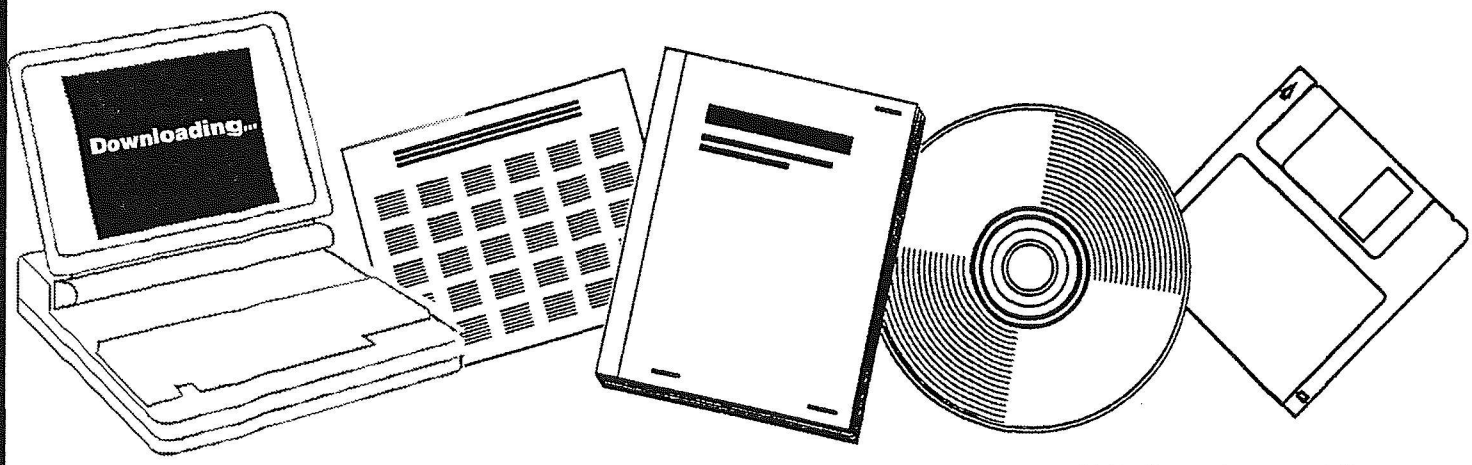
N6822981

NTIS
One Source. One Search. One Solution.

TECHNICAL REPORT C-1 ENGINE DEVELOPMENT BIPROPELLANT VALVE IMPROVEMENT PROGRAM

GEORGE C. MARSHALL SPACE FLIGHT CENTER

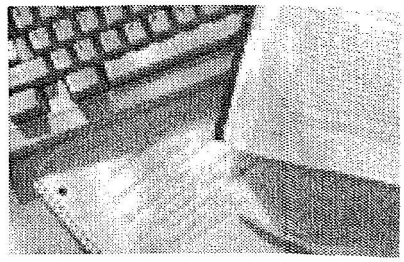
AUG 1967



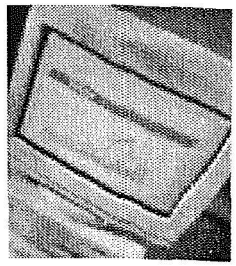
U.S. Department of Commerce
National Technical Information Service

One Source. One Search. One Solution.

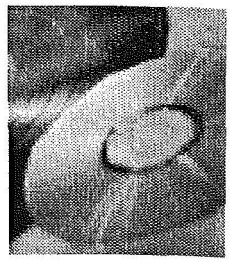
NTIS



Providing Permanent, Easy Access to U.S. Government Information



The National Technical Information Service is the Nation's largest repository and disseminator of government-initiated scientific, technical, engineering, and related business information. The NTIS collection includes almost 3 million information products in a variety of formats: electronic download, online access, DVD, CD-ROM, magnetic tape, diskette, multimedia, microfiche and paper.



Search the NTIS Database from 1990 forward

More than 600,000 government research information products have been added to the NTIS collection since 1990. All bibliographic entries for those products are searchable on the NTIS Web site at www.ntis.gov.

Download Publications (1997 - Present)

NTIS provides the full text of many reports received since 1997 as downloadable PDF files. When an agency stops maintaining a report on its Web site, NTIS still offers a downloadable version. There is a fee for each download of most publications.

For more information visit our website:

www.ntis.gov

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161

RADIAMIC C-1 ENGINE.

Thiokol CHEMICAL CORPORATION

C-1 ENGINE FINAL REPORT

Prepared for George C. Marshall Space Flight Center
Under Contract NAS8-15486

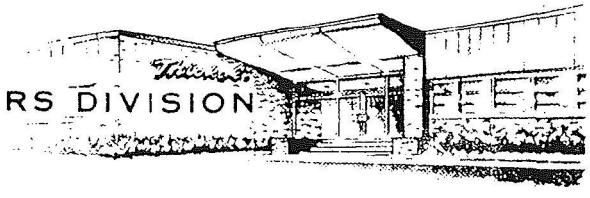
TECHNICAL REPORT C-1 ENGINE DEVELOPMENT

BIPROPELLANT VALVE IMPROVEMENT PROGRAM

Addendum No. 1

To Final Report RMD 6203F

31 August 1967



● REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

Thiokol
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

C-1 ENGINE PROGRAM

PHASE II DEVELOPMENT

Technical Report Bipropellant Valve
Improvement Program

Addendum No. 1

To Final Report RMD 6203-F1

Approved by: L. M. Bachman
C-1 Program Manager

CONTENTS

		Page
1.0	INTRODUCTION	1-1
1.1	PURPOSE	1-1
1.2	CONTRACTUAL COVERAGE	1-1
1.3	BACKGROUND	1-1
2.0	SUMMARY	2-1
APPENDIX	Moog Evaluation Test Report No. MR 1216	

ILLUSTRATIONS

Figure		Page
2.0-1	Flat Spring Flapper-Button Motion Restrictors	2-2
2.0-2	Design Sketch of Flat Spring Installation	2-3
2.0-3	Teflon Seat After Test S/N 45 Valve	2-4

Table		
2.0-I	Vibration Testing Matrix	2-5
2.0-II	Vibration Spectra	2-6

1.0 INTRODUCTION

1.1 PURPOSE

This report describes the program conducted to improve the vibration characteristics of the bipropellant valve used on the C-1 Engine and presents the test data obtained during this evaluation. The content of this document forms a part of Thiokol-RMD Report 6203-F1. The program reported herein completes the development work on the bipropellant valve for the C-1 Engine.

1.2 CONTRACTUAL COVERAGE

The bipropellant valve improvement program was conducted for the George C. Marshall Space Flight Center under NASA Contract NAS8-15486.

1.3 BACKGROUND

The bipropellant valve (Thiokol-RMD Part No. 316305-300) qualified as part of the C-1 Engine demonstrated marginal vibration characteristic when subjected to the unpressurized vibration test. The marginal condition was evidenced by excessive seal leakage after being exposed to the vibration environment. The leakage resulted from excessive relative motion between the flapper button and seat. At extreme vibration levels this motion generated hairlike teflon particles and chips which interfered with reliable sealing. A detailed discussion of this condition is contained in Thiokol-RMD Report No. 6203-F1, Sections 4.4 and 14.0, and in Thiokol-RMD Report No. 6203-Q2. To extend the vibration capability of the bipropellant valve, a design improvement and vibration evaluation program was conducted. The initial progress of this program was reported in Thiokol-RMD Report 6203-F1.

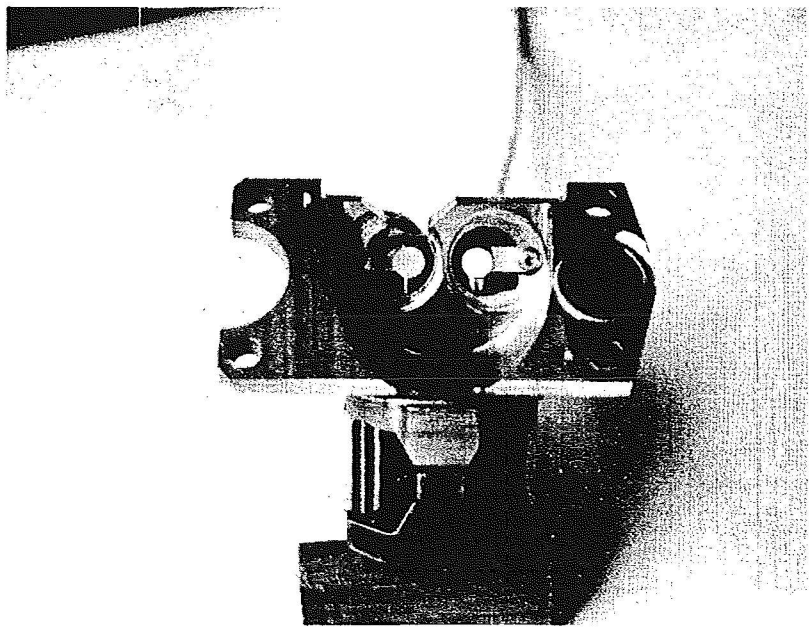
Appended to this document is a copy of the Moog Inc. Evaluation Test Report No. MR 1216 which contains a discussion of the design improvement program and the test data obtained during this program.

2.0 SUMMARY

Two bipropellant valve test specimens were modified by the addition of a flat spring motion restrictor to each flapper-button as shown in Figures 2.0-1 and 2.0-2. The test specimens successfully completed all the unpressurized vibration tests and the performance tests without malfunction. The vibration testing was conducted with the valve assembled to a Thiokol-RMD thrust chamber assembly (Part No. 317555). The vibration input was controlled at the thrust chamber test fixture mounting surface. Tables 2.0-I and 2.0-II describe the specified vibration envelopes which were utilized for these tests. Further detail regarding test parameters and recorded data is contained in Appendix A of this report.

The first test specimen, S/N 45, was subjected to 50,000 cycles after completing all vibration testing. The valve sealing elements (nozzles) were removed following these tests for visual examination. As shown in Figure 2.0-3, the teflon seat revealed negligible wear and no evidence of hairlike particles or chips. The second test specimen, S/N 112, was also disassembled following vibration testing and again visual inspection revealed a completely satisfactory condition.

The design change incorporating the flat spring motion restrictor to each flapper button has been made in the bipropellant valve assembly identified as Thiokol-RMD Part No. 316305-400. As shown in Figures 2.0-1 and 2.0-2, the flat spring is retained in the valve body by a small button head screw which is heli-arc spot welded to spring and body to lock in position. The other end of the spring is retained by an interference fit with the small diameter shaft end of the flapper button which is pressed into the valve body. The two sample test specimens were assembled in this manner and showed no signs of loosening or structural failure during the vibration tests. This revised design feature has greatly improved the vibration characteristics of the bipropellant valve when exposed to the unpressurized vibration levels which is the most severe environment. The valve assembly can now meet or exceed the specified unpressurized vibration requirements and can satisfactorily pass all functional tests following the vibration tests. Three bipropellant valve assemblies of the improved design will be delivered to the Marshall Space Flight Center for further evaluation.



Reproduced from best available copy.

Figure 2.0-1. Flat Spring Flapper-Button Motion Restrictors

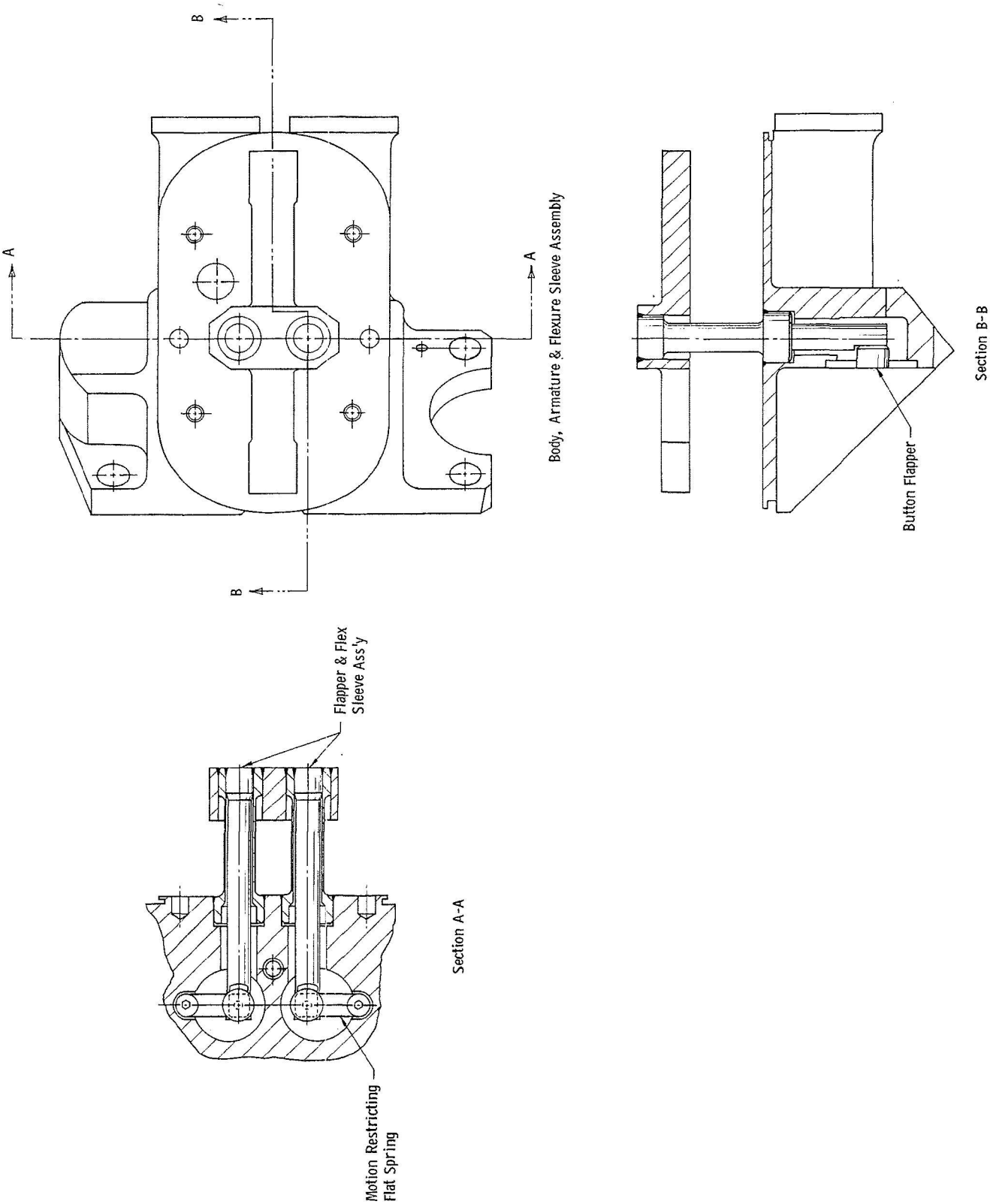
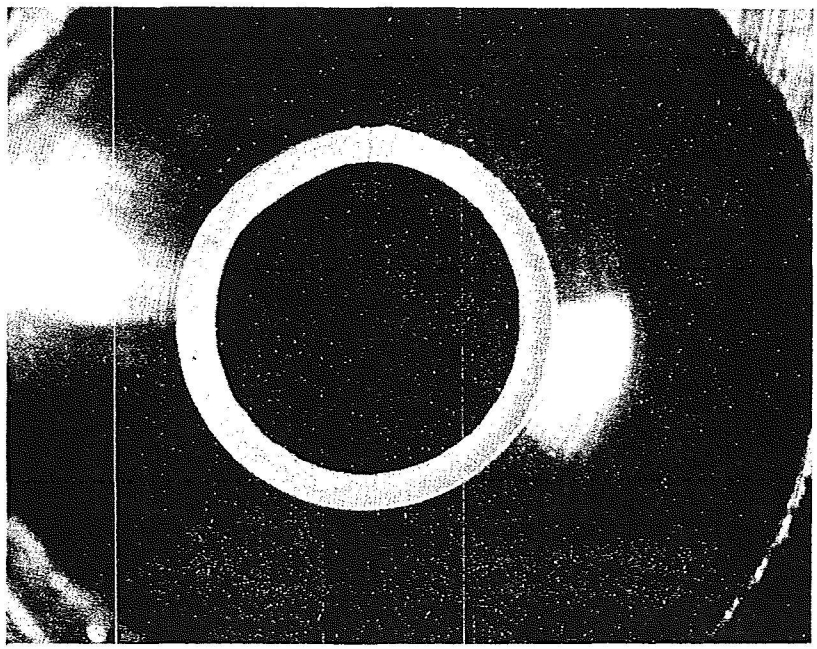


Figure 2.0-2. Design Sketch of Flat Spring Installation



Oxidizer Nozzle

Reproduced from best available copy.

Fuel Nozzle

Figure 2.0-3. Teflon Seat After Test S/N 45 Valve

TABLE 2.0-I

VIBRATION TESTING MATRIX

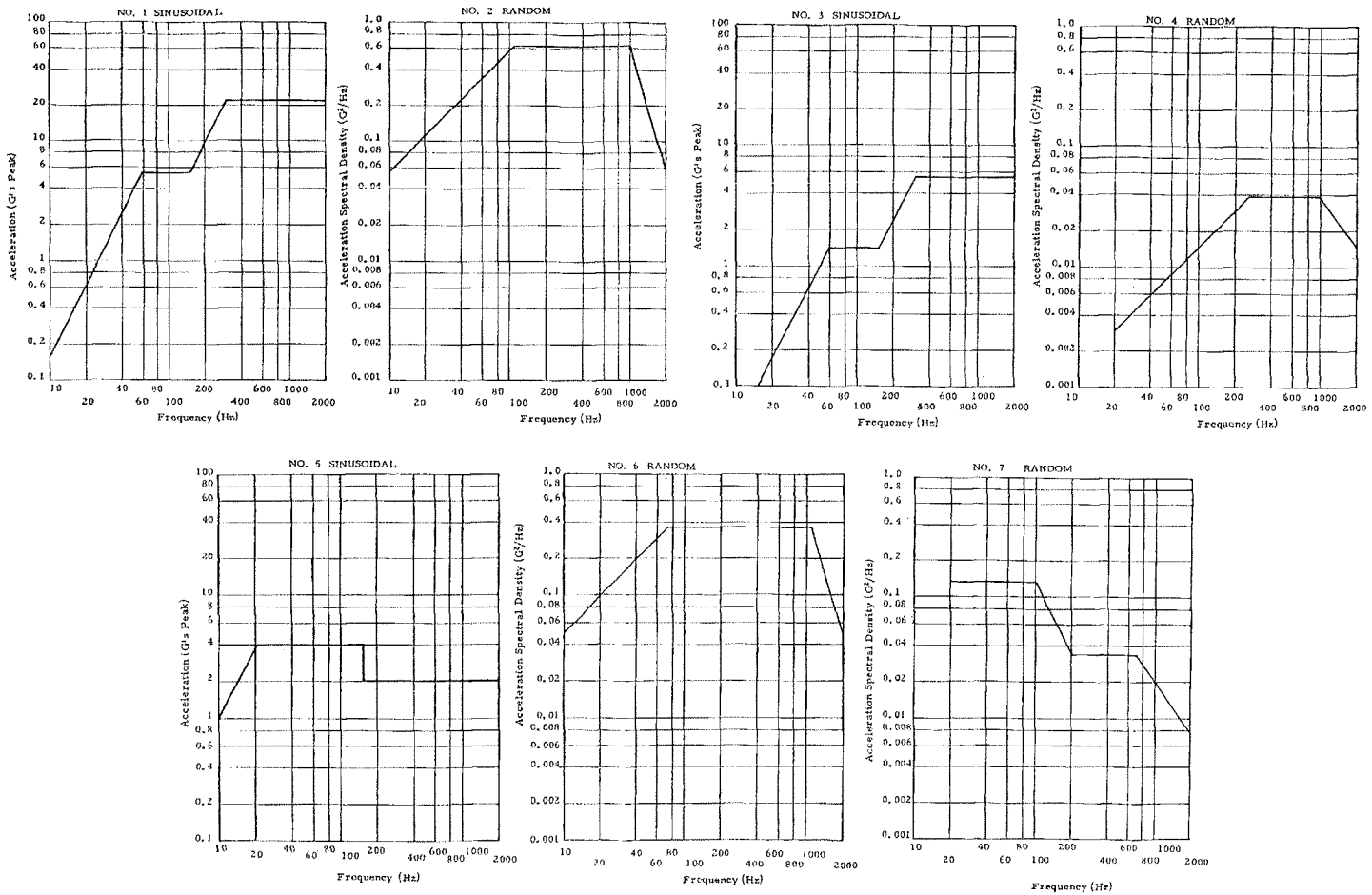
Configuration	Sequence	Non-Operating								Operating			
		Pressurized				Un Pressurized				Pressurized			
		Sine		Random		Sine		Random		Sine		Random	
		Spectrum	Time	Spectrum	Time	Spectrum	Time	Spectrum	Time	Spectrum	Time	Spectrum	Time
Bipropellant Valve Engine	A	--	--	--	--	1	54 min	2	36 min	--	--	--	--
	B	1	54	2	36	1	27	2	24	--	--	--	--
	C	--	--	--	--	5	54	6	15	3	54	4	27
	D	--	--	--	--	5	54	7	15	3	54	4	27
Quadredundant Valve Engine	A	1	54	2	36	--	--	--	--	3	54	4	27
	B	--	--	--	--	5	54	6	15	3	54	4	27
	C	--	--	--	--	5	54	7	15	3	54	4	27
	D	--	--	--	--	--	--	--	--	3	54	4	27

Note: Refer Table 2.0-II for Spectra Definition

Thiokol
REACTION MOTORS DIVISION

TABLE 2.0-II

VIBRATION SPECTRA



Thiokol
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

APPENDIX A

EVALUATION TEST REPORT

FOR THE

ADVANCED DESIGN OF THE

MOOG MODEL 52X147C BIPROPELLANT VALVE

MOOG INC.
Report No. MR 1216

Final Report RMD 6203-F1
Addendum No. 1

EVALUATION TEST REPORT

FOR THE

ADVANCED DESIGN OF THE

MOOG MODEL 52X147C BIPROPELLANT VALVE

MOOG INC.
Report No. MR 1216

Reproduced from best available copy.

Prepared by: _____
Gordon B. LeRoy
Sr. Reliability Engineer

Reviewed by: _____
Carl W. Naab
Project Engineer

Approved by: _____
David P. Elmer
Manager, Reliability
Engineering

Date: June 28, 1967

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	SUMMARY	2
3.0	TEST SPECIMENS	3
4.0	TEST OUTLINE	4
5.0	TEST METHODS	14
5.1	Vibration System and Fixturing	14
5.2	Instrumentation	14
5.2.1	Visual	14
5.2.2	Coil Voltage	15
5.3	Vibration Levels	16
6.0	TEST DATA	25

FIGURES

		Page
1.	Model 52-147, S/N 238, Axis A, 4/20/67; 10 g input to valve. Accelerometer located on oxidizer inlet in input direction	42
2.	Model 52-147, S/N 238, Axis A, 4/20/67; 10 g input to valve. Back emf vs frequency	43
3.	Model 52-147, S/N 238, Axis B, 4/20/67; 10 g input to valve. Accelerometer located on side of oxidizer inlet in input direction.	44
4.	Model 52-147, S/N 238, Axis B, 4/20/67; 10 g input to valve. Back emf vs frequency	45
5.	Model 52-147, S/N 238, Axis C, 4/20/67; 10 g input to valve. Accelerometer located on oxidizer inlet in input direction.	46
6.	Model 52-147, S/N 238, Axis C, 4/20/67; 10 g input to valve. Back emf vs frequency	47
	Model 52-147, Torque Motor Study, Axis A, 4/25/67; 10 g and 20 g input. Accelerometer located on top pole-piece in input direction	48
8.	Model 52-147, Torque Motor Study, Axis B, 4/25/67; 10 g and 20 g input. Accelerometer located on magnet in input direction	49
9.	Model 52-146, Axis C, 5/26/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input	53
10.	Model 52-146, Axis A, 5/26/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input	54
11.	Model 52-146, Axis B, 5/26/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input	55

Reproduced from best available copy.

FIGURES (cont'd.)

Page

12. Model 52-147, Axis A, 6/7/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input 56

13. Model 52-147, S/N 204, Axis B, 6/7/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input 57

14. Model 52-147, S/N 204, Axis C, 6/6/67. Wire armature motion restrictors on free end of armature, 27.7 g rms input 58

15. Model 52X147C, Body, S/N 45, Axis C, 7/25/67. Flapper button motion restrictors, flat spring, 27.7 g rms 67

16. Model 52X147C, Body, S/N 45, Axis A, 7/25/67. Flapper button motion restrictors, flat spring, 27.7 g rms input 69

17. Model 52X147C, Body, S/N 112, Axis C, 8/12/67. Flapper button motion restrictors, flat spring, 27.7 g rms input 85

18. Model 52X147C, Body, S/N 112, Axis A, 8/12/67. Flapper button motion restrictors, flat spring, 27.7 g rms input 87

19. Model 52X147C, Body, S/N 112, Axis B, 8/12/67. Flapper button motion restrictors, flat spring, 27.7 g rms input 89

Reproduced from best available copy.

PHOTOGRAPHS

		Page
1.	Model 52-147B, S/N 238; Test Setup Utilized to Determine Valve Mounting Frequencies	17
2.	Model 52-147B, S/N 238; Test Setup Utilized to Determine Valve Mounting Frequencies	18
	Model 52-147B, S/N 238; Test Setup Utilized to Determine Natural Frequency of Armature-Flexure Sleeve Assembly	19
4.	Model 52-147B Torque Motor Test Setup Utilized to Determine Natural Frequency of Torque Motor	20
5.	Model 52-147 "Wire" Armature Motion Restrictors	21
6.	Model 52-147 "Flat Spring" Flapper-Button Motion Restrictors	22
7.	Model 52-147, S/N 45; Oxidizer Nozzle and Fuel Nozzle	23
8.	Model 52-147, S/N 45; Fuel Button	24

REFERENCES

1. "Valve, Bipropellant, Electrical, Torque Operated, Pulse Modulated," Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey, Specification Document EC20517, Revision L, dated January 10, 1967.

2. "Qualification Test Procedure for Valve, Bipropellant, Electrical, Torque Motor Operated, Pulse Modulated, Moog Model 52-147B, Moog Inc., East Aurora, New York, Report Number MR 1144, Revision B.

Reproduced from best available copy.

1.0 INTRODUCTION

The bipropellant valves, presently being built for Reaction Motors Division of Thiokol Chemical Corp., do not meet the internal leakage performance requirements of RMD Specification EC 20517 Revision K after exposure to the vibration environment specified in paragraph 4.7.18. Moog was informed in late April that the bipropellant valve must be modified to incorporate the necessary design changes to insure passage of all performance requirements after exposure to vibration testing.

This report documents test data obtained during vibration evaluation of the existing valve design and of the various design concepts developed to eliminate the vibration problem. The purpose of these tests was to obtain information on the resonance behavior of the valve body and the torque motor armature-flexure sleeve assembly and the effect of certain modifications on this behavior.

The tests presented in this report were conducted in the Moog Reliability Engineering Laboratory during the period of April 20 through August 11, 1967, and were authorized by Moog Job Order Number 1766723.

Reproduced from best available copy.

2.0 SUMMARY

Two test specimens, modified by the addition of a flat spring motion restrictor to each flapper-button, completed all vibration and performance tests without malfunction. Vibration testing was conducted with the valve mounted on the RMD thrust chamber (P/N 317555), in accordance with paragraphs 5.2.2 and 5.2.3 of Moog Report No. MR 1144, Rev. B. The vibration input was controlled at the thrust chamber test fixture mounting surface. The test specimens were unpressurized during vibration.

The first specimen tested, Body S/N 45, was subjected to 50,000 cycles after completing all vibration testing. The nozzles were then removed from this specimen and visual examination of the teflon seat revealed negligible teflon wear. (See illustration 8 of this report). The second specimen, Body S/N 112, was disassembled following vibration testing and visual inspection again revealed negligible teflon wear.

The test specimens utilized for this evaluation are identical to the Model 52-147B configuration with the exception of the addition of the button motion restrictors. Review of the performance data recorded for these two specimens (see section 6.0) indicates that the modified valve configuration meets all the specification performance requirements.

3.0 TEST SPECIMENS

The following bipropellant valves were tested:

a. Model 52-147B, S/N 238, unmodified except motor cap removed and body slotted to permit observation of armature and flapper button.

b. Model 52-147B Torque Motor consisting of bottom and top polepieces, magnets, and four screws.

c. Model 52-147B, S/N 238, modified by jamming armature with wood. Same as item (a).

d. Model 52-147B modified by removing both polepieces and magnets.

e. Model 52-147B, S/N 238, same as item (a), modified by the addition of armature motion restrictors. Wire restraint.

f. Model 52-147B, S/N 238, same as item (a), modified by the addition of armature motion restrictors. Set screw restraint.

g. Model 52-146, modified by the addition of wire armature motion restrictors on free end of armature.

h. Model 52-147 S/N 204, modified by the addition of wire armature motion restrictors on free end of armature.

i. Model 52-147, modified by the addition of wire armature motion restrictors on both ends of armature.

j. Model 52-147, modified by the addition of a flapper-button motion restrictor. Flat spring. The nozzle assembly was not installed in this valve.

k. Model 52-147, S/N 45 modified by the addition of a flapper-button motion restrictor. Flat spring.

l. Model 52-147, S/N 112 modified by the addition of a flapper-button motion restrictor. Flat spring.

4.0 TEST OUTLINE

An outline of the tests performed is presented in Table I. This outline presents a tabulation of test procedures and results reported in chronological order. Test specimen configuration is identified in accordance with the itemized description presented in paragraph 3.0.

Reproduced from best available copy.

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
4/20/67	A	Sinusoidal sweep. 290 - 2000 Hz. 10 g peak input at valve mounting surface valve de-energized. Simultaneously made X-Y plots of body acceleration vs. frequency and of coil voltage generated by armature vs. frequency.	1. Axis A: see body acceleration plot #1 and coil voltage plot #2. Vibration sweep time: 9 min 48 sec. 2. Axis B: see body acceleration plot #3 and coil voltage plot #4 Vibration sweep time: 9 min. 48 sec. 3. Axis C: see body acceleration plot #5 and coil voltage #6 Vibration sweep time: 9 min. 48 sec.
4/21/67	A	Sinusoidal resonance search. 290 - 2000 Hz, 20 g peak input at valve mounting surface. valve de-energized	1. Axis B: a. observed end of button 1250 Hz - .007" D. A. vertical b. observed end of button stops. 1290 Hz - .0005 in. D. A. vertical .0005 in. D. A. horizontal c. observed "latched" end of armature 1320 Hz - .0007 in. D. A. vertical d. observed free end of armature 1273 Hz - .004 in. D. A. vertical Note: armature out of phase with both bottom & top polepieces.

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
4/25/67	B	Sinusoidal sweep 290 - 2000 Hz, 10 g and 20 g input at the torque motor mounting surface	1. Axis A: see torque motor acceleration plot #7 2. Axis B: see torque motor acceleration plot #8
4/27/67	C	Sinusoidal resonance search 290 - 2000 Hz, 20 g peak input at valve mounting surface, valve de-energized.	1. Axis B: a. observed end of button 1278 Hz - .0002 in. D. A. vertical; 1348 Hz - .0007 in. D. A. vertical b. observed free end of armature - 1186 Hz - .0008 in. D. A. vertical; 1388 Hz .0006 in. D. A. vertical Note: upper polepiece and armature are in phase, lower polepiece and armature are in phase
5/1/67	D	Sinusoidal resonance search, 100 - 2000 Hz 1. 1.0 g peak input at valve mounting surface	1. Axis A: observed long end of armature 496 Hz - .005 in. D. A. vertical 2. Axis B: observed long end of armature 801 Hz - .002 in. D. A. vertical 3. Axis C: observed long end of armature 240 Hz - .0006 in. D. A. vertical 500 Hz - .0005 in. D. A. vertical

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
		2. 3.0 g peak input at valve mounting surface	1. Axis A: observed long end of armature. Negligible movement throughout 600 - 2000 Hz bandwidth 2. Axis C: observed long end of armature. Negligible movement throughout 600 - 2000 Hz bandwidth
		3. 5.0 g peak input at valve mounting surface	1. Axis C: observed long end of armature 800 Hz - .0002 in. D.A. vertical 900 Hz - .0002 in D.A. vertical 1900 Hz - .0002 in. D.A. vertical
5/5/67	E	Sinusoidal resonance search. 2.90 - 2000 Hz, 22 g peak input at valve mounting surface, valve de-energized. Wires attached to both ends of armature. Posts mounted to bottom polepiece.	1. Axis B: a. observed end of button. Data considered invalid because one of the wires on the free end of the armature was found broken after search. b. observed free end of armature. Data considered invalid because one wire was found to have lost its preload after the search.

TABLE 1

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
5/9/67	E	Continue resonance search as conducted on 5/5/67. A new technique of securing the wire to its post was evaluated.	1. Axis B: observed end of button 1260 Hz - .0023 in. D.A. vertical 2. Axis A: observed end of button. Negligible movement throughout 290 - 2000 Hz bandwidth 3. Axis C: observed end of button. Negligible movement throughout 290 - 2000 Hz bandwidth Note: One of the wires was found broken after the third axis of vibration. Validity of data is questionable.
5/11/67	E	Continue resonance search as conducted on 5/5/67. A second new method of securing the wire to its post was evaluated.	1. Axis B: observed end of button. 1249 Hz - .0005 in. D.A. vertical 2000 Hz - .0012 in. D.A. vertical Note: The inboard wire on the short end of the armature was found broken after search.
5/18/67	E	Continue resonance search as conducted on 5/5/67. A third method of securing the wire to its post was evaluated.	1. Axis B: Observed end of button 1792 - 1820 - .003 in. D.A. vertical 1865 - .006 in. D.A. vertical Note: The outboard wire on the free end of armature was found broken after search. Validity of data is questionable.

TABLE 1

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
5/19/67	F	Sinusoidal resonance search. 290 - 2000 Hz. 22 g peak input at valve mounting surface, valve de-energized. Set screw restraint at free end of armature only. Post mounted on top polepiece.	1. Axis B: a. observe end of button: 1300 Hz - .0003 in. D. A. vertical; 1914 - 1960 Hz - .0025 in. D. A. vertical b. observe end of post: 1248 Hz - .0005 in. D. A. vertical; 1898 to 2000 - .001 in. D. A. vertical c. observe top polepiece: 1290 Hz - .0005 in. D. A. vertical; 1825 - 1990 - .001 in. D. A. vertical. d. observe bottom polepiece. Negligible movement throughout bandwidth.
5/23/67	E	Sinusoidal resonance search, 290 - 2000 Hz. 22 g peak input at valve mounting surface, valve de-energized. Wires attached to free end of armature only. Post mounted to bottom polepiece. A new post design was evaluated.	1. Axis B: a. observe end of button: 1236 - 1300 Hz - .0005 in. D. A. vertical; 2000 - .002 in. D. A. vertical b. observe end of post: 1200 Hz - .0005 in. D. A. vertical; 1850 - 2000 Hz - .0005 in. D. A. vertical 2. Axis A: observe end of button 1280 Hz - .001 in. D. A. vertical 3. Axis C: observe end of button: 1560 - 1650 Hz - .0002 in. D. A. vertical

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
5/24/67	F	Sinusoidal resonance search, 200 - 2000 Hz, 22 g peak input at valve mounting surface, valve de-energized. Set screw restraint at free end of armature only. Posts mounted on bottom polepiece.	1. Axis B: a. observe end of button: 1289 to 1321 Hz - .005 in. D. A. vertical. b. observe set screw post 1050 Hz - .0005 in. D. A. vertical. c. observe free end of armature 1279 - 1401 Hz - .002 in. D. A. vertical.
5/26/67	G	Sinusoidal and random vibration testing were conducted in accordance with Moog Report Number MR 1144, Rev. B, paragraphs 5.2.2 and 5.2.3. The valve was installed on the RMD thrust chamber and was unpressurized throughout vibration. The sequence of testing was: sinusoidal - axes C, A, B; random - axes C, A, B.	See tabulated data sheets for initial, interval, and final performance test results. Inspection of the nozzles after vibration revealed severe teflon wear. Visual inspection of the manifold to body mating surfaces revealed relative motion between the two components. Such motion would produce movement between the nozzle and its mating button resulting in teflon wear. Testing was, therefore, considered invalid.
6/3/67	H	Vibration testing same as testing conducted on 5/26/67. See above. After vibration, the valve was cycled 50,000 times before disassembly and subsequent visual inspection of the buttons and nozzles	See tabulated data sheets for initial, interval, and final performance test results. Inspection of the nozzles after vibration revealed excessive teflon wear.

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
6/22/67	J	Sinusoidal resonance search, 290-2000 Hz Valve energized closed with 16 volts	
		1. 22 g peak input at valve mounting surface	1. Axis B - observed end of button 1400 Hz -.003" D.A. horizontal 1690 Hz -.005" D.A. horizontal
		2. 30 g peak input at valve mounting surface	1. Axis B - observed end of button 1400 Hz -.005" D.A. horizontal
6/23/67	J	Sinusoidal resonance search, 290-2000 Hz, valve de-energized.	
		1. 30 g peak input at valve mounting surface	1. Axis B - observed end of button 1450 Hz -.002" D.A. vertical .002" D.A. horizontal
		2. 40 g peak input at valve mounting surface	1. Axis B - observed end of button 1370 Hz - .003" D.A. vertical 1200 Hz - .001" D.A. vertical
		3. 50 g peak input at valve mounting surface	1. Axis B - observed end of button 1200 Hz - .002" D.A. elliptical 1300 - 1380 Hz - .001" D.A. elliptical 1500 - 1550 Hz - .001" D.A. elliptical

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
6/28/67	I	Sinusoidal resonance search 290-2000 Hz, valve de-energized	
		1. 22 g peak input at valve mounting surface	1. Axis B - observed end of button 1200 - .0002" D.A. vertical
		2. 30 g peak input at valve mounting surface	1. Axis B - observed end of button 1230 Hz - .0015" D.A. vertical 1700 Hz - .002" D.A. vertical
		3. 40 g peak input at valve mounting surface	1. Axis B - observed end of button 1260 Hz - .002" D.A. vertical 1870 Hz - .002" D.A. vertical
		4. 50 g peak input at valve mounting surface	1. Axis B - observed end of button 1230 - .006" D.A. vertical 1470 - .006" D.A. vertical

TABLE I

MODEL 52-147 ADVANCED DESIGN STUDY PROGRAM

Date	Specimen Configuration	Test	Results
7/25/67	K	Sinusoidal and random vibration testing were conducted in accordance with Moog Report No. MR 1144 Rev. B paragraphs 5.2.2 and 5.2.3. The valve was installed on the RMD thrust chamber and was unpressurized throughout vibration. The sequence of testing was: sinusoidal axes C, A, B random axes C, A, B All functional checks were conducted at a reduced pressure level because of an external leak at the manifold to body weld interface	See tabulated data sheets for initial, interval, and final performance test results. No internal leakage was recorded. Inspection of the nozzles after vibration and life showed negligible wear of the teflon

5.0 TEST METHODS

5.1 Vibration System and Fixturing

All tests were performed using a Unholtz-Dickie Model 200 shaker driven by a 10 KVA amplifier. Vibration control was by a B & K 1018 controller, with an Endevco 2221C accelerometer filtered by a Spectral Dynamics SD101A Tracking Filter, bandwidth 20/100 Hz with 280 Hz crossover frequency. An Unholtz-Dickie 610R Dial-A-Gain accelerometer amplifier was also used.

The bipropellant valve was mounted to the shaker by means of a nearly cubical aluminum test fixture (Moog No. T12184-2), approximately 5 in. long x 5 in. wide x 5 in. deep. Valve mounting holes were provided on two edges of this block to permit mounting the valve in the three major mutually perpendicular axes. Acceleration was controlled from the top surface of this fixture.

5.2 Instrumentation

Two methods of detecting and measuring resonances were employed in the course of this test.

Reproduced from best available copy.

5.2.1 Visual

A Gaertner microscope with reticle graduated in .001 in. divisions was employed, primarily to observe motion of the end of the armature between the polepieces. A Chadwick-Helmuth Slip-Sync Stroboscope was used to illuminate the valve.

In general, motion of about .0002 inches double amplitude are discernable by this method.

5.2.2 Coil Voltage

Motion of the armature induced by applied vibration results in an e.m.f. being generated in the torque motor coils. This fact was used to detect resonances by making an automatic X-Y plot of coil voltage vs. vibration frequency. The valve coil was connected to a Moseley 60D Log Converter and an Electro-Instruments 400 X-Y plotter. Frequency signal was provided by the B & K 1018 Controller.

This method of detecting torque motor resonances appears to be quite sensitive, especially compared with the visual method described above. Limitations which should be observed in interpretation of these plots center around the hazards of comparing the amplitude of the voltage at various resonant frequencies. Voltage amplitude is dependent on, in part:

1. Relative velocity of the armature and polepiece
2. Angle at which lines of flux are cut
3. Mode of resonance (related to (2) above)

Reproduced from best available copy.

It can be seen that a thorough knowledge of the dynamic behavior of the torque motor under vibration would be required to interpret the significance of the amplitudes recorded.

5.3 Vibration Levels

Select test specimens were subjected to the vibration levels specified below while installed on the RMD thrust chamber (P/N 317555). These levels are in accordance with Moog Report No. MR 1144 Rev. B.

a. Sinusoidal Vibration

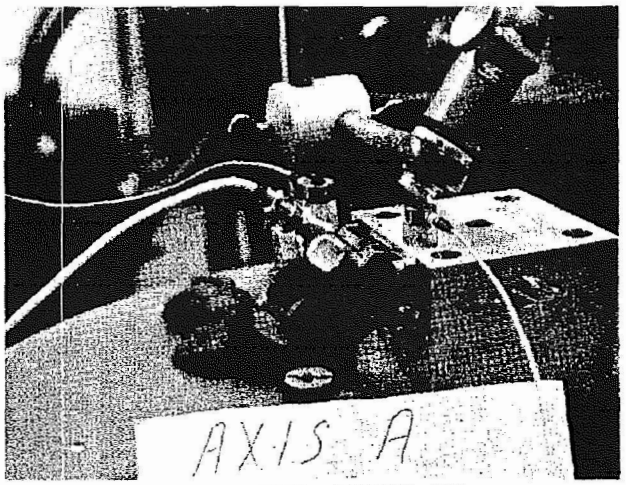
1. valve unpressurized
2. sweep rate - 2 octave/min. per axis
3. level:

5 - 58 cps	0.031 inch D.A.
58 - 150 cps	5.4 g peak
150 - 295 cps	0.0049 inch D.A.
295 - 2000 cps	21.8 g peak

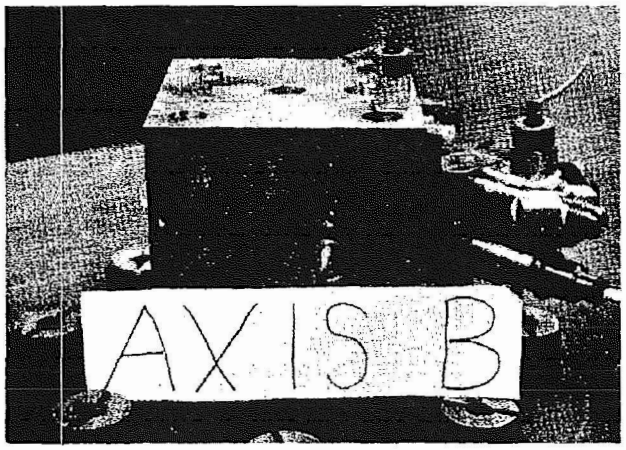
b. Random Vibration

1. valve unpressurized
2. 8 minutes/axis
3. level

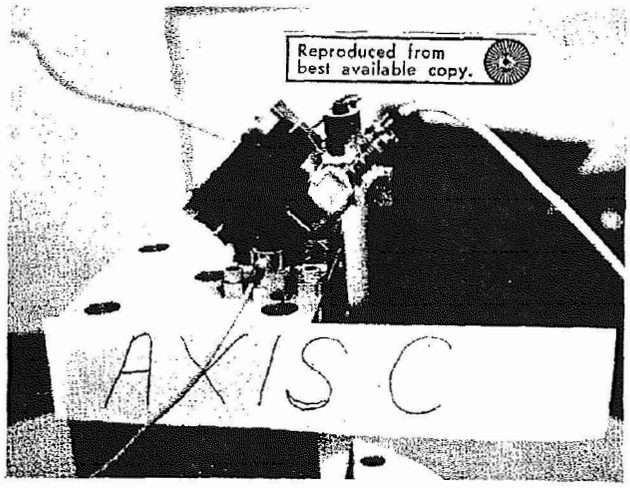
10 - 110 cps	0.055 g^2/cps at 10 cps increasing 3 db/octave to 0.62 g^2/cps at 110 cps
110 - 1000 cps	flat at 0.62 g^2/cps
1000 - 2000 cps	decreasing linearly on log-log coordinates from 0.62 g^2/cps at 1000 cps to 0.055 g^2/cps at 2000 cps



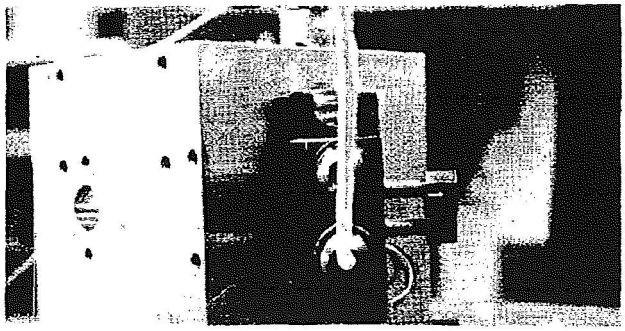
Reproduced from best available copy.

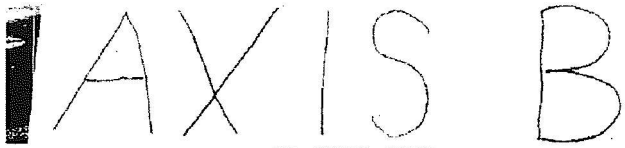


Model 52-147B - S/N 238
Test Set-Up Utilized To Determine
Valve Mounting Frequencies

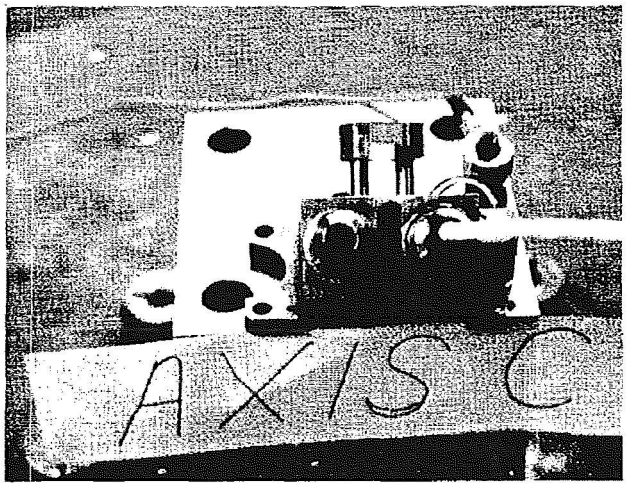


Model 52-147B - S/N 238
Test Set-Up Utilized To Determine
Valve Mounting Frequencies

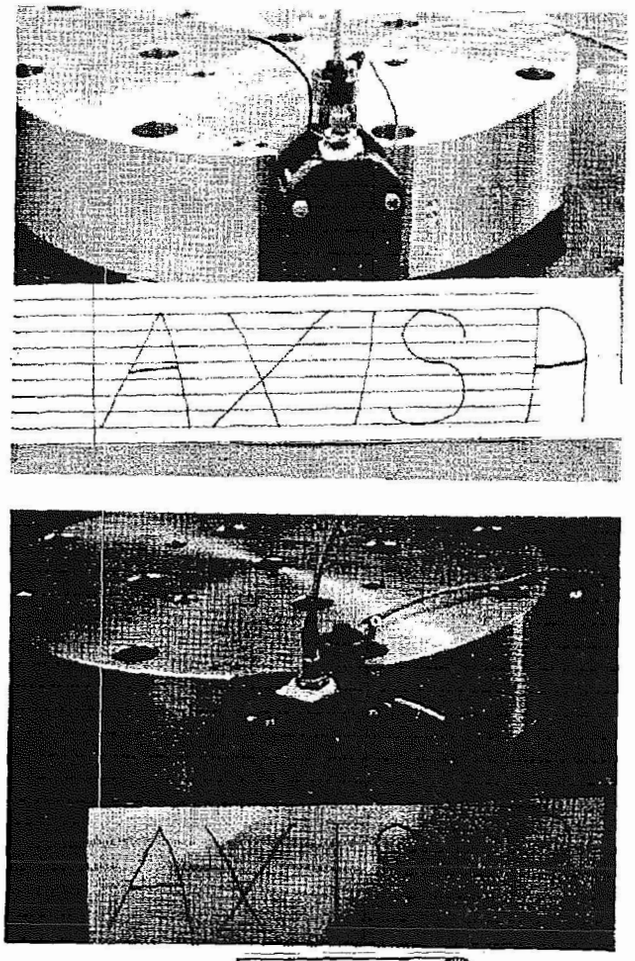




Reproduced from best available copy.

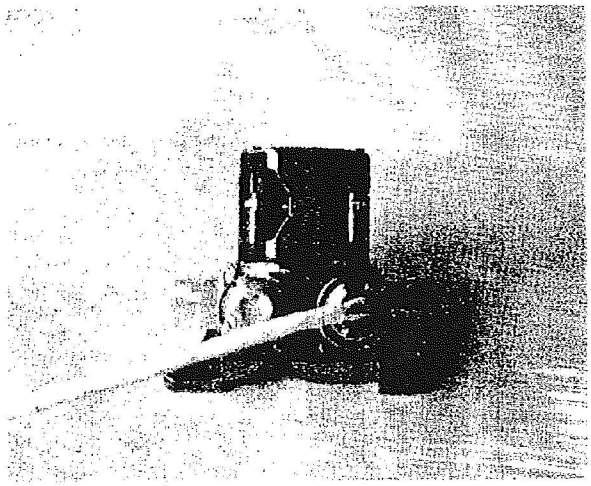


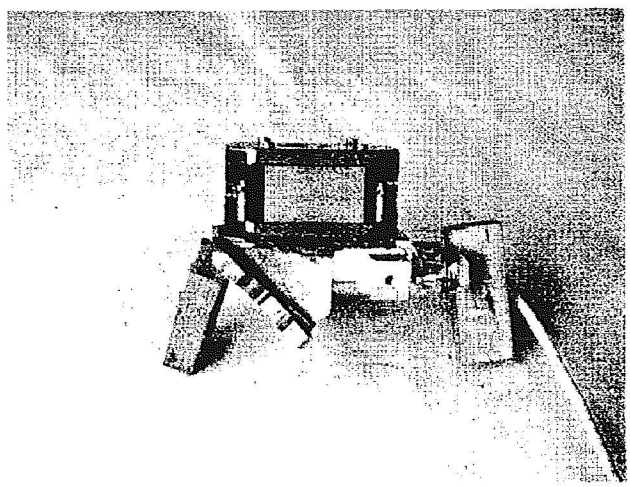
Model 52-147B - S/N 238
Test Set-Up Utilized To Determine
Natural Frequency of Armature-Flexure Sleeve Assembly



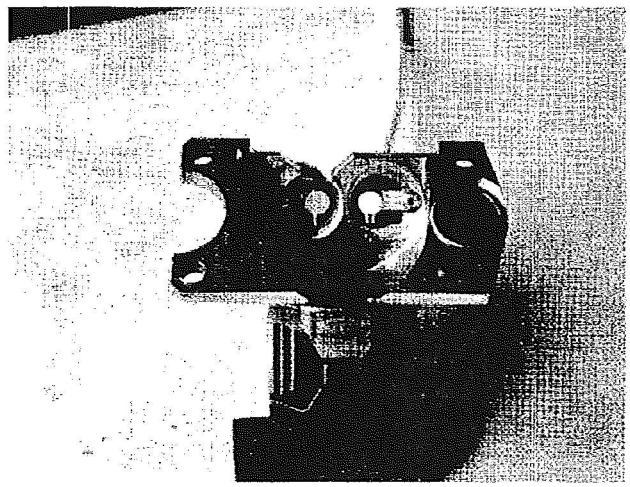
Reproduced from best available copy.

Model 52-147B - Torque Motor
Test Set-Up Utilized To Determine
Natural Frequency of Torque Motor

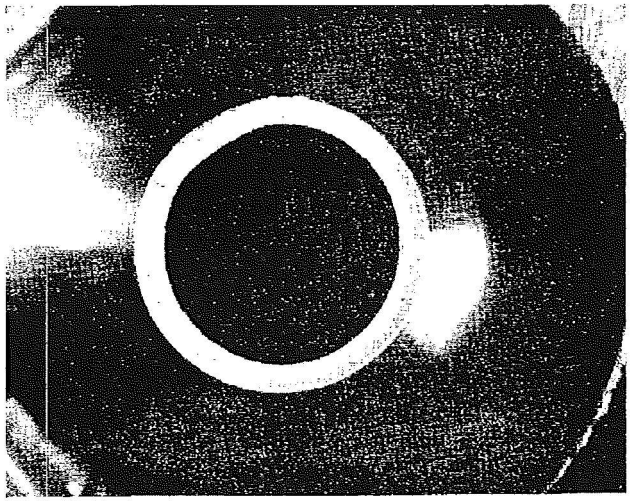




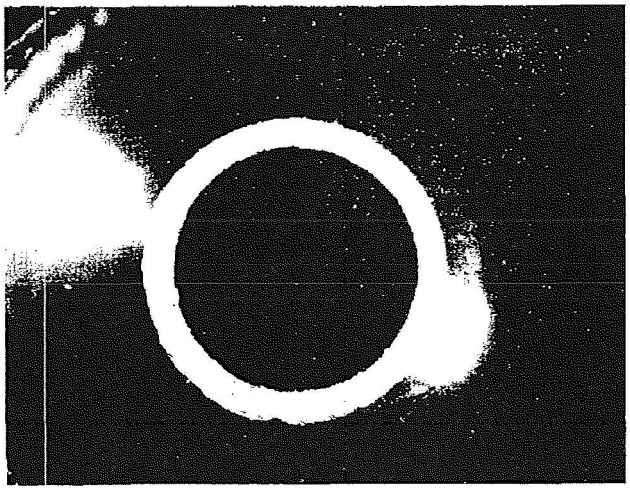
Model 52-147
"Wire" Armature Motion Restrictors



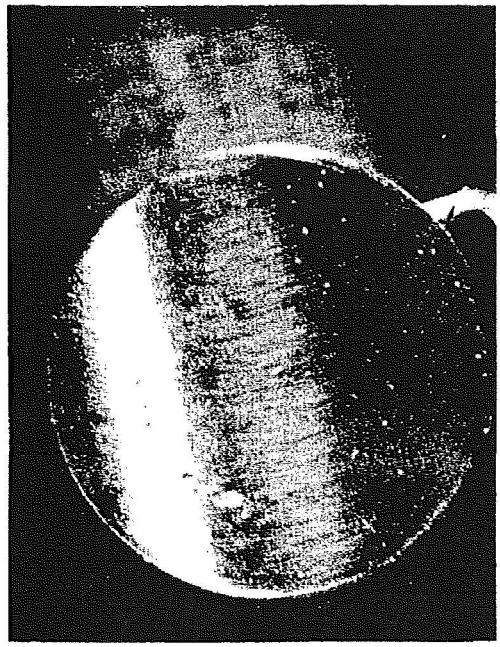
Model 52-147
"Flat Spring" Flapper-Button
Motion Restrictors



Model 52-147
S/N 45 Oxidizer Nozzle
10X



Model 52-147
S/N 45 Fuel Nozzle
10 X



Model 52-147
S/N 45 Fuel Button
15X

6.0 TEST DATA

Included in this section are the results of all performance and interval performance tests and all vibration X-Y plots generated during the Evaluation Test Program.

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/3/67

Specimen Designation Letter B
Tested By:
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance		Measure and Record Ambient temperature		F
a. Coil Resistance	5.1.3.1	Primary coil resistance		AB ohms
		Secondary coil resistance		CD ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9msec close 5 msec	
		Primary coil-0.80 amperes	secondary open 50 msec close 5msec	open 8.0 msec. close 2.7 msec.
		Secondary coil-0.44 amperes		open 48 msec. close 2.3 msec.
		Primary and Secondary as above.		open 6.3 msec. close 3.0 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press Drop	Flow -lb./sec. Fuel	Oxidizer
15	.1085	.1332
20	.1279	.1606
25	.1433	.1811
30	.1586	.1987
35	.1672	.2163
40	.1974	.2311
	0.144	0.179
	25.0	24.75

Functional Test				Volts	Amps
Pull-in Voltage	5.1.7.1	Inlet pressure at 360psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	<20volts	Pri 7.75	.48
				Sec 12.5	.39
				Both 4.65	.30

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/3/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts	Volts	Amps
				Pri 2.50	.152
				Sec 4.13	.14
				Both 1.51	.10
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion no leakage	
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/3/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.		100 ~	
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/5/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST AXIS A RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/1/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST AXIS A RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/7/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	Volts	Amps
Functional Test						
Pull-in Voltage	5. 1. 7. 1	Inlet pressure at 360 psig Measure minimum voltage required to open valve 10 consecutive times at 0. 25 cps	< 20 volts	Pri	6. 98	. 429
				Sec	13. 5	. 409
				Both	4. 19	. 264
					Volts	Amps
Drop-out Voltage	5. 1. 7. 2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	> 1. 0 volts	Pri	2. 66	. 163
				Sec	4. 14	. 129
				Both	1. 65	. 102

POST AXIS B RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/7/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		5.0 cc/hr.	none
		Oxidizer		6.0 cc/hr.	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST AXIS B RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/7/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results		
					Volts	Amps
Functional Test						
Full-in Voltage	5.1.7.1	Inlet pressure at 360 psig Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps	<20 volts	Pri	7.25	.449
				Sec	14.0	.431
				Both	4.55	.288
					Volts	Amps
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	> 1.0 volts	Pri	2.47	.150
				Sec	4.05	.128
				Both	1.54	.095

POST AXIS C RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/3/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/ hr.	Fuel	none
				Oxidizer	none

POST AXIS C RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 204
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	Volts	Amps
Functional Test						
Pull-in Voltage	5.1.7.1	Inlet pressure at 360 psig Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps	< 20 volts	Pri	6.6	.43
				Sec	13.1	.41
				Both	4.1	.27
					Volts	Amps
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	> 1.0 volts	Pri	2.62	.17
				Sec	4.16	.14
				Both	1.61	.101

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/8/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance a. Coil Resistance	5.1.3.1	Measure and Record Ambient temperature Primary coil resistance Secondary coil resistance		- AB - ohms CD - ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil-0.80 amperes Secondary coil -0.44 a amperes Primary and Secondary as above	secondary open open 50 msec close close 5 msec open close open close	8.4 msec. 3.0 msec. 96.0 msec. 3.2 msec. 7.0 msec. 3.4 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig		

Press Drop	Flow-lb/sec Fuel	Flow-lb/sec Oxidizer
15	.1089	.1336
20	.1277	.1600
25	.1441	.1818
30	.1590	.1990
35	.1671	.2160
40	.1980	.2314
	0.144	0.179
	25.0	26.75

Functional Test				Volts	Amps
Pull-In Voltage	5.1.7.1	Inlet pressure at 360 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	< 20 volts	Pri 7.25	.449
				Sec 14.0	.431
				Both 4.55	.288

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 104
Date 6/8/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results		
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes.	> 1.0 volts		Volts	Amps
				Pri	2.47	.150
				Sec	4.05	.128
				Both	1.54	.095
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion No Leakage		
		Open fuel inlet and measure external leakage		-		
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.		-		
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.	-		

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 204
Date 6/8/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5. 1. 9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		5 cc/hr.	none
		Oxidizer		6 cc/hr	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/ hr.	Fuel	none
				Oxidizer	none

POST 50,000-CYCLE PERFORMANCE

Model Number 32-147
Serial Number 204
Date 6/8/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance a/ Coil Resistance	5.1.3.1	Measure and Record Ambient temperature Primary coil resistance Secondary coil resistance		- AB - ohms CD - ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9msec close 5 msec	
		Primary coil-0.80 amperes Secondary coil-0.44 amperes Primary and Secondary as above.	secondary open 50 msec close 5msec at 340 psi	open 8.0 msec. close 3.2 msec. open 84.0 msec. close 2.8 msec. open 6.6 msec. close 3.3 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press Drop	Flow - lb./sec. Fuel	Oxidizer
15	.1105	.1344
20	.1283	.1610
25	.1441	.1797
30	.1583	.1978
35	.1729	.2128
40	.1852	.2284
	0.144	0.179
	25.0	24.75

Reproduced from best available copy.

Functional Test				Volts	Amps
Pull-in Voltage	5.1.7.1	Inlet pressure at 360psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	<20volts	Pri 7.98	.496
				Sec 12.70	.402
				Both 5.00	.316

POST 50,000 CYCLES PERFORMANCE

Model Number 52-147
Serial Number
Date

Specimen Designation Letter
Tested By
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results		
Drop-out Voltage	5.1.7.2	Inlet pressure at 160 psig Measure maximum voltage at which valve closes	>1.0 volts		Volts	Amps
				Pri	2.09	.131
				Sec	3.22	.105
				Both	1.24	.077
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion No Leakage		
		Open fuel inlet and measure external leakage				
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.				
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.			

POST 50,000 CYCLES PERFORMANCE

Model Number 52-147
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		26 cc/hr.	7.2cc/hr.
		Oxidizer		22 cc/hr.	55.2cc/hr.
		Cycle valve 100 times and repeat above tests.			
		Fuel		4 cc/hr.	5 cc/hr.
		Oxidizer		12 cc/hr.	41 cc/hr.
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/ hr.	Fuel 2.0 cc/hr. Oxidizer 6.0 cc/hr.	

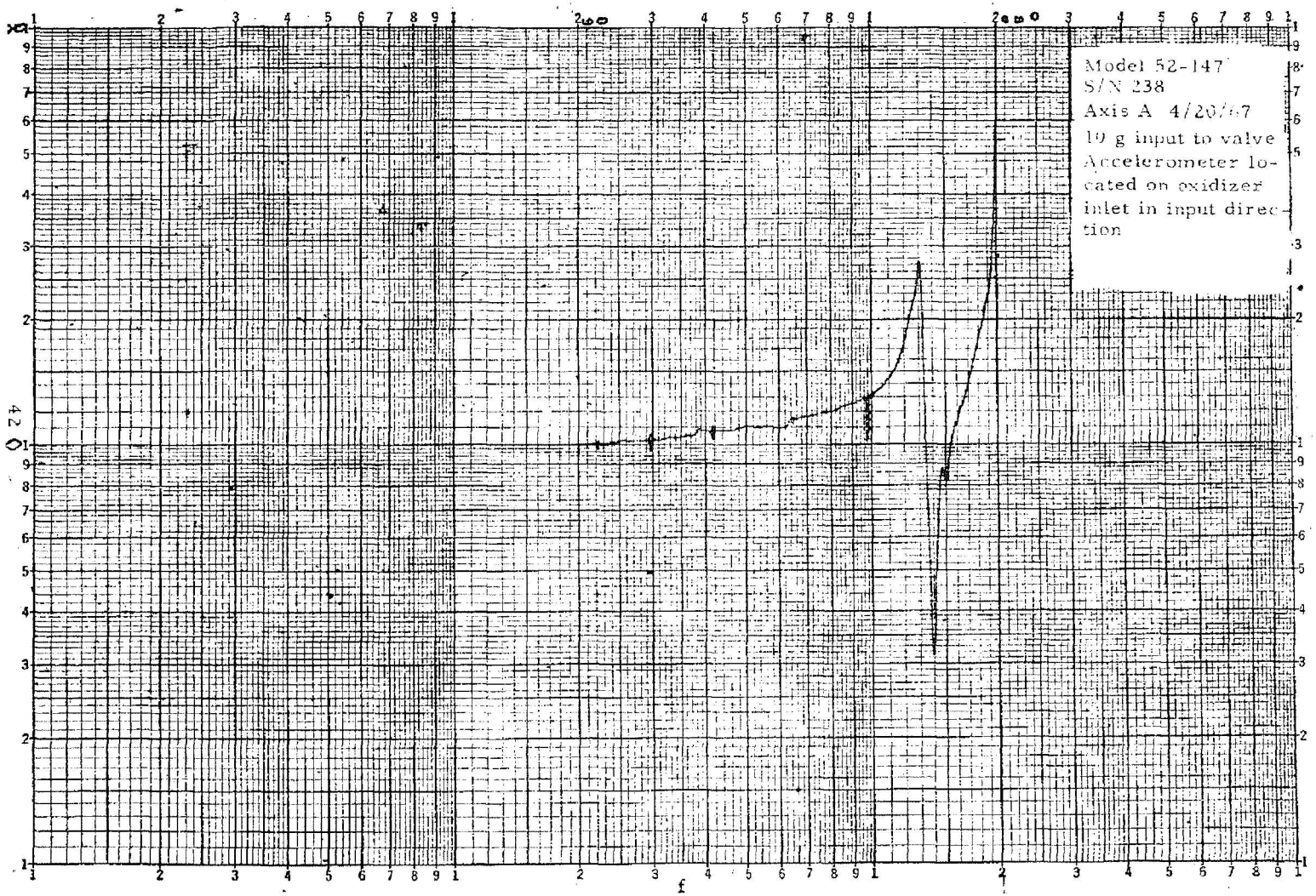

Model 52-147
S/N 238
Axis A 4/20/67
10 g input to valve
Accelerometer located on oxidizer inlet in input direction
Q
f

Figure 1

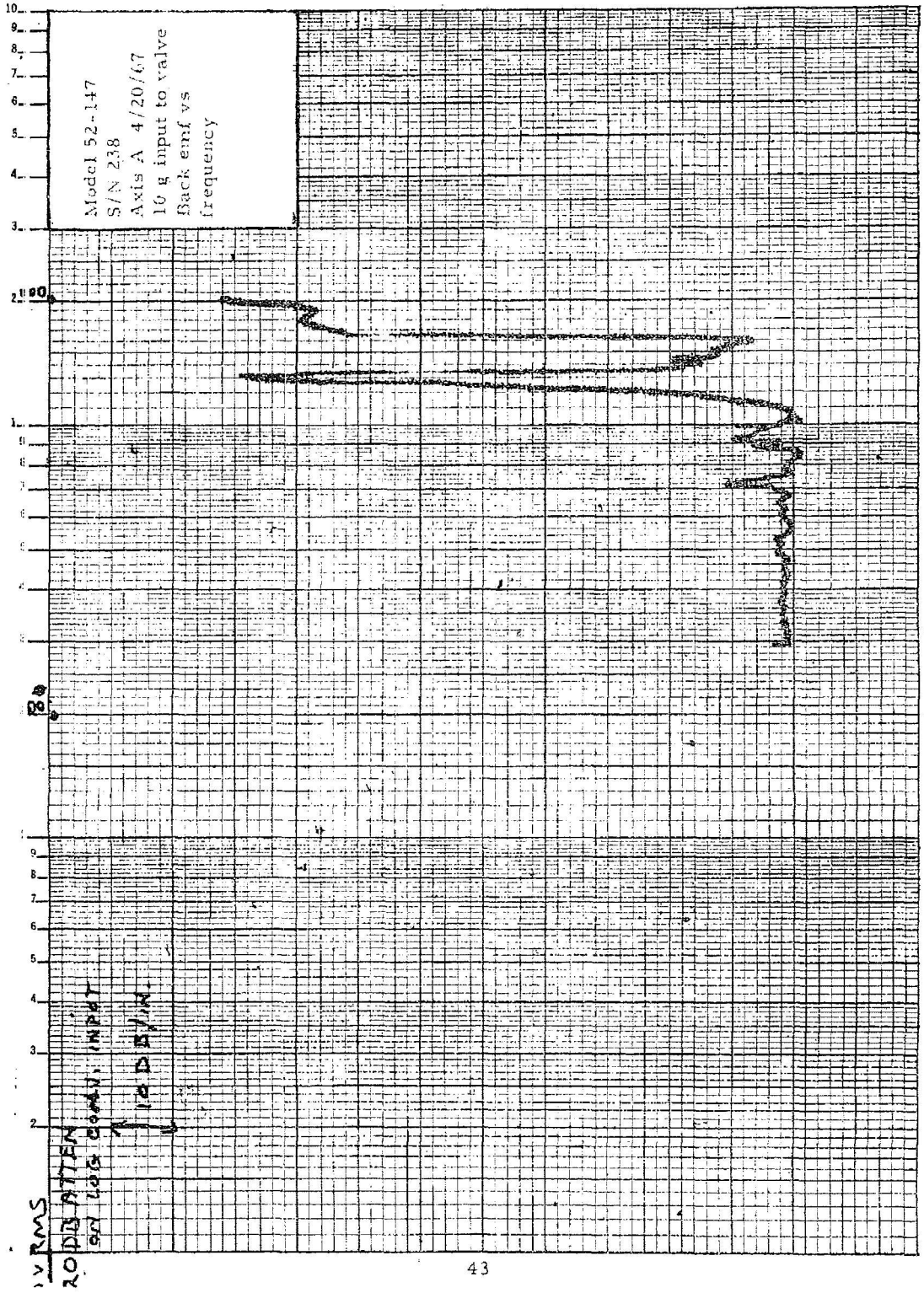

Model 52-147
S/N 238
Axis A 4/20/67
10 g input to valve
Back emf vs
frequency
10 DB/IN.
20 DB ATTEN
ON LOG CONV. INPUT
RMS

Figure 2

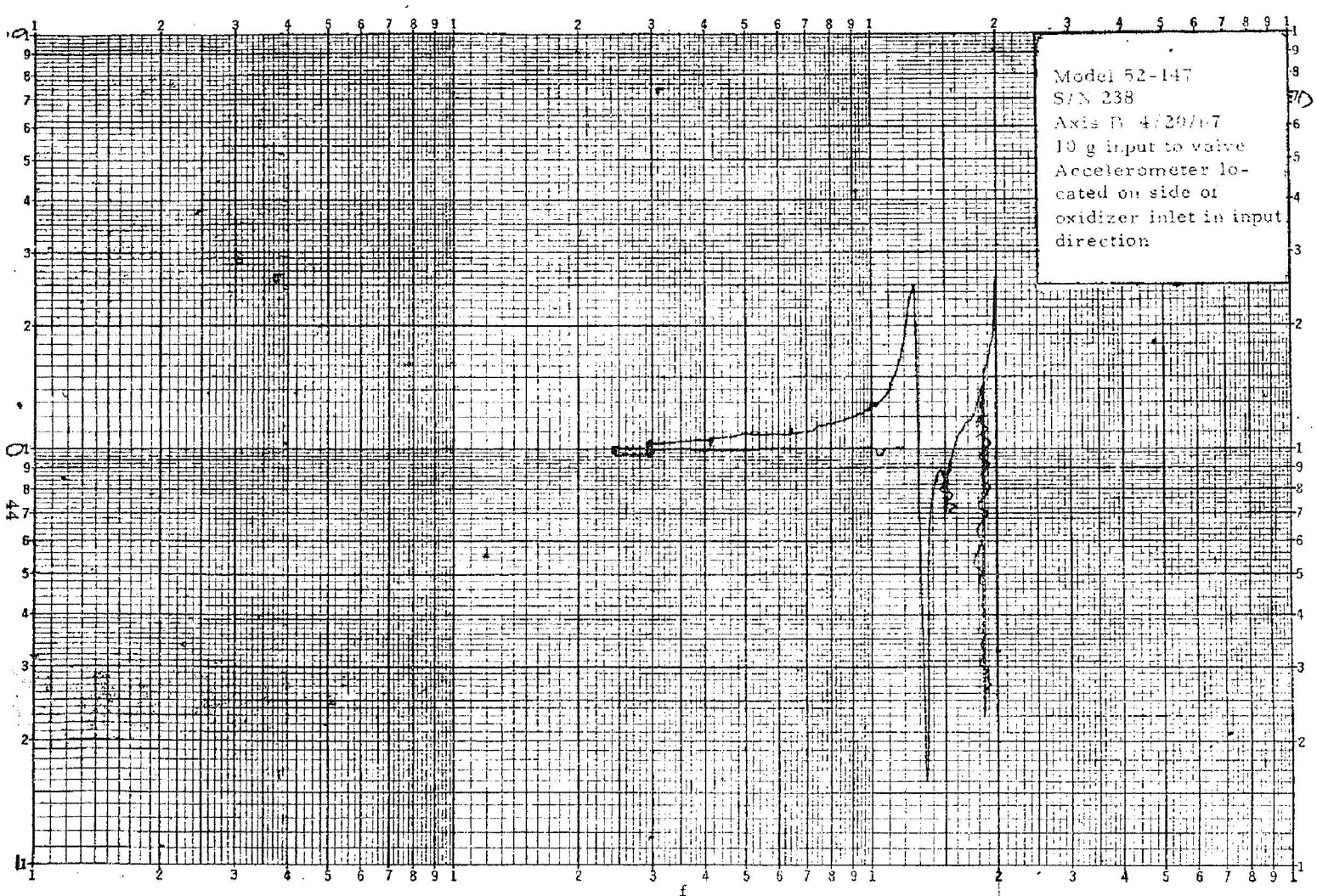

Model 52-147
S/N 238
Axis B 4/20/67
10 g input to valve
Accelerometer located on side of oxidizer inlet in input direction
f

Figure 3

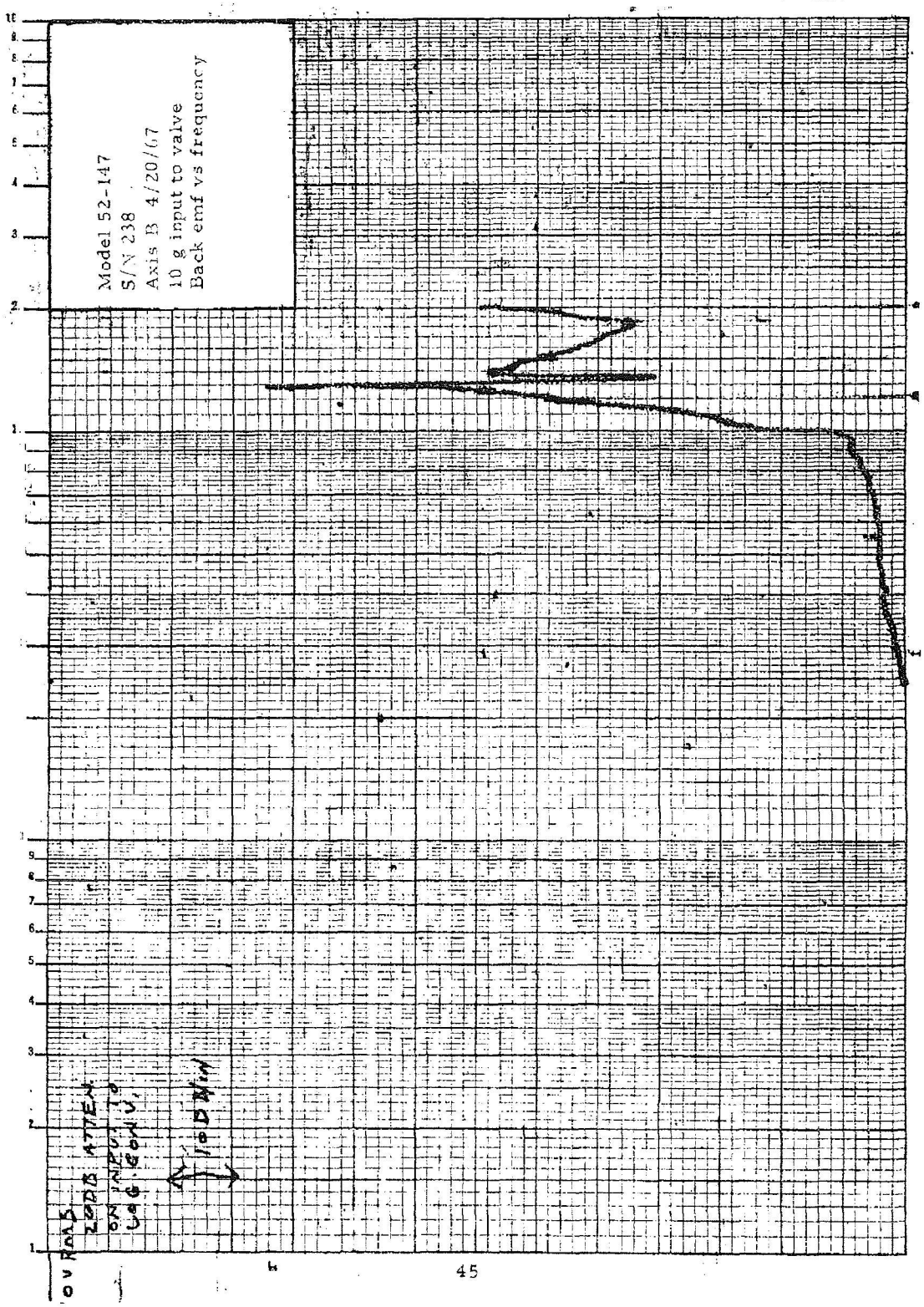

Model 52-147
S/N 238
Axis B 4/20/67
10 g input to valve
Back emf vs frequency
10 DB/IN

Figure 4

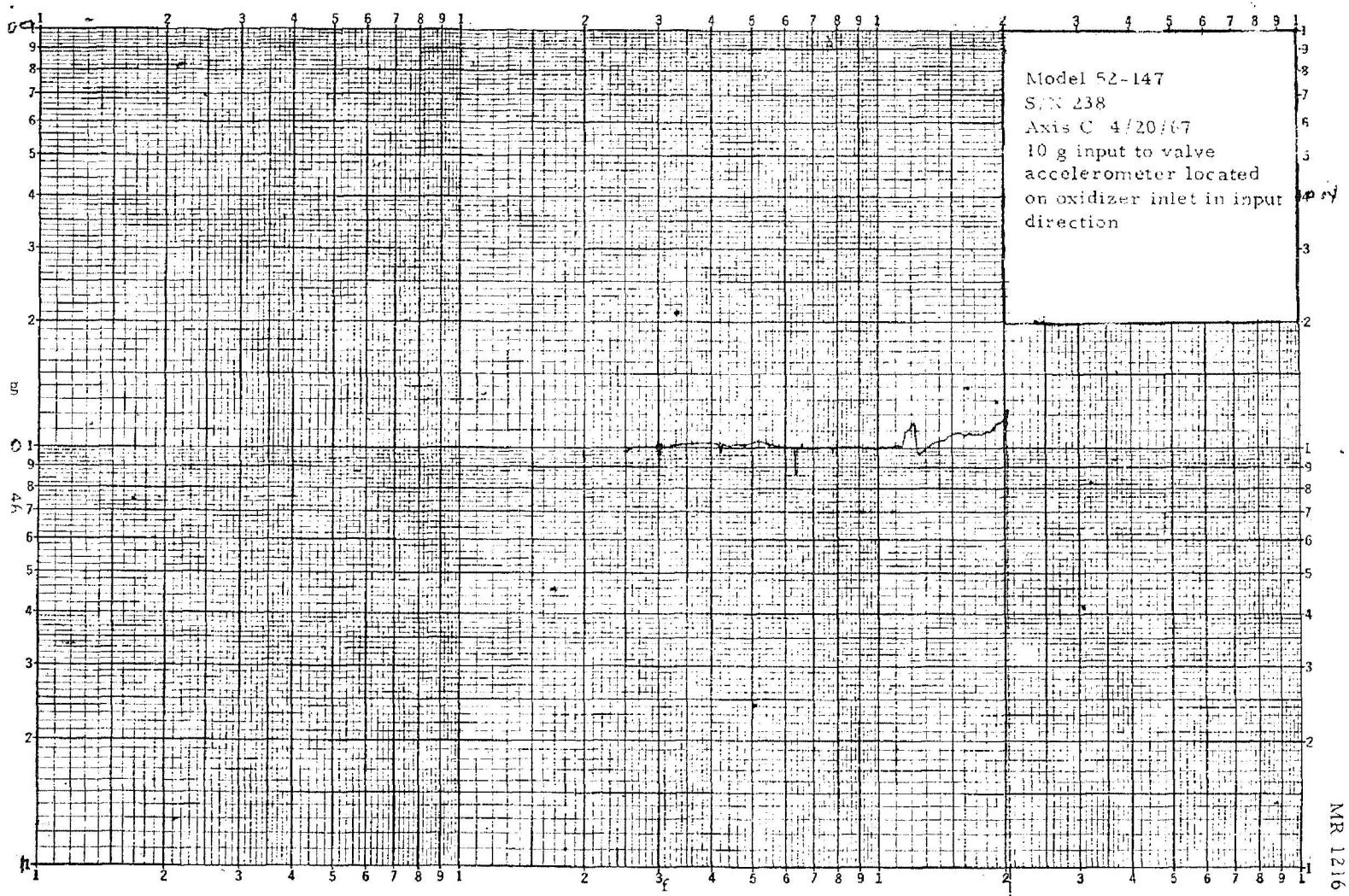


Figure 5

MR 1216

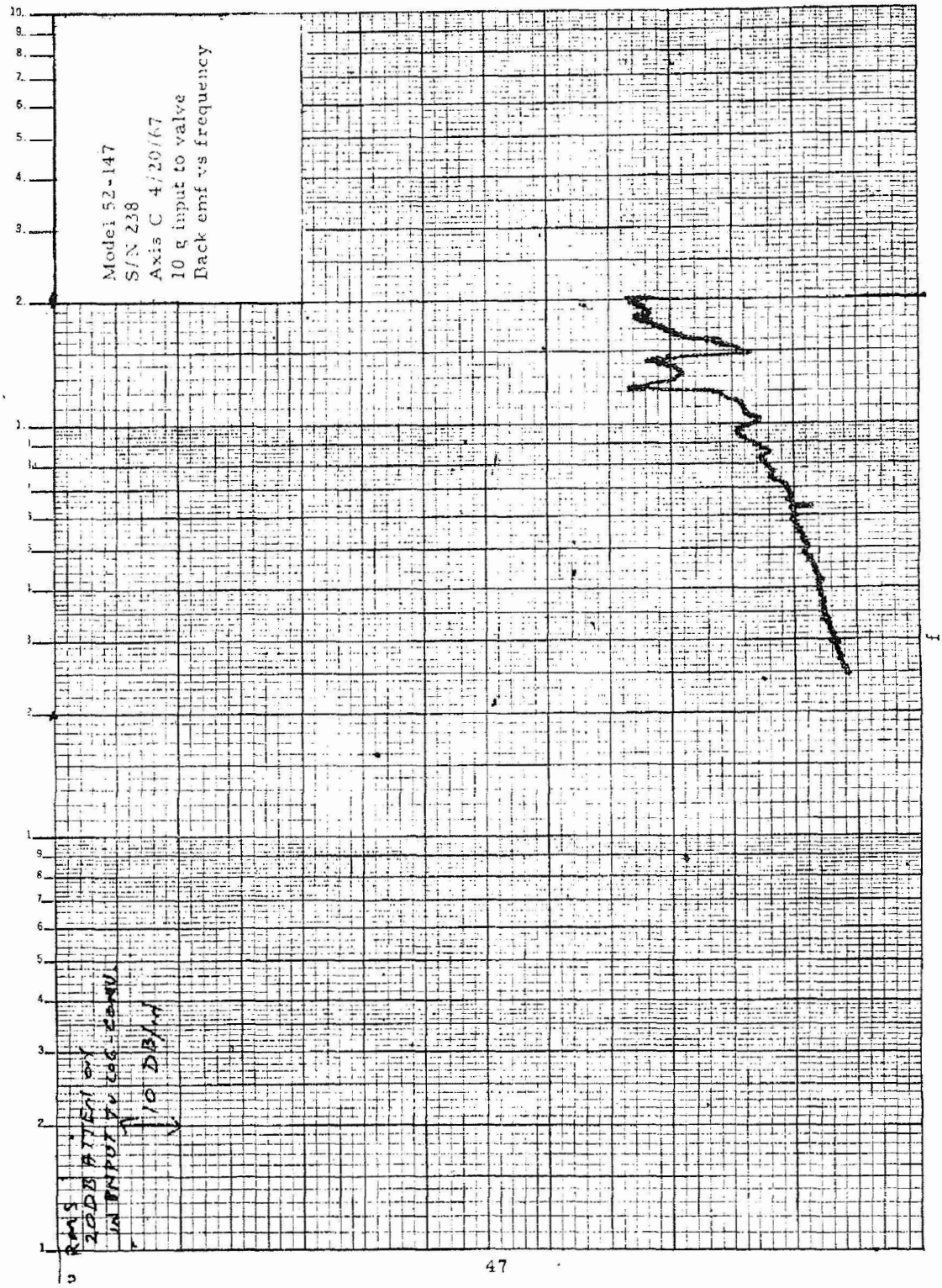

Model 52-147
S/N 238
Axis C 4/20/67
10 g input to valve
Back emf vs frequency
RMS
20DB ATTEN ON
IN INPUT TO LOG CONV
10 DB/IN

Figure 6

(12)

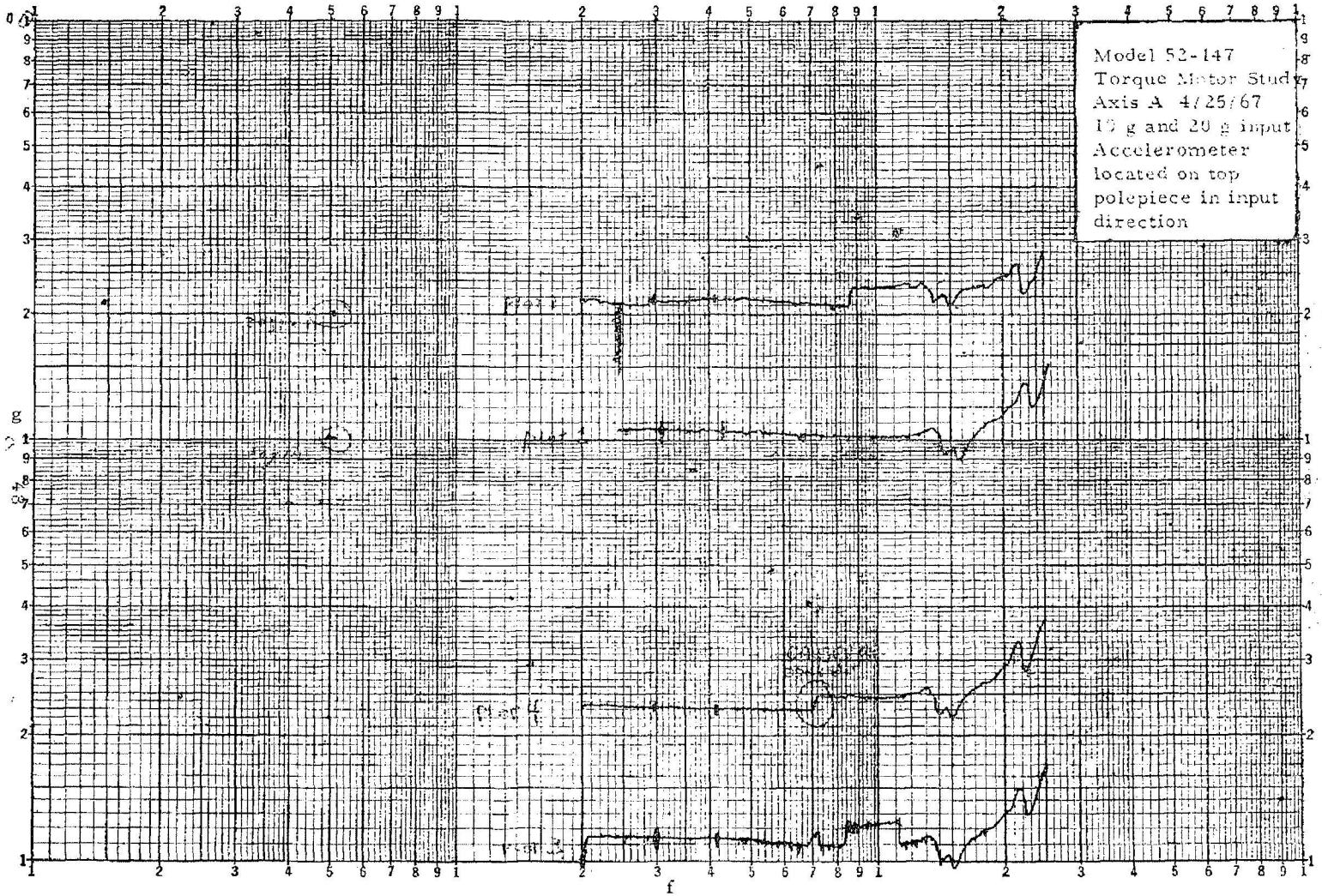


Figure 7

MR 1216

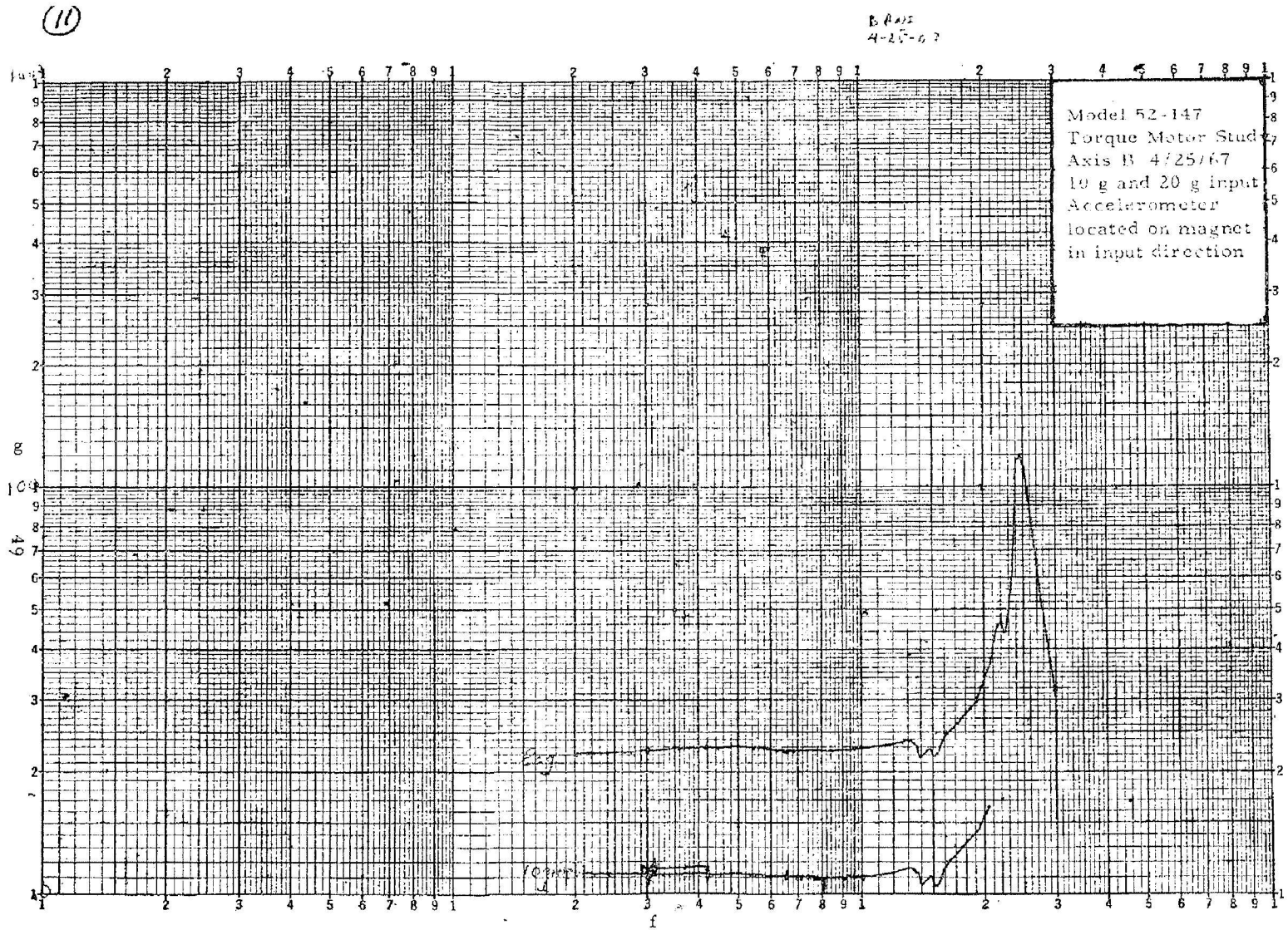

Model 52-147
Torque Motor Stud
Axis B 4/25/67
10 g and 20 g input
Accelerometer
located on magnet
in input direction
f

Figure 8

INITIAL PERFORMANCE

Model Number 52-146
Serial Number
Date 5/26/67

Specimen Designation Letter
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet port. Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-146
Serial Number _____
Date 5/26/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST RANDOM VIBRATION PERFORMANCE

Model Number 52-146
Serial Number _____
Date 5/26/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		35 cc/hr.	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

Model 52-146
Axis C 5/26/67
Wire armature motion
restrictors on free end of
armature
27.7 g rms input

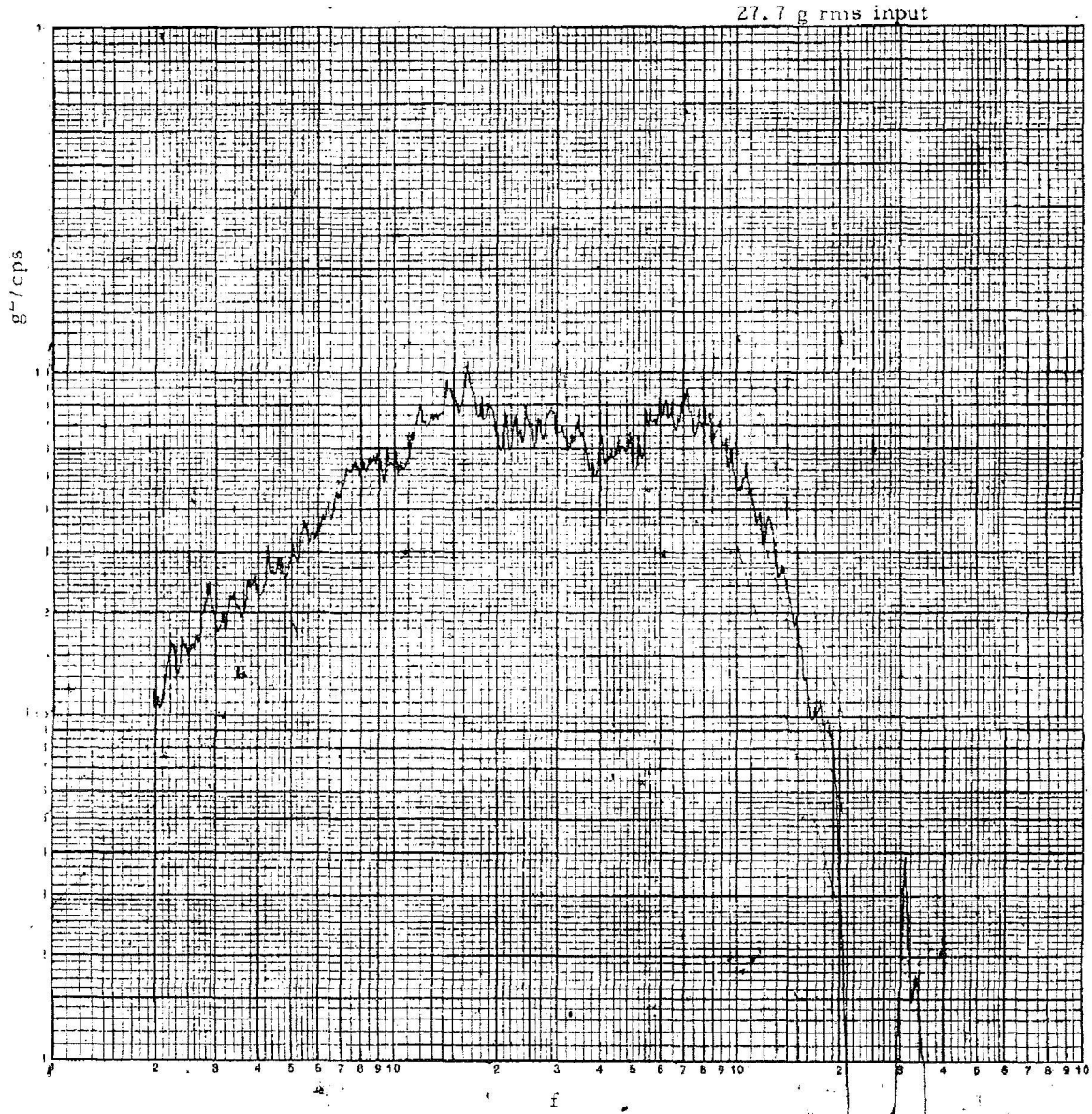


Figure 9

Model 52-14[illegible]
Axis A 5/2[illegible]/67
27.7 g rms input
Wire armature motion
restrictors on free end
of armature

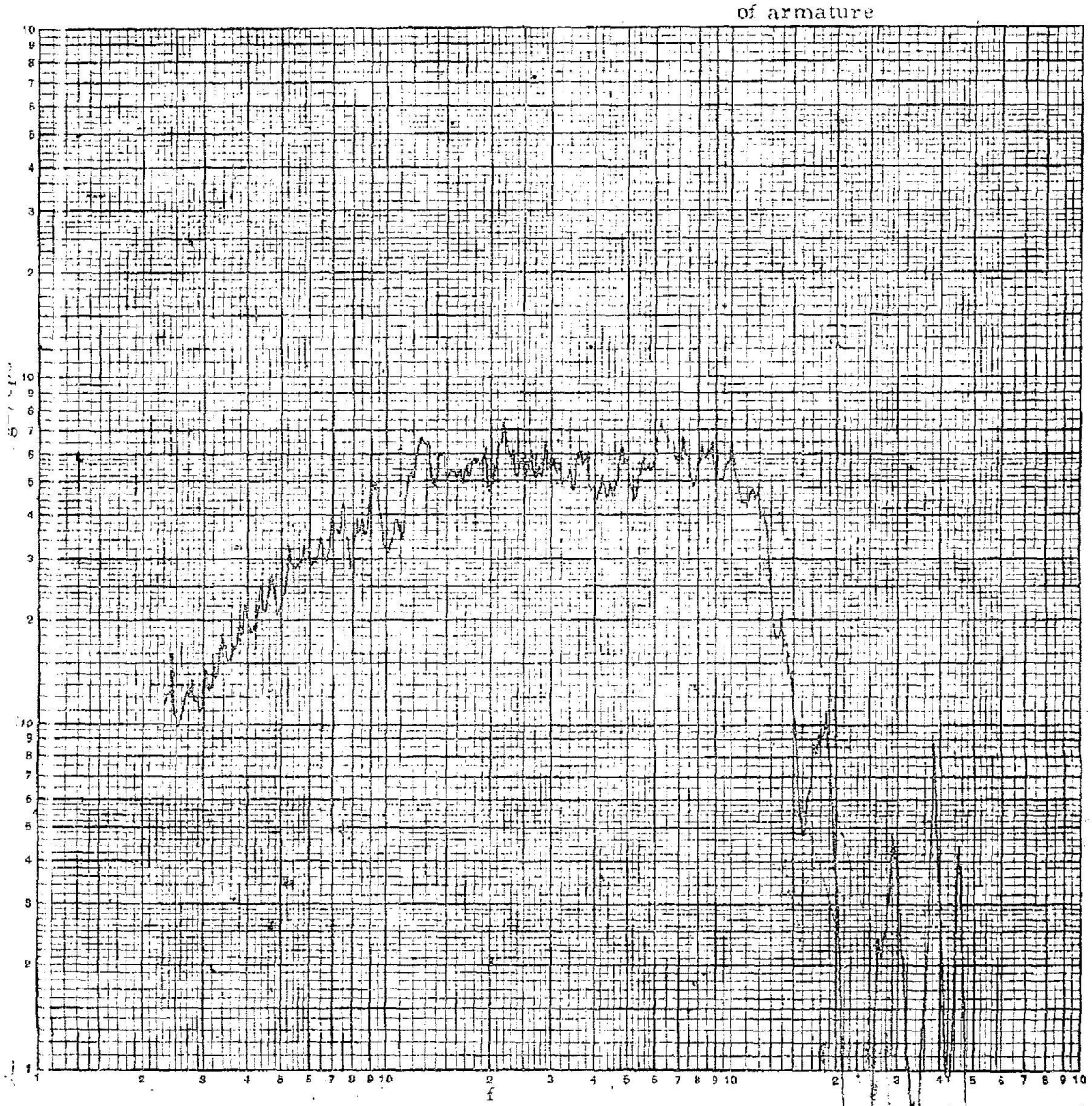


Figure 10

Model 52-146
Axis B 5/26/67
27.7 g rms input
Wire armature motion
restrictors on free end
of armature

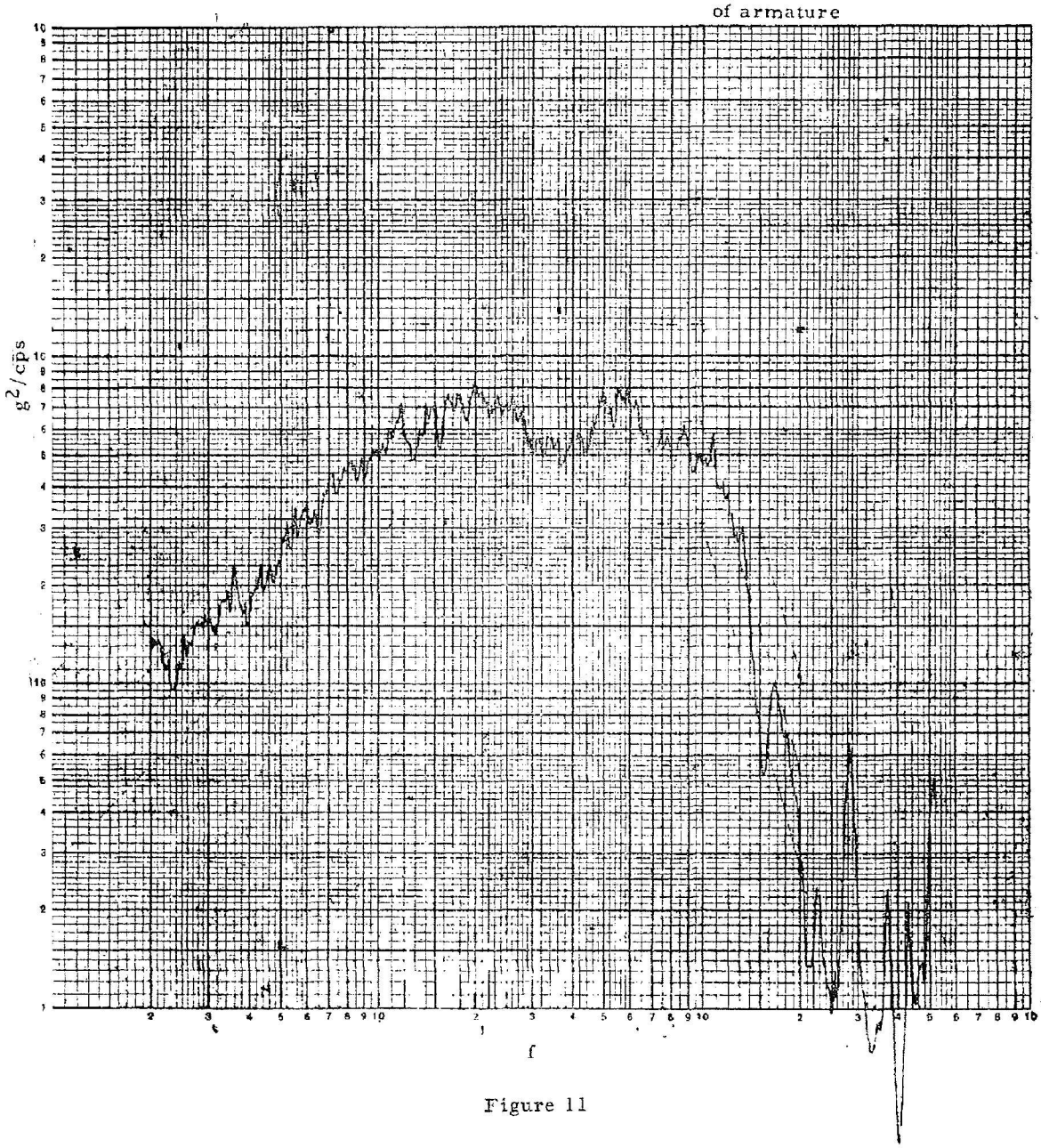


Figure 11

Reproduced from best available copy.

Model 52-147
Axis A 6/7/67
27.7 g rms input
Wire armature motion restrictors on free end of armature

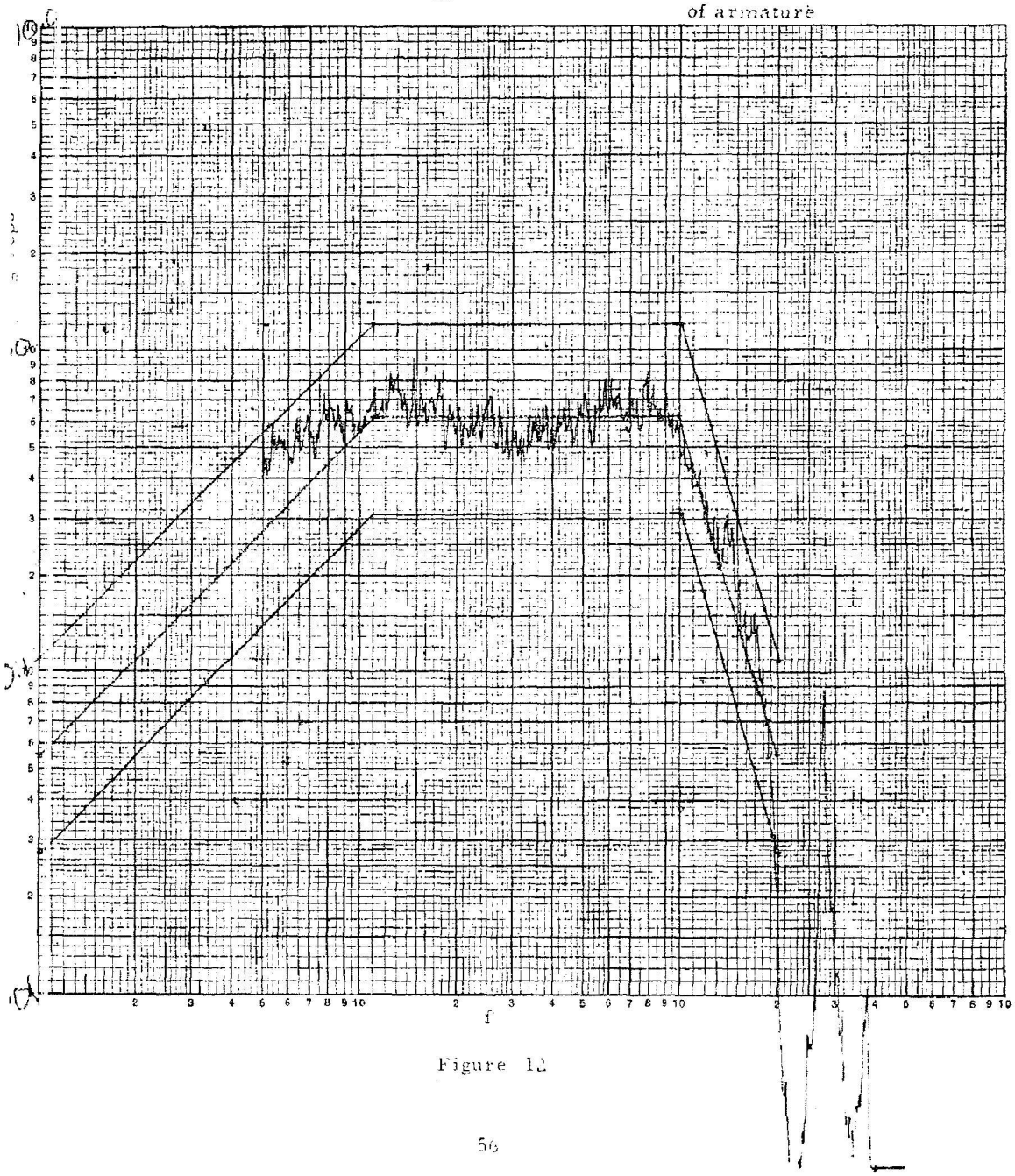


Figure 12

Model 52-147 S/N 204
Axis B 1/7/67
27.7 g rms input
Wire armature motion
restrictors on free end
of armature

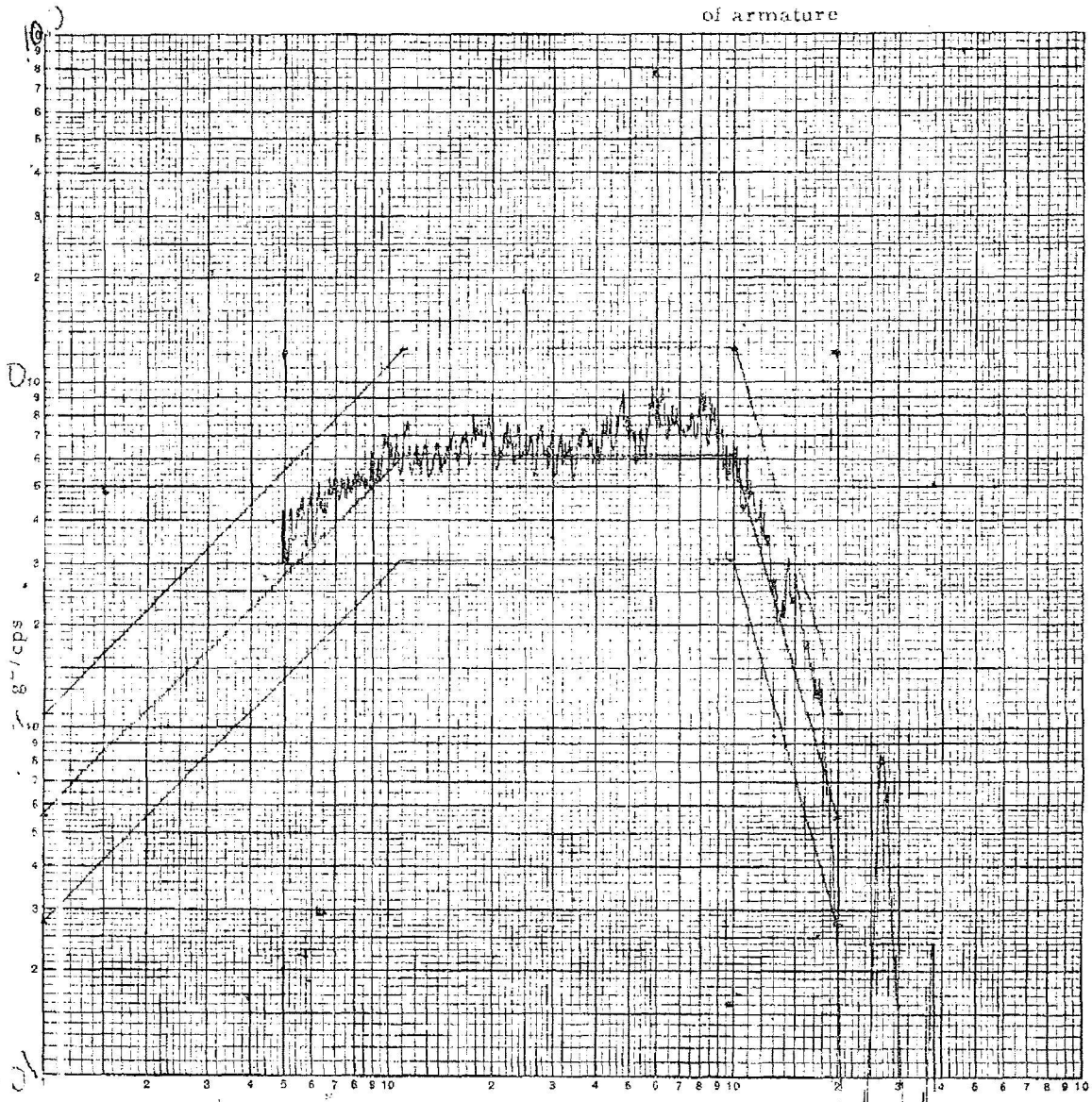


Figure 13

Reproduced from best available copy.

Model 52-147 S/N 204
Axis C 6/5/67
27.7 g rms input
Wire armature motion restrictors on free end of armature

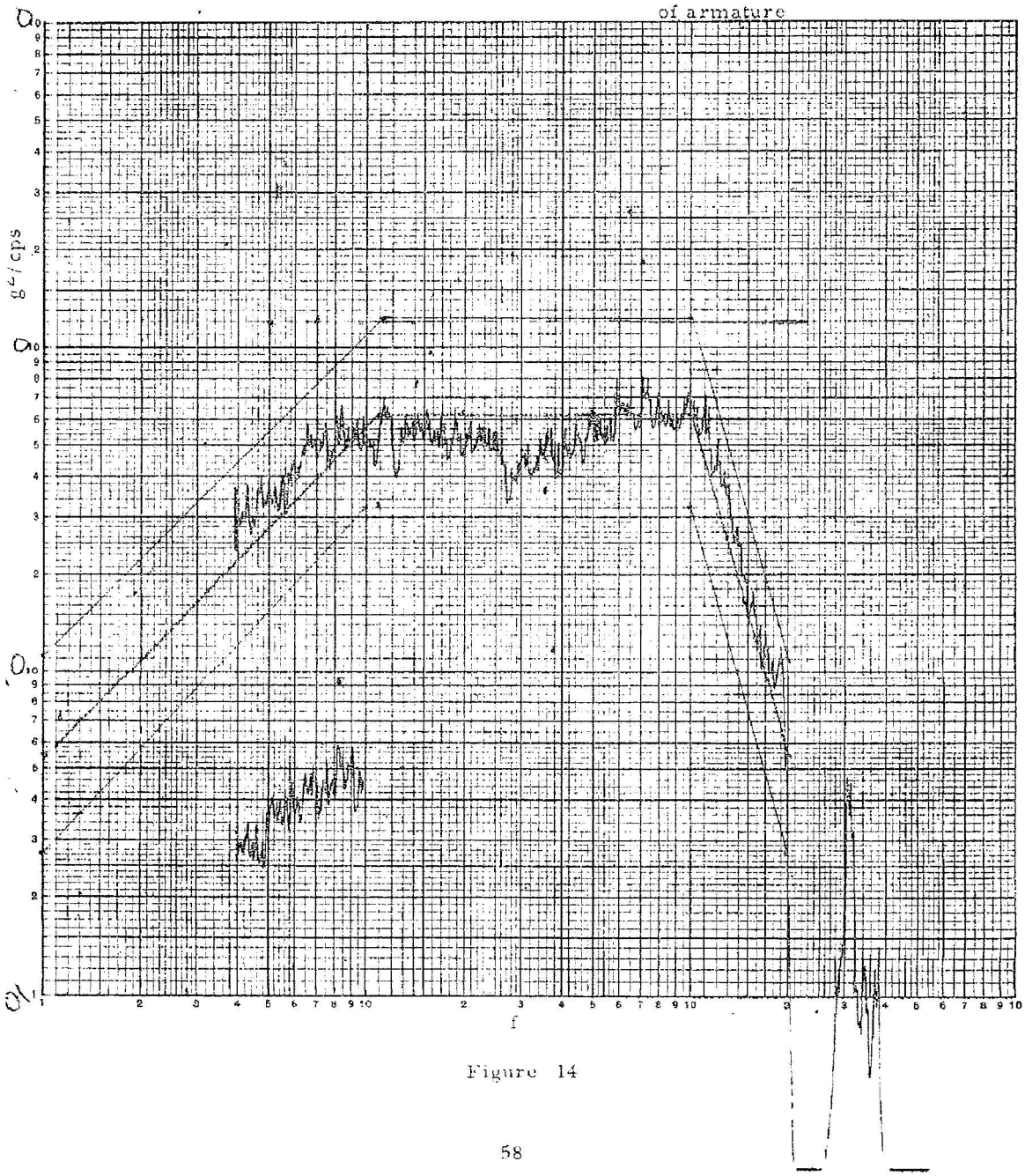


Figure 14

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/19/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance		Measure and Record		
		Ambient temperature		- °F
Coil Resistance	5.1.3.1	Primary coil resistance		AB - ohms
		Secondary coil resistance		CD - ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 200 psig for primary coil, at 200 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil-0.80 amperes	secondary open	4.2 msec.
			open 50 msec close	3.0 msec.
		Secondary coil-0.44 amperes	close 5msec open	7.4 msec.
			close	2.6 msec.
		Primary and Secondary as above.	open	4.9 msec.
			close	2.8 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press Drop	Flow - lb./sec. Fuel	Oxidizer
15	.1039	.1097
20	.1175	.1306
25	.1350	.1471
30	.1480	.1607
35	.1606	.1748
40	.1727	.1865
	0.144	0.179
	28.25	36.50

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits		Volts	Amps
Functional Test						
Full-in Voltage	5.1.7.1	Inlet pressure at 200 psig Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps	<20 volts	Pri	3.82	.249
				Sec	5.79	.194
				Both	3.10	.203

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/19/67

Specimen Designation Letter
Tested By
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts	Volts	Amps
				Pri 1.43	.087
				Sec 2.29	.071
				Both .84	.054
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion no leakage	
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

Reproduced from best available copy.

INITIAL PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/19/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports. Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

Reproduced from best available copy.

POST AXIS C SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/19/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/ hr.	Fuel	none
				Oxidizer	none

POST AXIS A SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/20/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak.		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/20/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance		Measure and Record		
		Ambient temperature		–
a. Coil Resistance	5.1.3.1	Primary coil resistance		AB – ohms
		Secondary coil resistance		CD – ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 200 psig for primary coil, at 200 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil - 0.80 amperes	secondary open	4.2 msec.
		Secondary coil - 0.44 amperes	open 50 msec close	2.8 msec.
		Primary and Secondary as above.	close 5 msec open	6.3 msec.
			close	1.3 msec.
			open	4.1 msec.
			close	3.0 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig		

Press Drop	Flow-lb/sec Fuel	Flow-lb/sec Oxidizer
15	.1017	.1113
20	.1193	.1309
25	.1339	.1462
30	.1469	.1607
35	.1586	.1751
40	.1686	.1871
	0.144	0.179
	29.0	32.0

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Functional Test				
Pull-in Voltage	5.1.7.1	Inlet pressure at 200 psig Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	< 20 volts	

	Volts	Amps
Pri	3.50	.226
Sec	5.77	.194
Both	2.24	.148

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 62-147
Serial Number 45
Date 7/20/69

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results		
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts		Volts	Amps
				Pri	1.21	.075
				Sec	1.87	.062
				Both	.62	.039
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion no leakage		
		Open fuel inlet and measure external leakage				
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.				
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.			

Reproduced from best available copy.

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/20/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel 5	
				Oxidizer 5	

Model 52X147C Body S/N 45
Axis C 7/25/67
Flapper button motion restrictors
flat spring
27.7 g rms

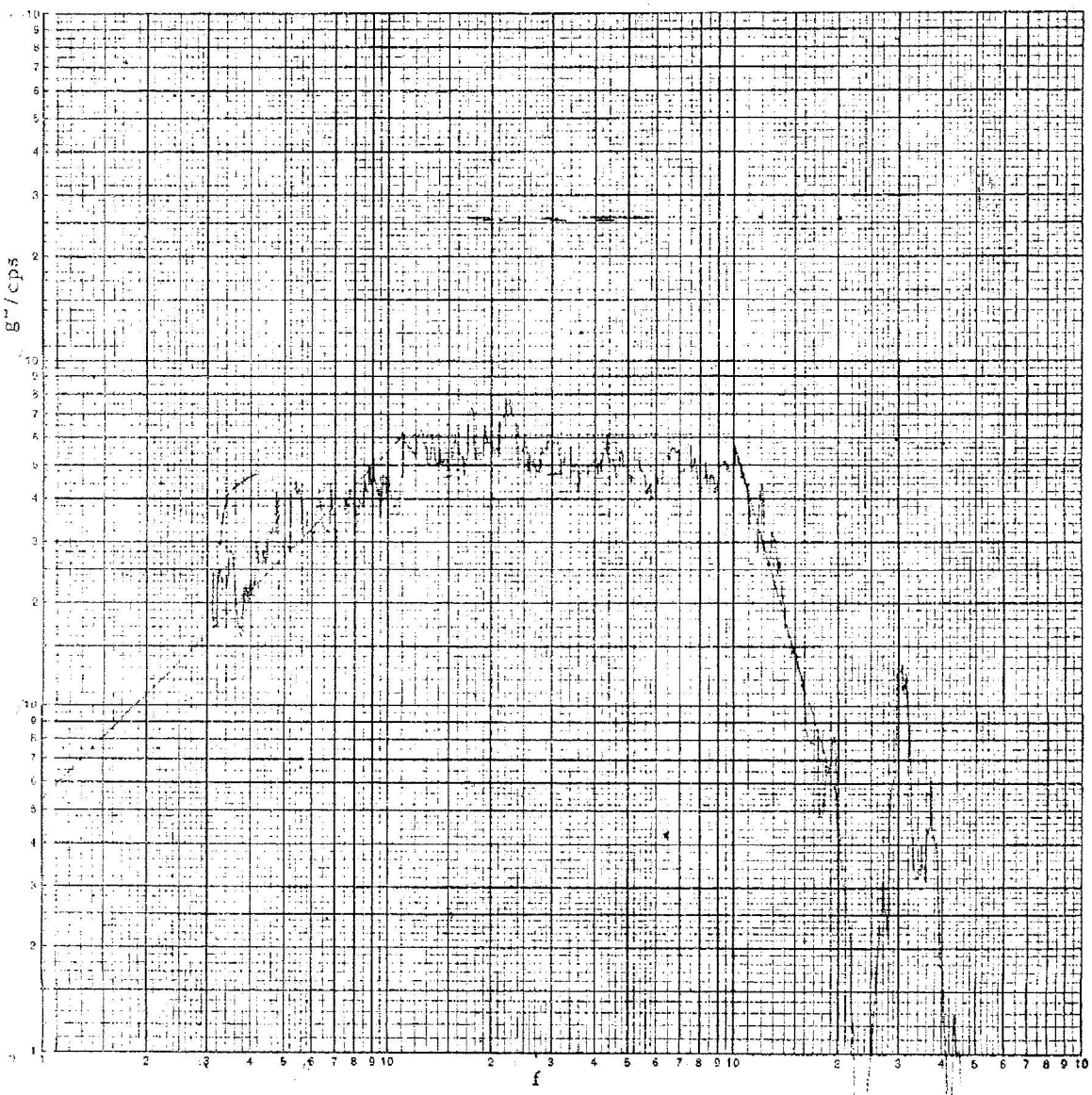


Figure 15

POST AXIS C RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/25/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/Hr.	Fuel	none
				Oxidizer	none

Reproduced from best available copy.

Model 52X147C Body S/N 45
Axis A 7/25/67
Flapper button motion restrictors
flat spring
27.7 g rms input

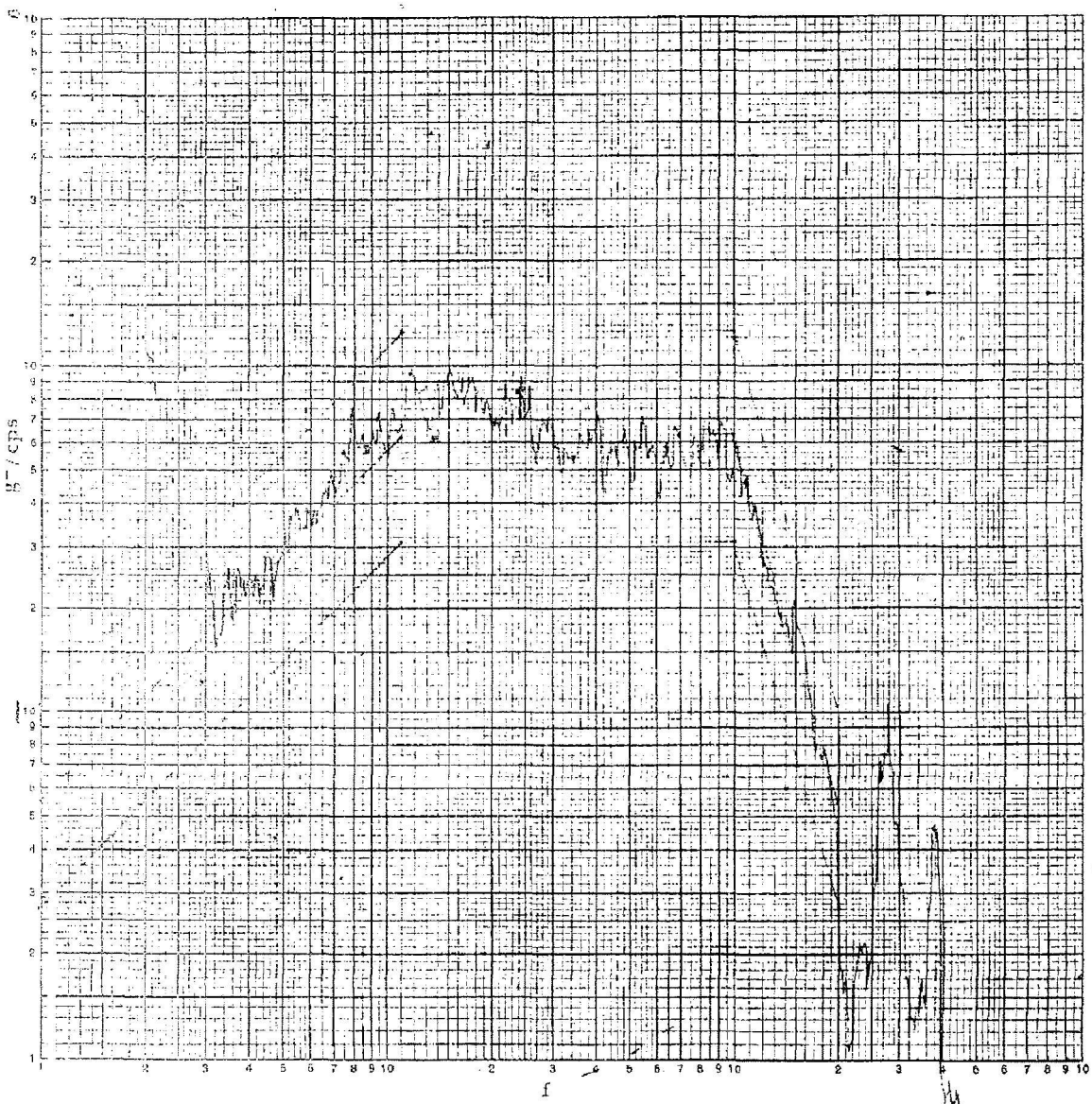


Figure 16

POST AXIS A RANDOM VIBRATION PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/25/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

Reproduced from best available copy.

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance		Measure and Record		
		Ambient temperature		– °F
a. Coil Resistance	5.1.3.1	Primary coil resistance		AB – ohms
		Secondary coil resistance		CD – ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 200 psig for primary coil, at 200 psig for secondary coil	primary open 9 msec close 5 msec	
		Primary coil - 0.80 amperes	secondary open	3.4 msec.
		Secondary coil - 0.44 amperes	open 50 msec close	4.9 msec.
		Primary and Secondary as above	close 5 msec open	5.0 msec.
			close	4.4 msec.
			open	3.2 msec.
			close	5.2 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press Drop	Flow - lb/sec Fuel	Oxidizer
15	.1040	.1142
20	.1200	.1320
25	.1340	.1470
30	.1470	.1605
35	.1580	.1718
40	.1690	.1813
	0.144	0.179
	29.0	38.6

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results	Volts	Amps
Functional Test						
Pull-in Voltage	5.1.7.1	Inlet pressure at 200 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	<20 volts	Pri	3.35	.219
				Sec	4.87	.167
				Both	1.05	.070

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts	Volts	Amps
				Pri 1.52	.096
				Sec 2.42	.080
				Both .90	.054
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.	Freon Immersion no leakage	
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

POST 50,000 CYCLE PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance		Measure and Record		
		Ambient temperature		– °F
Coil		Primary coil resistance		
Resistance	5.1.3.1	Secondary coil resistance		AB – ohms CD – ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 200 psig for primary coil, at 200 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil - 0.80 amperes Secondary coil - 0.44 amperes Primary and Secondary as above	secondary open open 50 msec close close 5 msec open close open close	4.1 msec. 4.2 msec. 6.5 msec. 3.9 msec. 4.0 msec. 5.0 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press Drop	Flow - lb/sec Fuel	Flow - lb/sec Oxidizer
15	.0971	.1110
20	.1110	.1281
25	.1232	.1420
30	.1340	.1536
35	.1435	.1645
40	.1513	.1745
	0.144	0.179
	35.8	42.1

Functional Test				Volts	Amps
Pull-in Voltage	5.1.7.1	Inlet pressure at 200 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps	<20 volts	Pri. 3.12 Sec. 4.71 Both 1.32	.201 .161 .090

POST 50,000 CYCLES PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts	Volts	Amps
				Pri 1.59	.096
				Sec 2.50	.082
				Both .90	.057
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage.	$<10^{-4}$ cc/sec.	Freon Immersion no leakage	
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

POST 50,000 CYCLES PERFORMANCE

Model Number 52-147
Serial Number 45
Date 7/26/67

Specimen Designation Letter _____
Tested By _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports. Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	none

INITIAL PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/8/67

Specimen Designation Letter C
Tested By
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance a. Coil Resistance	5.1.3.1	Measure and Record Ambient temperature Primary coil resistance Secondary coil resistance.		°F AB – ohms CD – ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil - 0.80 amperes Secondary coil - 0.44 amperes Primary and Secondary as above.	secondary open open 50 msec close close 5 msec open close open close	6.2 msec. 1.6 msec. 1.2 msec. 1.2 msec. 5.0 msec. 2.2 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press. Drop	Flow - lb/sec Fuel	Oxidizer
15	.1086	.1191
20	.1276	.1413
25	.1435	.1581
30	.1580	.1740
35	.1710	.1887
40	.1823	.2022
	0.144	0.179
	25.3	31.8

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results	Volts	Amps
Functional Test						
Pull-in Voltage	5.1.7.1	Inlet pressure at 360 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	<20volts	Pri Sec Both	6.80 10.30 3.70	.391 .305 .231

INITIAL PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/8/67

Specimen Designation Letter C
Tested By:
On Time _____ Cycles 4

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0volts	Volts	Amps
				Pri 1.37	.080
				Sec 1.97	.060
				Both .785	.049
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.		
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage	$<10^{-4}$ cc/sec.		

INITIAL PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/8/67

Specimen Designation Letter C
Tested By
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	15 cc/hr

POST AXIS C SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/10/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	none

POST AXIS A SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/10/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	none

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/11/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results		
Electrical Resistance a. Coil Resistance	5.1.3.1	Measure and Record Ambient temperature		—		
		Primary coil resistance		AB	—	ohms
		Secondary coil resistance		CD	—	ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9 msec close 5 msec			
		Primary coil - 0.80 amperes	secondary open		5.6	msec.
			open 50 msec close		2.2	msec.
		Secondary coil 0.44 amperes	close 5 msec open		12.0	msec.
			close		2.1	msec.
		Primary and Secondary as above.	open		4.8	msec.
			close		2.6	msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.				

Press Drop	Flow-lb/sec. Fuel	Oxidizer
15	.1091	.1187
20	.1270	.1400
25	.1425	.1570
30	.1573	.1715
35	.1703	.1878
40	.1830	.1998
	0.144	0.179
	25.4	32.30

Test	Proc. Par. No.	Conditions & Measurements	Limits		Volts	Amps
Functional Test Pull-in Voltage	5.1.7.1	Inlet pressure at 360 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps	<20 volts	Pri	6.31	.377
				Sec	9.48	.297
				Both	3.60	.232

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/11/67

Specimen Designation Letter C
Tested By:
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5.1.7.2	Inlet pressure at 166 psig. Measure maximum voltage at which valve closes	≥1.0 volts	Volts	Amps
				Pri 1.35	.081
				Sec 1.99	.064
				Both .780	.050
External Leakage	5.1.8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.		
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

POST SINUSOIDAL VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/11/67

Specimen Designation Letter C
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures at 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port	30 cc/hr.	Fuel	none
				Oxidizer	none

Model 52X147C Body S/N 112
Axis C 8/12/67
Flapper button motion restrictors
flat spring
27.7 g rms input

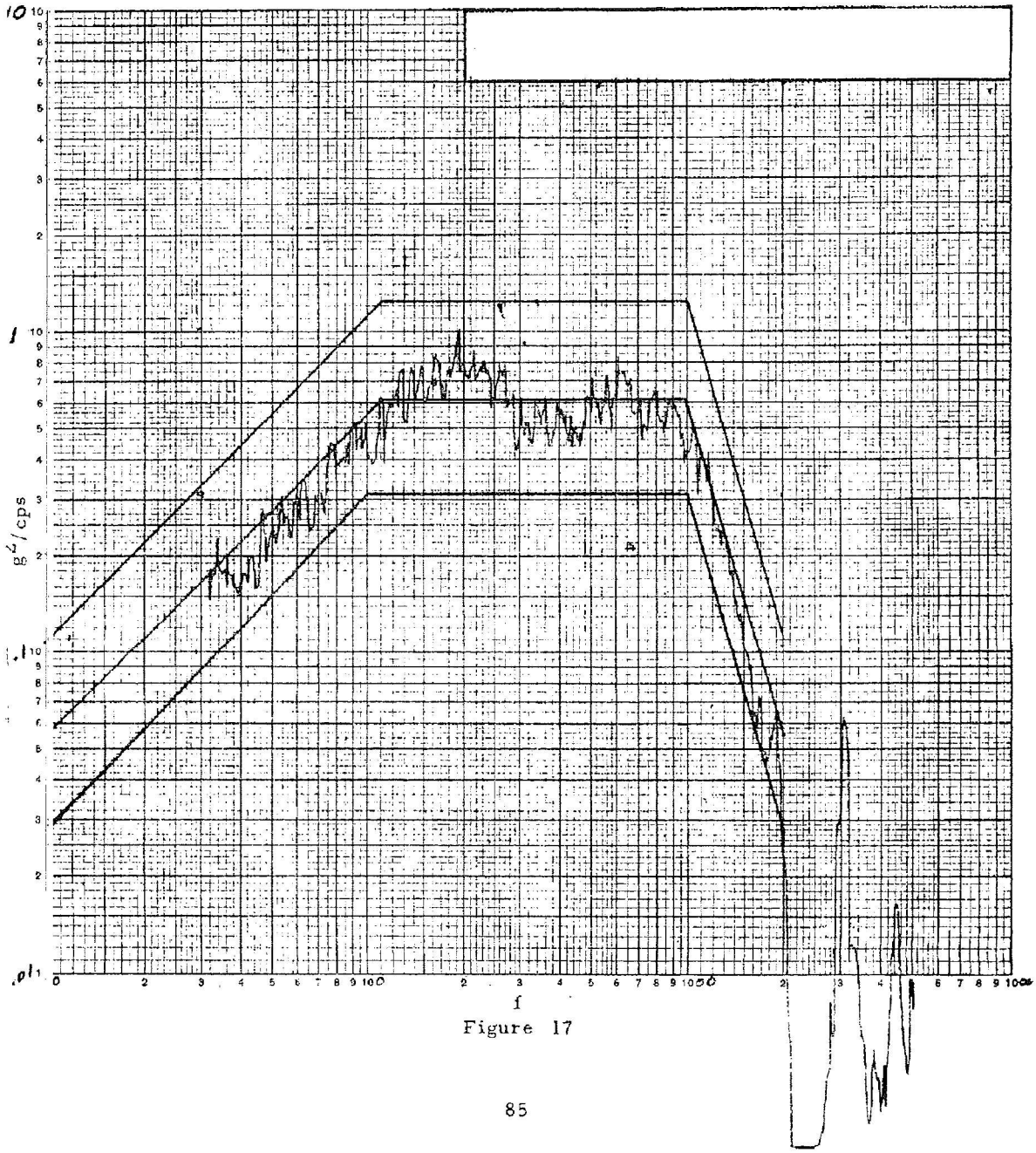


Figure 17

POST AXIS C RANDOM VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/12/67

Specimen Designation Letter C
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	none

Model 52X147C Body S/N 112
Axis A 8/12/67
Flapper button motion restrictors
flat spring
27.7 g rms input

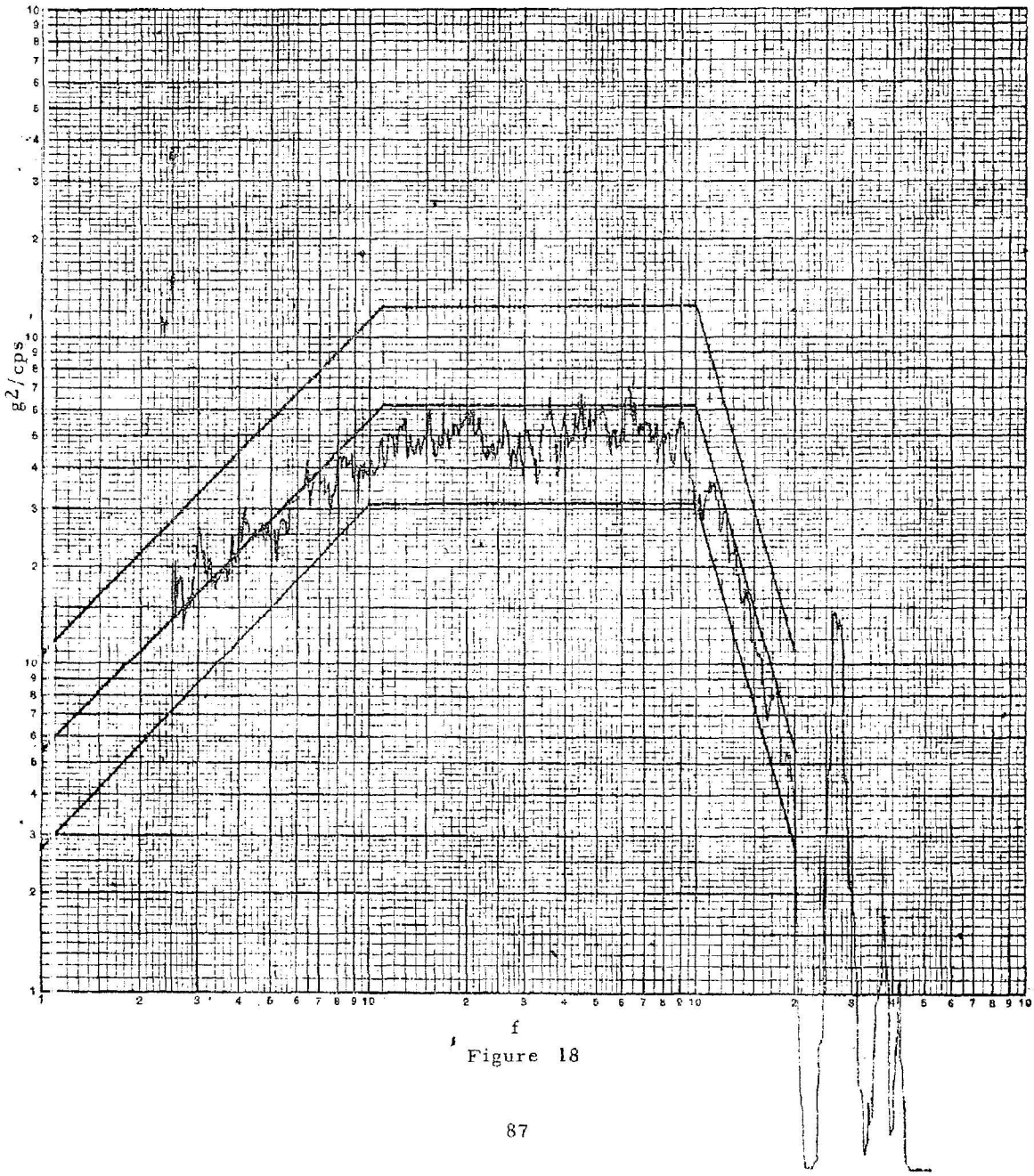


Figure 18

POST AXIS A RANDOM VIBRATION PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/12/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 m Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/ hr.	Fuel	none
				Oxidizer	none

Model 52X147C Body S/N 1.2
Axis B 8/12/67
Flapper button motion restrictors
flat spring
27.7 g rms input

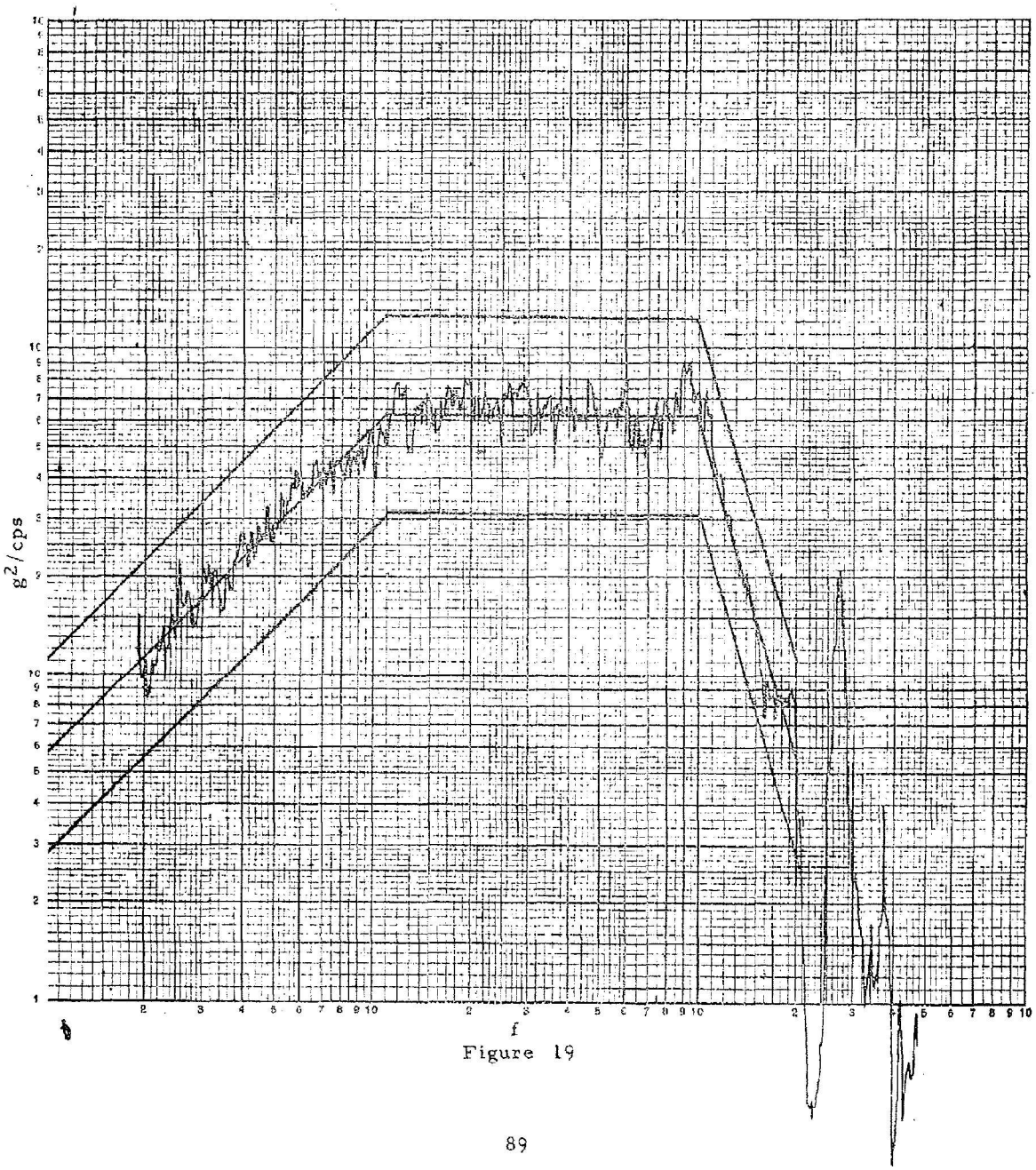


Figure 19

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/14/67

Specimen Designation Letter C
Tested By:
On Time _____ Cycles _____

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results
Electrical Resistance a. Coil Resistance	5.1.3.1	Measure and Record Ambient temperature Primary coil resistance Secondary coil resistance		– AB – ohms CD – ohms
Response Time	5.1.5	Measure opening and closing response from oscillograms. Inlet pressure at 310 psig for primary coil, at 360 psig for secondary coil.	primary open 9 msec close 5 msec	
		Primary coil - 0.80 amperes Secondary coil - 0.44 amperes Primary and Secondary as above	secondary open open 50 msec close close 5 msec open close open close	6.0 msec. 2.3 msec. 14.2 msec. 2.0 msec. 5.1 msec. 2.6 msec.
Flow Test	5.1.6	Measure flow and pressure drop with inlet of 310 psig.		

Press. Drop	Flow - lb/sec. Fuel	Oxidizer
15	.1094	.1183
20	.1258	.1393
25	.1411	.1553
30	.1549	.1706
35	.1675	.1850
40	.1792	.1980
	0.144	0.179
	26.3	33.5

Functional Test				Volts	Amps
Pull-in Voltage	5.1.7.1	Inlet pressure at 360 psig. Measure minimum voltage required to open valve 10 consecutive times at 0.25 cps.	<20 volts	Pri 6.33	.380
				Sec 9.66	.301
				Both 3.61	.232

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/14/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Drop-out Voltage	5. 1. 7. 2	Inlet pressure at 166 psig Measure maximum voltage at which valve closes	>1.0 volts	Volts	Amps
				Pri 1.52	.087
				Sec 2.18	.069
				Both .801	.051
External Leakage	5. 1. 8	Apply 360 psig helium pressure to the oxidizer inlet with both return ports blocked. Energize valve to allow helium to enter all oxidizer chambers. Block fuel inlet and measure external leakage	$<10^{-4}$ cc/sec.		
		Open fuel inlet and measure external leakage			
		Apply 360 psig helium pressure to fuel inlet with both return ports blocked. Energize valve to allow helium to enter all fuel chambers. Block oxidizer inlet and measure external leakage.			
		Open oxidizer inlet and measure external leakage.	$<10^{-4}$ cc/sec.		

VIBRATION POST SINUSOIDAL & RANDOM PERFORMANCE

Model Number 52X147
Serial Number 112
Date 8/14/67

Specimen Designation Letter C
Tested By:
On Time Cycles

Test	Proc. Par. No. MR 1144	Conditions & Measurements	Limits	Test Results	
Internal Leakage	5.1.9	Measure outlet port leakage with inlet pressures of 50 and 360 psig.		50 Psig	360 Psig
		Fuel		none	none
		Oxidizer		none	none
		Cycle valve 100 times and repeat above tests.			
		Fuel		none	none
		Oxidizer		none	none
Reverse Seat Leak		Apply 20 psig to outlet ports Measure leakage at the inlet port.	30 cc/hr.	Fuel	none
				Oxidizer	none

ALL SALES ARE FINAL

NTIS strives to provide quality products, reliable service, and fast delivery. Please contact us for a replacement within 30 days if the item you receive is defective or if we have made an error in filling your order.

▲▲ E-mail: customerservice@ntis.gov
▲▲ Phone: 1-888-584-8332 or (703)605-6050

Reproduced by NTIS

National Technical Information Service
Springfield, VA 22161

This report was printed specifically for your order from nearly 3 million titles available in our collection.

For economy and efficiency, NTIS does not maintain stock of its vast collection of technical reports. Rather, most documents are custom reproduced for each order. Documents that are not in electronic format are reproduced from master archival copies and are the best possible reproductions available.

If you have questions concerning this document or any order you have placed with NTIS, please call our Customer Service Department at 1-888-584-8332 or (703) 605-6050.

About NTIS

NTIS collects scientific, technical, engineering, and related business information – then organizes, maintains, and disseminates that information in a variety of formats – including electronic download, online access, DVD, CD-ROM, magnetic tape, diskette, multimedia, microfiche and paper.

The NTIS collection of nearly 3 million titles includes reports describing research conducted or sponsored by federal agencies and their contractors; statistical and business information; U.S. military publications; multimedia training products; computer software and electronic databases developed by federal agencies; and technical reports prepared by research organizations worldwide.

For more information about NTIS, visit our Web site at http://www.ntis.gov.

NTIS

Ensuring Permanent, Easy Access to U.S. Government Information Assets

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161 (703) 605-6000

N6822981

BX

BIN: M6 04-16-07
INVOICE: 1640878
SHIPTO: 1*85776
PAYMENT: NONE