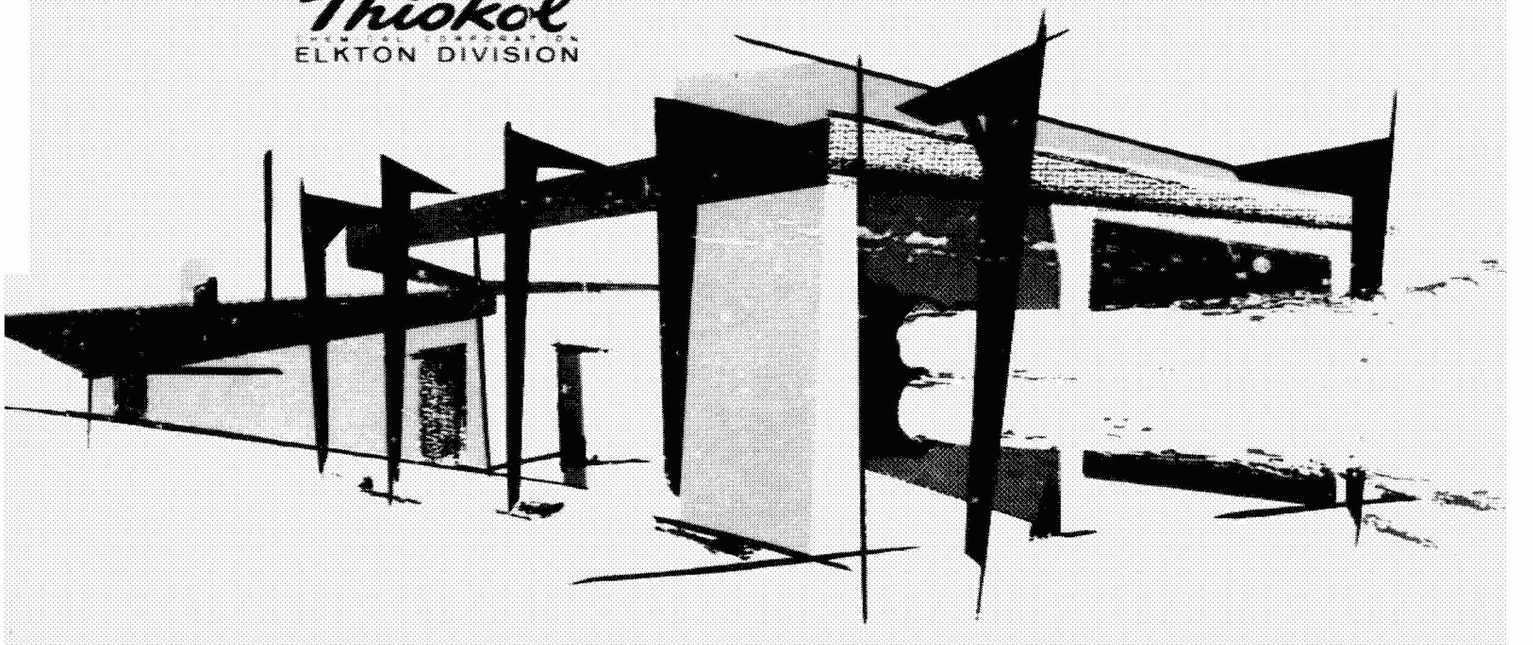
E54-64
May 4, 1964

Thiokol
CHEMICAL CORPORATION
ELKTON DIVISION



DESIGN, PROOF TEST AND DELIVERY PROGRAM OF TE 372-3 PYROGEN

E54-64

THIOKOL CHEMICAL CORPORATION
ELKTON DIVISION
ELKTON, MARYLAND

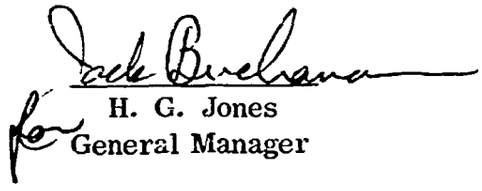
FINAL REPORT
OF
DESIGN, PROOF TEST AND DELIVERY PROGRAM
OF TE-372-3 PYROGEN
FOR TE-29 RECRUIT ROCKET MOTOR

CONTRACT NAS 9-2049

PREPARED FOR:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
APOLLO PROCUREMENT OFFICE
HOUSTON 1, TEXAS

MAY 4, 1964



H. G. Jones
for General Manager

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I. INTRODUCTION

This report describes the design modifications, proof test, and delivery phases of a program conducted to demonstrate the compatibility of Government Furnished Equipment initiators with the TE 372-3 PYROGEN igniters that will be used to ignite the Thiokol Recruit rocket motors on the Little Joe II vehicle.

The program consisted of modifying the design of the existing Recruit PYROGEN to accommodate two (GFE) one watt, one amp initiators, static test seven PYROGENS in an inert chamber, static test one Recruit motor ignited by a modified PYROGEN, and deliver nine PYROGENS.

II. PYROGEN MODIFICATIONS

The TE 372 PYROGEN igniter was modified to incorporate two GFE initiators, ME 453-0009-0004 configuration. The only component requiring modification was the headcap, or igniter mount.

Table I presents the Drawing List of significant drawings for this design. The specific configurations recommended for use on the Little Joe II vehicle are as follows:

E16454-02	Motor Assembly - Installation
E15922-04	Igniter Assembly
E16452-01	Initiator, Modified

Blueprints of these drawings are presented in Appendix A.

Figures 1 through 4 are photographs of a TE 372-3 PYROGEN igniter after having been fired in an inert Recruit rocket motor.

Figure 1 shows the PYROGEN assembly with two initiators installed. This photograph also shows the pressure connection in the PYROGEN headcap that was used to monitor PYROGEN chamber pressure. This pressure connection was used on all tests except the first. It was desired to limit the number of pressure connections on the first firing to the two initiator connections.

Figure 2 is a close-up view of this headcap.

Figures 3 and 4 are also close-up views of the modified initiator (washer removed), including the installed "O" ring.

TABLE I

DRAWING LIST

Drawing Number	Description
E 16454	Motor Assembly - Installation
E 15922	Igniter Assembly
E 15921	Igniter Mount
E 16452	Initiator, Modified
MS 9020-03	"O" Ring

FIGURE 1. TE 372-3 PYROGEN ASSEMBLY

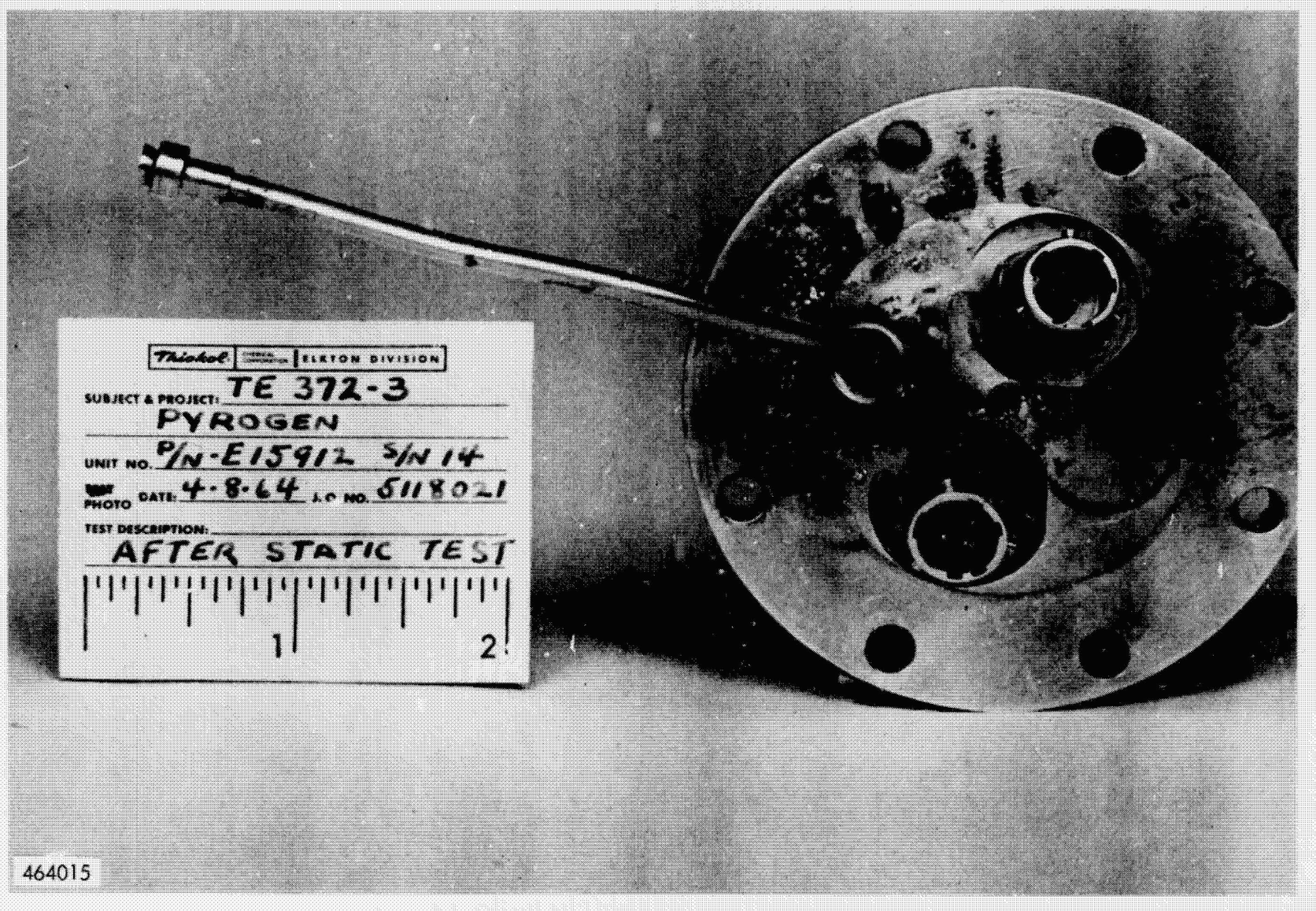

FIGURE 2. TE 372-3 PYROGEN HEADCAP ASSEMBLY

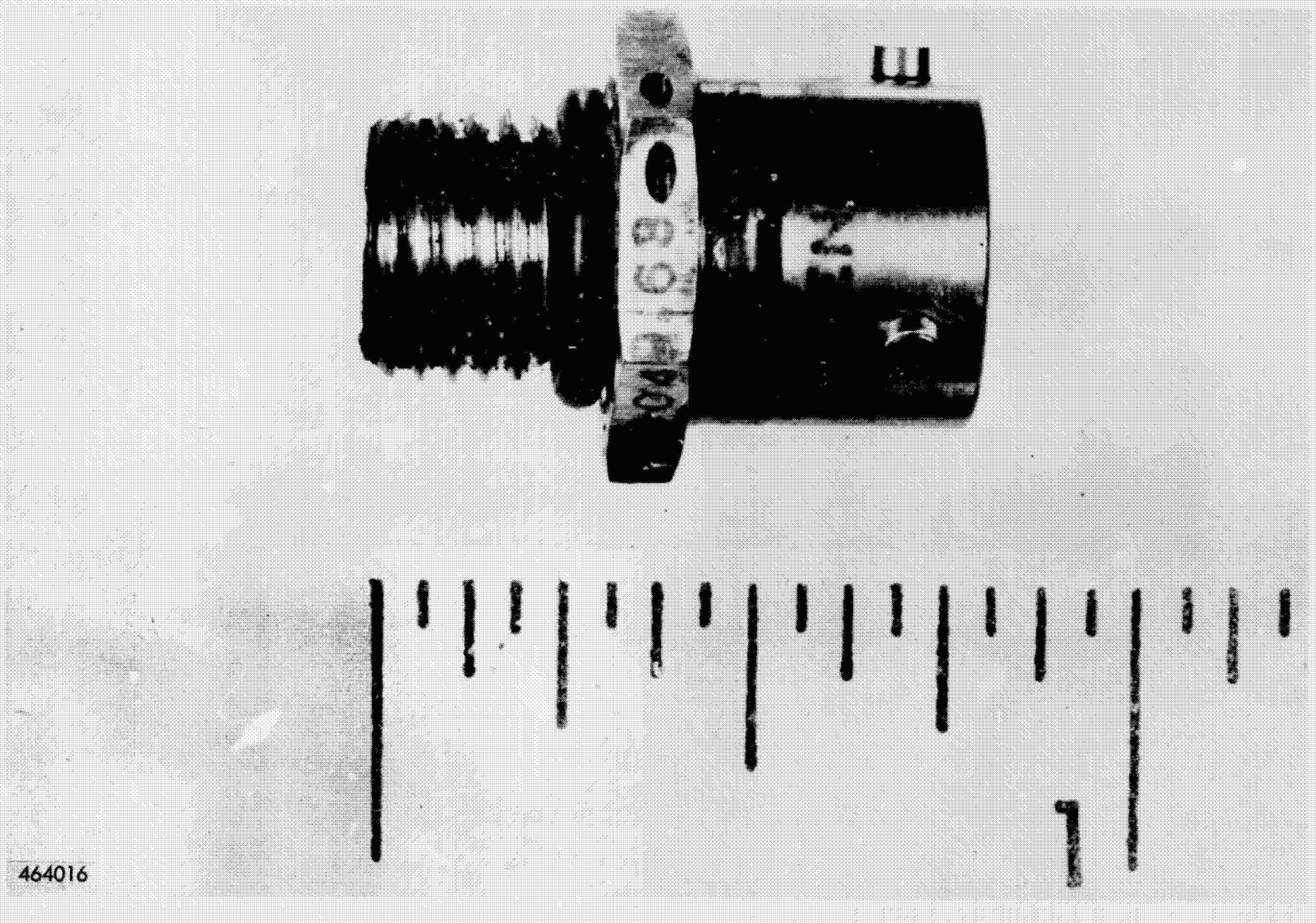

FIGURE 3. ME 453-0009-0004 INITIATOR MODIFIED - WASHER REMOVED

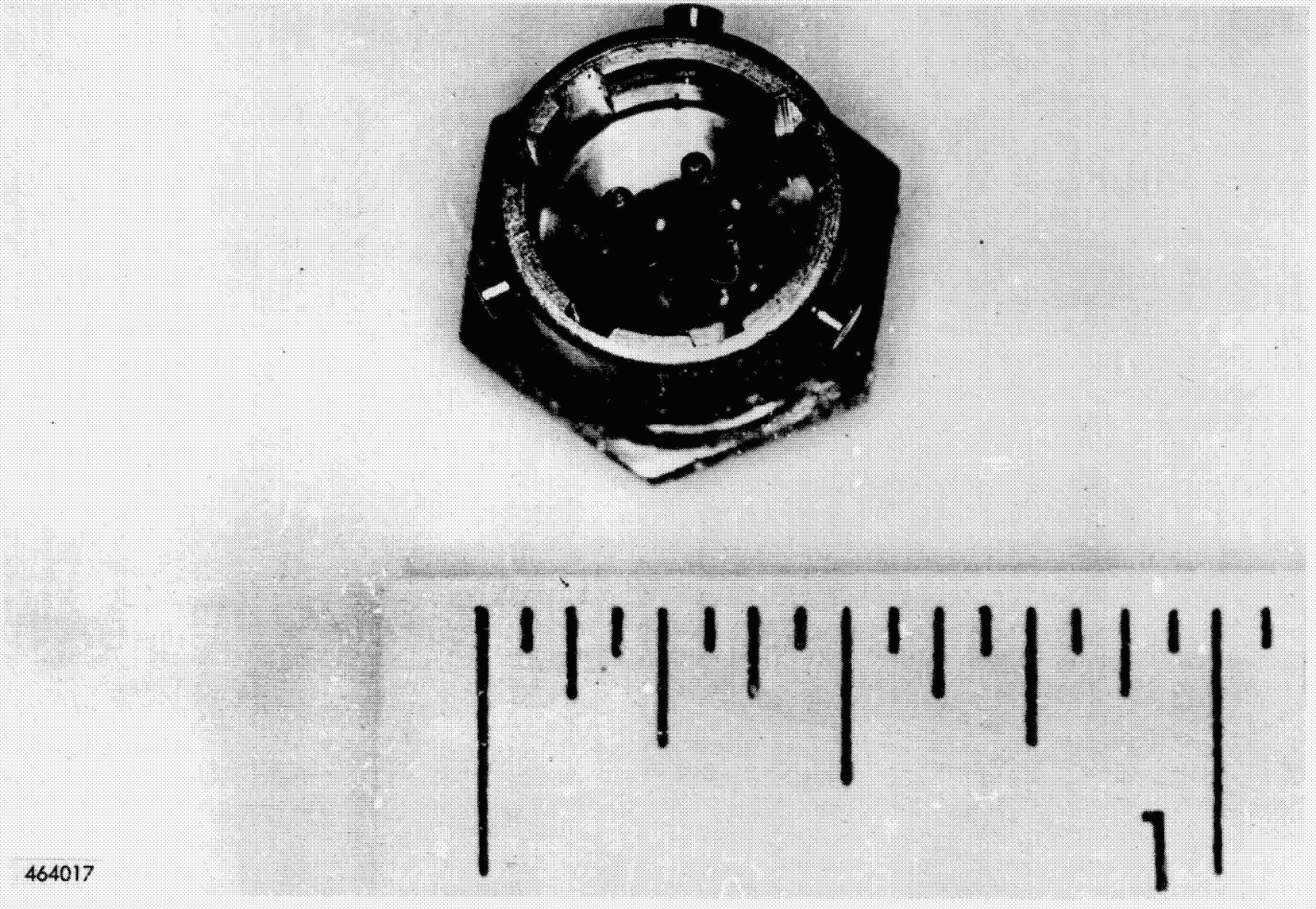

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FIGURE 4. ME 453-0009-0004 INITIATOR MODIFIED - WASHER REMOVED

III. INITIATORS

A. GOVERNMENT FURNISHED EQUIPMENT INITIATORS RECEIVED

Initiators for use on the PYROGEN Proof of Test Program were shipped to Thiokol-Elkton from North American Aviation as GFE items at the request of NASA/ Houston. These initiators were manufactured by Space Ordnance Systems, Inc. for North American.

Two shipments of Lot No. 8 initiators were received; thirty-six on January 8, 1964; and fifty-nine on February 6, 1964. However, initiator acceptance test data and resistance measurements were not supplied by SOS. This data was requested from NASA and later furnished.

Bridgewire resistances were measured on the thirty-six initiators received in the first shipment. With the exception of one initiator, all bridgewire resistances were acceptable - falling within the required range of 0.9 to 1.2 ohms. As noted in Table II, summary of bridgewire resistances of those initiators that did not function properly during the test program, initiator S/N 3933 showed an open AB circuit. This initiator was tagged "Reject" and was not used in the test program.

It was noted that all these initiators were tagged "For Engineering Test Only". NASA stated that these were prototype units, not yet fully qualified. However, Thiokol was authorized to use the initiators supplied in the test program.

B. INITIATOR CONFIGURATIONS

The specific initiator configuration delivered to Thiokol-Elkton for use on this program was ME 453-0009-0004. This configuration is defined dimensionally

TABLE II

SUMMARY

BRIDGEWIRE RESISTANCES

Initiator S/N	Space Ordnance Systems, Inc. Reported Values AB	CD	Thiokol Rec. Inspection AB	CD	Thiokol at Assembly AB	CD	Thiokol[3] on 3-4-64 AB	CD
3933	1.20	1.08	Open	1.10	-	-	1.18[2]	1.09
3879	1.01	0.99	(1)	(1)	1.00	1.06	1.08	0.97
3945	1.07	1.07	(1)	(1)	1.12	1.02	1.15	1.09
3937	1.09	1.04	(1)	(1)	1.07	1.13	1.08	1.12

[1]Acceptable: between 0.9 and 1.2 ohms

[2]This circuit previously reported open

[3]Check for short - each pin to case checked indicated open circuits; therefore, acceptable.

and electrically by North American Aviation Spec Control Drawing ME 453-0009, sheets 2 and 4. This includes the -0002 (inert) configuration and the -0004 (prototype) configuration. This drawing specifies that all firings shall be made at 5 $\pm$ 0.1 amps.

The -0004 configuration incorporates a 0.750" diameter washer, 0.050" thick, which is resistance welded to the underside of the hex nut. The underside of this washer contains a protruding "V" section near its periphery, which prevents proper mating of the two surfaces. This protrusion reduces the desired O-ring squeeze, and increases the possibility of fracture of the washer when torquing during assembly operations. Proper O-ring seal is further adversely affected by the recess resulting from incorporation of this washer. It was determined that this washer is used so that a booster cartridge can be added, by welding or brazing, to the basic ME 453-0009-0004 initiator configuration. However, the resulting interface of the initiator with booster is a flat-bottomed hex nut, which is compatible with an "AND" type joint.

It was recommended by Thiokol that this washer be removed from the initiator because it makes the joint unreliable from the standpoint of sealing. NASA stated that this type joint had been previously used successfully in other applications. However, since this joint will be exposed to full motor operating pressure, Thiokol should proceed to conduct a pressure test to demonstrate the integrity of this seal.

C. PRESSURE TEST

On February 3, 1964, a pressure test was performed on a PYROGEN headcap with an ME 453-0009-0004 initiator installed in the headcap and torqued to 50 $\pm$ 10 in-lbs. An MS 9020-03 O-ring was used for sealing. The headcap was installed in a specially

designed test fixture that was pressurized with nitrogen gas. The fixture was pressurized to 25 psi and held for two minuted, increased to 100 psi and held for two minutes, and then increased to 500 psi and held for five minutes. No pressure drop was noted at these pressures and times. However, when the pressure was increased to 2000 psi, the pressure dropped 2 to 3 psi after one minute, and 5 psi after two minutes after which time the fixture was depressurized. On disassembly, the initiator washer dropped out. The weld joint between the hex nut and washer had failed.

Based on the results of these pressure tests, Thiokol strongly recommended that the PYROGEN test program be conducted with GFE initiators without attached washers. As an alternate, Thiokol recommended that NASA consider furnishing these initiators with booster cartridges (loaded or unloaded) so that the interface between the initiator and PYROGEN headcap would be compatible with a standard "AND" type pressure connector.

D. HYDROSTATIC TESTS

On February 13, 1964, representatives of NASA/Houston and North American Aviation visited Thiokol-Elkton to witness a series of hydrostatic tests that were conducted to demonstrate the integrity of the O-ring seal between the initiator and PYROGEN headcaps. These tests are summarized in Table III.

Test 3(a), with the unmodified configuration with the MS 9020-03 O-ring, was the only leak detected during testing. All tests were conducted at 3000 psig.

TABLE III

HYDROSTATIC TESTS

TE-372-3 PYROGEN HEADCAPS - INITIATORS INSTALLED

Test	-0004 Initiator Configuration	O-Ring	Initiator S/N	Comments
1	Washer removed	A	4201	OK
2	Washer lip machined off	A	2974	OK
		B	2979	OK
3 (a)	No modifications	A	3166	Leaked at 50 psi
		B	3178	OK
(b)	No modifications	B	3166	OK
		B	3178	OK
4, 5, 6	Repeated this test 3 times, replacing O-rings before each re-test	B	3166	OK
		B	3178	OK
7, 8, 9	Repeated this test 3 times, replacing O-ring on 3028 initiator before each re-test	B	3166	OK
		B	3028	OK

O-Ring

A MS 9020-03 ID = .301 W = .064 $\pm$ .003

B AN 6227-07 ID = .364 W = .070 $\pm$ .003

The following three 'fixes' performed satisfactorily:

Fix	O-Ring Type*	Description
1	A	Remove washer from underside of initiator
2	A, B	Machine lip off lower face of washer
3	B	No initiator modification

*Type A MS 9020-03
Type B AN 6227-07 (Furnished by North American Aviation)

E. INITIATOR MODIFICATIONS

After further consideration of the test data, it was mutually agreed that the most valid modification would be to remove the washers from the GFE initiators. Thiokol was therefore directed to make this modification to the GFE initiators. The resulting configuration is presented in Appendix A as Thiokol drawing E-16452 (P/N E-16452-01).

IV. TEST PROGRAM

The PYROGEN test plan is shown in Table IV. PYROGEN tests were conducted at 0°F, 60°F, and 120°F with one or two initiators being actuated as outlined in the test plan. All tests were conducted in accordance with the Testing Procedures itemized below:

A - Test plan #1, TE-372-3, PYROGEN Igniter Proof Test Program

B - PCL-T-2181, Testing Technical Procedure, Static Test of the TE-372-3 PYROGEN in an Inert Recruit.

C - OI-T-6018 R-1, Testing Technical Procedure, Firing Current/ Voltage Regulator Used as Constant Current Regulator.

D - CL-T-6022, Testing Technical Procedure, Calibration of Current for Squib Activated Circuits

Seven tests were conducted with the PYROGEN being fired into an inert Recruit motor. Figure 5 shows the static test set-up of the inert Recruit motor in the test stand.

In Test No. 1 at 60°F, current was applied to both initiators and the PYROGEN fired satisfactorily. However, upon disassembly after test it was noted that one of the two initiators (S/N 3879) had not fired. It had not "cooked off" from exposure to heat generated by the other initiator or from the heat generated by the PYROGEN itself. The bridgewire resistances were again measured and recorded and this initiator was set aside and ultimately returned to Space Ordnance Systems for evaluation.

During evaluation of the firing trace, it was noted that the initiators received a peak current value of 7.4 amps and an average current value of 6.4 amps; after approximately 4 milliseconds the circuit opened. The switch remained closed for approximately 1100 milliseconds.

TABLE IV

PYROGENS FIRED IN INERT RECRUIT MOTOR

TEST	NO. OF INITIATORS	FIRING TEMPERATURE
1	2	+60°F
2	2	+60°F
3	2	+60°F
4	2	+120°F
5	2	0°F
6	1	+120°F
7	1	0°F
	RECRUIT MOTOR IGNITED WITH PYROGEN	
8	2	+60°F

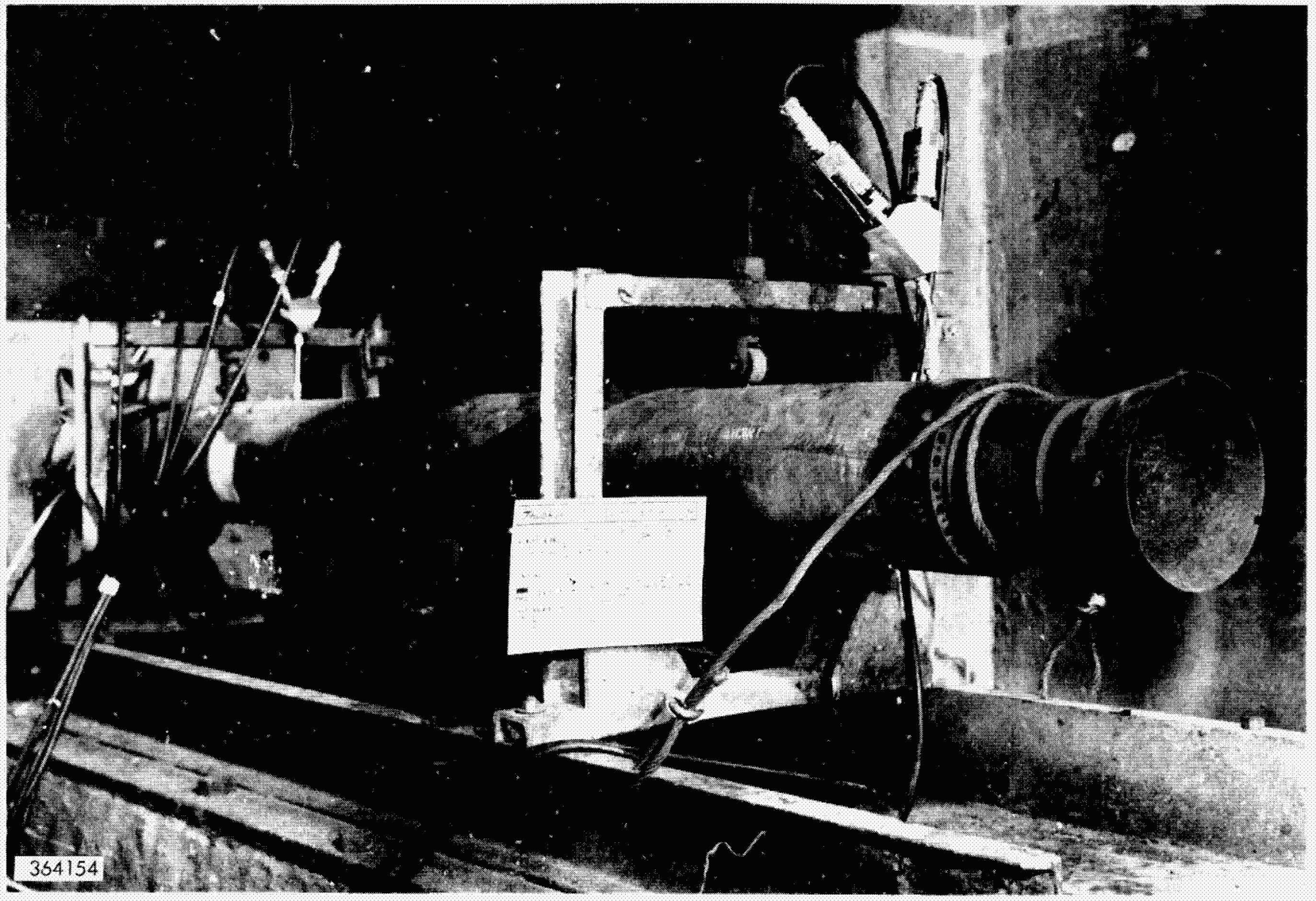


FIGURE 5. INERT RECRUIT MOTOR STATIC TEST SET-UP

Tests 2 and 3, both at 60°F, were satisfactory. Test No. 4 at 120°F was also satisfactory.

Test No. 5, 0°F, was performed but neither initiator fired. All connections were re-checked and firing current was re-applied. The initiators again failed to actuate.

A current regulated power supply was adjusted to deliver 10 amps through a load equivalent to the two initiator resistances. Function of the power supply was checked prior to the test with an ammeter and dummy load connected to the firing line in the test bay. Three attempts were made to fire the initiators with this power supply without success.

A substitute power supply was then connected to the firing line and calibrated with the dummy load and ammeter. Two attempts were then made with this power source to fire the initiators without success.

The two initiators, S/N 3937 and 3945 were removed and the bridgewire resistances were again measured and recorded. The initiators were set aside and ultimately returned to Space Ordnance Systems for evaluation.

Initiators S/N 3907 and 4206 were installed and the PYROGEN was reconditioned to 0°F. This unit fired satisfactorily.

Tests 6 and 7 both performed satisfactorily. In both tests, only one initiator was installed and actuated. Test No. 6 was conducted at 120°F, and Test No. 7 was performed at 0°F.

Test No. 8 was the final and most significant test of the series. This was a 60°F test in which a PYROGEN with two actuated initiators was used to ignite a Recruit motor. This test was witnessed by both NASA and Convair representatives.

Immediately prior to the test it was recommended by NASA that the applied firing current should be 20 amps to the PYROGEN, resulting in 10 amps going to each initiator and 5 amps to each bridgewire. This was twice the firing current applied during the previous PYROGEN tests in the inert Recruit. At NASA's direction, a firing current of 20 amps was applied to the PYROGEN. The test was completely successful. Figure 6 shows the static test set-up of the live Recruit motor in the Test stand.

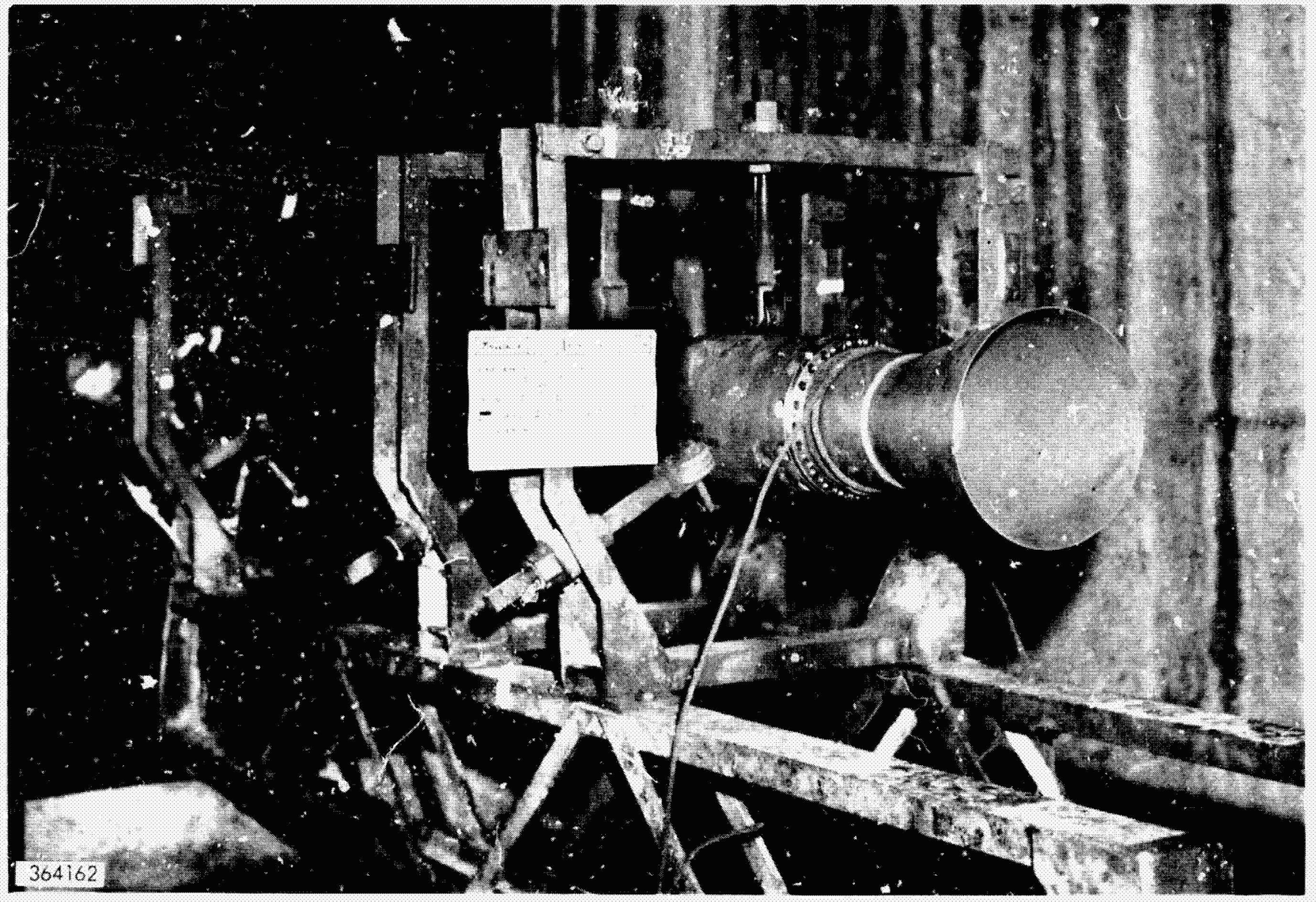


FIGURE 6. LIVE RECRUIT MOTOR STATIC TEST SET-UP

V. TEST RESULTS

Table II presents a summary of bridgewire resistances measured on those initiators that did not function properly during the test program.

The results of the test program are presented in Table V - Test Data Summary.

Data Summary Sheets for each test are presented in Appendix B. Also presented are replots of the following: (1) PYROGEN pressure versus time for Test No. 2, which is a typical 60° F test with both initiators actuated, and (2) pressure and thrust versus time for Test No. 8, the live Recruit motor test.

The Recruit motor firing replot shows that the PYROGEN pressure peaks to approximately 1700 psi on ignition and then declines to the 800 psi level. During this interval the PYROGEN gases are pressuring and heating the Recruit motor propellant cavity. When the Recruit propellant is ignited, the motor pressure rises sharply (at approximately 70 milliseconds).

Extremely high assurance of motor propellant ignition is evident, since the PYROGEN pressure levels off at the 700 psi level and operates for more than 300 milliseconds. In every previous instance when the PYROGEN grain was ignited, the Recruit motor propellant was also ignited.

When examining the summarized test data, several factors concerning ignition interval are significant. When a current of 10 amps was applied to each initiator, the ignition interval was 6 milliseconds. However, when 5 amps was applied to each

TABLE V

TEST DATA SUMMARY
TE 372-3 PYROGEN

Test No.	Test Date 1964	PYROGEN Number TED-	Cond. Temp. (° F)	Initiator S/N	Ignition Delay (MS)	Ignition Interval (MS)	Burn Time (MS)	Action Time (MS)	Max. Press. Ignition	Max. Press.	Min. Press.	Current (amps) Avg.	Current (amps) Peak	Resistance (ohms) Line	Resistance (ohms) Line + Init.
1	2-10	001-1 #1	60°	3879(1) 4201	-	-	-	-	-	-	-	6.4	7.4	.55	1.08
2	2-28	200-1 #1	60°	3900 3924	7.5	11.5	288.5	329.5	1819	720	626	7.9	8.3	.51	.79
3	2-28	201-1 #2	60°	3931 4212	12.5	17.0	269.0	337.5	1721	707	685	7.7	8.2	.51	.79
4	2-28	201-1 #1	120°	3885 4210	58.0	63.0	261.0	329.0	1837	769	717	7.7	8.3	.51	.78
5	2-28	200-1 #2	0°	3945(1) 3937(1)	-	-	-	-	-	-	-	-	-	-	-
5A	2-28	(Rerun) 200-1 #2	0°	3907 4206	46.0	49.5	298.0	354.0	1740	651	629	7.9	10.3	.51	.81
6	2-28	300-2 #2	120°	3940	48.5	54.0	262.5	321.5	1841	740	650	4.3	5.1	.51	1.12
7	2-28	300-1 #1	0°	4221	49.5	54.5	301.0	356.0	1730	665	606	4.2	5.3	.51	1.19
8	3-3	(PYROGEN) 200-1 #3 (Motor) PV 16-317-8	60°	3980 4197	2 65	6 76	- 1487	- 1828	1752 2153	- 1815	- 1405	19.0	19.0	.69	.97

(1) Did not fire

initiator, the ignition interval averaged 14.3 milliseconds. Another significant observation is that the ignition interval at 60° F was shorter than at either 0° F or 120° F. It is noteworthy that the ignition intervals for one initiator actuated at 0° F and 120° F was very similar, 49.5 and 54 milliseconds, respectively. Also the ignition interval was not significantly improved when actuating two rather than one initiator.

VI. DELIVERIES

A summary of all deliveries made under this contract is as follows:

12/31/63 Three sets of TE-372-3 PYROGEN drawings E-15922(B), E-15921(A), E-15912(B)
Three copies of Test Plan and Test Schedule

2/18/64 Three copies of the following:

(a) Static Test Procedure of the TE-29 Rocket Motor PCL-T-2154 R-2 dated 1/28/64
(b) Static Test Arrangement (LO-1121)
(c) Data Summary Sheet for TE-29 Recruit (TF-5120)

2/28/64 Shipped four (4) expended TE-372-3 PYROGENS to White Sands Missile Range

3/13/64 Delivered nine (9) TE-372-3 PYROGEN igniters to White Sands Missile Range. Included with this shipment, at NASA request, were the following spare items: (1) MS 9020-03 O-Ring, (6) AN 814-3C shipping plugs, and (8) modified ME 453-0009-0004 initiators (E-16452-01 Configuration).

3/20/64 Data Package per NASA request to Space Ordnance Systems, Inc., El Segundo, California including "Summary of Test Data", data Summary Sheets for each test, reproduced portions of CEC Traces, replots of one inert and the live firing data, Test Procedures and Test Plan, and pertinent drawings.

3/20/64 Shipped residual (52) GFE initiators ME 453-0009-0004 (unmodified) to Space Ordnance Systems, Inc. Also shipped were the 4 modified initiators that did not function properly during the test program.

3/25/64 Three sets of TE-372-3 PYROGEN drawings E-16454(A), E-15922(E), E-15921(B), E-15912(C), E-16452(None)

VII. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from evaluating the test data:

The E-16452-01 initiator (modified ME 453-0009-0004) successfully ignites the TE-372-3 PYROGEN igniter in the temperature range of 0°F to 120°F.

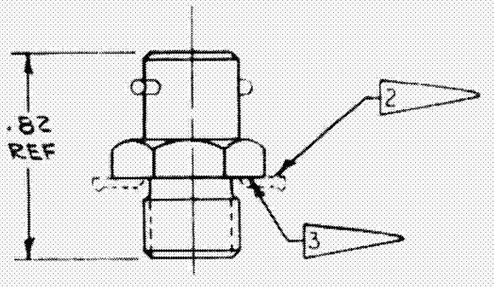
One initiator also successfully ignites the PYROGEN igniter in the same temperature extremes, thus demonstrating the desired system redundancy.

Based on the results of the test program conducted under this contract, Thiokol recommends that the TE-372-3 PYROGEN igniters (P/N E-15922-04) be used to ignite the TE-29 Recruit rocket motors on the Little Joe II vehicle.

This recommendation is based on the use of the modified version of the ME 453-0009-0004 initiator (P/N E-16452-01) and the application of a 20 amp firing current to the PYROGEN.

APPENDIX A

DRAWINGS



NOTES:

1. PART NO. (P/N ____) TO BE MARKED PER T.C.C. SPEC P10001-10.
2. PART NO. ME 453-0009-0004 NORTH AMERICAN AVIATION, INC, DOWNEY, CALIF (CODE IDENT NO. 03953) TO BE MODIFIED AS SHOWN BY REMOVING THE WASHER WITH PLIERS.
3. THIS SURFACE TO BE CLEANED WITH CROCUS CLOTH TO AN APPROXIMATELY 32 FINISH.

QTY REQD PER DASH NO.			1	1		2	INITIATOR		
			-01	ITEM NO.	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION

LIST OF MATERIAL OR PARTS LIST

USED ON	
MODEL NO.	NEXT ASSY
TE-29	E 15322

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES
.XX = ± .030: .XXX = ± .010:
ANGULAR ± 30' FRACTIONS ± 1/16
BREAK SHARP EDGES .003-.015
ALL SMALL FILLETS .020-.040 R
THREADS PER FED. HNDBK H-28 AND SUPPLEMENTS
DIMENSIONING PER MIL-STD-8
WELD SYMBOLS PER JAN-STD-19
SURFACE ROUGHNESS SYMBOLS PER MIL-STD-10
ALL FINISHED SURFACES ✓

DRAWN	W.C. BROWN	28 FEB 64
CHECKED	GIVENS	3 Mar 64
ENGR		
ENGR		3 Mar 64
ENGR		
USER		
STRESS	N/A	
SAFETY		
APPD		

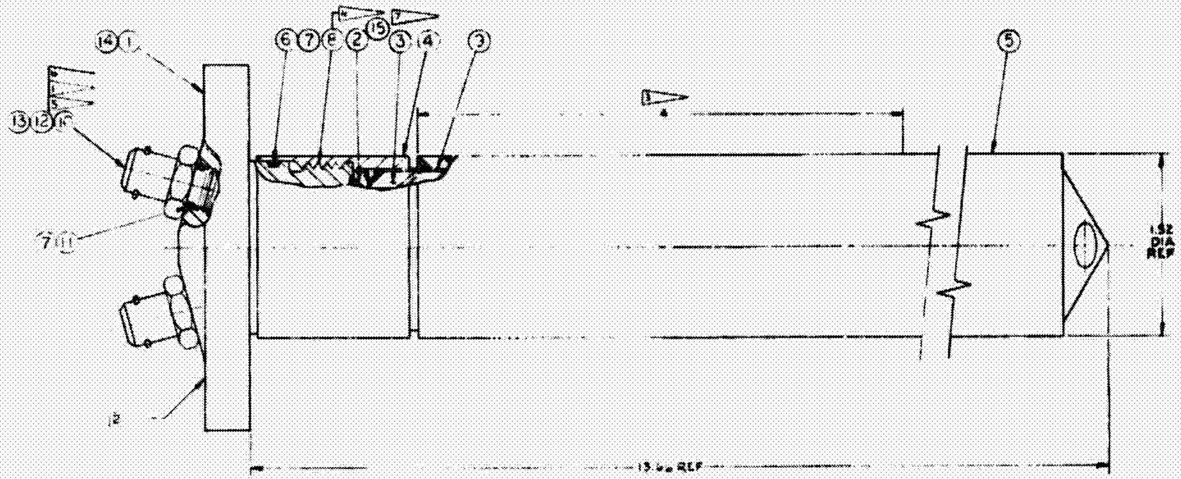
DESIGN ACTIVITY APPROVAL 3 Mar 64

Thiokol. CHEMICAL CORPORATION
ELKTON DIVISION ELKTON, MARYLAND

INITIATOR, MODIFIED

CODE IDENT NO.	SIZE	
07299	B	E 16452
SCALE	WEIGHT	CALC ACTUAL / SHEET

EFFECTIVITY	SYM	DESCRIPTION	CHANGE	DFTSMN	DATE	APPROVED
11 DEC 1963	A	SEE ECO NO. 5460				
20 DEC 1963	B	SEE ECO NO. 5474				
23 JAN 1964	C	SEE ECO NO. 5521				
28 FEB 1964	D	SEE ECO NO. 5613				
12 MARCH 1964	E	SEE ECO NO. 5655				



NOTES:

1. MATES WITH BENDIX PYGMY CONNECTOR PTC06E-8-4P
2. ASSEMBLY NO.(ASSY____) & SERIAL NO.(S/N____) TO BE MARKED PER T.C.C. SPEC. TOC 21-6
3. BOND ITEM 5 TO ITEM 4 WITH ITEM 9 FOR DIMENSION SHOWN.
4. APPLY ITEM 8 TO THREADS OF ITEM 1 OR 14 AND USE SUFFICIENT TORQUE TO SEAT ITEM 1 OR 14 IN ITEM 4.
5. GOVERNMENT FURNISHED EQUIPMENT.
6. TORQUE ITEM 10 OR 13 INTO ITEM 1 OR 14 USING 50 ± 10 INCH-LBS.
7. MODIFY ITEMS 2 & 15 AT ASSEMBLY TO INSURE NO MOVEMENT OF ITEM 3.

WIRING DIAGRAM

RESISTANCE PER BRIDGEWIRE: 0.8 - 1.2 OHMS
FIRING CURRENT PER BRIDGEWIRE: 5.0 AMPS

E15922

-06	-03	-02	-01	ITEM NO.	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION
1				15		E12952-02	SPACER		7
		1		14		E15921-02	INITIATOR ASSY		
	1	2		13		E16452-01	INITIATOR		
2				12		AN 919-9C	PLUG		
2	1	2	2	11		MS9020-03	O RING		
			2	10		[illegible]	INITIATOR		5
AR	AR	AR	AR	9		TC074-L-203	ADHESIVE		
AR	AR	AR	AR	8	05972		SEALANT		MIL-S-22473, CLASS A
AR	AR	AR	AR	7			LUBRICANT	[illegible]	MIL-L-4343
1	1	1	1	6		MS29513-027	O RING		
1	1	1	1	5		E15601-01	INS, IGNITER TUBE		
1	1	1	1	4		E12666-01	IGNITER TUBE ASSY		
1	1	1	1	3		E12657-01	CARTRIDGE		
	1	1	1	2		E10982-01	SPACER		7
1	1		1	1		E1592 -01	INITIATOR ASSY		
QTY REQD PER DASH NO									

LIST OF MATERIAL OR PARTS LIST

USED ON	
MODEL NO	NEXT ASSY
TE-572-3	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
.XX ± .03 .XXX ± .010
ANGULAR ± 0° FRACTIONS ± 1/16
BREAK SHARP EDGES .005-.015
ALL SMALL FILLETS .025-.060 R
THREADS PER FED. HANDBOOK H-28 AND SUPPLEMENTS
DIMENSIONING PER MIL-STD-8
WELD SYMBOLS PER MIL-STD-19
SURFACE ROUGHNESS SYMBOLS PER MIL-STD-10
ALL FINISHED SURFACES

DRAWN	V.LEE	OCT 63
CHECKED		
CHKR		
ENGR		
ENGR		
WELD		
STRESS		
SAFETY		
APPD		

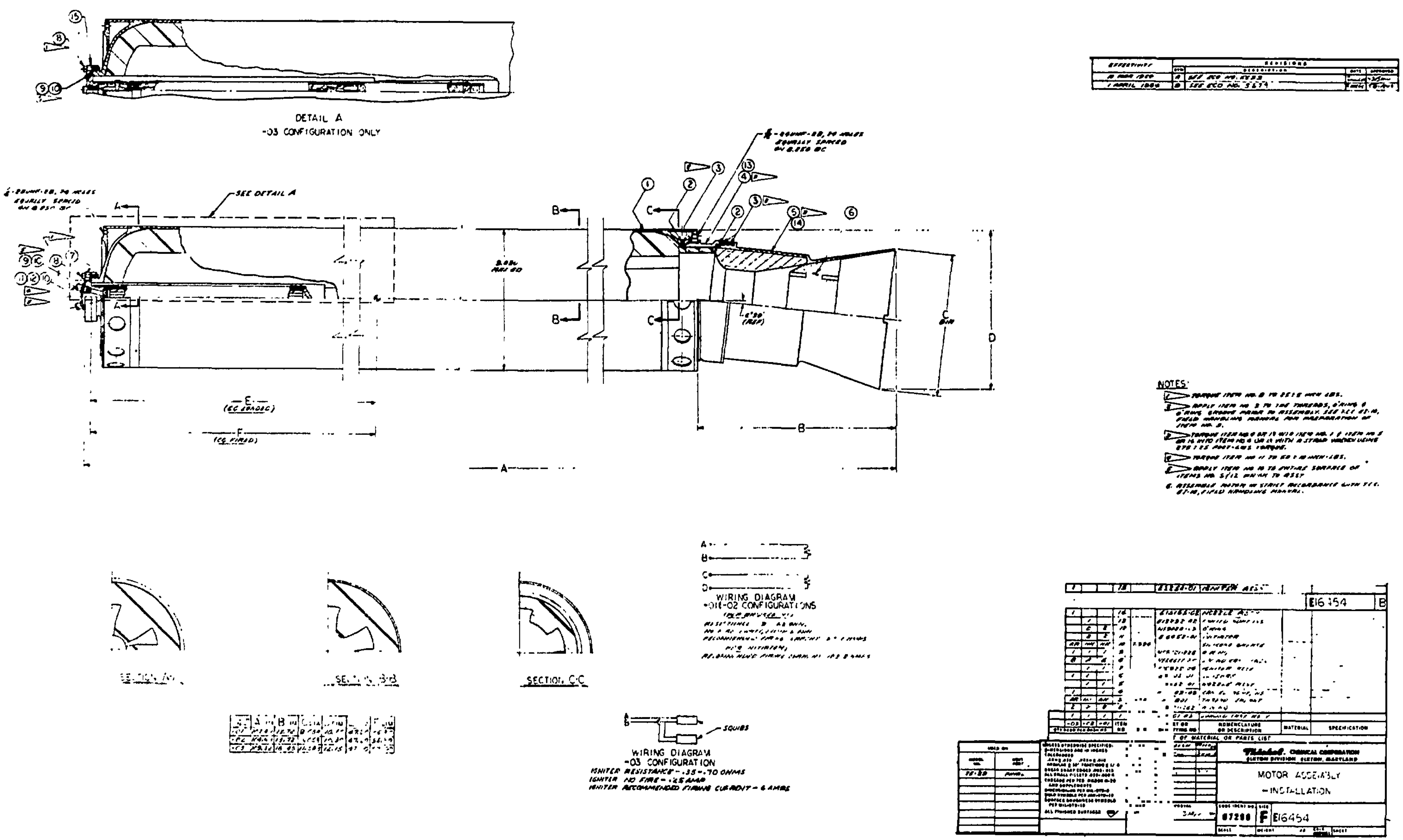
DESIGN ACTIVITY APPROVAL

Thiokol CHEMICAL CORPORATION
ELKTON DIVISION ELKTON, MARYLAND

IGNITER
ASSEMBLY

CODE IDENT NO 07209 SIZE D E15922

SCALE | WEIGHT | CALC ACTUAL | SHEET


DETAIL A
-03 CONFIGURATION ONLY
SEE DETAIL A
SECTION C-C
WIRING DIAGRAM
-01 -02 CONFIGURATIONS
WIRING DIAGRAM
-03 CONFIGURATION
SQUIBS
NOTES:
Thiokol CHEMICAL CORPORATION
ELKTON DIVISION ELKTON, MARYLAND
MOTOR ASSEMBLY
-INSTALLATION
NOMENCLATURE OR DESCRIPTION
MATERIAL
SPECIFICATION
07288
F
E16454
B

APPENDIX B

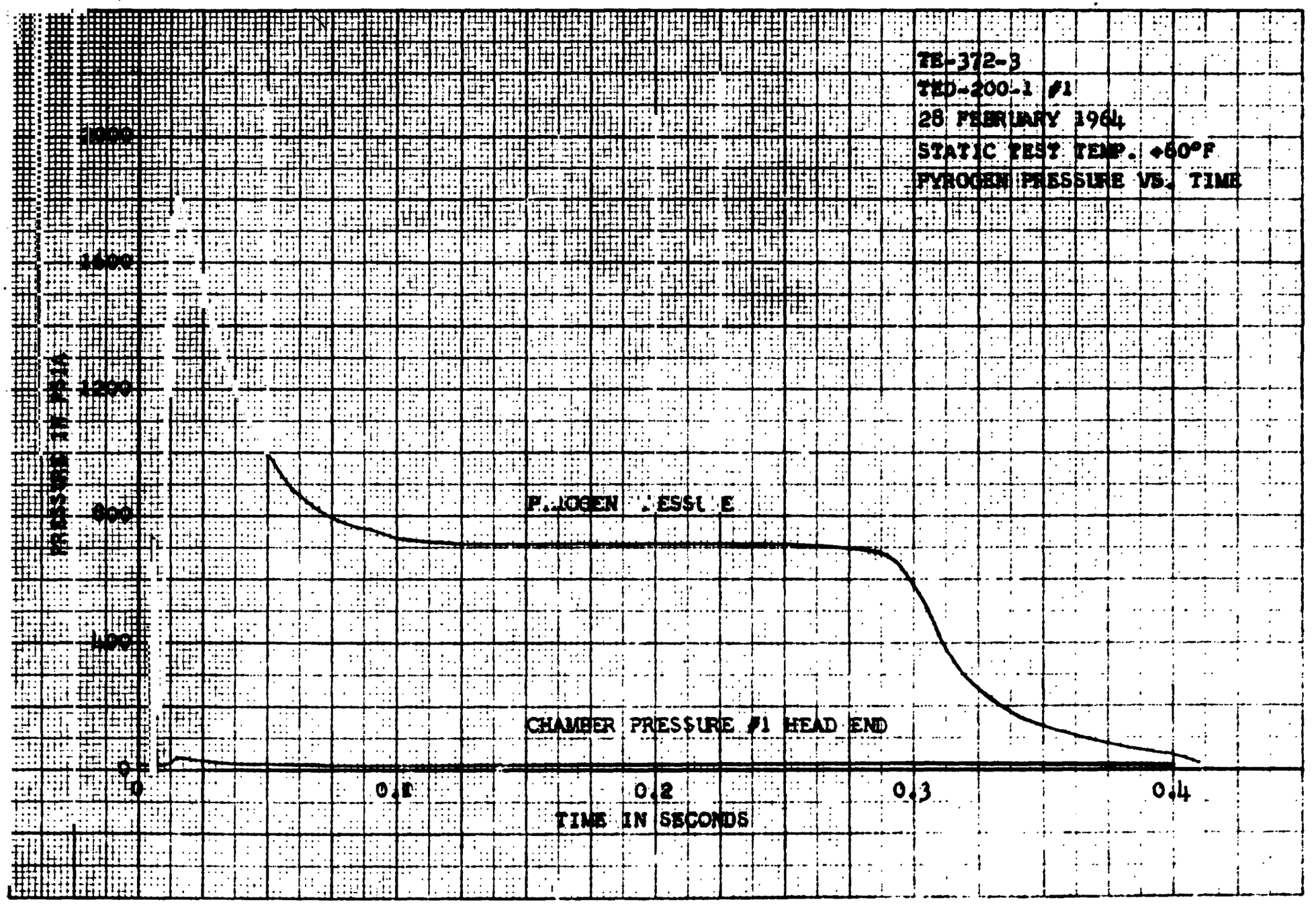
DATA SUMMARY SHEETS

TF-5161

DATA SUMMARY SHEET
TE-372-3 PYROGEN IGNITER

Identification	a.	Project	5118
	b.	PYROGEN Igniter Number	TED-200-1 #1
	c.	Case Serial Number	NA
	d.	Firing Record Number	CK-7983
	e.	Test Date	28 Feb. 1964
	f.	Test Time	1015
Test Conditions	a.	Ambient Temperature, °F	38
	b.	Barometric Pressure, in Hg	29.93
	c.	Relative Humidity, %	75
	d.	Conditioned Temperature	
		(1) PYROGEN Igniter, °F	60
		(2) Initiator, °F	60
	e.	Ignition Environment, mm Hg	760
Initiator Data	Initiator-Booster Type		E-16452-10 ME453-0009-0004(Mod)
		Part Numbers (1)	S01-266
		(2)	S01-266
		Serial Numbers (1)	3900
		(2)	3924
Ignition Data	a.	Ignition Delay, t_d , sec	0.0075
	b.	Ignition Time, t_i , sec	0.0115
	c.	Burning Time, t_b , sec	0.2885
	d.	Action Time, t_a , sec	0.3295
Pressure Data	a.	Maximum Ignition PYROGEN Pressure, psia	1819
	b.	Maximum PYROGEN Pressure, Pmax, psia	720
	c.	Minimum PYROGEN Pressure, Pmin, psia	626

TE-372-3
TED-200-1 #1
28 FEBRUARY 1964
STATIC TEST TEMP. +60°F
PYROGEN PRESSURE VS. TIME



TF-5161

DATA SUMMARY SHEET
TE-372-3 PYROGEN IGNITER

Identification	a.	Project	5118
	b.	PYROGEN Igniter Number	TED-200-1 #2
	c.	Case Serial Number	NA
	d.	Firing Record Number	CK-7992
	e.	Test Date	28 Feb. 1964
	f.	Test Time	1505
Test Conditions	a.	Ambient Temperature, °F	38
	b.	Barometric Pressure, in Hg	29.92
	c.	Relative Humidity, %	75
	d.	Conditioned Temperature	
		(1) PYROGEN Igniter, °F	0
		(2) Initiator, °F	0
	e.	Ignition Environment, mm Hg	760
Initiator Data	Initiator-Booster Type		E-16452-10 ME453-0009-0004(Mod)
	Part Numbers (1)		S01-266
		(2)	S01-266
	Serial Numbers (1)		3907
		(2)	4206
Ignition Data	a.	Ignition Delay, t_d , sec	0.046
	b.	Ignition Time, t_i , sec	0.0495
	c.	Burning Time, t_b , sec	0.298
	d.	Action Time, t_a , sec	0.354
Pressure Data	a.	Maximum Ignition PYROGEN Pressure, psia	1740
	b.	Maximum PYROGEN Pressure, Pmax, psia	651
	c.	Minimum PYROGEN Pressure, Pmin, psia	629

DATA SUMMARY SHEET
TE-372-3 PYROGEN IGNITER

Identification	a.	Project	5118
	b.	PYROGEN Igniter Number	TED-201-1 #2
	c.	Case Serial Number	NA
	d.	Firing Record Number	CK-7984
	e.	Test Date	28 Feb. 1964
	f.	Test Time	1057
Test Conditions	a.	Ambient Temperature, °F	38
	b.	Barometric Pressure, in Hg	29.93
	c.	Relative Humidity, %	75
	d.	Conditioned Temperature	
		(1) PYROGEN Igniter, °F	60
		(2) Initiator, °F	60
	e.	Ignition Environment, mm Hg	760
Initiator Data	Initiator-Booster Type		E-16452-10 ME453-0009-0004(Mod)
	Part Numbers (1)		S01-266
		(2)	S01-266
	Serial Numbers (1)		3931
		(2)	4212
Ignition Data	a.	Ignition Delay, t_d , sec	0.0125
	b.	Ignition Time, t_i , sec	0.017
	c.	Burning Time, t_b , sec	0.269
	d.	Action Time, t_a , sec	0.3375
Pressure Data	a.	Maximum Ignition PYROGEN Pressure, psia	1721
	b.	Maximum PYROGEN Pressure, Pmax, psia	707
	c.	Minimum PYROGEN Pressure, Pmin, psia	685

DATA SUMMARY SHEET
TE-372-3 PYROGEN IGNITER

Identification	a.	Project	5118
	b.	PYROGEN Igniter Number	TED-300-2 #2
	c.	Case Serial Number	NA
	d.	Firing Record Number	CK-7987
	e.	Test Date	28 Feb. 1964
	f.	Test Time	1205
Test Conditions	a.	Ambient Temperature, ^{o}F	38
	b.	Barometric Pressure, in Hg	29.93
	c.	Relative Humidity, %	75
	d.	Conditioned Temperature	
		(1) PYROGEN Igniter, ^{o}F	120
		(2) Initiator, ^{o}F	120
	e.	Ignition Environment, mm Hg	760
Initiator Data	Initiator-Booster Type		E-16452-10 ME453-0009-0004(Mod)
	Part Numbers (1)		S01-266
		(2)	NA
	Serial Numbers (1)		3940
		(2)	NA
Ignition Data	a.	Ignition Delay, t_d , sec	0.0485
	b.	Ignition Time, t_i , sec	0.0540
	c.	Burning Time, t_b , sec	0.2625
	d.	Action Time, t_a , sec	0.3215
Pressure Data	a.	Maximum Ignition PYROGEN Pressure, psia	1841
	b.	Maximum PYROGEN Pressure, Pmax, psia	740
	c.	Minimum PYROGEN Pressure, Pmin, psia	650

TF-5161

DATA SUMMARY SHEET
TE-372-3 PYROGEN IGNITER

Identification	a.	Project	5118
	b.	PYROGEN Igniter Number	TED-300-1 #1
	c.	Case Serial Number	NA
	d.	Firing Record Number	CK-7986
	e.	Test Date	28 Feb. 1964
	f.	Test Time	1156
Test Conditions	a.	Ambient Temperature, ^{o}F	38
	b.	Barometric Pressure, in Hg	29.93
	c.	Relative Humidity, %	75
	d.	Conditioned Temperature	
		(1) PYROGEN Igniter, ^{o}F	0
		(2) Initiator, ^{o}F	0
	e.	Ignition Environment, mm Hg	760
Initiator Data	Initiator-Booster Type		E-16452-10 ME453-0009-0004(Mod)
	Part Numbers (1)		S01-266
		(2)	NA
	Serial Numbers (1)		4221
		(2)	NA
Ignition Data	a.	Ignition Delay, t_d , sec	0.050
	b.	Ignition Time, t_i , sec	0.055
	c.	Burning Time, t_b , sec	0.301
	d.	Action Time, t_a , sec	0.356
Pressure Data	a.	Maximum Ignition PYROGEN Pressure, psia	1730
	b.	Maximum PYROGEN Pressure, Pmax, psia	665
	c.	Minimum PYROGEN Pressure, Pmin, psia	606

HERCOL CHEMICAL CORPORATION
ELKTON DIVISION
ELKTON, MARYLAND

DATA SUMMARY SHEET
FOR TE-29, REDACTED

Project 4171 — Invoice No. CK-8010

Propellant TP-E-8035 — Engine No. PV16-317-8

Test Date 3-3-64 — Engine Type TE-29

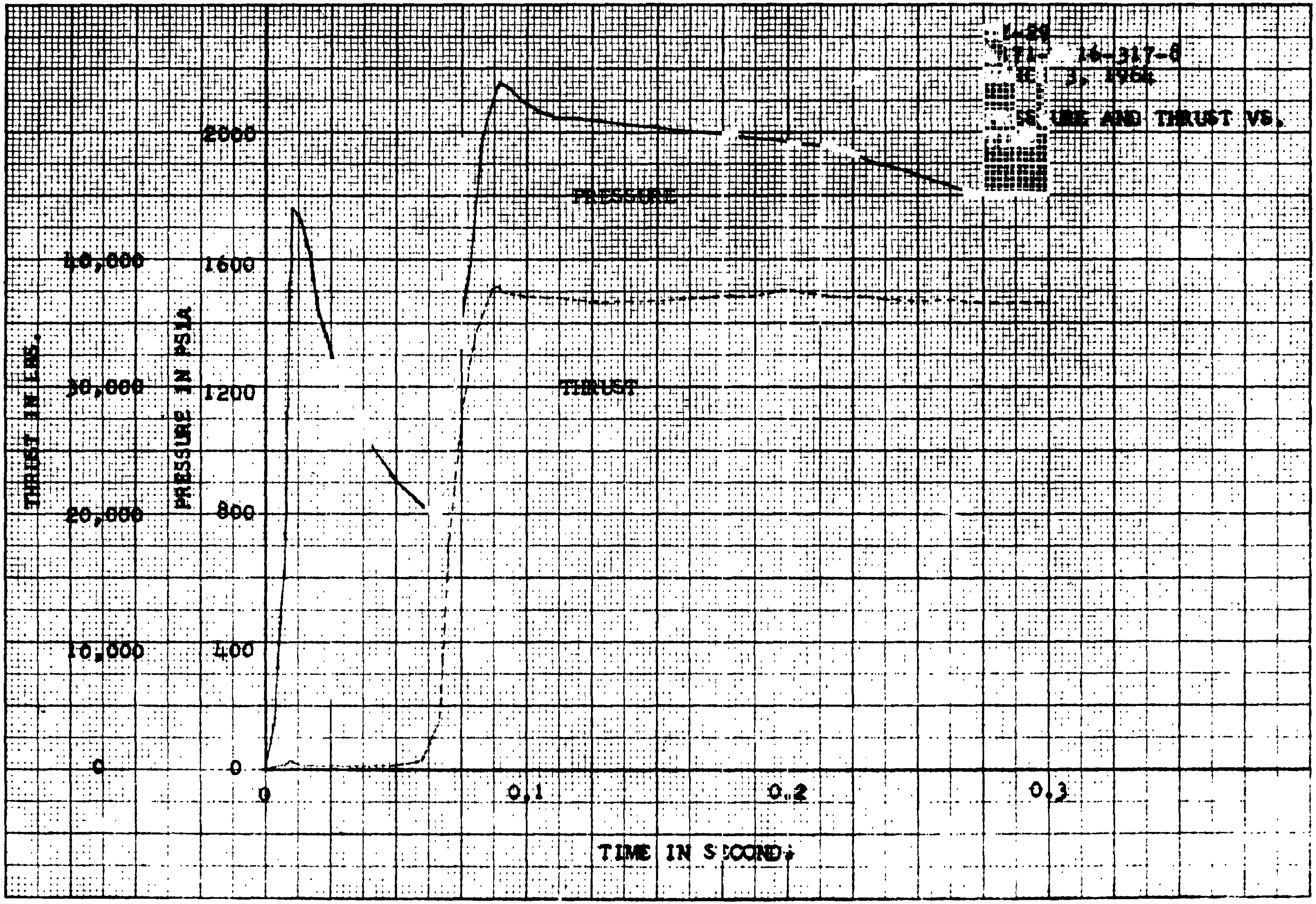
1.	Total Motor Weight, lbs.	362.50
2.	Propellant, Weight, lbs.	263.50
3.	Weight burned, lbs.	265.40
4.	Nozzle Throat: before test, in.	4.296
	after test, in.	4.309
5.	Nozzle Exit: before test, in.	11.4062
	after test, in.	11.4062
6.	Nozzle Throat Area, A_t, in.^{2}	14.539
7.	Nozzle Exit Area, A_e, in.^{2}	102.182
8.	Ambient temperature at time of test, °F	44
9.	Engine and Igniter temperature at test, °F	+60
10.	Relative Humidity, %	93
11.	Ignition Delay, t_d, secs.	0.065
12.	Ignition Rise Time, t_r, secs.	0.011
13.	Burning time, t_b, secs.	1.487
14.	Action time, t_a, secs.	1.828
15.	Average burning rate, in/sec.	1.049
16.	Maximum Ignition Pressure	2153

Engine No. PV16-317-8

17.	**Maximum Pressure, psia**	1815
18.	**Average Pressure, psia**	1508
19.	**Minimum Pressure, psia**	1405
20.	$\int P\, dt_a$	2756
21.	$\int P\, dt_b$	2549
22.	**Maximum Ignition Thrust, lbs.**	37,988
23.	**Maximum Thrust, lbs.**	38,585
24.	**Average Thrust, lbs.**	31,667
25.	**Minimum Thrust, lbs.**	30,928
26.	$\int F\, dt_a$	57,887
27.	$\int F\, dt_b$	53,598
28.	C_F Thrust Coefficient	1.44
29.	**Discharge Coefficient,** C_d	0.90
30.	**Deliverable Total Impulse, lb-sec.**	58,729
31.	**Overall Specific Impulse, lb-sec/lb.**	162
32.	**Propellant Specific Impulse, lb-sec/lb.**	223
33.	**Characteristic Exhaust Velocity, ft/sec.**	4897

Data from PYROGEN

1.	Maximum pressure, psia	1752
2.	Ignition Delay, t_d, sec	0.002
3.	Ignition Rise Time, t_r, sec	0.004


2000
1600
1200
800
400
0
40,000
30,000
20,000
10,000
0
THRUST IN LBS.
PRESSURE IN PSIA
PRESSURE
THRUST
0
0.1
0.2
0.3
TIME IN SECONDS
16-317-6
3, 1964
AND THRUST VS.