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HERCULES POWDER COMPANY
INCORPORATED
KENVIL WORKS KENVIL, N.J.

Contract AF 04(647)-243
Exhibit "E"

PROGRAM PROGRESS
1 March 1963 through 31 August 1963
K-35/MR-100-4

WING II MINUTEMAN Reverse Thrust System
Weapon System 133A

Prepared by

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Prepared for

HEADQUARTERS
BALLISTIC SYSTEMS DIVISION
UNITED STATES AIR FORCE
Norton AFB, California

Report No. K-35/MR-100-4

Copy No. 00020

Date 31 October 1963

PROGRAM PROGRESS (U)
1 March 1963 through 31 August 1963
Wing II MINUTEMAN Reverse Thrust System
Weapon System 133A

Approved by

for J. S. Maurer
Project Manager

ABSTRACT

This document describes briefly the progress made from 1 March 1963 through 31 August 1963 on the Retro/Tumble Rocket Motor Program conducted under cognizance of Hercules Powder Company, Kenvil Works, Kenvil, New Jersey. The Retro Rocket Motor and Tumble Rocket Motor have been developed and fabricated for use in the Reverse Thrust System of the Wing II MINUTEMAN (Weapon System 133A).

During the period covered by this report, progress was documented by reports covering different aspects of the program. Information has been extracted from these documents for compilation into this progress report.

The body of this document consists of two sections: Section I, Schedules; and Section II, Narrative Summary. The schedules shown in Section I comprised the Milestone Schedules dated 15 September 1963 and were submitted to BSD/STL. Accomplished and unaccomplished targets for aspects of the program such as research and development, testing, production, operational milestones, and delivery dates are listed as they existed on 15 September 1963.

An explanation and discussion of the events scheduled in the Milestone Schedules are presented in the Narrative Summary, Section II, wherever information was available to expound or support accomplishments or slippages. Target slippages are discussed initially, then testing, component development, and reliability activities.

FOREWORD

This program progress report covers the work accomplished by Kenvil Works of Hercules Powder Company on the Wing II MINUTEMAN Reverse Thrust System Retro and Tumble Rocket Motors from 1 March 1963 through 31 August 1963.

This report has been prepared in compliance with Contract AF 04(647)-243, Exhibit "E" Work Statement Section V, Paragraph A, 1, 2.2, and has been compiled in conformance to Air Force Ballistic Exhibit 58-1.

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LIST OF FIGURES

SECTION I

SCHEDULES

SECTION I

SCHEDULES

A report is submitted monthly to BSD/STL to show targeted and accomplished milestones scheduled for the Retro/Tumble Program conducted at Kenvil Works.

The Milestone Schedules submitted in Kenvil Works report Milestone Schedules K-35/MR-400-20, dated 15 September 1963, are included in this section. Progress on the Retro/Tumble Program is condensed in the schedules and is developed more fully in Section II of this report.

Included also in this section are delivery schedules compiled from Kenvil Works records. Tabulated therein are the quantities of retro and tumble motors projected for delivery during this report period and the quantities of motors actually delivered.

See Section II, paragraph A for an explanation of milestone and delivery slippages.

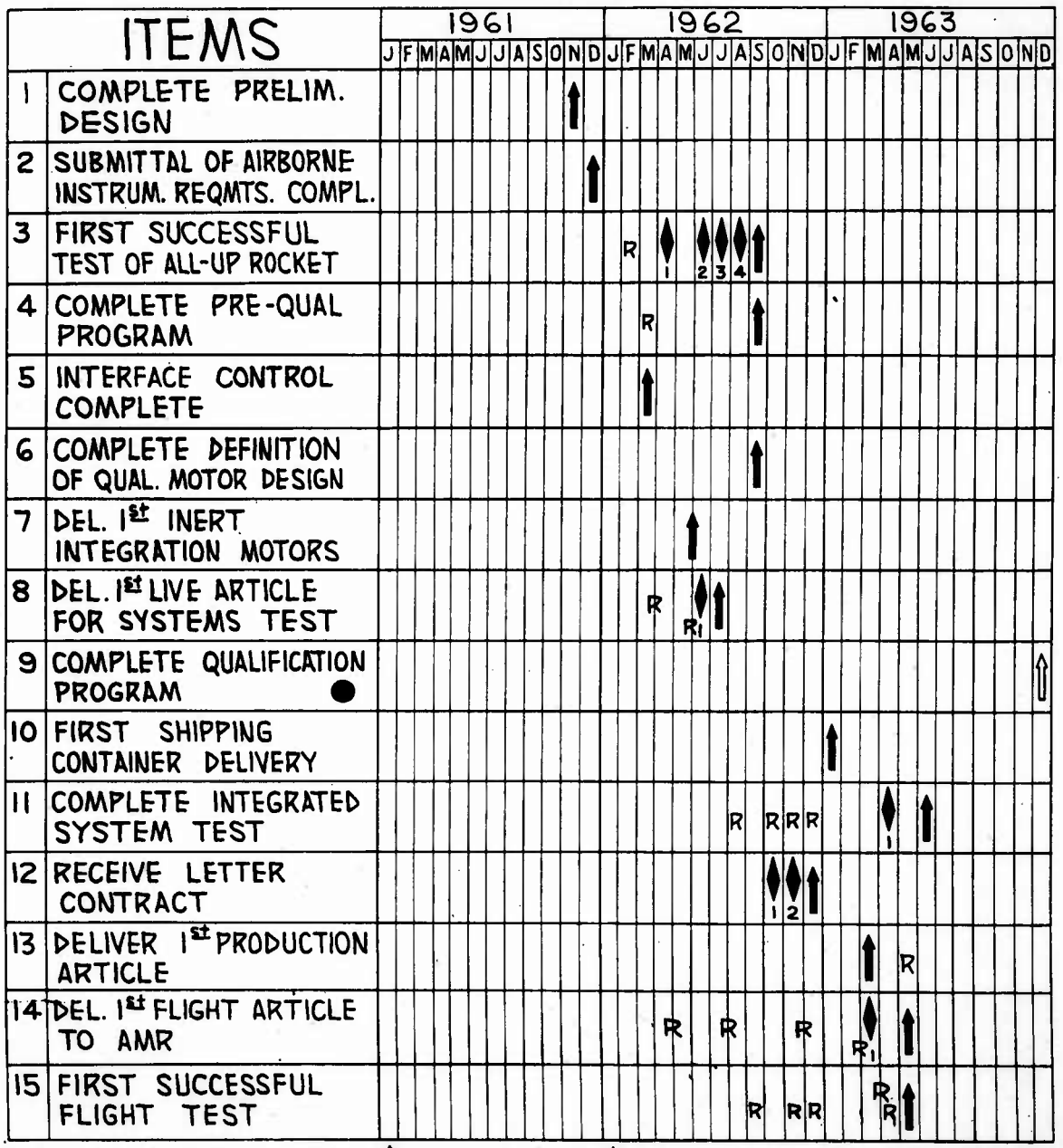
MILESTONE SCHEDULE

WING II

MINUTEMAN REVERSE THRUST SYSTEM

CONTRACT AF 04(647)-243 EXHIBIT "E"

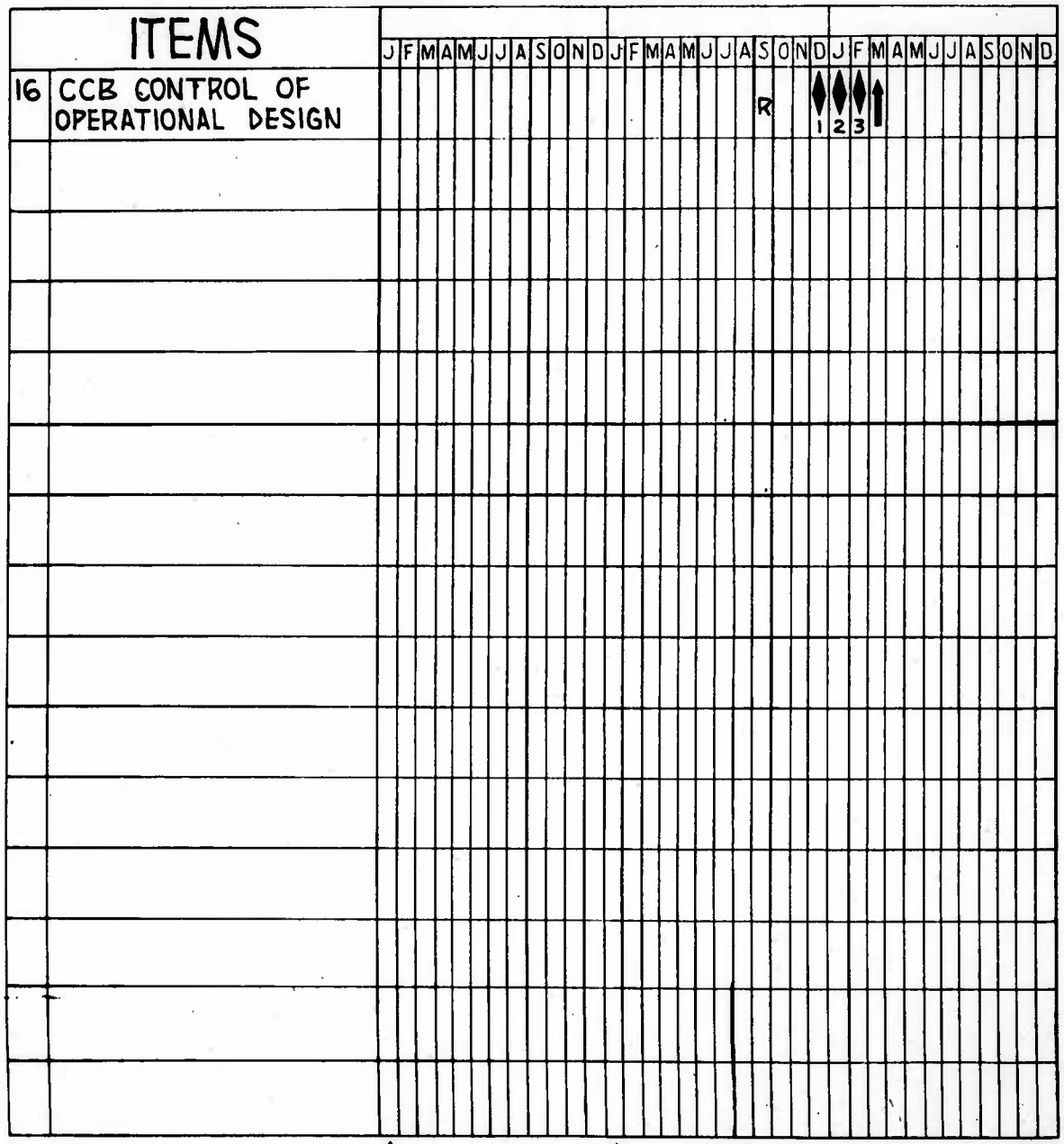
TIER I



MILESTONE SCHEDULE

WING II

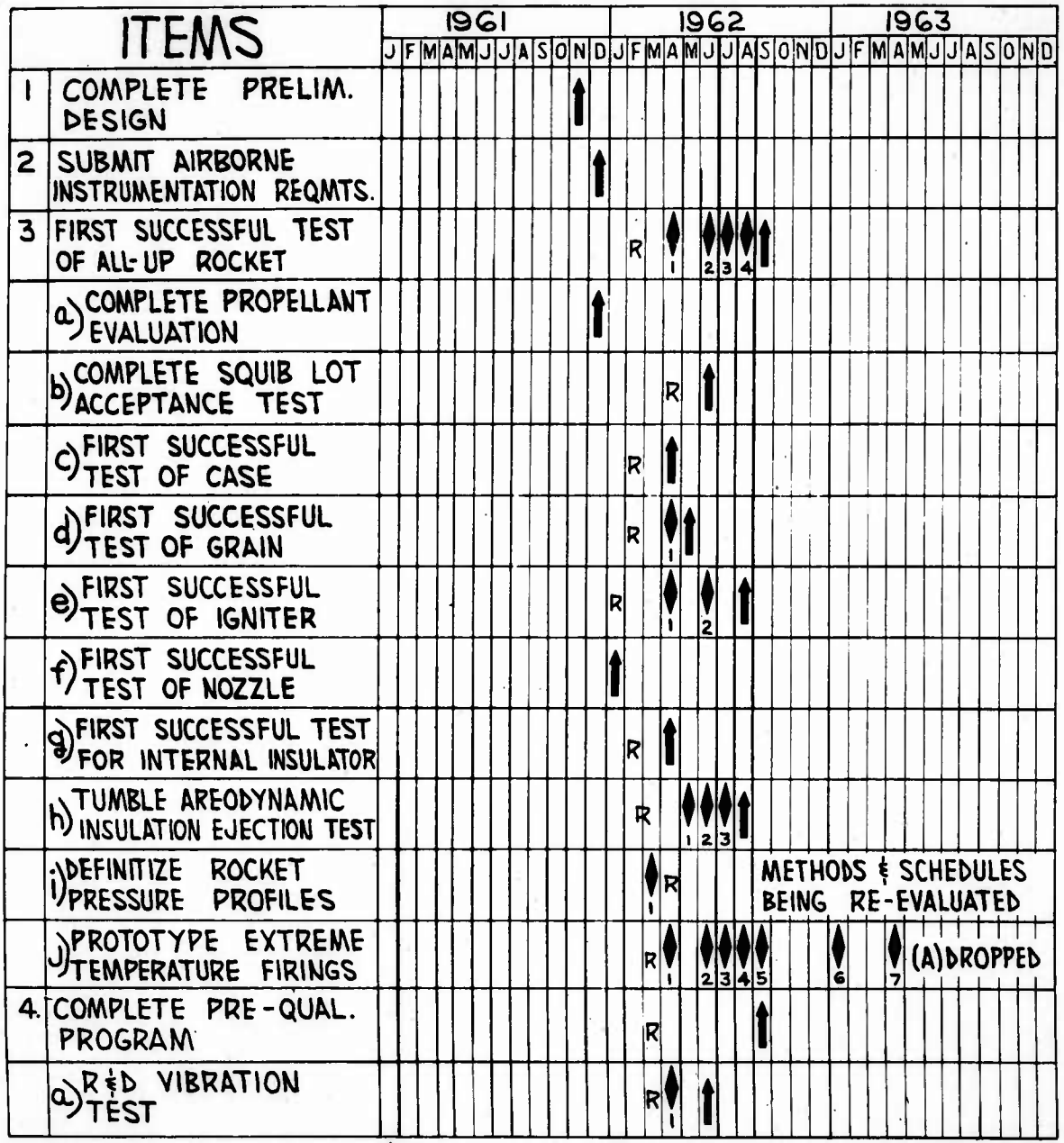
MINUTEMAN REVERSE THRUST SYSTEM CONTRACT AF 04(647)-243 EXHIBIT "E" TIER I (CONT.)



MILESTONE SCHEDULE

WING II

MINUTEMAN REVERSE THRUST SYSTEM
CONTRACT AF 04(647)-243 EXHIBIT "E"
TIER II



(A) REFERENCE T1 MEETING 6, MARCH 1963 AT SALT LAKE CITY, UATH

ACCOMPLISHED

TARGET DATE

SLIPPAGE

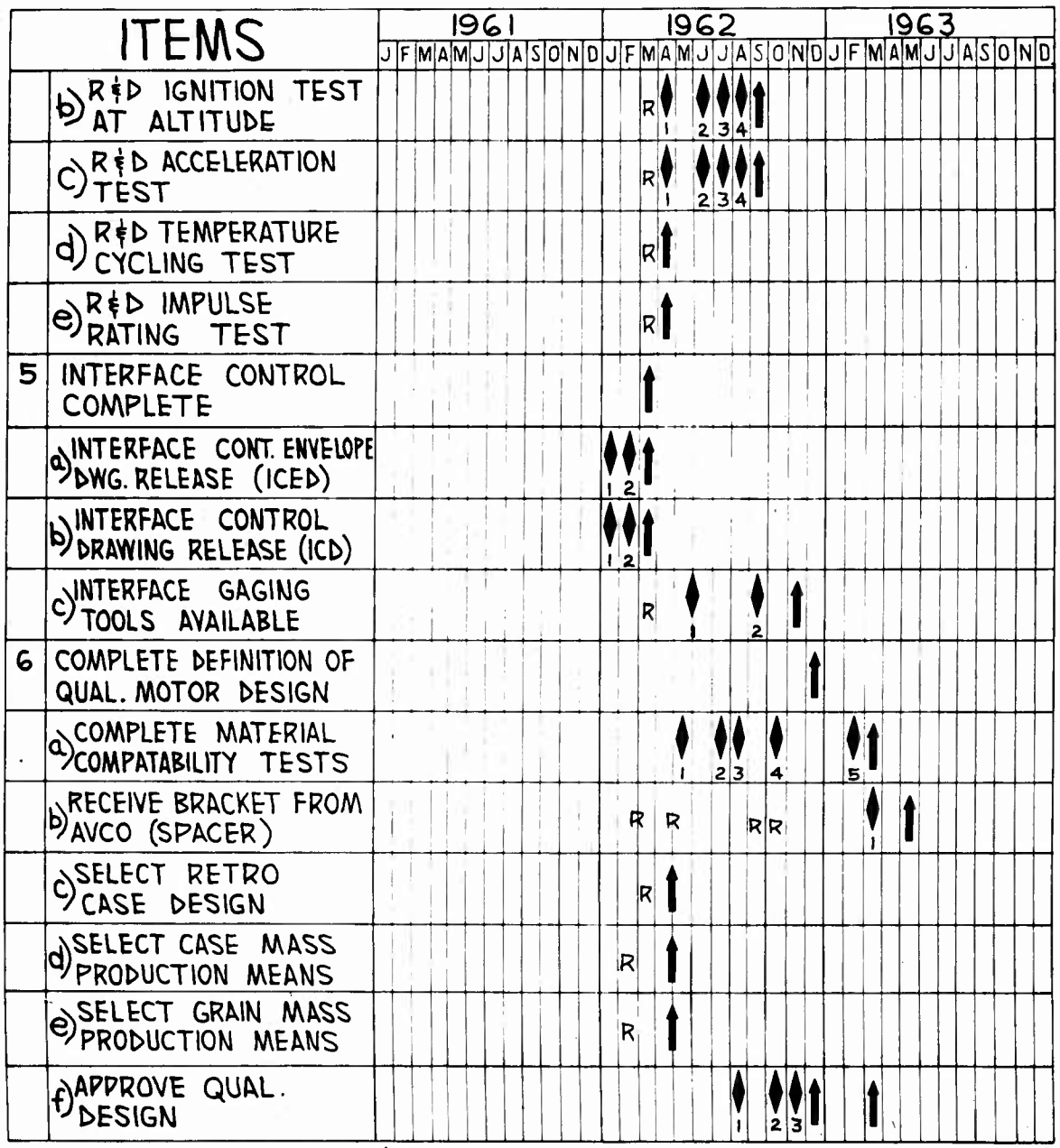
● CHANGE FROM LAST REPORT

R REDIRECTED

MILESTONE SCHEDULE

WING II

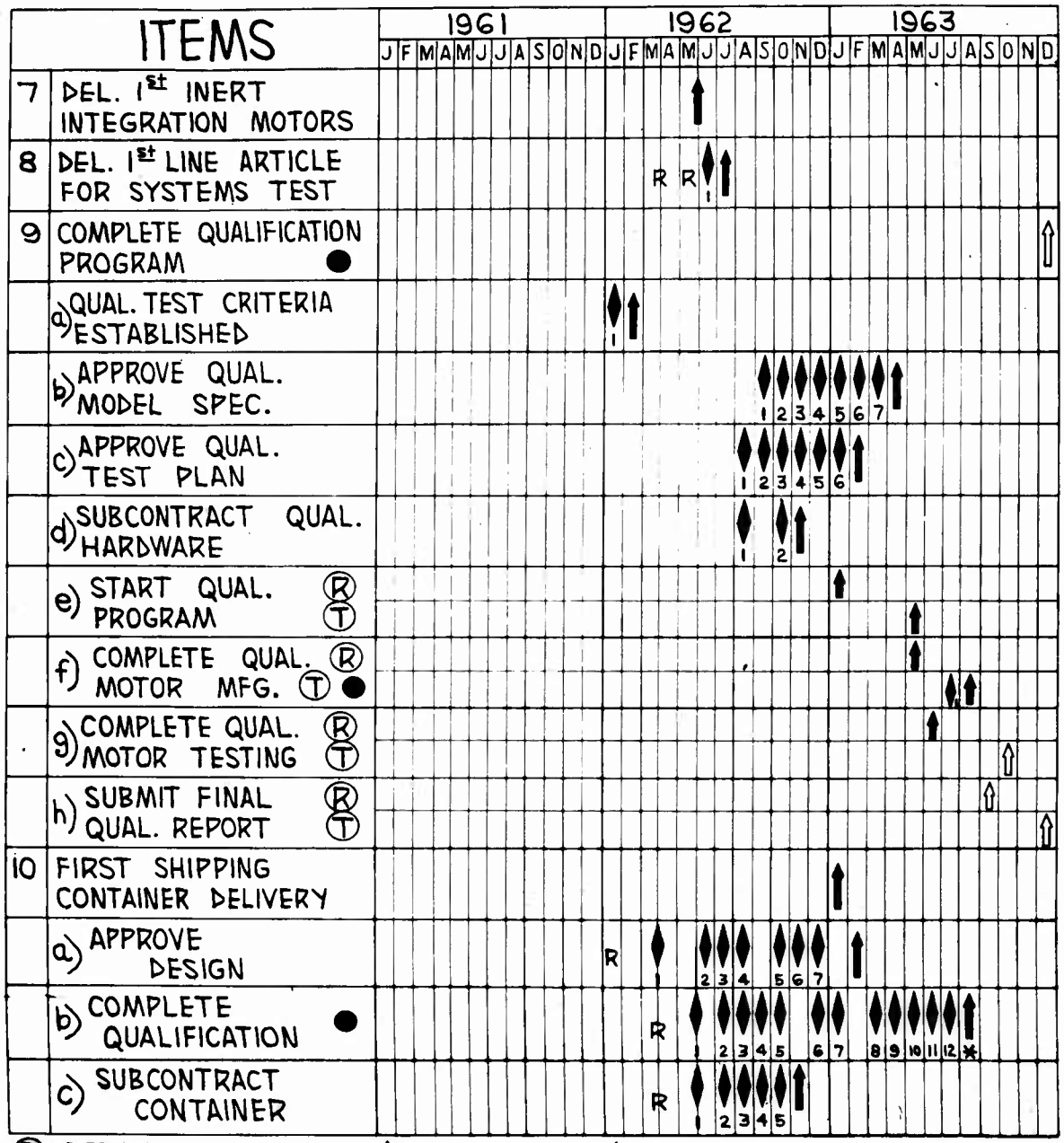
MINUTEMAN REVERSE THRUST SYSTEM
CONTRACT AF 04(647)-243 EXHIBIT "E"
TIER II (CONT.)



MILESTONE SCHEDULE

WING II

MINUTEMAN REVERSE THRUST SYSTEM
CONTRACT AF 04(647)-243 EXHIBIT "E"
TIER II (CONT.)



(R)- RETRO
(T)- TUMBLE
* RETRO SHIPPING CONTAINER QUAL. COMPLETED IN JULY 63

ACCOMPLISHED
TARGET DATE
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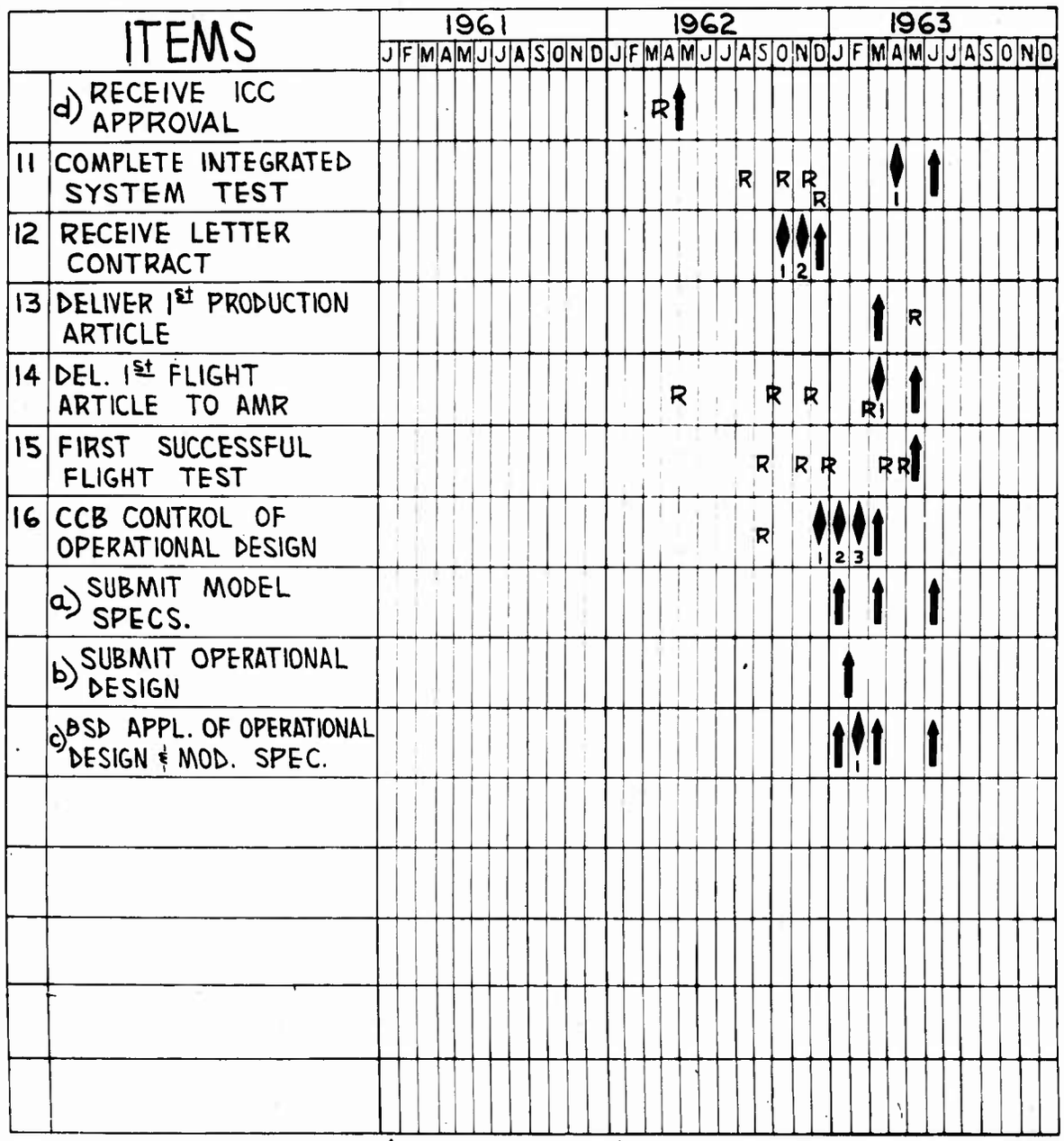
MILESTONE SCHEDULE

WING II

MINUTEMAN REVERSE THRUST SYSTEM CONTRACT AF 04(647)-243 EXHIBIT "E" TIER II (CONT.)



DELIVERY SCHEDULE

RETRO ROCKET MOTOR

PROJECTED / ACTUAL

MONTH	QUANTITY OF ROCKET MOTORS FOR DELIVERY						
	INERT UNIT	LIVE UNITS FOR SYSTEMS TEST	FLIGHT TEST	QUAL PROGRAM	AGING PROGRAM	SHIPPING CONTAINER QUAL	TOTAL FOR MONTH
MARCH	50 / 10	20 / 0	20 / 0	19 / 19	0 / 0	0 / 0	109 / 29
APRIL	10 / 10	0 / 0	20 / 30	26 / 0	0 / 0	0 / 0	56 / 40
MAY	0 / 20	0 / 20	20 / 20	0 / 26	0 / 9	0 / 1	20 / 96
JUNE	0 / 20	0 / 0	20 / 30	0 / 0	30 / 0	0 / 1	50 / 51
JULY	0 / 0	0 / 0	20 / 20	0 / 0	36 / 0	0 / 1	56 / 21
AUGUST	0 / 0	0 / 0	20 / 20	0 / 0	0 / 57	0 / 0	20 / 77
TOTAL	60 / 60	20 / 20	120 / 120	45 / 45	66 / 66	0 / 3	311 / 314

DELIVERY SCHEDULE

TUMBLE ROCKET MOTOR

PROJECTED / ACTUAL

MONTH	QUANTITY OF ROCKET MOTORS FOR DELIVERY						
	INERT UNIT	LIVE UNITS FOR SYSTEMS TEST	FLIGHT TEST	QUAL PROGRAM	AGING PROGRAM	SHIPPING CONTAINER QUAL	TOTAL FOR MONTH
MARCH	5 / 1	2 / 0	2 / 0	0 / 0	0 / 0	0 / 0	9 / 1
APRIL	1 / 1	0 / 0	3 / 3	75 / 0	0 / 0	0 / 0	79 / 4
MAY	0 / 2	0 / 2	2 / 2	0 / 16	0 / 9	0 / 0	2 / 31
JUNE	0 / 2	0 / 0	2 / 3	0 / 0	30 / 0	0 / 1	32 / 6
JULY	0 / 0	0 / 0	2 / 2	0 / 4	36 / 0	0 / 0	38 / 6
AUGUST	0 / 0	0 / 0	2 / 2	0 / 36	0 / 57	0 / 1	2 / 96
TOTAL	6 / 6	2 / 2	13 / 12	75 / 56	66 / 66	0 / 2	162 / 144

SECTION II

NARRATIVE SUMMARY

SECTION II

NARRATIVE SUMMARY

A. SLIPPAGE AREAS

During this report period it is evident from the schedules (see Section I) that certain Milestone items and Delivery Schedules show several instances of slippage.

1. Milestone Slippage

The explanations for Milestone Schedule slippages are submitted in Table I, below.

2. Motor Delivery Quantity Slippage

The Delivery Schedules (Section I) show a tabulation of the actual shipments versus the projected shipments for the Retro and Tumble Rocket Motors. This information is presented in graphic form in Figures 1 and 2, and shows more clearly the extent of slippage and subsequent improvement toward the end of the report period, as well as the relationship between the Delivery slippages and the Milestone slippages. Details concerning the reasons for slippages and subsequent completion of the major programs for the Retro and Tumble Rocket Motors are given in Table I, below.

TABLE I

EXPLANATION OF MILESTONE SLIPPAGES

Month	Milestone Item	Slippage	Retro	Tumble
March	1. Receive Bracket Hardware (Spacer) from Avco	Rescheduled - 4 times	Avco Corporation slipped their delivery schedule for the spacers. Since these units were to be sent to Bacchus, this was not a Kenvil Works problem.	
	2. Deliver First Flight Article for AMR	Rescheduled - 4 times Slipped - once	First Operational Motor deliveries were made in March. Due to a shortage of completed motors, FTM's were diverted to the Production Contract. Delay in finalization of the design package as well as a consequent delay in procuring igniters from the vendor contributed to the shortage of motors.	Same as Retro. Revision of the final Tumble igniter design contributed to the motor shortage.
	3. Approval of Qualification Model Specification	Slipped - 7 times	Submittal and approval of the Qualification Model Specification was delayed by a change in grain configuration and the consequent completion of ballistic data. Some delay also resulted from changes to the Retro mounting plate that involved the addition of studs. The Qualification Model Specification was verbally agreed upon by BSD/STL and HPC, but no written approval was obtained.	Same as Retro. In addition, some delay resulted from the inclusion of new Tumble R&D design changes on the igniter cable and plastic basket.

TABLE I - (Cont.)

Month	Milestone Item	Slippage	Retro	Tumble
March	4. Start Qualification Program	Slipped - 6 times	Retro Qualification motors were delivered in January and March.	Shortage of Tumble motors was due chiefly to the new Tumble igniter cable design and consequent delays in procurement from the vendor. Processing problems, igniter basket cracks, and design changes, as well as bond separation of insulator to case, also contributed to the motor shortage.
	5. Complete Motors for Qualification Program	Slipped - 3 times	Retro Qualification Program on schedule.	Shortage of motors - see item 4 for March.
	6. Complete Shipping Container Qualification	Rescheduled - once Slipped - 8 times	Delay in completing the Test Plan matrix.	Same as Retro
April	1. Prototype Extreme Temperature Firings	Rescheduled - Once Slipped - 6 times	This Milestone was dropped (reference TI Meeting, 6 March 1963, Salt Lake City, Utah).	Same as Retro
	2. Start Qualification	Slipped - 7 times	Retro program was in progress. Delay in test firing program due to check-out at the Kenvil Works range, and tight test schedules at AEDC.	Motor shortage due to new cable design and consequent delays in procurement of igniters from vendors. Delay in approval of Model Specification was also a factor. Priority was given to the Operational Motors.

TABLE I - (Cont.)

Month	Milestone Item	Slippage	Retro	Tumble
April	3. Complete Motors for Qualification Program	Slipped - 4 times	Priority given to Operational Motors. Shortage of motors due to lack of Retro nozzles and igniter assemblies.	See item 2 for April
	4. Complete Shipping Container Qualification	Rescheduled - once Slipped - 9 times	Shortage - see item 3 for April. Delay in completion of test plan matrix.	Same as item 2 for April
	5. Complete Integrated Systems Tests	Rescheduled - 4 times Slipped - once	Due to delay in receipt of Avco Corporation Spacer by HPC at Bacchus.	Same as Retro
May	1. Complete Motors for Qualification Program	Slipped - 5 times	Retro motors complete.	Shortage of motors due to lack of Tumble igniters with new cable design.
	2. Complete Shipping Container Qualification	Rescheduled - once Slipped - 10 times	Delay in completion of Test Plan. De-emphasized motor manufacturing rating: Production - 1, FTM - 2, Qualification - 3, Shipping Container Qualification - 4	Same as Retro
June	1. Complete Shipping Container Qualification	Rescheduled - once Slipped - 11 times	De-emphasized motor manufacturing rating (see item 2 for May).	Same as Retro
	2. Complete Motors for Qualification Program	Slipped - 6 times	Retro motors complete	Shortage of motors due to: (1) lack of acceptable grains resulting from use of wrong base powder, and (2) bent Tumble core rod.

TABLE I - (Cont.)

Month	Milestone Item	Slippage	Retro	Tumble
July	1. Complete Motors for Qualification Program	Rescheduled - once Slipped - 5 times	Program completed for Retro Rocket Motor.	Shortage of motors due to (1) wrong base powder in Tumble grains, and (2) required resolution of Tumble X-Ray Specification Acceptable Criteria. Tumble test matrix revised from 75 to 56 motors.
August	No Slippages		Production capacity increased to meet peak load.	Same as Retro. Many motors made available thru release of X-Ray Specification.

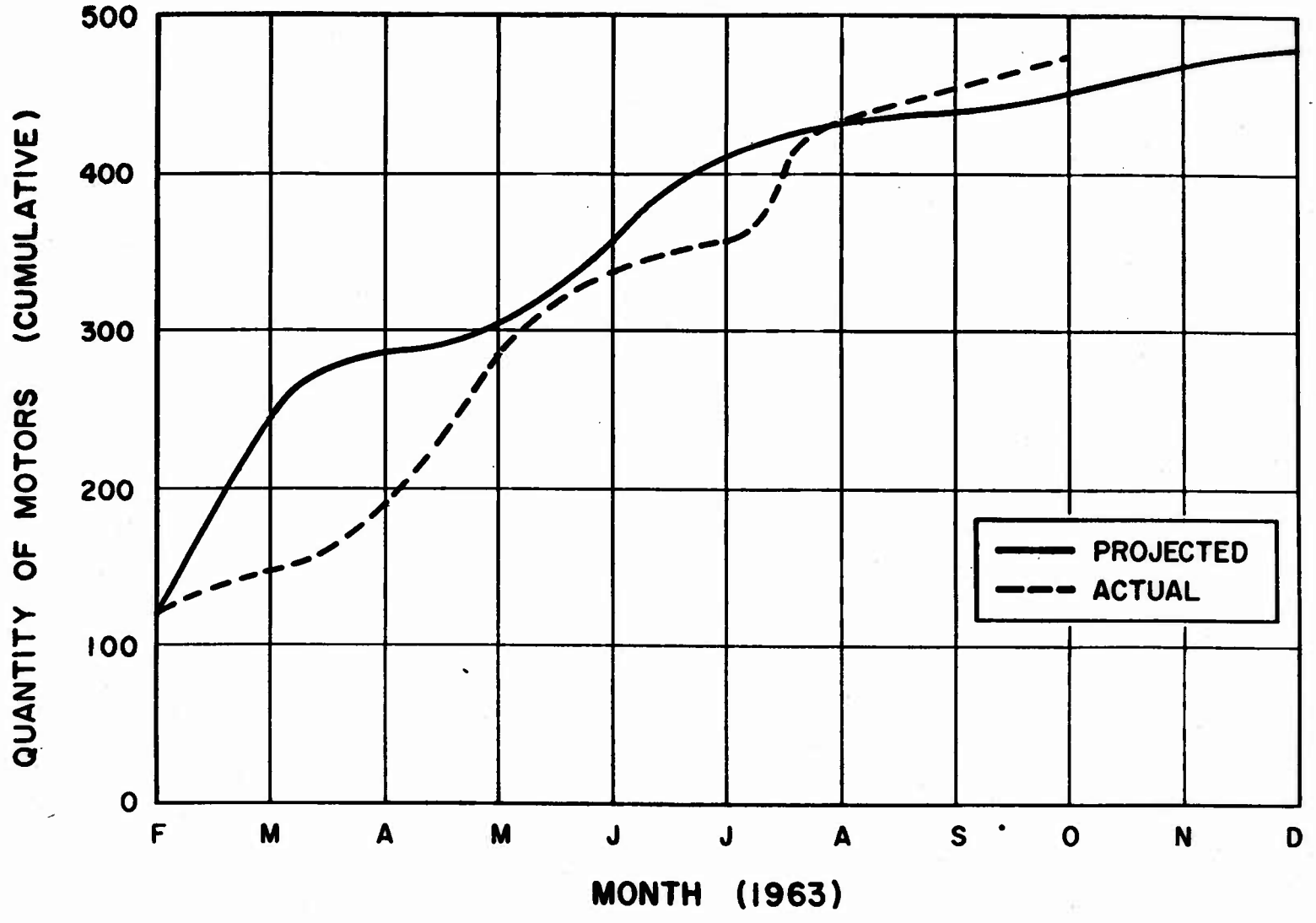


Figure 1. Retro Rocket Motor Projected and Actual Deliveries (Cumulative)

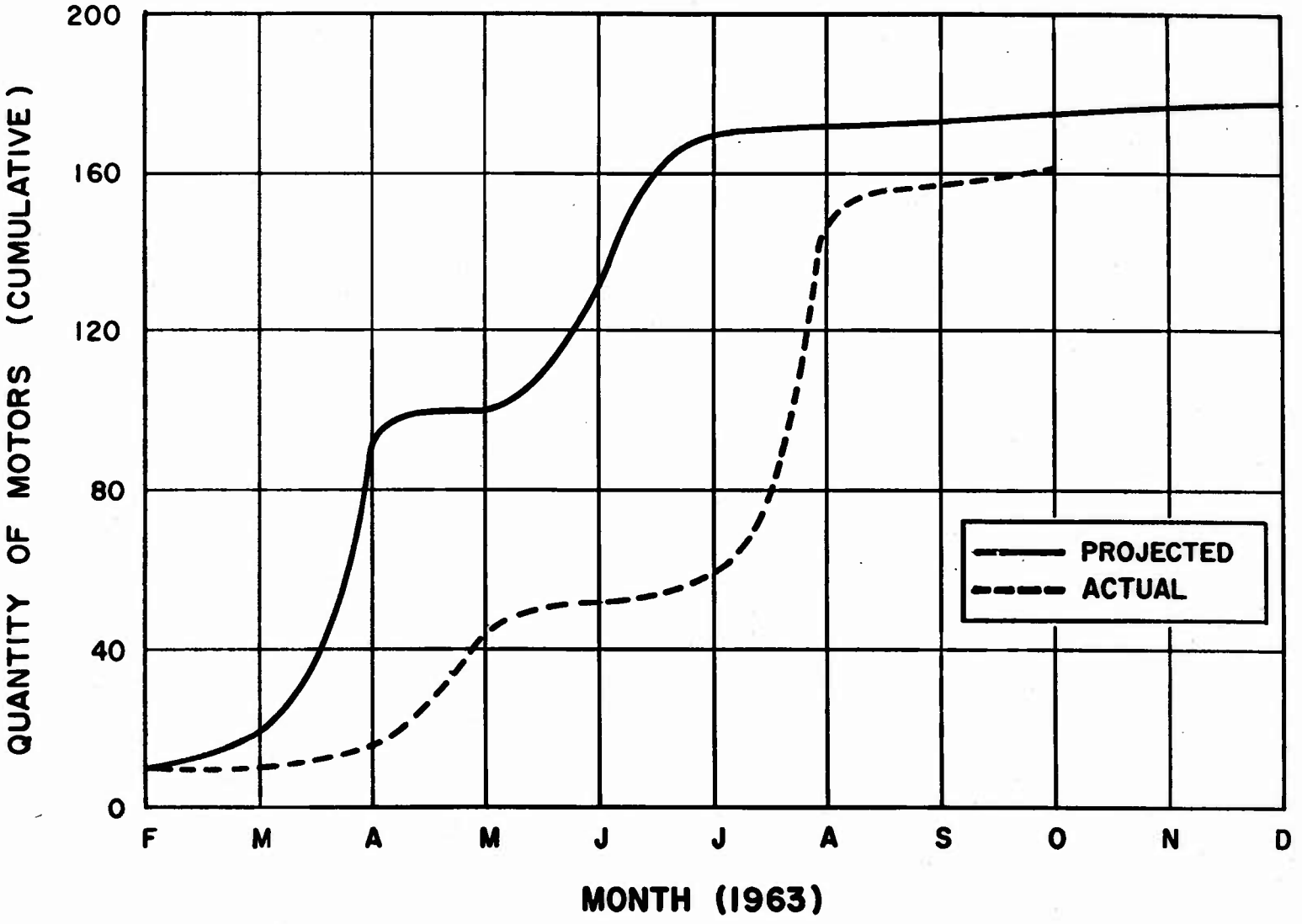


Figure 2. Tumble Rocket Motor Projected and Actual Deliveries (Cumulative)

B. TESTING

During this report period Retro and Tumble Rocket Motors were subjected to static firing tests, hydroburst tests, and igniter tests. Several systems tests were conducted at the Atlantic Missile Range, Cape Canaveral, Florida, and at Vandenberg Air Force Base, California. Contained herein is an account of the results of those tests conducted during this period.

Static Firing Tests

Static firing tests were conducted to determine ballistic properties, ignition characteristics, and inert component evaluation. Parameters recorded were chamber pressure, axial thrust, case strain, case temperature, and ignition current values. High-speed motion pictures and still photographs of tests provided graphic records in support of test data. Results of the tests were reported monthly and are summarized below.

Hydroburst Tests

Hydroburst tests were conducted to evaluate the structural limits of the motor case, to determine mode of case failure, and to provide data for calculation of case safety factors. Each Retro Rocket Motor was pneumatic-tested and each Tumble Rocket Motor case was hydrotested prior to hydroburst testing. The hydroburst test was performed by forcing water into the motor (Retro) or case (Tumble) at the rate of 100 ± 10 psi/sec until the unit burst. Maximum pressures were recorded with the aid of pressure sensors.

Igniter Tests

Igniters for the Retro and Tumble Rocket Motors were static fired in igniter test chambers (ITC) which simulated the void volumes of the respective rocket motors by the use of aluminum (Retro) and inert grain material (Tumble) in the configuration of the live grain. All tests were conducted under ambient atmospheric conditions at Kenvil Works. Continuous test records of pressure-time data were recorded on oscillograph recorders.

Special Tests

Any tests performed on the Retro or Tumble Rocket Motors during this report period which did not come under the specific static firing, hydroburst, or igniter test categories are reported, for the purpose of this document, as special tests.

1. March 1963

During the month of March 25 Retro and 12 Tumble Rocket Motors were static fired, 24 Retro and two Tumble igniters were tested, and two Retro and three Tumble Rocket Motors were hydroburst. Four special tests were conducted on the Retro Rocket Motor. The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-17, dated 15 April 1963.

a. Retro Rocket Motor

1) Static Firing Tests

Twelve Retro Rocket Motors were static fired to evaluate blends of Casting Powder Lot K-15 for burning rate parameters and ballistic performance. A secondary objective of these tests was to evaluate the performance of the inert components of the rocket motor. Of the 12 motors tested, three had been previously observed to leak during pneumatic testing. Those three were therefore excluded from Demonstrated Reliability computations, and the resultant test data was excluded from the K-15 blend analysis. The other nine motors exhibited no unusual characteristics before, during, or after static firing.

Two Retro Rocket Motors were static fired to evaluate Casting Powder Lot K-15 in its pure state for burning rate parameters and ballistic performance. Both motors were successfully fired.

Two Retro Rocket Motors were static fired in a Multiple Rocket Firing Unit (MRFU) to satisfy Qualification Program test requirements. The objectives of this checkout test was to ensure the efficient operation of the MRFU as well as to evaluate the ballistic performance of the individual motors. Test results revealed that the MRFU performed satisfactorily.

Eight Retro Rocket Motors were static fired singly in compliance with the Qualification Test Plan. These tests appeared to yield satisfactory results. The Reliability section of Quality Assurance at Kenvil Works later evaluated all eight of these tests as successes, and included them in their Demonstrated Reliability studies.

One Retro Rocket Motor was static fired to evaluate any possible damage that may have occurred as the result of a drop-and-quick-leak test performed on the shipping container assembly in which the motor had been housed. The shipping container had been drop tested at -30 degrees F and quick-leak tested in +120 degree F water. Results of the subsequent static firing test appeared satisfactory, and were later substantiated as successful by Reliability.

2) Hydroburst Tests

Two Retro Rocket Motors were hydroburst in March. Both motors exceeded the minimum acceptable burst pressure of 2270 psig at +70 ± 10 degrees F and were considered successfully tested.

3) Igniter Tests

The 24 Retro igniter tests were conducted for the purpose of qualifying igniter lots for acceptance by Kenvil Works. All 24 igniters appeared to fire successfully.

4) Special Tests

Three Retro Rocket Motors were subjected to case expansion tests. These tests were performed to determine whether the Retro case had sufficient expansion room between the forward dome and the floating studs of the mounting plate. Performed in conjunction with the regular pneumatic tests, at 1400 psi proof pressure, the expansion tests yielded movement of 0.0075 inch, 0.0105 inch, and no measurable expansion respectively for the three motors. It was concluded that no interference problems were encountered during case pressurization, although it was suggested that future tests be conducted to further investigate Retro case expansion.

One Retro Rocket Motor underwent a special test to determine the chamber pressure at which the nozzle closure was ejected from the exhaust nozzle. The test was performed on modified pneumatic testing apparatus fitted with a timing device.

The test results were not conclusive, and it was determined that additional testing would be required to ascertain more accurately the pressure value of nozzle closure ejection.

b. Tumble Rocket Motor

1) Static Firing Tests

Two Tumble Rocket Motors were static fired as part of the Quality Assurance program for the first Qualification buy-off. Both motors fired successfully, and the buy-off group of Tumble Rocket Motors was accepted. Both motors were included in Demonstrated Reliability computations.

Ten Tumble Rocket Motors were static fired to evaluate blends of Casting Powder Lot K-15; five for Blend I and five for Blend II. Blend I consists of 80 percent K-15 and 20 percent Radford SR-102-62 (product of Radford Ordnance Works, Radford, Virginia). Blend II consists of 60 percent K-15 and 40 percent Radford SR-102-62. The objectives of these tests were to determine burning time-pressure relationships and ballistic performance of Blend I and Blend II. The rocket motors appeared to fire satisfactorily, but the test results were excluded from Reliability analyses.

Two Tumble Rocket Motors were static fired in a Multiple Rocket Firing Unit (MRFU) checkout test to ensure efficient operation of the MRFU as well as to evaluate the ballistic performance of the individual motors. The test was conducted at Arnold Engineering Development Center (AEDC), Tullahoma, Tennessee. Both motors were successfully fired; and the specific objectives of the test were accomplished.

2) Hydroburst Tests

Nine Tumble Rocket Motor cases were hydroburst in March. All nine cases exceeded the minimum acceptable burst pressure of 3100 psia at +70 ± 10 degrees F and were considered successfully tested.

3) Igniter Tests

Two Tumble igniter tests were conducted to qualify an igniter lot for acceptance by Kenvil Works and to obtain required ballistic data. Both igniters appeared to fire successfully, and the lot was accepted for use.

2. April 1963

During the month of April 31 Retro and three Tumble Rocket Motors were static fired, three Retro Rocket Motors were hydroburst, and 25 Retro and Two Tumble igniters were tested. The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-18, dated 15 May 1963. No Tumble Rocket Motor cases were hydroburst in April.

a. Retro Rocket Motor

1) Static Firing Tests

Three Retro Rocket Motors were static fired to qualify three Flight Test Motor (FTM) lots for Air Force acceptance. The tests were successful and all three lots were accepted for use. These tests were included in the Demonstrated Reliability studies.

Four Retro Rocket Motors were static fired to evaluate the Ballistic Data Acquisition System at Kenvil Works "A" Range. Test data evaluation indicated that the equipment used in the Kenvil Works "A" Range Data Acquisition System provide data accurate to one percent or less. Results of these tests indicated that optimum accuracy was obtained when the rocket motors were static fired in a vertical position. All four tests were classified by Reliability as successful, and one test was included in Demonstrated Reliability computations.

One Retro Rocket Motor was static fired to evaluate Casting Powder Lot K-15 in March (see paragraph B.1.a.1). Insufficient test data due to an instrument or equipment malfunction caused this motor to be excluded from Reliability evaluation.

Twenty-three Retro Rocket Motors were static fired in Qualification tests at Kenvil Works and at Allegany Ballistics Laboratory (ABL), Cumberland, Maryland. Twenty-one motors fired successfully. Two motors did not meet performance requirements. Each exceeded the Qualification Model Specification upper limit on thrust-time curves.

2) Hydroburst Tests

Three Retro Rocket Motors were hydroburst in April. All three motors exceeded the minimum acceptable burst pressure of 2270 psig at +70 ± 10 degrees F and were considered successfully tested.

3) Igniter Tests

Twenty-three Retro igniters were fired to qualify five igniter lots for use by Kenvil Works. All igniters appeared to fire successfully, and the lots were accepted for use.

Two Retro igniters were fired while exposed to the atmosphere to observe the physical characteristics of ignition through the use of high-speed motion picture equipment.

b. Tumble Rocket Motor

1) Static Firing Tests

Three Tumble Rocket Motors were static fired to qualify three FTM lots for Air Force acceptance. The tests were successful and all three lots were accepted for use. These tests were included in the Demonstrated Reliability studies.

2) Igniter Tests

Two Tumble igniters were fired to qualify an igniter lot for use at Kenvil Works. Both igniters appeared to fire successfully, and the lot was accepted.

3. May 1963

During the month of May five Retro and two Tumble Rocket Motors were static fired, 10 Tumble cases were hydroburst, and 12 Retro and four Tumble igniters were tested. In addition 40 Retro and four Tumble Rocket Motors underwent systems tests (described under Special Tests, below). The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-19, dated 15 June 1963. No Retro Rocket Motors were hydroburst in May.

a. Retro Rocket Motor

1) Static Firing Tests

Two Retro Rocket Motors were static fired to qualify a buy-off group for Qualification, and two motors were static fired to qualify two FTM lots for Air Force acceptance. All four static tests were successful, and the lots were accepted for use. The four motors tested were included in Demonstrated Reliability studies.

One Retro Rocket Motor was static fired as part of the shipping container qualification test. Although subsequent shipping container tests were neccessary to evaluate the results in compliance with the Qualification Test Plan, it was determined from this test that the static firing was satisfactory, and that the shipping container provided adequate protection of the motor. This test was included in Demonstrated Reliability computations.

2) Igniter Tests

Eight Retro igniters were fired to qualify two igniter lots for use by Kenvil Works. All igniters appeared to fire successfully.

Four igniters were fired outside the ITC at ambient conditions to observe physical ignition characteristics with the aid of high speed motion pictures. Analysis of the four resultant films provided a basic for comparison with average ballistic results, and indicated, in conjunction with contemporaneous slow-pressure-rise igniter tests, that the ability of the igniter to provide reproducible ignition should be more thoroughly analyzed. A program plan for continued investigation was subsequently submitted to BSD/STL.

3) Special Tests

Forty Retro motors underwent thrust reversal systems tests. Four systems, consisting of 10 motors each, were tested at Vandenberg AFB, California; Atlantic Missile Range (AMR), Cape Canaveral, Florida; and Hercules Powder Company, Bacchus Works, Magna, Utah (two systems). Two systems underwent flight tests at AMR and Vandenberg AFB; and at Bacchus Works one system underwent an altitude control test and the other was tested for ground level integrity. The results of these tests indicated that all Retro Rocket Motors used in the systems fired successfully.

b. Tumble Rocket Motor

1) Static Firing Tests

Two Tumble Rocket Motors were static fired to qualify two FTM lots. Both motors fired successfully, and the lots were accepted.

2) Hydroburst Tests

Ten Tumble Rocket Motor cases were hydroburst in May. All tests were successful, each case exceeding the minimum acceptable burst pressure of 3100 psia at +70 ± 10 degrees F.

3) Igniter Tests

Four Tumble igniters were tested to qualify an igniter lot for use by Kenvil Works. All four igniters appeared to fire successfully.

4) Special Tests

Four Tumble Rocket Motors were tested as part of four thrust reversal systems tested at Vandenberg AFB, AMR, and Bacchus Works. Two systems underwent flight tests, one underwent an altitude control test, and one system was tested for ground level integrity. All four Tumble Rocket Motors appeared to fire successfully.

4. June 1963

During the month of June 50 Retro and four Tumble Rocket Motors were static fired, six Retro igniters were tested, and seven Tumble cases were hydroburst. In addition, one Tumble and 10 Retro Rocket Motors were fired in a thrust reversal system test (described under Special Tests, below). The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-20, dated July 15, 1963. No Retro hydroburst tests or Tumble igniter tests were conducted in June.

a. Retro Rocket Motor

1) Static Firing Tests

Forty-one Retro Rocket Motors were static fired at Arnold Engineering Development Center (AEDC), Tullahoma, Tennessee, and three were static fired at Allegany Ballistic Laboratory (ABL), Cumberland, Maryland in compliance with the Qualification Test Plan K-35/MR-82, Rev. 2. Three of the 44 motors tested failed, one due to low total impulse, one because of excessive action time, and one due to burn-through of the case.

The results of the remaining 41 tests were successful. All 44 motors tested were included in Demonstrated Reliability studies.

Three Retro Rocket Motors were static fired to evaluate X-Ray procedure and criteria as part of the Retro Rocket Motor Continued Development Program. These three motors were not included in Demonstrated Reliability computation.

One Retro Rocket Motor was static fired subsequent to a shipping container assembly test, which was conducted in accordance with the Qualification Test Plan. The motor fired satisfactorily, and its ballistic performance once was in no way affected by the previous tests on the shipping container assembly.

Two Retro Rocket Motors were static fired at AEDC to ensure correct preparation of the MRFU apparatus for Qualification testing. Both motors appeared to fire satisfactorily.

2) Igniter Tests

Five Retro igniters were tested to qualify an igniter lot for acceptance by Kenvil Works. All five igniters appeared to fire successfully.

One Retro igniter was static fired to study the effect of impact on the pellet and charge containers, and to determine to what extent the squib contributes pressure during ignition. The results of this test are being analyzed and are not immediately available.

3) Special Tests

Ten Retro Rocket Motors were fired as part of a thrust reversal system in a test of the system at AMR. Present available information indicates that the 10 motors used in the system fired successfully.

b. Tumble Rocket Motor

1) Static Firing Tests

Two Tumble Rocket Motors were static fired to evaluate X-Ray procedure and criteria as part of the Tumble Rocket Motor Continued Development Program. These motors were not included in Demonstrated Reliability studies.

One Tumble Rocket Motor was fired subsequent to, and as part of, a shipping container assembly test, which was conducted in accordance with the Qualification Test Plan. The assembly had been conditioned at +150 degrees F and then drop tested. A quick-leak test followed in +83 degrees F water. The motor was then removed from the container, conditioned at +70 degrees F, and then static fired. Results of the static firing showed that the test was successful, the shipping container tests in no way affecting the ballistic performance of the motor.

One Tumble Rocket Motor was static fired on an MRFU at AEDC as a final shakedown of the Qualification testing apparatus. The motor appeared to fire satisfactorily, and the MRFU was judged adequate for the Qualification Test Program.

2) Hydroburst Tests

Seven Tumble Rocket Motor cases were hydroburst in June. All seven cases exceeded the minimum acceptable burst pressure of 3100 psia at +70 ± 10 degrees F.

3) Special Tests

One Tumble Rocket Motor was fired as part of a thrust reversal system in a test of the system at AMR. The motor apparently fired successfully.

5. July 1963

During the month of July one Retro and four Tumble Rocket Motors were static fired, five Retro and 12 Tumble igniters were tested, and seven Tumble cases were hydroburst. In addition, 30 Retro and 3 Tumble Rocket Motors were static fired in thrust reversal systems tests (described under Special Tests, below). The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-21, dated 15 August 1963. No Retro Rocket Motors were hydroburst in July.

a. Retro Rocket Motor

1) Static Firing Tests

One Retro Rocket Motor was static fired subsequent to, and as part of, a shipping container assembly test, which was conducted in accordance with the Qualification Test Plan. Results of the static firing showed that test was a success. The shipping container tests did not affect the ballistic performance of the motor.

2) Igniter Tests

Five Retro igniters were tested to qualify two igniter lots for acceptance by Kenvil Works. However, due to an instrumentation error during one of the tests, another test had to be conducted in August. With this substitution both igniter lots were accepted.

3) Special Tests

Thirty Retro Rocket Motors underwent tests as part of three thrust reversal system flight tests conducted at AMR, Cape Canaveral, Florida. The Retro Rocket Motors in two of the systems tested appeared to fire in a satisfactory manner. The flight test missile in which the third thrust reversal system was employed was destroyed because of a malfunction during first-stage ignition. Therefore, no test data for that system could be obtained.

b. Tumble Rocket Motor

1) Static Firing Tests

Four Tumble Rocket Motors were static fired at AEDC in compliance with the Qualification Test Plan. All four motors appeared to fire in a satisfactory manner.

2) Igniter Tests

Five Tumble igniters were static fired in an ITC to qualify one igniter lot, and seven Tumble igniters were static fired in an ITC to qualify another igniter lot. All igniters appeared to fire successfully, and both lots were accepted for use by Kenvil Works.

3) Hydroburst Tests

Seven Tumble Rocket Motor cases were hydroburst in July. All seven cases exceeded the minimum acceptable burst pressure of 3100 psia at +70 ± 10 degrees F.

4) Special Tests

Three Tumble Rocket Motors were tested in Flight Test Missiles as part of three thrust reversal systems. These system tests were conducted at AMR. The two motors used in two of the three systems tested appeared to fire successfully. One Flight Test Missile was destroyed because of a malfunction during first stage burning. No data could therefore be obtained on the thrust reversal system of that missile.

6. August 1963

During the month of August seven Retro and eight Tumble Rocket Motors were static fired, 10 Retro and 14 Tumble igniters were tested, and four Retro Rocket Motors were hydroburst. In addition, 20 Retro and two Tumble Rocket Motors were fired in thrust reversal systems tests on Flight Test Missiles at AMR (see Special Tests below). The data derived from these tests is described in more detail in Monthly Test Results K-35/MR-300M-22, dated 15 September 1963. No Tumble cases were hydroburst in August.

a. Retro Rocket Motor

1) Static Firing Tests

Four Retro Rocket Motors were static fired for quality assurance purposes and to complete the ballistic performance requirements for acceptance of one lot of Aging Program motors (one motor tested), and to qualify another lot for use in the Aging Program (three motors tested). All four motors were successfully fired, and both lots were accepted for use in the Aging program.

Three motors were static fired to evaluate the procedure for the repair of forward grain obturation defects in Retro Rocket Motors. These three motors were successfully fired. It was concluded that the repair of forward grain obturation defects did not affect the ballistic performance of any of the three motors tested.

2) Igniter Tests

Ten Retro igniters were static fired in an ITC for quality assurance and to qualify three igniter lots for acceptance by Kenvil Works. All igniters fired successfully, and the three lots were accepted for use.

3) Hydroburst Tests

Four Retro Rocket Motors were hydroburst for quality assurance and to satisfy case integrity performance requirements for the acceptance of two motor lots for use in the Aging Program. The objectives were to exceed minimum burst pressures and to obtain burst pressure values to be used in determination of case safety factors. All motors tested exceeded the minimum acceptable burst pressure of 2270 psia at +70 ± 10 degrees F and completed the case integrity performance requirements for both Aging Program lots.

4) Special Tests

Twenty Retro Rocket Motors were fired as part of two thrust reversal system tests in two Flight Test Missiles at AMR. All 20 motors appeared to have fired successfully.

b. Tumble Rocket Motor

1) Static Firing Tests

Six Tumble Rocket Motors were static fired for quality assurance and to complete ballistic performance requirements for acceptance of five motor lots to be used in the Aging Program. All motors fired successfully and produced satisfactory ballistic performance results.

One Tumble Rocket Motor was static fired subsequent to, and as part of a shipping container assembly test. The shipping container was drop tested, leak tested, and then the motor was removed from the container and fired to determine whether the container provided adequate protection for the motor. The results of this test indicated that the performance of the motor was satisfactory, and that the shipping container had adequately protected the motor.

One Tumble Rocket Motor was static fired in conformance with the Qualification Test Plan. The motor had been scheduled to be temperature conditioned at +60 degrees F prior to testing, but in reality was temperature conditioned at +80 degrees F for four hours before static firing. A change in the designation of this test was therefore requested, and was approved by BSD/STL. The motor fired successfully in the +80 degrees F temperature conditioned category.

2) Igniter Tests

Fourteen Tumble igniters were static fired in an ITC for quality assurance and to satisfy ballistic performance requirements for the acceptance of two igniter lots. All 14 igniters fired successfully, and both lots were accepted by Kenvil Works.

3) Special Tests

Two Tumble Rocket Motors were fired as part of two thrust reversal system tests in two Flight Test Missiles at AMR. Both motors appeared to have fired successfully.

C. COMPONENT DEVELOPMENT

During this report period there were only three major design changes - one on the Retro Rocket Motor, and two on the Tumble Rocket Motor. As production of these motors increased under the AF 04(694)-302 Contract, the R&D effort had passed its peak and was declining. Most of the component development had been accomplished previously, and is covered in three previous documents, entitled Program Progress, K-35/MR-100-1, dated 1 September 1961 through 28 February 1962; K-35/MR-100-2, dated 1 March 1962 through 31 August 1962; and K-35/MR-100-3, dated 1 September 1962 through 28 February 1963. Most of the Retro/Tumble activity from 1 March 1963 through 31 August 1963 was in the Production phase. The following paragraphs, accompanied by supporting illustrations, outline those design changes incorporated in this period.

1. Retro Rocket Motor

Brief mention was made in the Supplement to Program Progress K-35/MR-100-3, dated 1 September 1962 through 28 February 1963, about a proposed design change on the Retro Rocket Motor igniter cable. The design change was disapproved at that time, but has since been approved.

The igniter cable used up to this time consisted of a twisted, shielded pair of wires insulated with a fluorocarbon plastic and covered with glass yarn impregnated with a fluorocarbon. This particular outside covering of glass yard impregnated with fluorocarbon had an extreme tendency to fray and abrade in normal handling. In an effort to solve this problem, a new cable was designed which was similar to the original cable except that a neoprene cover replaced the braided yarn. The neoprene rubber was considerably more abrasion resistant and there was no possibility of fraying with this type of covering. During the time of the design's submittal (when it was disapproved by BSD/STL) until July 1963, an increasing number of motors were being declared discrepant due to fraying of the igniter cable. In a second effort to eliminate this problem the design of the new cable was resubmitted to BSD/STL in the form of an ECP, number WS-133A-HP-60. This ECP was finally approved and the new cable design will be incorporated in future units.

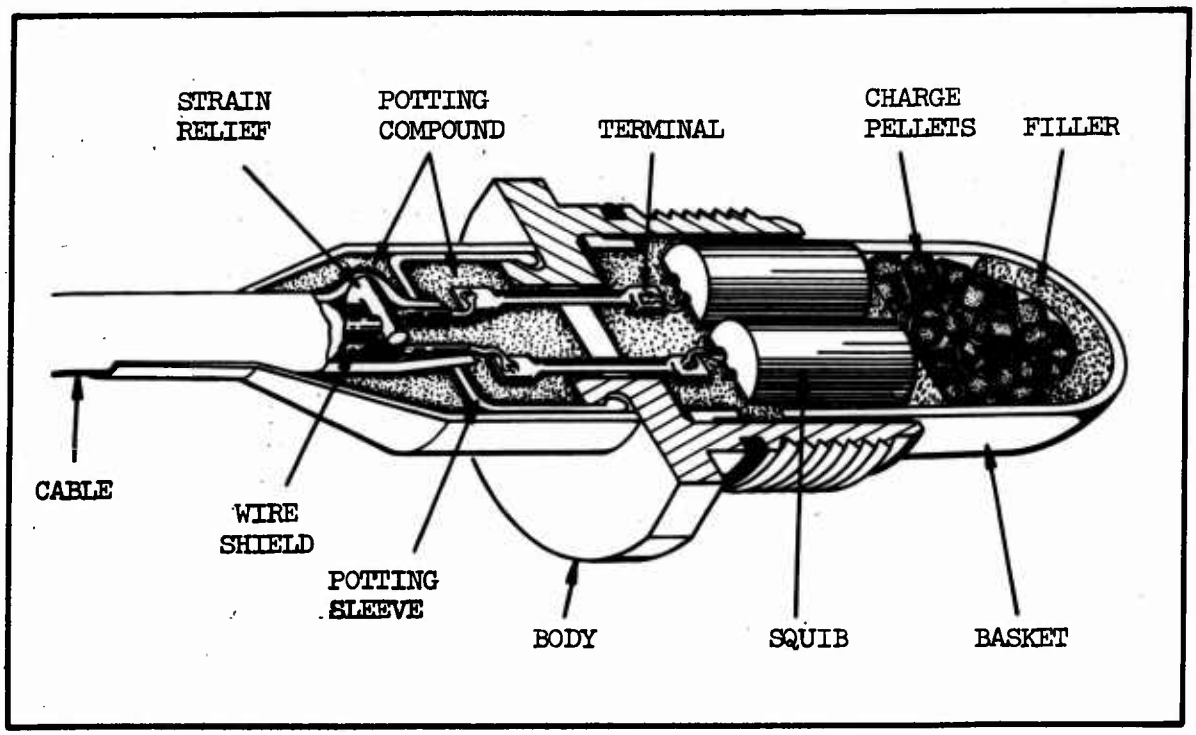
2. Tumble Rocket Motor

a. Igniter

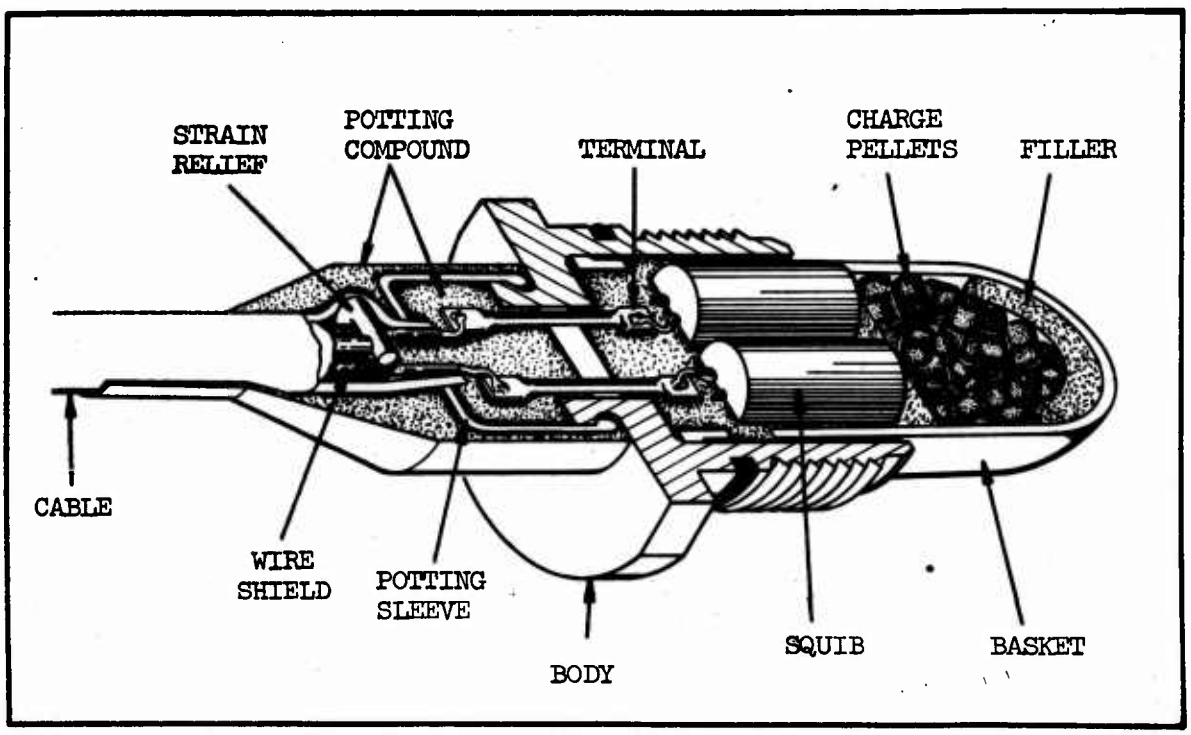
Just prior to deliveries of the first production motor on the Tumble Rocket Motor Program, it was noted that the igniter cable was separating from the potting compound at the igniter end of the cable. In an effort to eliminate this problem, it was proposed that the potting boot and potting compound be removed and that the cable be molded directly to the igniter using a polyurethane molding compound (see figure 3). Since this design modification was carried out prior to the first delivery of production motors, no ECP was submitted. The modification has proven itself in use since its introduction.

b. Case

At the conclusion of the systems test run at HPC, Bacchus Works, Magna, Utah, and at AEDC, it was found that certain temperatures due to ascent heating were compromising the Tumble Rocket Motor case safety factor. Further analysis of the data derived from these tests indicated that the case wall thickness would have to be increased in order to maintain the Weapon System design criteria requirement for a 1.25 minimum safety factor. Review and analysis of all the applicable data indicated that the minimum case wall thickness would have to be increased from 0.033 inch to 0.043 inch. The wall thickness was thus increased and the design modification was submitted to BSD/STL on ECP WS-133A-HP-44. This design modification was accepted and the new cases were incorporated in production deliveries starting approximately in September 1963. See Figure 4 for exaggerated views of the case before and after modification.

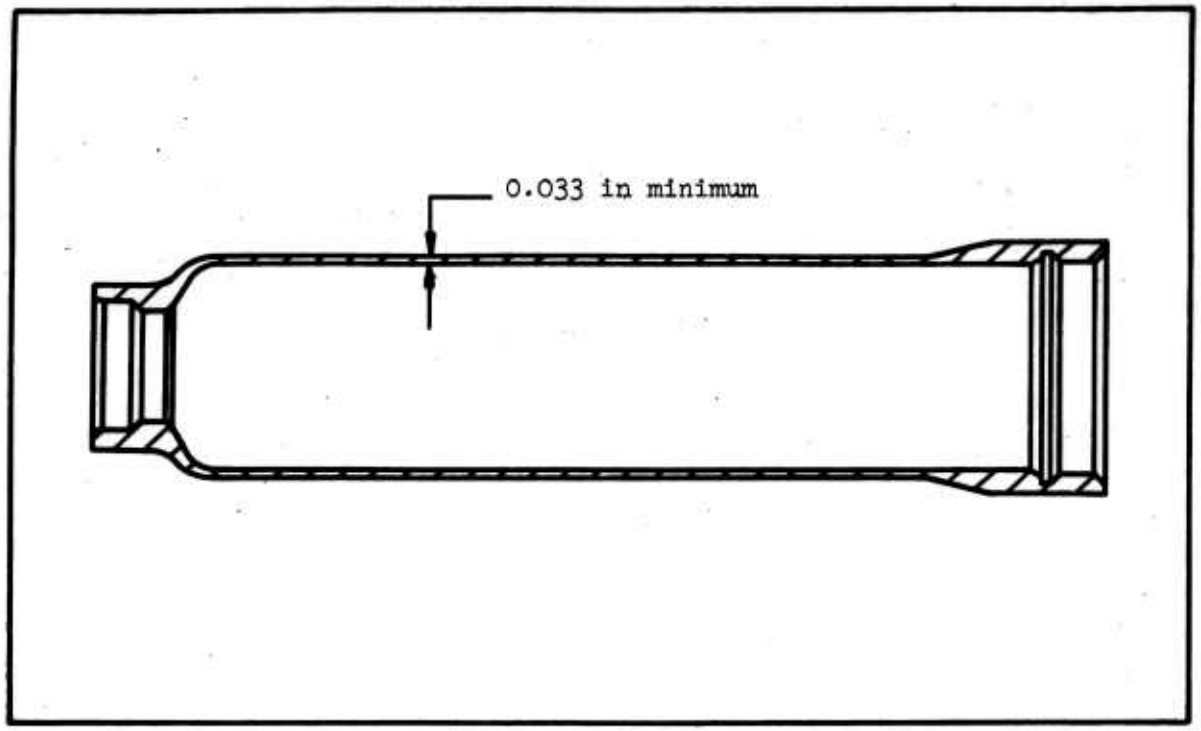


A. Before Modification

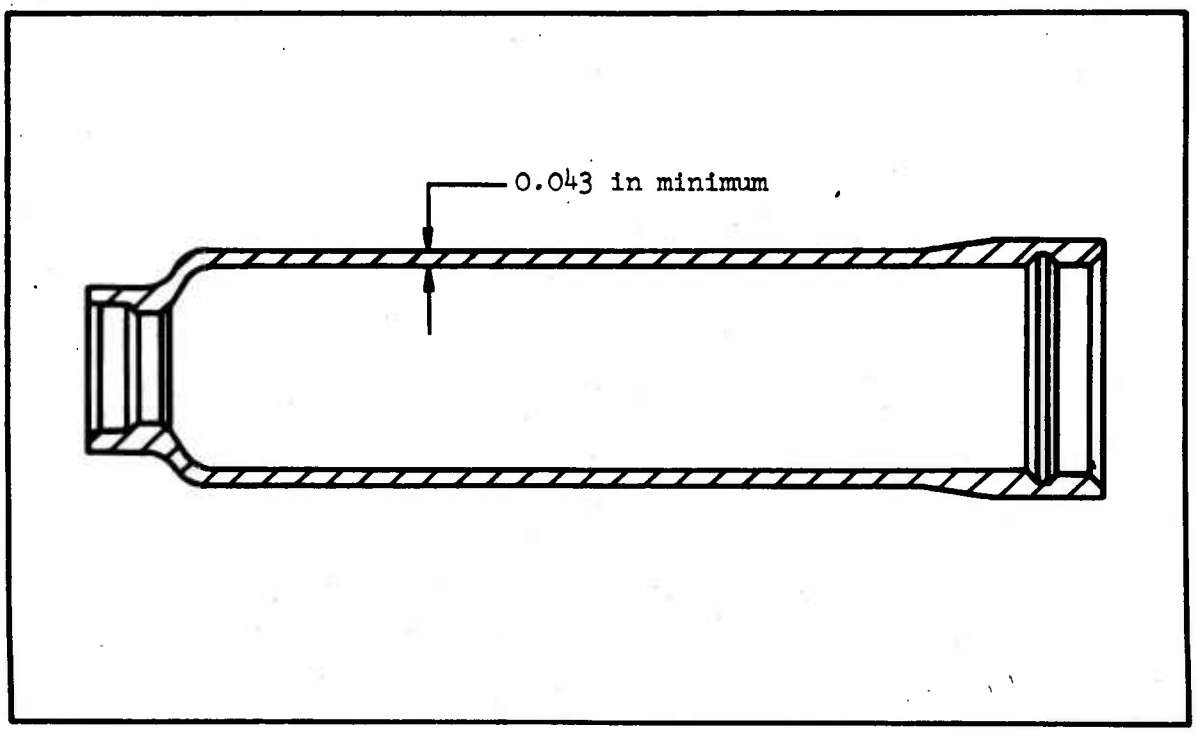


B. After Modification

Figure 3 Tumble Rocket Motor Igniter



A. Before Modification



B. After Modification

Figure 4 Tumble Rocket Motor Case

D. RELIABILITY

The activities of the Reliability section of Quality Assurance at Kenvil Works during this report period, with respect to the Retro/Tumble Program, are covered fully in the following Reliability and Failure Reports: K-35/MR-701-8, dated 30 April 1963; K-35/MR-701-9, dated 31 May 1963; K-35/MR-701-10, dated 30 June 1963; K-35/MR-701-11, dated 20 July 1963; K-50/RR-701-1 and K-51/TR-701-1, dated 20 August 1963; and K-50/RR-701-2 and K-51/TR-701-2, dated 20 September 1963.

A total of 192 Retro and 28 Tumble Rocket Motors were fired and evaluated as applicable for Demonstrated Reliability during this report period. For an estimate of Demonstrated Reliability for the Retro and Tumble Rocket Motors, see Table II, below. Bear in mind that all classifications are based on model specifications reflecting preliminary data. Final classifications and subsequent upgrading of Reliability estimates will be accomplished after the model specifications are revised to reflect Qualification Program data.

TABLE II

DEMONSTRATED RELIABILITY

Motor	Declared Tests (through Aug)	Failures	Demonstrated Reliability (%)
Retro	215	6	0.93
Tumble	51	1	0.92

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