to the standard single spring. While this did consistently produce the desired first-round failure, it was found that once the round was manually assisted into the chamber the rifle would successfully fire all remaining rounds in the magazine.

In other trials in which feeding type failures were desired, segments of the standard single magazine spring were removed in order to provide inadequate cartridge follower response. In these trials it was found that consistent feeding failures would occur only after $3\frac{1}{2}$ of the 9 working coils of the spring were removed.

This information should be reviewed with considerable caution as only one rifle was used; the experimental trials were very few and no

dynamic cycling data (rate of fire, displacement-time records, etc.) were obtained. However, future work in this area requires modification of 100 magazines and each magazine will be test fired and a cyclic rate obtained.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Rifle, M16A1 Cyclic rate Weapon reliability Weapon durability Acceptance criteria						

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