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**RELIABILITY AND QUALITY CONTROL
REPORT**

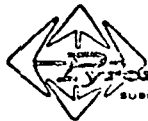
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5 Oct. 1971

PYRONETICS, INC.

SEA CORDON INTERNATIONAL COMPANY

REPORT NO. QC & R 6-046

EVALUATION TEST PROGRAM

FINAL REPORT

VALVE, EXPLOSIVE ACTUATED, NORMALLY CLOSED

PYRONETICS MODEL 1400

JET PROPULSION LABORATORY

PURCHASE ORDER NO. ES-536829

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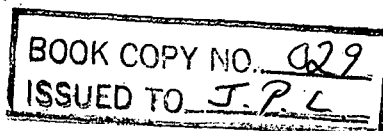
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INTRODUCTION AND SUMMARY

The Evaluation Test Program for the Explosive Actuated, Normally Closed Valve, Model 1400, was conducted in compliance with JPL Purchase Order Number ES-536829.

The objective of this Evaluation Test Program was to demonstrate compliance of this valve with the requirements of JPL P.O. ES-536829 by a series of operating tests applied to three (3) valves.

There was one test malfunction during actuation testing. One of the valves under actuated and caused approximately 25% obstruction of the flow passage. The ram/body bore clearance was increased and a requirement for blending of radius into the ram taper was added to the drawing.

Additionally the ram slot was elongated .020 to prevent any obstruction in flow passage (Ref. TFR 0069). Valve S/N 003 was modified and successfully tested with a 75% (under load) cartridge. All subsequent testing was successfully completed with no further anomalies encountered.

Compliance of the Explosive Actuated, Normally Closed Valve with all specification requirements was successfully demonstrated by this Test Program.

Additionally, within the testing parameters specified, the JPL cartridge P/N 10028949, demonstrated successfully its capability to properly actuate the Model 1400 valves which underwent this testing program.



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DESCRIPTION OF CARTRIDGE ACTUATED, NORMALLY CLOSED VALVE MODEL 1400

The Model 1400 is a normally closed cartridge actuated valve which will be utilized in the trajectory correction propulsion subsystem of the Thermoelectric Outer Planets- Spacecraft. (TOPS).

The normally closed valve will be used to control and isolate the flow of hydrazine to a 25 pound thrust monopropellant thruster.

The Model 1400 valves will be utilized in conjunction with the Pyronetics Model 1399, Cartridge Actuated, Normally open valve in a manifold assembly to provide a multiple start-stop capability. Each assembly is normally closed in the TOPS vehicle at launch. The projected usage of the propulsion subsystem is for trajectory correction during mission duration as long as ten years in the interplanetary and outer space environments within the solar system.

Upon actuation, the normally closed valves of each assembly will supply the fuel to the rocket engine assembly. Prior to actuation, the propellant and pressurization fluids are isolated by the valves until engine ignition is desired. Valve actuation is accomplished by explosive energy generated when the JPL cartridges, P/N 10028049, are ignited by the application of electrical power.

The valves are mounted in the propulsion subsystem by welding the inlet and outlet ports into a manifold tubular system. In the normally closed position internal leakage is prevented by two integral nipples. Upon actuation, the nipples are sheared and retained within the valve body by a ram propelled by the pressure cartridge. A flow passage is opened through the valve by the shearing of the nipples.



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EVALUATION TEST PROGRAM
EXPLOSIVE ACTUATED VALVE
MODEL 1400 NORMALLY CLOSED

1.0 TEST PROGRAM

Three (3) normally closed valves were submitted for evaluation testing in accordance with Pyronetics Test Procedure TS 1400. The objective of the test program was to verify design concept compatibility with the test requirements of JPL PO. ES-536829 for a normally closed explosive valve that will control the flow of hydrazine to a 25-pound thrust mono-propellant thruster. The cartridge utilized for actuation testing (JPL P/N 10028049) was supplied by Jet Propulsion Laboratory and underwent only the actuation test.

The three valves were subjected to the following test sequences:

1. Proof Pressure and Internal Leakage Test (Body Subassembly)
2. Proof Pressure and External Leakage Test
(Body Subassembly)
3. Proof Pressure and Leakage Test (Actuator Assembly)
4. Gross Leak Test (Actuator Assembly)
5. Examination of Product
6. Cleanliness Verification
7. Actuation Test
8. Post Actuation Proof Pressure
9. Flow vs Pressure Drop Test
10. Post Actuation Disassembly Inspection
11. Post Actuation Leakage (Actuator Assembly)
12. Post Actuation Leakage-Gross (Actuator Assembly)
13. External Leakage After Actuation
(Valve Assembly less Actuator Assembly)
14. Burst Pressure Test



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2.0 REFERENCE DOCUMENTS

The following documents comprise the criteria for this test program.

2.1 Military

MIL-C-45662A	Calibration System Requirements 9 February 1962
MIL-P-27401 B	Propellant, Pressurizing Agent Nitrogen, 19 September, 1962
MIL-P-27407	Propellant, Pressurizing Agent Helium, 8 June 1965

2.2 JPL

P.O. No. ES-536829	Requirements for Fabrication, Assembly and Test of Normally Open and Normally Closed Explosive Actuated Valve
FS 504574	General Cleanliness Required for Spacecraft Systems and Support Equipment, Detail Specification for
Drawing 10028049	Squib

2.3 Pyronetics, Inc.

Drawing 1400	Valve, Normally Closed, Explosive Actuated
TS 1400	Acceptance and Evaluation Test Procedure



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3.0 TEST DESCRIPTION AND RESULTS

The evaluation test requirements, descriptions and test results of the Normally Closed Valves, Pyronetics Model 1400, employed in the evaluation test program (in accordance with Pyronetics Procedure TS 1400), are described in the following paragraphs.

3.1 Proof Pressure and Internal Leakage (Body Subassembly) 3 units

Requirement

(Reference JPL P.O. ES-536829)

Each body subassembly shall be internally pressurized simultaneously through both nipple tubes to $1000 + 30/-0$ psig with gaseous helium for thirty (30) minutes minimum. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec of helium. The leakage shall be measured through the cartridge port. There shall be no evidence of deformation or failure as a result of this test.

Test Description

The proof and internal leakage test was performed on the valve body subassembly during inprocess testing per TS 1400, prior to submitting the assembled valves to the functional evaluation tests. The normally closed valves were subjected to a combined proof pressure and internally leakage test. (See Figure 1). Each valve was simultaneously pressurized through both nipple tubes to $1,000 +30/-0$ psig with gaseous helium. A test adaptor was connected to the cartridge port which in turn was connected to a helium mass spectrometer and subsequently evacuated to 10^{-4} torr. The internal leakage was then monitored on the mass spectrometer for 30 minutes minimum for evidence of leakage in excess of 1×10^{-6} sccs of helium. Upon completion of test, the valves were removed from the test system and the nipple tubes were blown off with gaseous nitrogen to prevent any residual helium potentially entrapped in the tubes from yielding erroneous leakage rates during subsequent tests.

Test Results

None of the units tested sustained any evidence of yielding, permanent deformation or other visible damage. Additionally, the valves did not exhibit any detectable leakage in excess of 1×10^{-6} sccs. Maximum internal leakage recorded was 3.0×10^{-8} sccs. Reference test results in Appendix 1.



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3.0 TEST DESCRIPTION AND RESULTS (Contd.)

3.2 Proof Pressure and External Leakage (Body Subassembly) 3 units

Requirement

(Reference JPL P.O. ES-536829)

Subject the body subassembly to an external leakage test by applying a pressure of $1000 +30/-0$ psig helium gas to the actuator cavity for a period of at least thirty (30) minutes. Measure the external leakage. The leakage shall not exceed 1×10^{-6} scc/sec.

Test Description

The proof and external leakage test was performed on the valve body subassembly during inprocess testing per TS 1400 prior to submitting the assembled valves to the functional evaluation tests. The normally closed valves were subjected to a combined proof pressure and external test (see Figure 2). Each valve was individually pressurized through the cartridge port, while installed in a bell jar, to $1000 +30$ psig with gaseous helium. The bell jar was connected to a helium mass spectrometer and subsequently evacuated to 10^{-4} torr. The external leakage was then monitored on the mass spectrometer for 30 minutes minimum for evidence of leakage in excess of 1×10^{-6} sccs of helium. Upon completion of test, the valves were removed from the test system and the cartridge port was blown off with gaseous nitrogen.

Test Results

None of the units tested sustained any evidence of yielding, permanent deformation or other visible damage. Additionally, the valves did not exhibit any detectable leakage in excess of 1×10^{-6} sccs. Maximum external leakage recorded was 2.0×10^{-8} sccs. Reference test results in Appendix 1.

3.3 Proof Pressure and Leakage Test (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

Each actuator assembly shall be installed in a suitable holding fixture and subjected to an external pressure of $500 \pm 10/-0$ psig with gaseous helium for thirty (30) minutes minimum. Following pressurization period, actuator assembly shall be removed from the helium pressurization and subjected to a helium mass spectrometer leak test. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec helium. There shall be no evidence of deformation or damage as a result of these tests.

Test Description

The combined proof pressure and leakage test was performed on each actuator assembly prior to assembling into valve body as an inprocess test per TS 1400. Each actuator sub-assembly was installed in a holding fixture as shown in Figure 3 and subjected to an external pressure of $500 \pm 10/-0$ psig with gaseous helium for thirty minutes. The actuator assembly was then removed from the pressure fixture and blown off with gaseous nitrogen and within sixty seconds after removal from fixture was installed in the leakage test fixture. The test fixture was evacuated to 10^{-4} torr and the leakage rate from the actuator assembly was checked with a mass spectrometer for evidence of leakage in excess of 1×10^{-6} sccs, the initial value indicated by the mass spectrometer was recorded. The bellows assembly was then visually examined for evidence of damage or deformation as a result of the proof pressure test.

Test Results

None of the units tested exhibited any evidence of yielding, permanent deformation or other visible damage. There was no evidence of leakage in excess of 1×10^{-6} sccs. Maximum leak rate recorded was 5.5×10^{-9} sccs, reference test results in Appendix 2.



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3.4 Gross Leak Test (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

The actuator assembly shall be tested for gross leakage by submerging in hot deionized water at $+180 \pm 15^\circ\text{F}$ and checked for evidence of bubbles.

Test Description

The gross leak test on the actuator assembly was performed prior to assembling into valve body as an in process test per TS 1400. Each actuator assembly was immersed in hot water ($+180 \pm 15^\circ\text{F}$) with axis in a horizontal position and the entrapped air in the bellows was removed by slightly agitating the assembly, reference Figure 4. Actuator assembly was maintained immersed in the hot water for one minute minimum while visually observing for bubble emission from the bellows of the actuator assembly as an indication of gross leakage.

Test Results

No evidence of bubble emission was detected from any of the actuator assemblies during the test. Hence, no gross leaks were found in the bellows area of the actuator assembly as recorded on the data sheet of Appendix 3.

3.5 Examination of Product (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Each valve body and components shall be visually examined for freedom from blemishes, tool marks, burrs, legibility and correctness of markings and any other characteristics which reflect the general quality of workmanship. The size, configuration and mounting dimension shall be in accordance with the dimensions noted on the appropriate drawings. These units shall be inspected with suitable gauges and/or instruments for conformance to the dimensions noted on the appropriate drawings, reference drawing 1400. The specimens shall be deemed acceptable for testing if they conform to the drawing requirements and are free from damage.

Test Description

The examination of product was performed upon completion of all the in process tests and prior to assembling the valve. Each valve body and components were visually examined for freedom from blemishes, tool marks, burrs, legibility and correctness of markings and other characteristics which reflected the general quality of workmanship. The size, configuration and mounting dimensions were inspected for conformance to the appropriate drawing.

Test Results

All of the major dimensions and characteristics were one hundred percent inspected and were per print. The requirements, results and verification of special processes are on file at Pyronetics. Appendix 4 includes the Configuration Identification Index indicating the as built configuration of the valves, and inspection buy-off records. The index indicates all documents, by revision letter, necessary for the manufacture of the parts.



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3.6 Cleanliness Verification (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Units shall be cleaned and assembled in accordance with applicable drawing requirements. (Reference level D.2 of JPL Spec. FS-504574.) Units selected for Evaluation Tests shall have JPL 10028049 squib installed in the actuator assembly prior to cleaning. Installation torque shall be 300 ± 20 in-lbs.

Verify cleanliness level of completed assembly and sign off on data sheet.

Test Description

The cleaning operation was performed by Garwood Laboratories in accordance with JPL Specification FS 504574 (Level D.2). The JPL 10028049 cartridge was installed in the actuator assembly prior to cleaning with 300 ± 20 in-lbs. Upon completion of cleaning operation Pyronetics personnel assembled the valves in the clean room. After the units were assembled, a final particulate count was performed and the cleanliness level of FS 504574 D.2 was verified. The units were again vacuum oven dried and the tube ports were sealed with nylon film and tape cleaned to the same level as the valves. Each valve was placed in a polyethylene bag; purged with gaseous nitrogen, vacuum evacuated and heat sealed.

Test Results

All applicable surfaces of the components were cleaned as specified in FS 504574 and certified to a cleaning level of D.2. Reference test results in Appendix 5.

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3.7 Actuation Test (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

The actuation test shall be performed on a sample selected at random from the production lot. The valve shall be actuated while a water pressure of 500 psig is applied to one of the normally closed nipples. The response time shall be measured from bridgewire burnout to first indication of pressure rise on the downstream side of the valve. Response time shall not exceed 10 milliseconds.

Test Description

The valves were mounted in a holding fixture as indicated in Figure 5. A pressure transducer was connected on the downstream side of the valves to detect response time. The bridgewire resistance of each bridgewire on the 10028049 JPL cartridge was measured and recorded with an Alinco Ohmmeter. The normally closed nipple tubes were pressurized to 500 ± 10 psig with water. The valves were actuated individually upon application of 5.0 amperes from a constant current power supply to one bridgewire of the cartridge while one nipple tube was pressurized to 500 psig. The response time was measured by the transducer installed on the downstream side of the valve with an oscilloscope and camera. Upon actuation of the valve, transfer of the valve to the open mode caused the pressure to rise on the downstream side as the water flowed through the valve. Hence, response time was measured from bridgewire burnout to first indication of pressure rise on the downstream side of the valve.

Test Results

The first valve tested actuated to the closed mode satisfactorily without any detectable evidence of damage to the structural integrity of the valves. However on the second firing, valve S/N 1068-002 underactuated and obstructed the flow passage by approximately 25% (Reference TFR 0069 in Appendix 14) Failure analysis conducted on the test unit (after subjecting the valve to the remaining test in TS 1400, excluding Flow vs Pressure Drop Test) revealed that leading edge of ram tap had minimum allowable radius and was not smoothly blended.



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3.7 Actuation Test (3 Units) (Contd.)

Test Results (Contd.)

Also the ram/body bore clearance was approximately .0010/.0015 tighter than on other units fired successfully during DVT. Examination of the body bore indicated evidence of ram leading edge digging into mating body taper. Hence, to preclude a recurrence, the ram/body bore clearance was increased in addition to increasing the radius on leading edge of ram taper. A requirement was also added to the drawing for blending radius on ram into taper. An additional safety margin, (proper alignment of ram crosshole) was incorporated by elongating the ram slot by 0.020. The remaining test unit was then modified to incorporate the design change. At JPL's request the reworked valve was actuated with a 75% (underload) cartridge. Valve actuated successfully with no obstructions in flow passage. Response time ranged from 1.0 to 1.1 milliseconds for all valves. Hence all valves complied with the 10 milliseconds maximum response time requirement.

Since all the units passed the subsequent post actuation leakage and burst test, the test was deemed successful. See test data sheets in Appendix 6.

3.8 Post Actuation Proof Pressure (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

Each valve assembly shall be subjected to a hydrostatic pressure of 1000 +30/-0 psig. One (1) port shall be capped and the other pressurized from 0 to 1000 psig for two (2) minutes minimum. There shall be no evidence of deformation or failure as a result of this test, nor shall the ram retract.

Test Description

The actuated valves were firmly secured in a proof test holding fixture (reference Figure 6) and one tube port was connected to a hydrostatic pressure source. The valves were placed behind a safety barricade and the tube port was slowly pressurized to 1,000 psig with water for two minutes.

Test Results



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3.8 Post Actuation Proof Pressure (3 Units) (Contd.)

Tests Results

None of the actuated valves proofed exhibited any visual evidence of external leakage. The test was considered successful since the valves did not reveal evidence of structural damage, nor did the ram retract. Reference test results in Appendix 7.

3.9 Flow vs Pressure Drop Test (2 units)

Requirements

(Reference JPL ES-536829)

The flow rate versus the pressure drop shall be determined across the open flowpath of each normally closed valve. The pressure drop across the unit shall not exceed 5.0 psid when a water pressure of 500 psig is applied at the inlet port and a flow of 0.15 lbs/sec of H₂O is established.

Test Description

Each valve was installed in a holding fixture (Ref. Figure 7) and the tube ports were pressurized to 500 psig with water while a regulated flow rate through the open flow path was maintained at 0.15 lbs/sec. The pressure drop through the entire system was determined with a differential pressure gauge and recorded. The net pressure drop across the valve was determined by subtracting the tare pressure drop from the gross pressure drop. The tare pressure drop was determined by removing the valve from the system and replacing it with a tare tube and repeating the flow test. The tare tube is a straight section one half inch long and has the same I.D. and O.D. as the valve under test.

Test Results

The flow was performed on only the two valves that actuated satisfactorily. Neither of the two units exceeded the maximum pressure drop requirements of 5.0 psid. The maximum gross pressure drop of the two units was 4.45 psid with a tare value of 3.65 psid. The test was considered successfully passed since the net pressure drop was 0.80 psi with a variation in pressure drop between valves of 0.03. Actual test results are found in Appendix 8.

3.10 Disassembly Inspection (3 Units)

Requirement

(Reference JPL P.O. ES-536829)

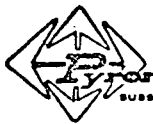
The JPL 10028049 squib shall be removed from the actuator assembly and the actuator assembly shall be removed from the valve body. Valve and actuator assembly shall be examined for proper actuation and there shall be no evidence of abnormal deformities, cracks, etc. on the actuator assembly bellows.

Test Description

The fired JPL 10028049 cartridge was removed from the actuator assembly first, then the actuator assembly was removed from the valve body. Examination of the actuator assembly was then performed under a 40X microscope for evidence of abnormal deformities, cracks, etc on the bellows and all observations were recorded, the valve body was also visually examined for proper actuation.

Test Results

No cracks or other anomalies were detected on the actuator assembly bellows exterior. There was no evidence of cartridge gas blowby. No visual evidence of abnormal deformation was found in the valve bodies. The structural integrity of the actuated valves appeared sound. Reference test results in Appendix 9.



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3.11 Post Actuation Leakage (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

Each actuator assembly shall be installed in a suitable holding fixture and subjected to an external pressure of $500 +10/-0$ psig with gaseous helium for thirty (30) minutes minimum. Following pressurization period, actuator assembly shall be removed from the helium pressurization and subjected to a helium mass spectrometer leak test. There shall be no evidence of leakage in excess of 1×10^{-6} scc/sec helium. There shall be no evidence of deformation or damage as a result of these tests.

Test Description

The actuator assembly from each actuated valve was installed in a holding fixture as shown in Figure 3 and externally pressurized with helium to $500 +10/-0$ psig for 30 minutes. Upon completion of the pressurization period the actuator assembly was removed from the test fixture and within 60 seconds was blown off externally with gaseous nitrogen and subjected to a leak check. A mass spectrometer was utilized to check for evidence of leakage in excess of 1×10^{-6} sccs.

Test Results

No evidence of leakage in excess of 1×10^{-6} sccs of helium was detected on any of the actuator assemblies. Maximum leakage rate detected was 4.3×10^{-8} sccs. Reference actual test results in Appendix 10.

3.12 Post Actuation Gross Leakage (Actuator Assembly) 3 Units

Requirement

(Reference JPL P.O. ES-536829)

The actuator assemblies from the actuated valves shall be tested for gross leakage by submerging in hot deionized water at $+180 \pm 15^\circ\text{F}$ and checking for evidence of bubbles.

Test Description

Each actuator assembly that had been removed from the actuated valve was immersed in hot water ($+180 \pm 15^\circ\text{F}$) with axis in a horizontal position and the entrapped air in the bellows was removed by slightly agitating the assembly, reference Figure 4, and checked for gross leakage. Actuator assembly was maintained immersed in hot water for one minute minimum while visually observing for bubble emission from the bellows in the actuator assembly as an indication of gross leakage.

Test Results

No evidence of bubble emission was detected in the bellows area during the time the actuator assembly was immersed in the hot water. Reference test results in Appendix II.

3. 13 External Leakage After Actuation (Valve Assembly Less
Actuator Assembly (3 Units))

Requirement

(Reference JPL ES-536829)

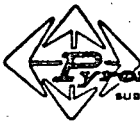
The external leakage after actuation of each valve shall be determined. The tube ports shall be pressurized to 1000 $\pm 30/-0$ psig with helium gas for a minimum duration of thirty (30) minutes. The external leakage shall not exceed 1×10^{-6} scc/sec of helium. The actuator assembly shall be removed for this test.

Test Description

Following the actuation test, the actuator assembly was removed from the valve body. The actuated valves were then secured in a pressure fixture, reference Figure 8, placed in a bell jar and both tube ports were simultaneously pressurized to 1000 $\pm 10/-0$ psig with helium gas. The bell jar was connected to a helium mass spectrometer and then evacuated to 10^{-4} torr. The valves were leak checked for evidence of external leakage by monitoring a mass spectrometer for leakage in excess of 1×10^{-6} sccs of helium for 30 minutes.

Test Results

None of the valves tested exhibited any detectable external leakage in excess of 1×10^{-6} sccs during the 30 minute test period. The post actuation leakage rate recorded ranged from 7.6×10^{-8} to 9.0×10^{-8} sccs. Therefore, test was considered acceptable since no leakage in excess of 1×10^{-6} sccs was detected. Reference test results in Appendix 12.



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3.14 Post Actuation Burst Pressure Test (3 Units)

Requirement

(Reference JPL ES-536829)

The valve assembly (actuator assembly removed) shall be subjected to a burst pressure test and burst pressure determined. One nipple tube shall be capped and the other pressurized with hydrostatic pressure from 0 to 10,000 psig in increments of 1000 psig. Minimum burst pressure shall be 2000 psig. If unit fails to burst at 10,000 psig pressure, discontinue test.

Test Description

The actuated valves were firmly secured in a burst test holding fixture (reference Figure 6) and one nipple tube was capped and the other was connected to a hydrostatic pressure source. The valves were placed behind a safety barricade and the nipple tube was slowly pressurized in increments of 1000 psig and maintained for 15 seconds at each level up to 10,000 psig with water. During the test valves were visually examined for evidence of leakage with the aid of a mirror.

Test Results

None of the actuated valves burst tested exhibited any visual evidence of external leakage. The test was considered successful since the valves did not burst and no evidence of structural damage was observed as a result of the burst pressure. In order to further ascertain the structural integrity of the normally closed valves, upon completion of the burst test, the nipple tube of each valve was pressurized until the ram retracted from its taper lock. The pressure required to retract the rams ranged from 12,600 to 13,500 psig for S/N 002 (under actuated unit). Reference test results in Appendix 13.



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4.0 TEST PROGRAM CONCLUSIONS

Accomplishment of the evaluation tests in accordance with Pyronetics Test Procedure TS 1400 Rev A, dated 22 March 1971 signify the acceptance of the Normally Closed Explosive Actuated Valve, Pyronetics Model 1400, as having fulfilled the test requirements of JPL Purchase Order No ES-536829. The evaluation test program was conducted by Pyronetics, Inc. and witnessed and acknowledged by JPL Engineering.

Examination of the data included herein indicates excellent repeatability of all functional characteristics, i.e., ignition time, response time and flow vs pressure drop. Additionally, post actuation proof and leakage test of the actuator assembly and valve body revealed adequacy of the taper lock (metal-to-metal seal) between the ram and valve body after actuation. It should also be noted that the internal proof pressure had no effect on the integrity of the shear section of the normally closed nipple tubes.

The structural integrity of the valve assemblies was successfully demonstrated by the post actuation 10,000 psig burst test and in the fact that the pre-actuation and post-actuation leak rates detected far surpassed the 1×10^{-6} sccs requirements. The fact that no anomalies or degradation in performance was experienced with an 75% cartridge load; in addition to the fact that a minimum pressure of 12,600 psi is required to retract the ram, further testifies to the soundness of the design.

Finally, it should be noted, that the Bellows which is incorporated into the valve design to positively prevent any cartridge products of combustion from entering the flow stream, performed exactly as required. Positive retention of all contamination was achieved.

Therefore, based on the data described herein, and the modification made in the ram/body bore no other changes to the valve design are recommended.

5.0 TEST EQUIPMENT AND SETUPS

The test equipment and environmental apparatus employed in the performance of the various tests described herein are listed below. All equipment was checked for reliable performance prior to initiation of specific tests. Accuracy and capability is as specified and all calibrations are traceable to the National Bureau of Standards.

5.1 Test Equipment -- Proof Pressure and Leakage

Instrument	Mass Spectrometer
Manufacturer	Consolidated Electrodynamics
Model No.	24-120B S/N 9593
Range	5×10^{-11} scc/sec
Type	Helium Detector
Calib. Frequency	Prior to use

Instrument	Sensitivity Calibrator
Manufacturer	Consolidated Electrodynamics
Model No.	25643 S/N 122G6
Range	Helium Leak Rate 8.8×10^{-7} scc/sec
Accuracy	$\pm 10\%$ of indicated leak rate

Instrument	Pressure Gauge
Manufacturer	Marsh Instrument Co.
Model No.	100 S/N 535
Range	0-1500 psi
Accuracy	$\pm 0.5\%$
Calib. Frequency	90 days
Calib. Due	10-28-71

Instrument	Stop Watch
Manufacturer	Minerva
Model No.	136-L S/N 1355
Range	0-15 Min x .01 sec
Accuracy	± 0.05 min/hr
Calib. Frequency	6 months
Calib. Due	2-5-72

5.2 Test Equipment - Gross Leakage

Instrument	Hot Plate
Manufacturer	Thermolyne Corp.
Model No.	HP-A1915B
Range	100-500°F
Accuracy	N/A
Calib. Frequency	N/A

Instrument	Thermometer
Manufacturer	Van Waters Rodgers
Model No.	0-230°F
Range	0-230°F
Accuracy	±1%

5.3 Test Equipment - Examination of Product

As examination of products consists of visual inspections, dimensional measurements, surface finish inspection measurements, all of the equipment necessary to perform these inspections will not be listed below. However, all inspection tools utilized in the accomplishment of this task were verified to be within calibration prior to use.

5.4 Test Equipment - Actuation Test

Instrument	Ignition Circuit Tester
Manufacturer	Alinco
Model No.	1015 AF S/N 501
Range	0-10, 0-20 ohms
Accuracy	±0.02 ohms
Calib. Frequency	90 days
Calib. Due	12-18-71

Instrument	Constant Current Pulse Generator
Manufacturer	E&R Development Co.
Model No.	PS-4A S/N 653
Range	0 to 10 amp; 0 to 100m ¹ sec
Accuracy	±0.5%
Calib. Frequency	6 months
Calib. Due	9-29-71



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QC & R 6-046

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5.4 Test Equipment - Actuation Test (continued)

Instrument	Charge Amplifier
Manufacturer	Kistler Corp.
Model No.	503 S/N 746
Type	Dial Calibration
Range	0-10 volts
Calib. Frequency	Prior to use
Instrument	Oscilloscope Camera
Manufacturer	Tektronix
Model No.	C12 S/N 003939
Instrument	Oscilloscope
Manufacturer	Tektronix
Model No.	502 S/N 002367
Type	Dual Beam
Range	100 μ to 20 v/centimeter
Accuracy	$\pm 3\%$
Calib. Frequency	90 days
Calib. Due	12-12-71
Instrument	Pressure Transducer
Manufacturer	Kistler Corp.
Model No.	603H S/N 2773
Range	0-15,000 psi
Accuracy	$\pm 1\%$
Calib. Frequency	Prior to use

5.5 Test Equipment - Burst Pressure

Instrument	Pressure Gauge
Manufacturer	U.S. Gauge
Model	19035, Serial No. 669
Range	0-20,000 psig
Accuracy	$\pm 0.5\%$
Calib. Frequency	90 days
Last Calibration	11-2-71
Instrument	Hydrostatic Test Console
Manufacturer	Pyronetics, Inc.
Model No.	N/A
Range	0-20,000 psig
Calib. Frequency	N/A

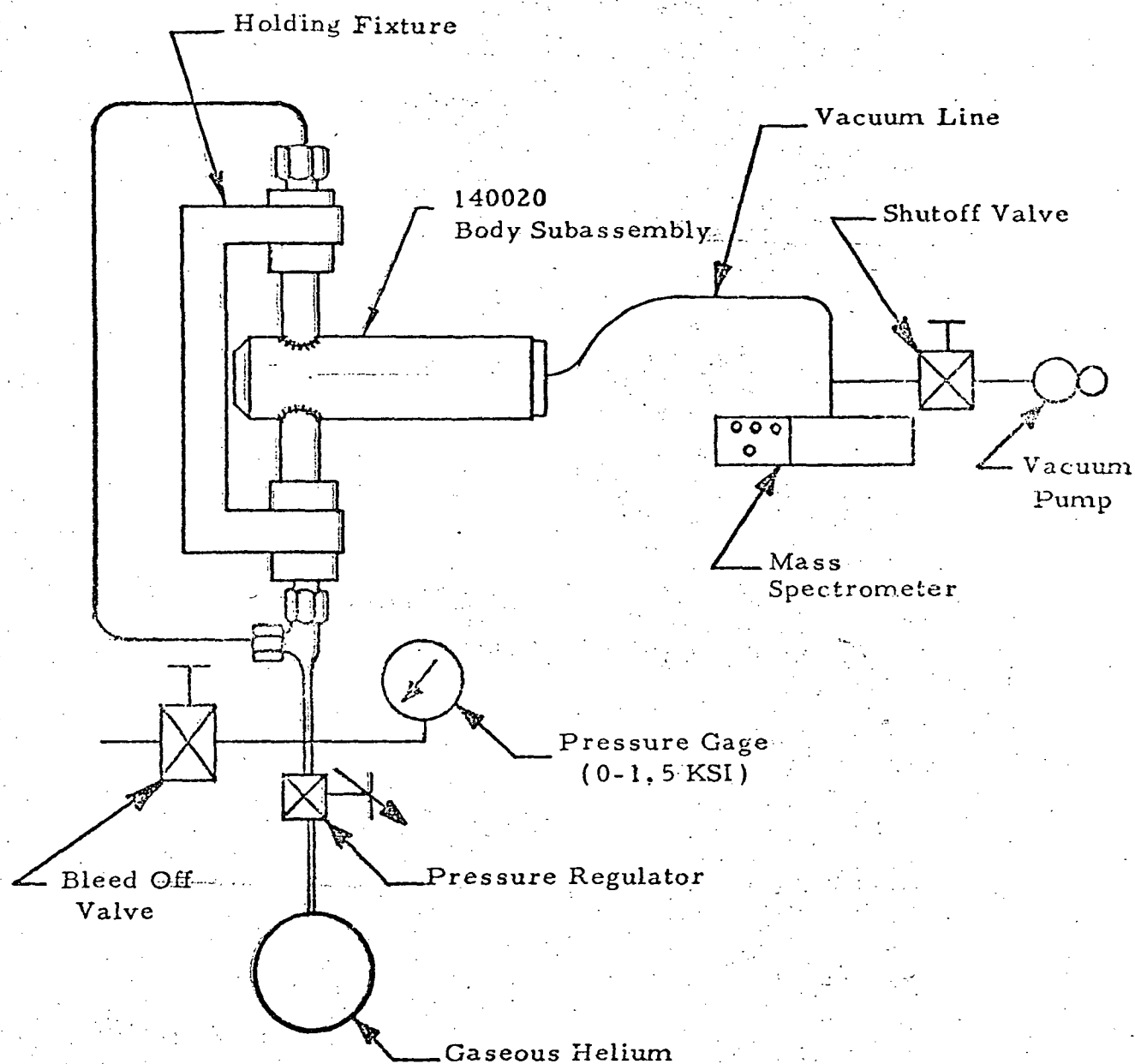


Aerometrics Inc.
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PROOF PRESSURE & INTERNAL LEAKAGE TEST SETUP

FIGURE 1.

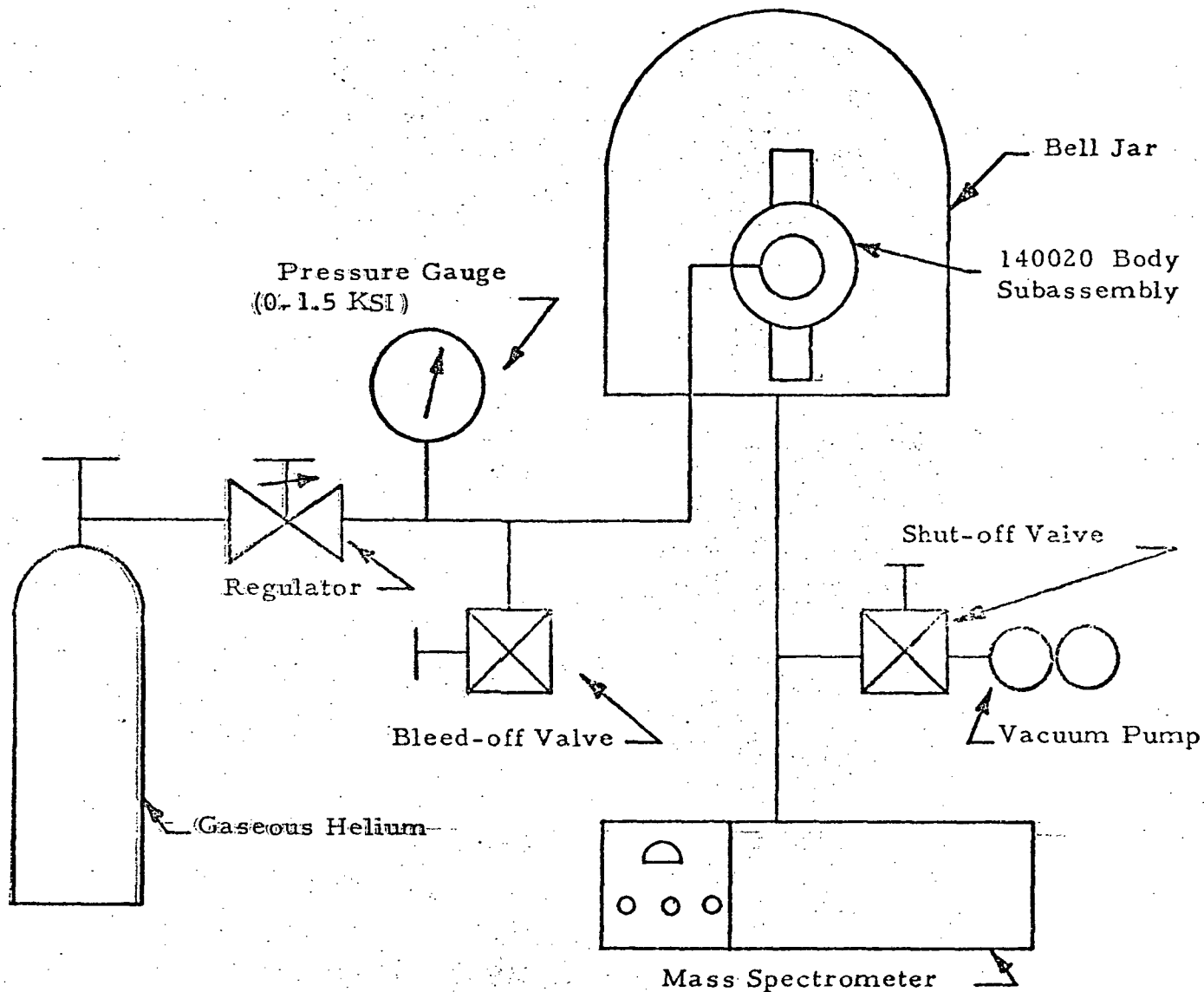


Aerojet Inc.
SUBSIDIARY OF COSMOVINE

10025 SHOEMAKER AVE.
SANTA FE SPRINGS, CALIF.

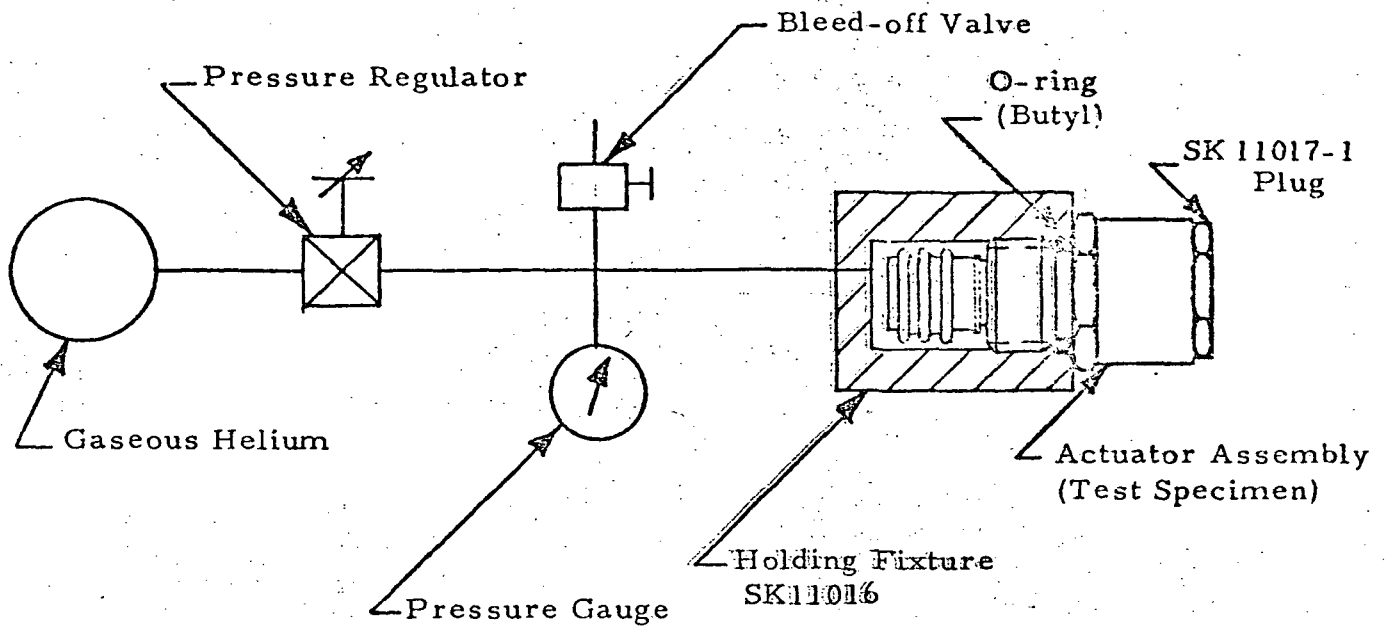
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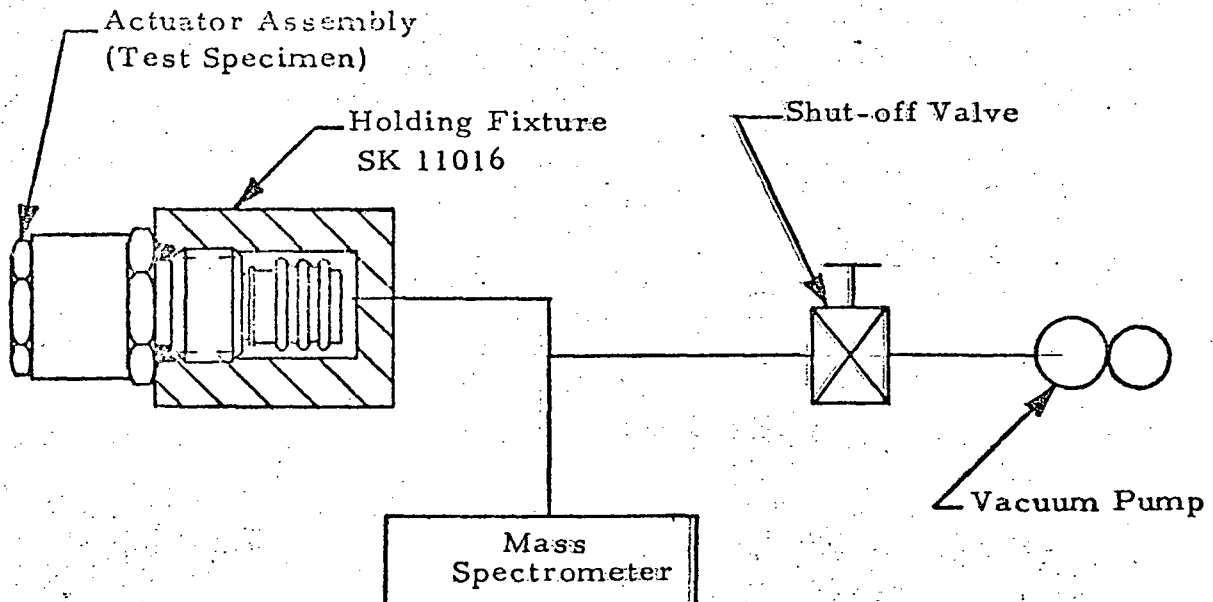


PROOF PRESSURE & EXTERNAL LEAKAGE TEST SETUP

FIGURE 2



(A) PROOF PRESSURE



(B) LEAK TEST

PROOF PRESSURE & LEAK TEST SETUP
(ACTUATOR ASSEMBLY)

FIGURE 3

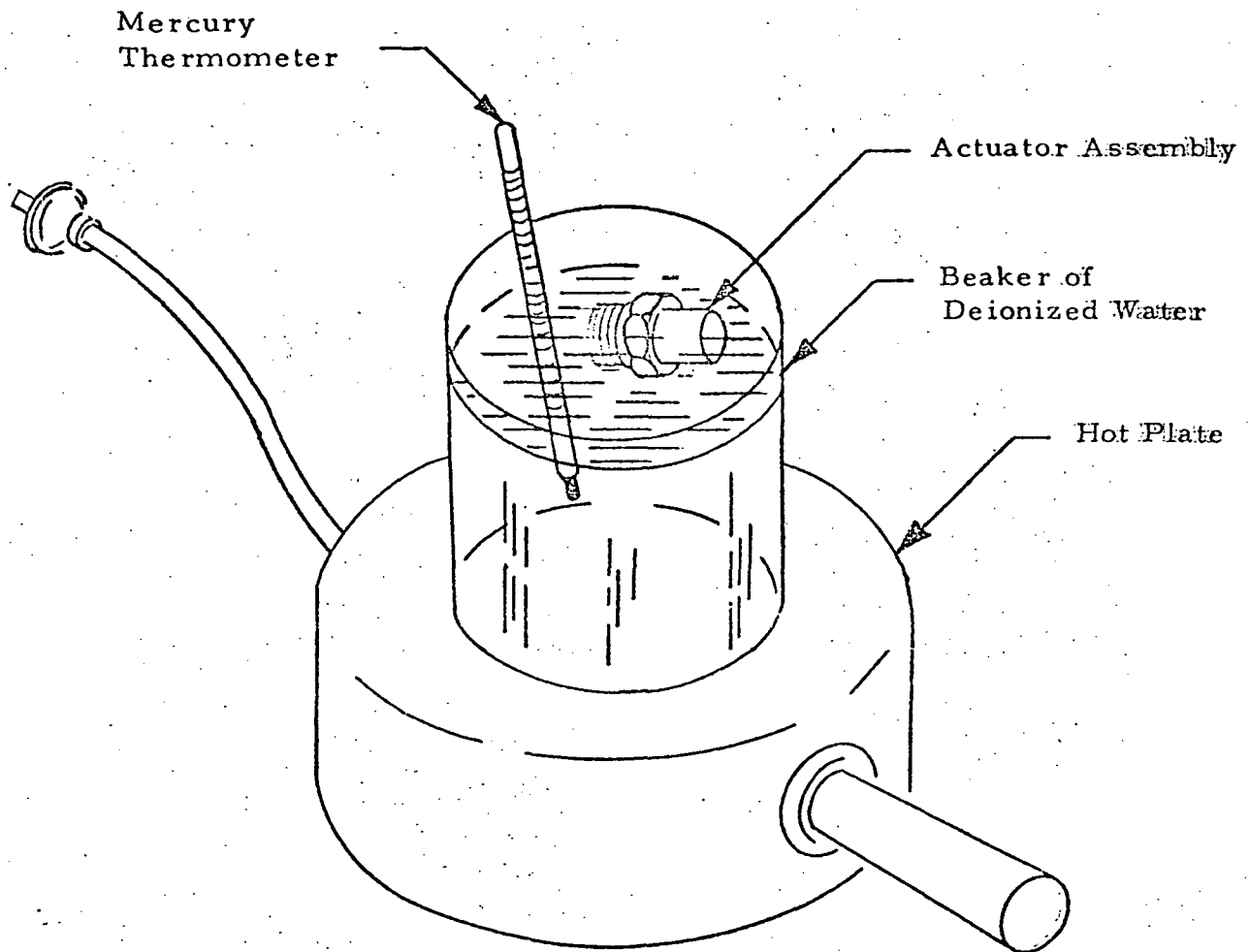


Aeroflex Inc.
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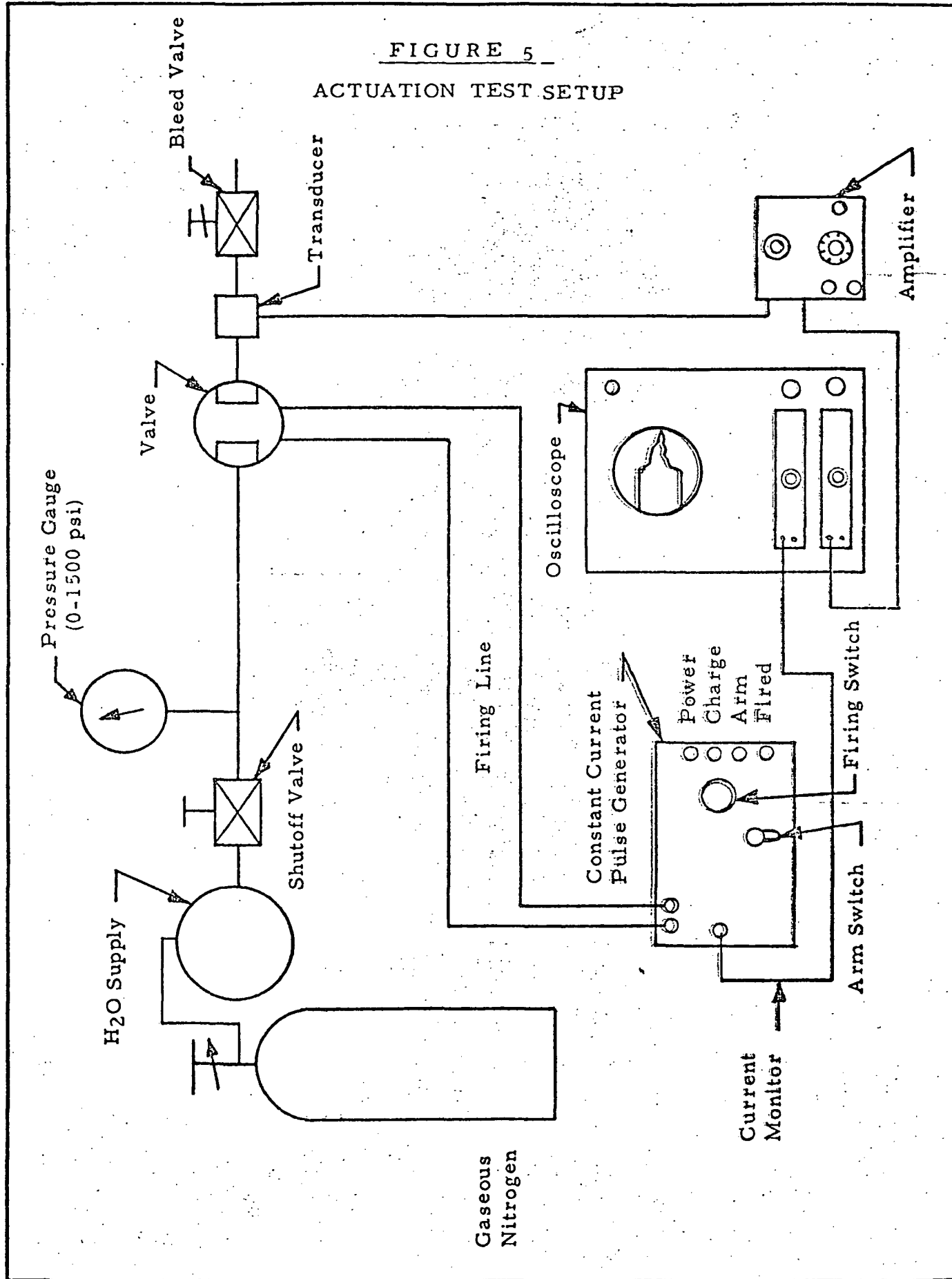
5 Oct. 1971



LEAK TEST (HOT WATER) SETUP

FIGURE 4

FIGURE 5
 ACTUATION TEST SETUP



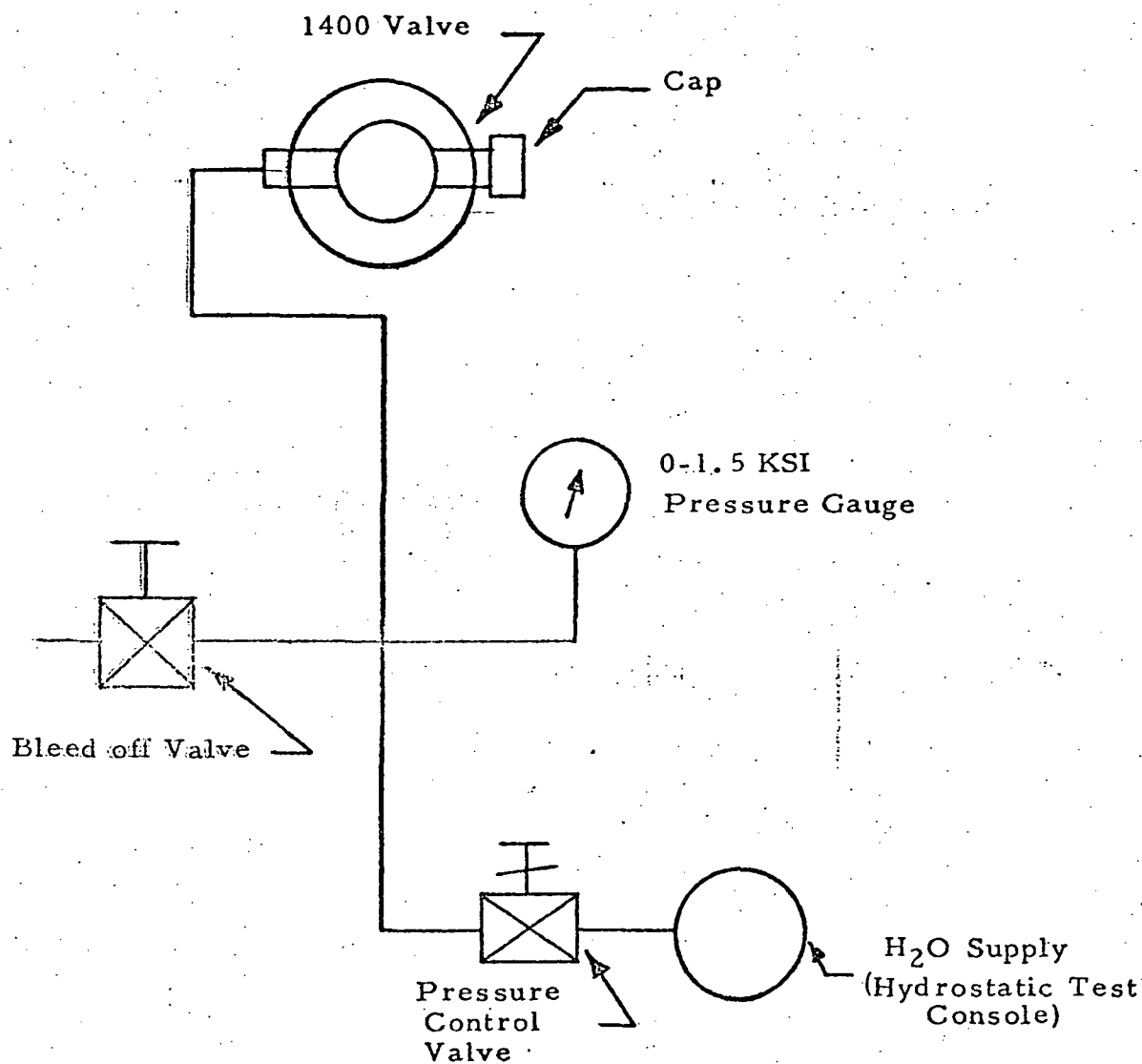


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POST ACTUATION PROOF PRESSURE TEST SETUP

FIGURE 6

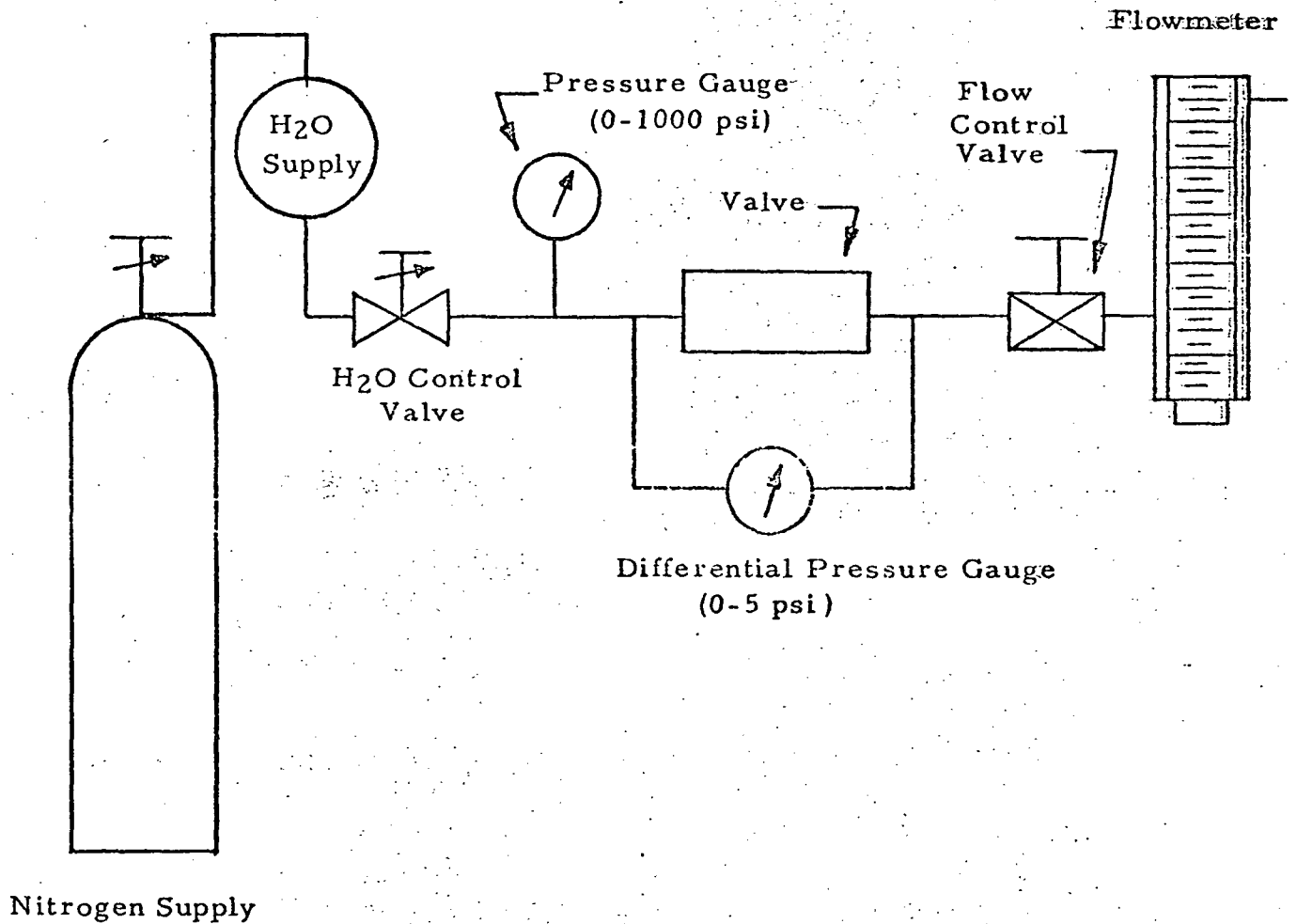


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FLOW VS PRESSURE DROP SETUP

FIGURE 7

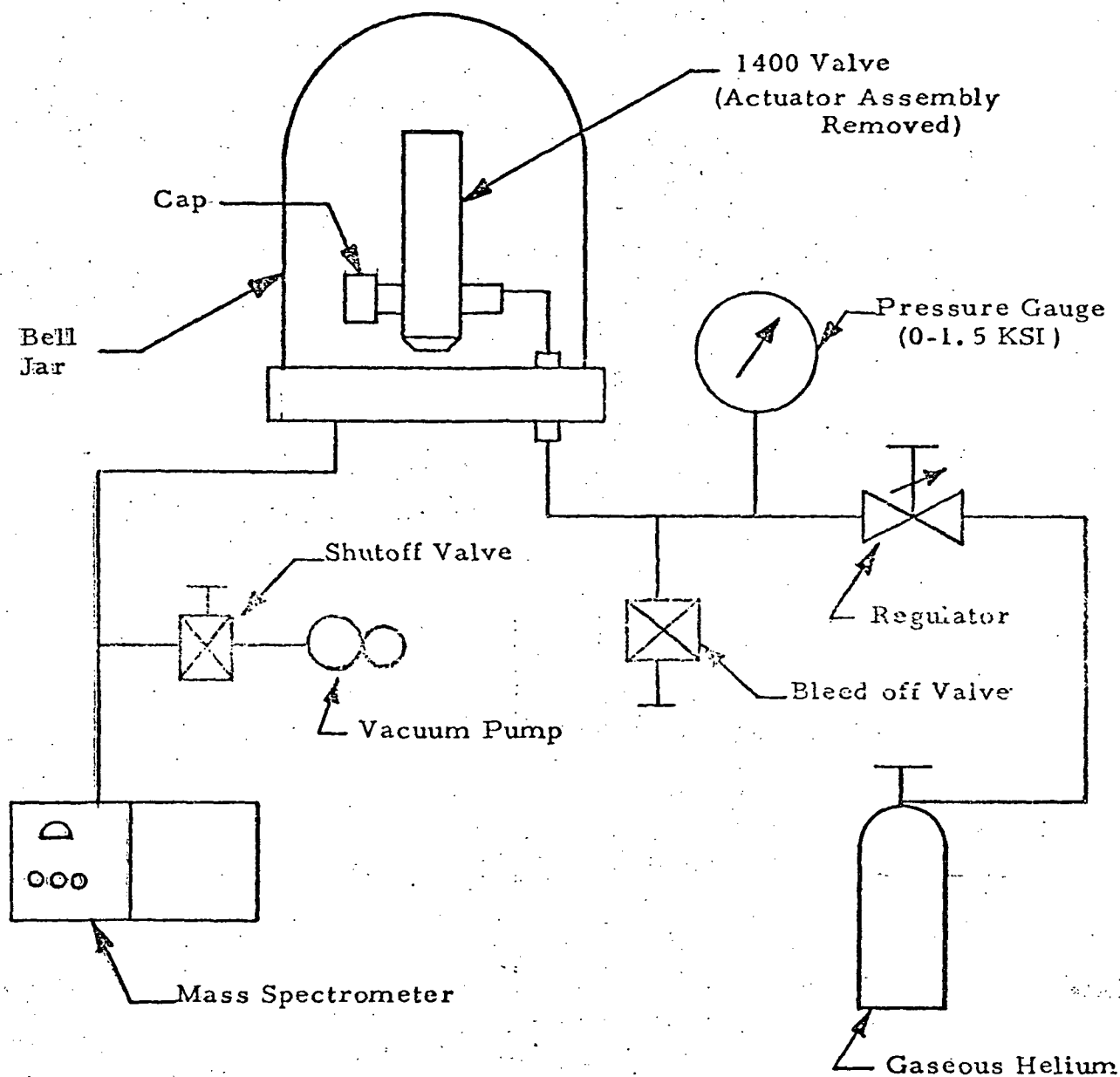


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POST ACTUATION LEAKAGE TEST SETUP
(LESS ACTUATOR ASSEMBLY)

FIGURE 8



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APPENDIX 1



SANTA FE SPRINGS, CALIF.

LABORATORY TEST REPORT

700 2/2 1100

JOB NO.:

MODEL 1420

Tests Conducted By

Instruments and Procedure Per:

TS 1400

DATE

Witnessed By _____ Source Insp.

Traveler S/N 4183

PARAGRAPH NO.

4.1 Proof Pressure &

4.2 Proof Pressure and External Leakage

[illegible]



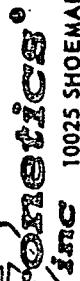
Aeronotica Inc.
SUBSIDIARY OF COSMOGYNE

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5 Oct. 1971

APPENDIX 2



SANTA FE SPRINGS, CALIF.

MODEL 1400

Tests Conducted By

TS 1400

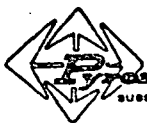
DATE

Witnessed By _____ Source Insp. _____

Traveler S/N 4196

Proof Pressure and Leakage Test (Actuator Assembly)

34



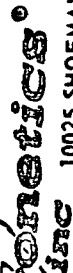
Pyrotechnics Inc.
SUBSIDIARY OF COSMOBYNE

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5 Oct. 1971

APPENDIX 3



SANTA FE SPRINGS, CALIF.

LABORATORY TEST REPORT

LOG S/N 581185

JOB NO. 1068 MODEL 1400

Tests Conducted By R.D. 

Instruments and Procedure Per:

TS 1400

Witnessed By _____ Source Insp.

Traveler S/N 4496

PARAGRAPH NO. 4.4

Gross Leak Test (Actuator Assembly)

36



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SANTA FE SPRINGS, CA 90670

QC & R 6-04

5 Oct. 1971

APPENDIX 4

SCALE 2/1

V

DWG 140000 NO.

68961

C

מזל טוב

CODE IDENT. NO.

SIZE

3-29-71

450854

۴۰

12-21-71

Handwritten signature

1 L-A-b

249

VALVE ASSEMBLY

10025 SHOEMAKER AVENUE
SANTA FE SPRINGS, CALIF. 90370

Pyrotechnics, Inc.
SUBSIDIARY OF COSMODYNE

FACT NO.

DOE
AT

PART NUMBER

DESCRIPTION

140020

BODY SUBASSEMBLY

140023

RAM

140024

ACTUATOR ASSY

8-5153,606-E

O-RING

MS 20995 C 32

LOCKWIRE

DATE 6-16-71 INSP. BY
AMT. INSP. 3
AMT. ACC. 3
DMR. NO. 2
JOB NO. 5771

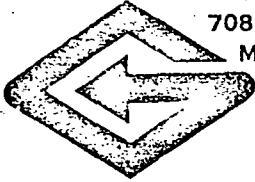
JUL 12 1977

5/11/88-001007-000

140000

A

B

GARWOOD LABORATORIES, INC.

708 SO. VAIL AVENUE
MONTEBELLO, CALIF.
90640
(213) 723-0011

Pyronetics Inc.
10025 Shoemaker Ave.
Santa Fe Springs, Calif. 90670

Attention:

CERTIFICATION**PYRONETICS**

Number C3824-5
Date 7-13-71
12176
Your Order 1230-1068
Delivered To _____
Date _____ Via Pickup
VLW
Eng'r. _____

QUAN

Description

- 3 Pyronetics P/N 1400-B, Valve Normally Closed
S/N 1063-001 thru 1068-003
- 3 Pyronetics P/N 1399-B, Valve Normally Open
S/N 1068-001 thru 1068-003
JPL P.O. ES-536829
Cont. NAS 7-100

This will certify that the above items were processed according to the following methods and that the specification requirements were complied with:

~~XXXXXX~~
~~Tested Per~~ Assy by Pyronetics per Applicable Dwg.
Cleaned Per JPL Spec. FS504574, Level D2
Packaged Per JPL Spec. FS 504574

Delmar L. Robinson

Quality Assurance Supervisor



Aeromatics Inc.
SUBSIDIARY OF COSMOGYNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 6



Part Name: <u>VALVE Normally Closed</u>	Test Title: <u>Lot Acceptance Tests</u>
Pyronetics P/N: <u>1400</u>	Customer: <u>JPL</u>
Pyronetics Spec: <u>TS 1400</u>	Customer P/N: _____
Test Para. No.: <u>4.7</u>	Cust. Spec. No.: _____
Test Sequence No.: <u>7</u>	Cust. Spec. Para. No.: _____
Date Started: <u>15 JULY 1971</u>	Customer P. O.: <u>ES -536829</u>
Date Completed: <u>30 JULY 1971</u>	Prime Contr. No.: _____

[illegible]

REMARKS: * Cartridge P/N 10033514-1 75% Load
S/N 76765

E.A. BHL (5)

Tested by

E-A

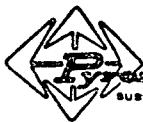
Test Engineer

R. Hägler

Customer
Witness

Customer
Witness

DCAS



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SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 7



5 Oct. 1971

Part Name: Valve Normally Closed

Pyronetics Spec: TS 1400

Test Para. No.: 4-8

Test Sequence No.: 8

Date Started: 15 July 1971

Date Completed: 15 July 1971

8-3-71

Test Title: Hot Acceptance Test

Customer: JPL

Customer P/N:

Cust. Spec. No.:

Cust. Spec. Para. No. :

Customer P.O.: ES-536829

Prime Contr. No.:

TEST DESCRIPTION: *Proof Pressure Test
(after Actuation of Valve)*

REMARKS:

APPROVALS:

G Tested by Anzor Test Engineer

Customer
Witness

Customer Witness

DCAS



Synetics Inc.
SUBSIDIARY OF COSMOBYNE

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SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 8



Part Name: <u>VALVE NORMALLY CLOSED</u>	Test Title: <u>LOT ACCEPTANCE TEST</u>
Pyronetics P/N: <u>1400</u>	Customer: <u>JPL</u>
Pyronetics Spec: <u>TS 1400</u>	Customer P/N: _____
Test Para. No.: <u>4.9</u>	Cust. Spec. No.: _____
Test Sequence No.: <u>9</u>	Cust. Spec. Para. No.: _____
Date Started: <u>15 JULY '71</u>	Customer P.O.: <u>ES-536829</u>
Date Completed: <u>30 JULY '71</u>	Prime Contr. No.: _____

TEST DESCRIPTION: *Flow vs Pressure Drop Test*

[illegible]

REMARKS:

APPROVALS: (U)

E. A. # B. L.

Tested by

E. A.

Test Engineer

R. HAGLER

Customer
Witness

Customer
Witness

DCAS



Aytronics Inc.

SUBSIDIARY OF COSMOOVNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 9

5 Oct. 1971

TEST DATA SHEET

Part Name: VALVE N.C.
Pyronetics P/N: 1400
Pyronetics Spec: T.S. 1400
Test Para. No.: 4.10
Test Sequence No.: 10
Date Started: 7-19-71
Date Completed: 7-19-71
8-3-71

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N: _____
Cust. Spec. No.: _____
Cust. Spec. Para. No.: _____
Customer P.O.: ES-536229
Prime Contr. No.: _____

TEST DESCRIPTION: *DISASSEMBLY INSPECTION*

[illegible]

REMARKS:

APPROVALS:

R. DeFRISCO E. Avalos
Tested by — Test Engineer

Customer
Witness

Customer
Witness

DCAS



Eyrone Inc.
SUBSIDIARY OF COSMOGYNE

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5 Oct. 1971

APPENDIX 10



5 Oct. 1971

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N: _____
Cust. Spec. No.: _____
Cust. Spec. Para. No.: _____
Customer P. O.: ES-53629
Prime Contr. No.: _____

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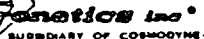
Tyronetics Inc.
SUBSIDIARY OF COSMOBYNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 11



5 Oct. 1971



Aeronautics Inc.
SUBSIDIARY OF COSMOGYNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 12



5 Oct. 1971

Test Title: LOT ACCEPTANCE
Customer: JPL
Customer P/N: _____
Cust. Spec. No.: _____
Cust. Spec. Para. No.: _____
Customer P. O.: ES-536829
Prime Contr. No.: _____

TEST DESCRIPTION: *EXTERNAL LEAKAGE AFTER ACTUATION
(VALVE ASSEMBLY LESS ACTUATOR ASSY.)*

PAGE 55



Tyronetics Inc.

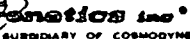
SUBSIDIARY OF CORMODYNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

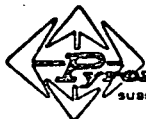
QC & R 6-046

5 Oct. 1971

APPENDIX 13



5 Oct. 1971



Synetics Inc.
SUBSIDIARY OF COSMOBYNE

10025 SHOEMAKER AVE.,
SANTA FE SPRINGS, CA 90670

QC & R 6-046

5 Oct. 1971

APPENDIX 14



1068

TROUBLE & FAILURE REPORT

PROJECT NAME

S/N 0069

THIS REPORT COVERS A

☐ REWORK ACTION☐ TROUBLE☒ FAILURE

SYSTEM/SUBSYSTEM NAME

P/N

S/N

DATE

VALVE, N.C. EXPLOSIVE ACT'D

1400

002

7 15 71

REPORTING FACILITY

REPORTED BY

TFR CONTINUATION USED

PYRONETICS

E. AVALOS

TROUBLE/FAILURE OBSERVED WAS: (TEST CONDITIONS, SYMPTOMS, SEVERITY, ETC., INCLUDING "IS" AND "SHOULD BE" DATA)

VALVE UNDERACTUATED ON FIRING CAUSING APPROX
25% OBSTRUCTION OF THE FLOW PASSAGE.

TROUBLE/FAILURE OCCURRED DURING

ACTION TAKEN TO CORRECT TROUBLE/FAILURE

EVALUATION TESTING (LAT)

(A) ☐ REPLACED ITEM(B) ☐ REPAIRED ITEM

ITEM REPLACED NAME

P/N

S/N

ITEM INSTALLED NAME

P/N

S/N

DISPOSITION OF REPLACED ITEM

WERE OTHER TROUBLES/FAILURES, NOT RELATED TO ORIGINAL NOTED?

(A) ☒ NO (B) ☐ YES

LIST ON NEW TFR - TFR NO.

WAS REPORTED TROUBLE/FAILURE VERIFIED?

(A) ☒ YES (B) ☐ NO

FAILED ITEM NAME

P/N

S/N

MANUFACTURER

VALVE, N.C.

1400

002

PYRONETICS

NEXT HIGHER ASSY: NAME

P/N

S/N

MANUFACTURER

N/A

(A) ☐ REWORK REQUIRED IS (B) ☒ REWORK IS NOT REQUIRED BECAUSEVENDOR REWORK/ANALYSIS IS REQUIRED ☒

SINGLE SHOT ITEM

DISPOSITION OF ITEM IF NOT REWORKED

USE FOR ANALYSIS

AUTHORIZATION BY

DATE

LIST BELOW ALL PARTS REPLACED, REPAIRED OR ADJUSTED

PART NUMBER	S/N	MANUFACTURER	DEFECT	REWORK ACTION TAKEN	RECEIVING LOT NO.

OTHER REWORK ACTION

REMAINING LAT UNIT (S/N 003) RAM (P/N 140023) REWORKED
TO REV 'B' FOR REMAINING LAT TEST

REWORKED BY

RETESTED BY

RETEST RESULTS APPROVAL

DATE

RETEST RESULTS: REPAIRED ITEM IS ACCEPTABLE FOR

☐ UNRESTRICTED USE ☐ RESTRICTED USE ☐ NOT ACCEPTABLE

N/A

DISPOSITION OF ITEM AFTER RETEST

N/A

Q.C.

CAUSE OF FAILURE - COMMENTS (IF ANALYSIS NOT PERFORMED, EXPLAIN)

RAM/BODY BORE CLEARANCE APPROX

.0010/.0015 TIGHTER THAN OTHER UNITS FIRED SUCCESSFULLY. LEADING
EDGE OF RAM TAPER HAD MINIMUM ALLOWABLE RADIUS AND
WAS NOT SMOOTHLY BLENDED AS ON SUCCESSFUL UNIT
FIRINGS. RAM LEADING EDGE SHOWED EVIDENCE OF DIGGING
INTO MATING BODY TAPER.

BASIC CAUSE OF TROUBLE/FAILURE (SELECT FROM BLOCK 1)

SHEET 2 DESIGN

SIGNATURE

DATE

WORKMANSHIP

CORRECTIVE ENGINEERING ACTION TAKEN (IF NONE, JUSTIFY) - CONCLUSIONS

RAM/BODY BORE CLEARANCE

INCREASED. RADIUS INCREASED ON LEADING EDGE OF RAM
TAPER AND REQUIREMENT FOR BLENDED OF RADIUS INTO TAPER
ADDED. RAM SLOT ELONGATED .020 FOR ADDED INSURANCE

SIGNATURE

DATE

1068
PROJECT NAME

TROUBLE & FAILURE REPORT

S/N 00

GENERAL INSTRUCTIONS

1. THE TFR IS USED TO DOCUMENT THE TROUBLE FAILURE OF ONLY ONE (1) ITEM PER REPORT. IF MORE THAN ONE ITEM IS INVOLVED IN A SINGLE FAILURE EVENT, OR IF TWO OR MORE FAILURES ARE DISCOVERED IN A SINGLE ITEM, A SEPARATE REPORT SHALL BE COMPLETED FOR EACH ITEM OR FAILURE AND IDENTIFIED BY CROSS-REFERENCING.
2. UNLESS INSTRUCTED OTHERWISE, ALL REQUIRED BLOCKS MUST BE COMPLETED.
3. USE A TFR CONTINUATION SHEET WHENEVER ADDITIONAL SPACE FOR ENTRIES IS REQUIRED.

DETAIL INSTRUCTIONS

ENTRIES ON THE TFR ARE SELF-EXPLANATORY AND DO NOT REQUIRE DETAIL INSTRUCTIONS. SPECIAL INSTRUCTIONS FOR ENTRIES ARE COVERED IN IMPLEMENTING INSTRUCTIONS ISSUED BY THE USING ORGANIZATION.

1. CAUSE OF DIFFICULTY

- | | |
|---|---|
| ☒ DESIGN | ☐ ROUGH HANDLING |
| ☐ MFG. PROCESS | ☐ ENVIRONMENTAL EFFECT(S) |
| ☐ TEST EQUIPMENT | ☐ OTHER ITEM FAILURE SPECIFY _____ |
| ☐ TEST PROCEDURE | ☐ DEFECTIVE PARTS |
| ☐ HUMAN ERROR | ☐ UNKNOWN |
| ☒ WORKMANSHIP | ☐ OTHER SPECIFY _____ |

2. EFFECT ON

VALVE, V.C.
(ITEM NAME)

☐ INOPERATIVE
☐ BADLY DEGRADED
☒ SLIGHTLY DEGRADED
☐ NUISANCE

3. CORRECTIVE ACTION STATUS

- ☒ IN EFFECT
☐ UNDER INVESTIGATION
☐ SCHEDULED
☐ INTERIM FIX
☐ NOT REQUIRED
☐ ACTION PREVIOUSLY TAKEN

DATE

8-3-7

ANALYSIS

THIRD L.A.T. UNIT, S/N 003, HAD MODIFICATION OF
RAMP TO REV. B PERFORMED AND WAS THEN TESTED
PER TS 1400. A 75% (UNDERLOAD) SQHIB WAS
UTILIZED AT JPL REQUEST. RESULTS WERE
SATISFACTORY.

RELIABILITY ANALYSIS BY C NAGENGAST

DATE 8-3-7

APPROVALS:

VENDOR CUSTOMER (IF APPLICABLE)

ENGINEERING (IF APPLICABLE)

RELIABILITY

TFR CLOSED