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PROGRAM SUMMARY REPORT

10-INCH LOX VENT AND RELIEF VALVE
PN 5640073

Reference:

NASA Contract No. NAS8-11833
Parker Program No. S126

Parker Aircraft Co.

SYSTEMS AND ADVANCED COMPONENTS DIVISION

22

Parker

Hydraulic and fluid system components

Parker Aircraft Co.
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1.0 INTRODUCTION

1.1 Scope - This report summarizes the efforts of Parker Aircraft Co. on the 10-Inch LOX Vent and Relief Valve program performed for NASA-MSFC under Contract No. NAS8-11833. The program included complete design, development and manufacturing effort required to supply valves in two configurations (25 psig flight, and 52 psig test) and a mating coaxial tank sensing line. A list of other documents previously submitted is provided in Section 6.0 of this report.

1.2 Function - The valve was designed to serve two basic functions on the S-1C LOX tank. The first is to open, as required, to limit the pressure in the LOX tank in the event of tank pressurization control failure. Two modes of actuation are provided to accomplish this function. The primary mode consists of an external 750 psig command signal controlled by a pressure switch and applied to the override actuators. In the event this command is not received, the valve senses tank pressure through an auxiliary tank pressure sensing line and automatically opens using tank pressure as the power fluid. In this mode of operation the valve modulates flow to control tank pressure to a preset level.

The second function of the valve is to open to vent the tank during LOX loading. This is accomplished by applying a ground controlled pressure to the override actuators.

2.0 SCOPE OF WORK

2.1 The original contract and its subsequent modifications provided for Parker to perform the following effort:

a. Design, develop and manufacture 10-inch LOX vent and relief valves and the mating tank sensing line in accordance with NASA-MSFC Design Procurement Drawing 20M32016. The valves and sensing line are identified by Parker Part Number 5640073 (25 psig flight configuration), 5650016 (52 psig test configuration) and 5650061 respectively.

b. Manufacturing and preflight certification (qualification) testing of three flight configuration (25 psig) valves (PN 5640073).

c. Manufacturing, acceptance testing, and delivery to NASA for system testing two test configuration (52 psig) valves (PN 5650016).

d. Manufacturing, acceptance testing and shipping to NASA two flight configuration valves (PN 5640073) for system testing and vehicle use.

e. Development tests as required to support engineering activities.

f. Modifications to NASA-supplied functional test simulator, PN 5640048, for PFCT and acceptance test work to be performed.

g. Fabrication of six additional flight configuration valves (PN 5640073). This work which, designated as Phase III to the contract, was only partially completed under the original contract, then later transferred to contract NAS8-20734 for completion of the six units.

3.0 DESCRIPTION OF SIGNIFICANT FEATURES

3.1 Operation - The valve consists of four main sections as described in the following paragraphs: (See figures 1 through 6).

a. Pilot Valve - The pilot valve consists of two stages; the first stage or sensing stage, and the second stage or booster stage. The sensing stage senses tank pressure in excess of the set point, opens and allows pressure within the booster stage. The booster stage opens and allows pressure to enter the power bellows. With two stages in the pilot valve, small motions in the sensing stage cause large motions in the booster stage, which allows flow into the power bellows to actuate it. As the tank pressure increases, the pilot valve stages continue to open until the tank pressure decreases or remains within the control band of the valve.

b. Override Bellows - The override bellows assembly consists of two bellows linked to the main linkage mechanism. The override bellows when pressurized (using a high pressure external source) will fully open the main valve. It has sufficient power to overcome any pilot valve regulation, thus it is a positive opening device.

c. Power Bellows - The power bellows is essentially a large annular bellows surrounding the valve body. One end is rigidly attached to the body and the other end is attached to the main linkage mechanism. The only function of the power bellows is to position the linkage according to the demands of the tank pressure.

d. Main Valve - The main valve consists of a flapper plate and a curved tapered beam lever arm. The essential functions of the main valve are to modulate flow during venting and to provide a positive seal against leakage for tank pressures below the selected set point. The sealing feature is accomplished by tank pressure force deforming the thin flapper plate against the body seat.

3.2 Sequence of Operating Events

a. If during LOX tank filling operations the LOX tank pressure rises above the desired pressure, a high pressure source can be applied to the override bellows of the vent and relief valve. The high pressure compresses the bellows and forces a linkage to pivot about a fixed support, which in turn, pivots the main valve lever arm and relieves the tank pressure. This particular function can be controlled either by pressure switches or by manual command.

b. During the normal flight of the missile, the tank pressure force slightly deforms the main valve against the valve body seat, thereby permitting virtually no leakage out of the tank past the main valve. In this mode of operation, the valve acts as a positive seal (immune to major leakage) and cannot contribute to any degradation of system performance.

c. Assume that during the normal flight of the missile, the upstream pressurization system of the LOX tank fails in the open position. This will cause the tank pressure to increase and the need for relief operation becomes necessary. The vent and relief valve will now vent when the tank pressure exceeds a preset level. This will be accomplished by one of two methods or both depending on the atmospheric pressure. Pressure switches located on the inside walls of the LOX tank sense absolute pressure. The pilot valve senses gage pressure. If failure occurs at low altitudes, the pressure switches will actuate solenoids located in the high pressure lines to the override bellows assembly to actuate and fully open the main valve. When the tank pressure drops below the set point, the override bellows will be vented. In this mode of operation, the vent and relief valve acts as an on-off type controller and cycles the tank pressure within the switch control band. As the altitude increases or if failure occurs at a high altitude, the pilot valve senses pressure forces sufficient to open the first stage valve. As the tank pressure increases, the pilot valve stages open just enough to move the main valve to a position that will stabilize the tank pressure. In this mode of operation, the LOX vent and relief valve operates as a modulating controller using tank pressure as the error signal.

3.3 Description of Tank Pressure Sensing Line - The functions of the sensing line are to convey sensing pressure and booster supply pressure from the LOX tank to the vent and relief valve, PN 5640073 or PN 5650016. The sensing line is co-axial to permit segregation of these two functions. A bellows is integral with the line to take up variation in attachment points and is designed to deflect during vibration. Figure 6 shows a cross-sectional view of the sensing line.

4.0 SUMMARY OF PROGRAM PROGRESS

4.1 The following is a chronological summary of major program activities and milestones.

December 1964:

After receipt of the contract, preliminary design on the 10-Inch LOX vent and relief valve was started. This included planning activities for Block Model tests and a computer study. Specification requirements and preliminary system parameters were also established at this time.

January 1965

Preliminary design work continued and a computer program for system and valve analysis was established. Designs were released for a 1/3 scale model to determine flow torque forces on the valve flapper which were required in programming the computer analysis.

February 1965

The flow and torque tests of the 1/3 scale model were successfully completed at Wyle Laboratories and test report EER5640073 covering the results was released and submitted to NASA. These tests permitted an accurate estimate of the flapper flow forces to be made for the design study and the start of computer analysis of the full scale valve.

In addition, a digital computer analysis of the mechanical linkage required to operate the flapper was started, along with the necessary stress analysis of the linkages.

The initial analog computer simulation of valve performance was completed. The results of this initial analysis indicated that additional system performance requirements would have to be more fully defined to permit completion of the final analysis.

March 1965

Stress analysis and valve design layout continued during this period. The final analog computer simulation using the redefined system requirements supplied by NASA was completed. The results indicated that the design as proposed would satisfactorily meet all the NASA system requirements for control and modulation. Development testing was started on the metal power bellows. Initial test results indicated that a redesign of this bellows would be required to add additional strength.

April and May 1965

A critical design review was held at Parker on May 11 and 12 to review the final proposed design of the vent valve. Messrs. Fuhrmann, Schnelle, Weitenbeck, Olson, and Holmes of MSFC particpated in the review.

As a result of this design review, valve operating temperature requirements were dropped from 450°F to 300°F to make the use of an aluminum body feasible. This temperature change was based on test data not available at the time the initial specification was written. The material change involved redesign of the valve body to eliminate the stainless steel sheet metal construction previously proposed. These changes resulted in some delays to the engineering design schedules.

During this period the following tasks were also accomplished.

a. The final performance parameters for the vent valve were established.

b. The preliminary design of the valve was completed.

c. The detail design of all production components was begun.

d. Designs for an engineering development pilot and booster unit were released.

e. Development testing was started.

f. A first stage pilot valve was assembled and tested.

g. Life cycle tests on the power bellows configuration change were successfully completed.

h. A life cycle test on the override actuator bellows was successfully completed.

June 1965

Design and development test activities continued during this period. In addition, a weight estimate and weight reduction study was initiated. Design of assembly and test tooling was started.

July 1965

Final design activities continued and development tests involving life cycling and vibration tests on the pilot booster assemblies were conducted. Work on the redesign of the functional test simulator was initiated and long lead components for fabrication of the simulator were placed on order.

The weight reduction study was completed and resulted in a decrease from 103 lb to an estimated weight of 86.25 lb. Both the power bellows and override bellows for the 25 psi valve successfully passed development vibration tests during this period. Accordingly, the design of the vibration dampers used in these tests was finalized and released for production.

September 1965

Additional development tests were run on 52 psi valve bellows and pilot valves concurrently with the assembly of the first production 52 psi valve. This valve successfully passed initial simulator tests.

November 1965

The first 52 psi valve was tested at Wyle Laboratory for flow capacity on a 2500 cu. ft. ullage tank at rated flow. Wyle test report 46836 was issued covering these tests. The test results indicated that the valve would modulate as intended over a full range of flow conditions. Seat leakage and pilot operation was also verified during these tests.

Flow force parameters, flow capacity, and override response times were also established and checked against the original calculations supplied with the 1/3 scale model. All parameters checked out closely with the original estimates. The functional test simulator program was changed to incorporate actual values obtained during this test series.

The operational requirements and design approach for a coaxial sensing line were coordinated with NASA and a formal proposal for incorporation was submitted on 19 November.

December 1965

Testing was continued on the first 52 psi unit, and a second unit was started into assembly. Acceptance test parameters and test setups were revised slightly to more closely reflect the actual operating requirements of the unit.

The first 52 psi valve completed acceptance testing and was shipped to NASA on December 3. Assembly of the second 52 psi unit was completed and acceptance testing was started.

The final drawings of the 25 psi valve were completed and initial sub-assembly work was started on the first valve. All test procedures were completed during this period and were submitted to NASA for approval.

January 1966

The second 52 psi valve was shipped during this period. A number of minor redesigns were incorporated for use on the 25 psi valve during this period. Planning and fixture design for preflight certification test (PFCT), vibration tests was started.

PFCT commenced on 25 psi valves No. 1 and No. 2. Flow tests were conducted at Wyle Laboratories on Unit No. 1 and initial functional tests and life cycle tests were commenced on Unit No. 2. The Wyle tests on Unit No. 1 were successful, however, the life cycle testing induced a bellows failure in the override actuator of Unit No. 2.

February 1966

PFCT continued on specimen No. 1 with the completion of vibration tests at Component Evaluation Laboratories. Although difficulties were encountered in equalization of the valve and fixture, the specimen successfully passed all vibration requirements.

Additional test work was conducted on development parts to evaluate the cause of failure of the actuator bellows on unit No. 2. Based on test data, a minor redesign of the bellows end fittings to adjust working stroke was accomplished and minor changes to the test procedure were made to more closely simulate the actual vehicle conditions of tests. These changes, along with a change in the dry film lubricant compound used in the linkages and pivot pins, were incorporated into PFCT unit No. 2.

March 1966

PFCT unit No. 1 successfully completed the balance of environmental testing required in the PFCT schedule. Unit No. 2, which had been rebuilt using modified parts described earlier, also successfully completed life cycle and temperature shock tests. After completion of the test series with Unit No. 1 it was also used to provide overstress cycling data on actuator life expectancy. Assembly and build up of PFCT Unit No. 3 was started.

April 1966

PFCT commenced on Unit No. 3. During life cycling, a bellows failure developed both on the power bellows and override actuator bellows. Since the failure did not affect valve operation the cycling test was completed. Investigation of these two failures indicated that the failure condition was related to manufacturing weld control problems rather than bellows design. Unit No. 3 accordingly was rebuilt with new components and restarted into PFCT.

May 1966

PFCT continued on Unit No. 3 during this period. During vibration test and during the final axis of vibration a failure of the actuator pressurization line occurred. Although no failure of this component had occurred on the other unit which had been vibrated it was decided to redesign this actuator line to incorporate a flexible metal hose to eliminate possible installation stresses. Although this redesign was minor in nature, fabrication of new lines delayed completion of the qualification tests on unit No. 3.

August 1966

After incorporation of the revised actuator lines described earlier PFCT continued. The revised line successfully passed vibration and thermal shock tests in addition to a vibration penalty test which was conducted on the actuator line. This concluded the environmental testing on the three PFCT valves.

September 1966

Vibration testing of the coaxial sensing line resulted in a premature vibration failure in the first axis. Examination of the test specimen indicated that the manufacturing process for the flexible bellows section of this line resulted in minor stress concentrations caused by tool marks. In addition, it was believed that the test specimen had received some overstress testing during the vibration while attached to the valve No. 3. This overstress had occurred when a vibration power failure had resulted in overtravel of the vibration table. A second test specimen of identical design which also included manufacturing tool marks successfully passed an identical vibration test. After completion of these tests it was then subjected to life cycling and thermal shock tests.

October 1966

Two production 25 psi valves were shipped to NASA for their evaluation.

November 1966

Final destructive burst tests were conducted on the PFCT valves.

December 1966

A preliminary draft of the PFCT report on the three valves was submitted to NASA for review. The final vibration tests on the coaxial sense line were also completed. Completion of this vibration and post vibration tests finished all testing required under the contract.

January 1967

The preliminary draft of the sense line PFCT report was submitted for NASA review.

5.0 SUMMARY OF VALVE PERFORMANCE

5.1 Actual performance data of the vent and relief valve are presented in tabular form in Table I, together with appropriate design specification performance requirements. A typical modulation curve is shown in figure 7. Review of this data verifies the valve's ability to meet or exceed all design requirements, and therefore its suitability for the intended application.

6.0 RELATED DOCUMENTS

6.1 The following documents provide additional detailed information on various significant aspects of the program. These documents have been prepared in support of program activities and reviewed and approved by NASA-MSFC. These documents are on file at NASA MSFC.

Document No.	Title
PTS5650016	Acceptance Test Procedure LOX Vent and Relief Valve, Type II, PN 5650016 (52 psig).
EEP5650016	Design Verification Test Procedure LOX Vent and Relief Valve, Type II, PN 5650016 (52 psig).
PTS5650061	Acceptance Test Procedure Co-Axial Tank Pressure Sensing Line, PN 5650061.

Document No.	Title
QTP5650061	Preflight Certification Test Procedure,Co-Axial Tank Pressure Sensing Line, PN 5650061.
QTR5650061	Preflight Certification Test Report,Co-Axial Tank Pressure Sensing Line, PN 5650061.
PTS5640073	Acceptance Test Procedure,LOX Vent and Relief Valve, Type I, PN 5640073 (25 psig).
QTP5640073	Preflight Certification Test Procedure,LOX Vent and Relief Valve, Type I, PN 5640073 (25 psig).
QTR5640073	Preflight Certification Test Report,LOX Vent and Relief Valve, Type I, PN 5640073 (25 psig).

7.0 SUMMARY AND CONCLUSIONS

7.1 Summary - The PFCT units demonstrated complete fulfillment of all required performance parameters and additionally demonstrated their ability to withstand life cycle and vibration testing substantially exceeding the levels required by the specification.

Although a few minor changes were made to balance performance, the overall valve design concept required no changes as a result of development or PFC testing results. Extensive use of computer simulation techniques coupled with sound,conservative mechanical design concepts proved valuable in achieving this performance. This approach was used throughout the vent valve program. In addition to achieving the optimum design more quickly, "cut and try" patchup compromises were avoided. Additionally, use of the computer permitted time to fully investigate every area of potential design improvement and to identify and avoid any major problem areas.

7.2 Mechanical Design Features - The conservative design application of this concept and careful design integration of its features resulted in a rugged, high-reliability valve configuration. The mechanical features which contributed to this successful valve configuration are as follows:

a. An all-metal seal and main poppet, operated by a swing arm, provides essentially unlimited endurance and very low main seal leakage. During development tests, leakage at 0 to 50 psig inlet pressure never exceeded 50 scim helium during

8,000 cycles accumulated at -320°F and +450°F and with flow at room temperature.

b. Metal bellows are used in the actuators for both modes of operation. These provide zero actuator leakage at all temperatures. In combination with the no-sliding-fit drive linkage they eliminate the possibility of sticking or jamming which may be associated with other valve arrangements.

c. A four-bar drive linkage arrangement approaches dead center as the poppet approaches the seat. This eliminates all closing impact and provides extremely rigid poppet support when it is just off the seat so that flutter or vibration cannot cause seat damage.

d. An automatically retracting poppet stiffener holds the poppet rigid while it is off the seat so that it cannot flutter, but allows flexibility when the poppet is on the seat so that manufacturing tolerances are easy and thermal or load distortion cannot affect leakage.

e. An inherently damped, high natural frequency but low pneumatic spring rate pilot makes valve performance independent of vibration. There is no detectable shift of controlled pressure at any frequency within specification vibration levels.

f. Inherent reliability is enhanced by such features as: pressure closing gate, valve closure at the tank exit, interlocking linkage assembly and the absence of sliding fits.

g. The valve configuration is designed to be "fail closed" across the board, which makes possible in the future, the improved system reliability associated with parallel redundant, single actuator relief valves.

h. The valve is designed to modulate tank pressure during the pilot relief mode so as to provide a completely redundant means of tank pressure control.

7.3 Redesign For Test Failure - During the entire test program there were no functional failures and only one mechanical failure which dictated a design change. The failure occurred in a weld of a 3/8-inch diameter tube to one of the two override actuators. This failure did not occur in the other vibration sample which completed vibration including significant over-stress testing. The design change consisted of installing a multiple-ply, braid covered, bellows flex section in these lines to elir[illegible] unpredictable installation stresses.

7.4 Redesign for Design Improvement - Four design improvement changes were incorporated in the third PFCT unit. These changes eliminated conditions which were found to be marginal but which did not prevent the first two PFCT valves from meeting specification requirements.

a. The dry film lubricant used on linkage parts was changed from Everlube 811 to Lubeco 905. This provided a lubricant which could not be degraded by cutting oil or cleaning fluids.

b. A Bearium Bronze (B-11) bushing was added to the bell crank to prevent galling between the bell crank and its pin.

c. The key between the main drive shaft bushing and the valve body was removed. It was found that the key was not necessary.

d. The override actuator bellows were improved by minor changes in design and fabrication process. These changes were made as a result of premature bellows failure in life cycle. However, continued investigation showed that the true cause of failure was excessive pressure when the bellows was extended. It was found that due to the way the tests were being run on the simulator, the actuation pressure at the extended position was far higher than planned (and than it would be in actual service). By development test it was shown that the original configuration would pass life cycle when exposed to a proper pressure cycle.

7.5 Functional and Structural Margins - The test program demonstrated that the valve has substantial margins of safety both functionally and structurally.

Functional data interpreted in terms of actual system operation indicates that: the modulation band width will be under 1 psi vs 1.5 psi required; internal and external leakages will be approximately half of specification requirements;

override actuator minimum operating pressure will be 460 psi versus 750 psi normal and 500 psi minimum; flow capacity as installed will be about 10% over the requirements; function will be unaffected by vibration; and endurance capabilities are far beyond requirements.

Structurally there is also margin. One PFCT valve experienced vibration in excess of 150% of the required time in both sine and random with inputs 1.5 to 3 times the sine requirement in one axis. The other PFCT valve experienced over 130% of the required random time at full level and four times the required time at 20% which occurred during the excessive level sine run. Destructive burst pressure tests also demonstrated substantial performance margins.

7.6 Conclusions - The results of Parker's test program conclusively prove that the 10-Inch Vent and Relief Valve is qualified for its intended useage on the S1C LOX tank. In addition, it is felt that the valve design concept developed under this contract provides a state-of-the-art advance in tank relief valve design which has the potential to be used without change in advanced applications.

ABLE I

TYPI LVE PERFORMANCE

Test Parameter	S1C-Vehicle Specification Requirement	PAC Room Temp. (Simulator)	PAC -320°F (Simulator)	S-1C System
External Leakages				
Vent Actuation System (Overrides)	1.0 scim GN_2 max	0.2 scim	0.5 scim	0.3 scim
Main Shaft Seals	10.0 scim GN_2 max	1.0 scim	20.0 scim (1)	5.0 scim
All Others	Bubble Tight	Bubble Tight	Bubble Tight	Bubble Tight
Internal Leakages				
Main Seal (Flapper)	50.0 scim GN_2 max	10.0 scim	40.0 scim	25.0 scim
Pilot/Booster Valve	5.0 scim GN_2 max	3.0 scim	4.5 scim	4.0 scim
Override Performance (Vent Operation)				
Min. Operating Pressure	500 psig max	440 psi	480 psi	
Response Time - To Open	600 ms max	600 ms	270 ms (2)	(3)
Response Time - To Close	600 ms max	820 ms	290 ms	
Pilot/Booster Performance (Relief) Oper.)				
Fully Open Pressure	25.5 psig max	25.3 psig	25.4 psig	25.3 psig
Reseat Pressure	24.0 psig min	24.6 psig	24.4 psig	24.6 psig
Modulation Band	24.0 to 25.5 psig	24.5 to 25.5 psig	23.0 to 25.5 psig	24.3 to 25.3 psig
Flow Rate - Fully Open at 40 psia Tank Press. and +100°F	50 lb/sec min GN_2	N/A	N/A	54.7 lb/sec GN_2

(1) This leakage exceeds the specification leakage only under these off limit test conditions. Under vehicle conditions the leakage would be as shown.

(2) Measured with helium.

(3) Will be determined by NASA at a later date by actual vehicle test.

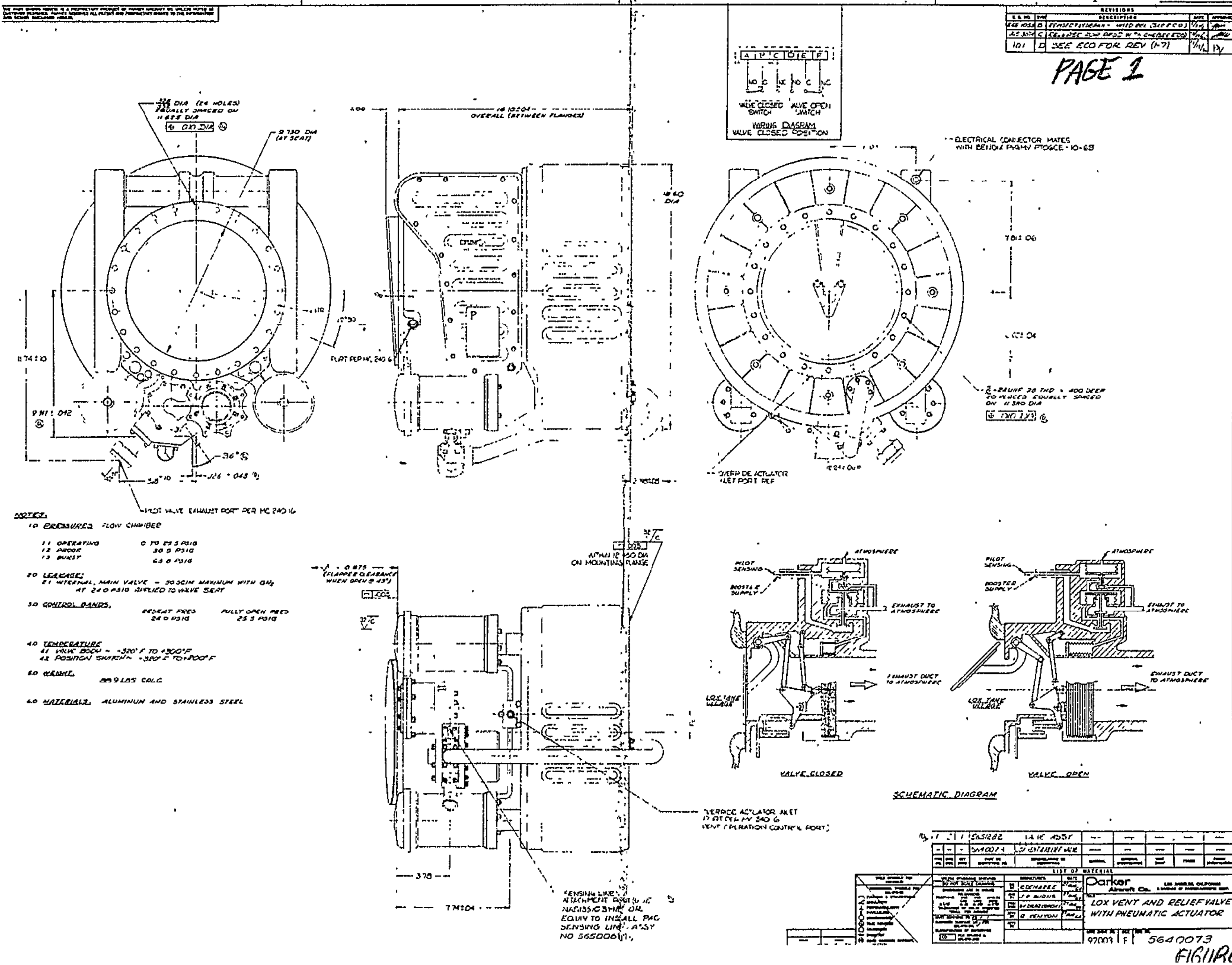

PAGE 1
WIRING DIAGRAM
VALVE CLOSED POSITION
VALVE CLOSED SWITCH
VALVE OPEN SWITCH
OVERALL (BETWEEN FLANGES)
ELECTRICAL CONNECTOR MATES WITH BENDIX PYGMY PT06CE-10-6S
PILOT VALVE EXHAUST PORT PER MC 240 16
NOTES:
1.0 PRESSURES FLOW CHAMBER
1.1 OPERATING 0 TO 25.5 PSIG
1.2 PROOF 36.5 PSIG
1.3 BURST 64.0 PSIG
2.0 LEAKAGE:
2.1 INTERNAL, MAIN VALVE = 50 SCIM MAXIMUM WITH GN2 AT 24.0 PSIG APPLIED TO VALVE SEAT
3.0 CONTROL BANDS,
RESEAT PRES 24.0 PSIG
FULLY OPEN PRES 25.5 PSIG
4.0 TEMPERATURE
4.1 VALVE BODY ~ -320°F TO +300°F
4.2 POSITION SWITCH ~ -320°F TO +200°F
5.0 WEIGHT,
89.9 LBS CALC
6.0 MATERIALS, ALUMINUM AND STAINLESS STEEL
PILOT SENSING
BOOSTER SUPPLY
ATMOSPHERE
EXHAUST TO ATMOSPHERE
EXHAUST DUCT TO ATMOSPHERE
LOX TANK ULLAGE
VALVE CLOSED
VALVE OPEN
SCHEMATIC DIAGRAM
LIST OF MATERIAL
Parker Aircraft Co.
LOX VENT AND RELIEF VALVE WITH PNEUMATIC ACTUATOR
5640073

Figure 1

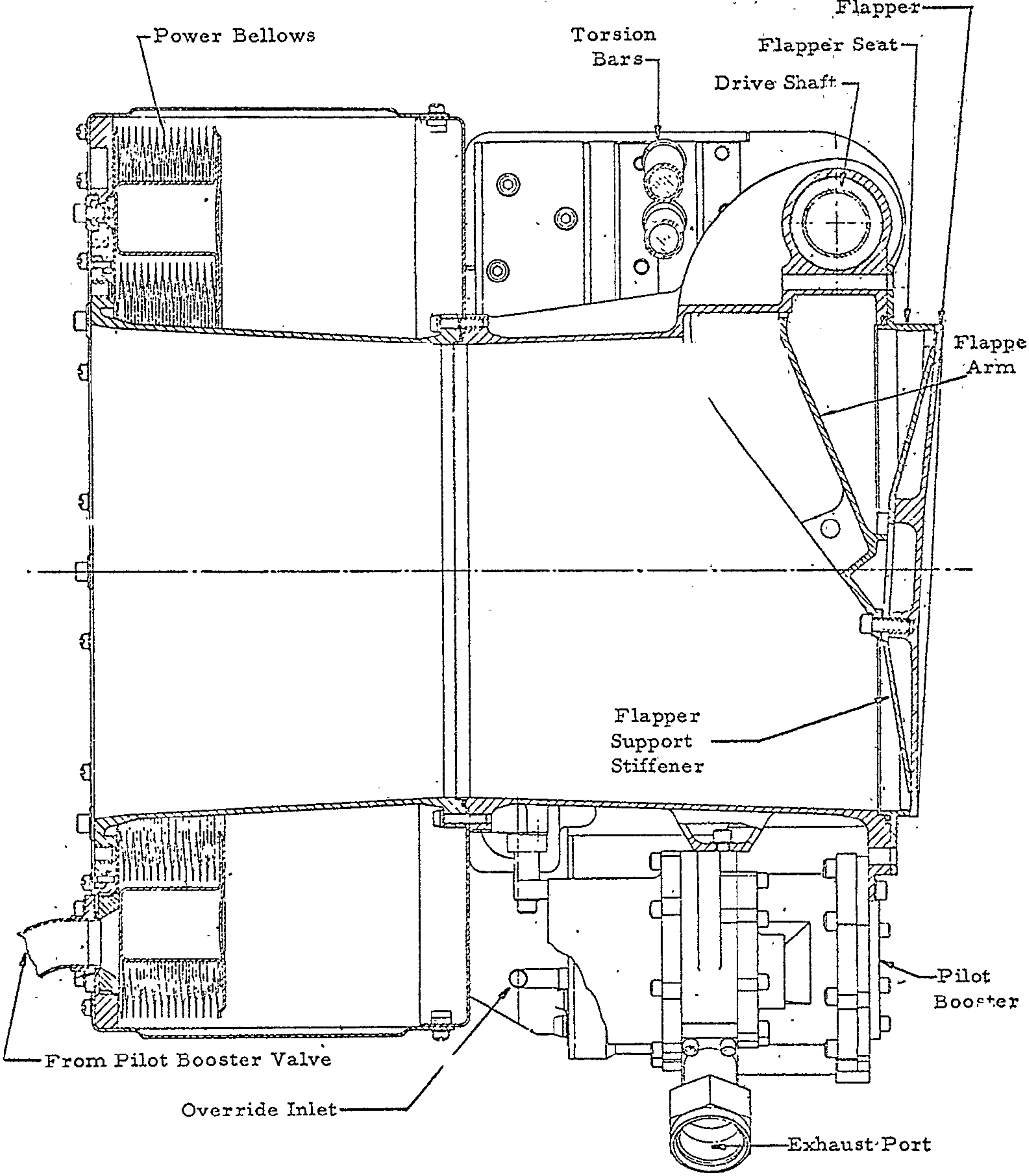


Figure 2. Cross-Section of Valve Flow Chamber

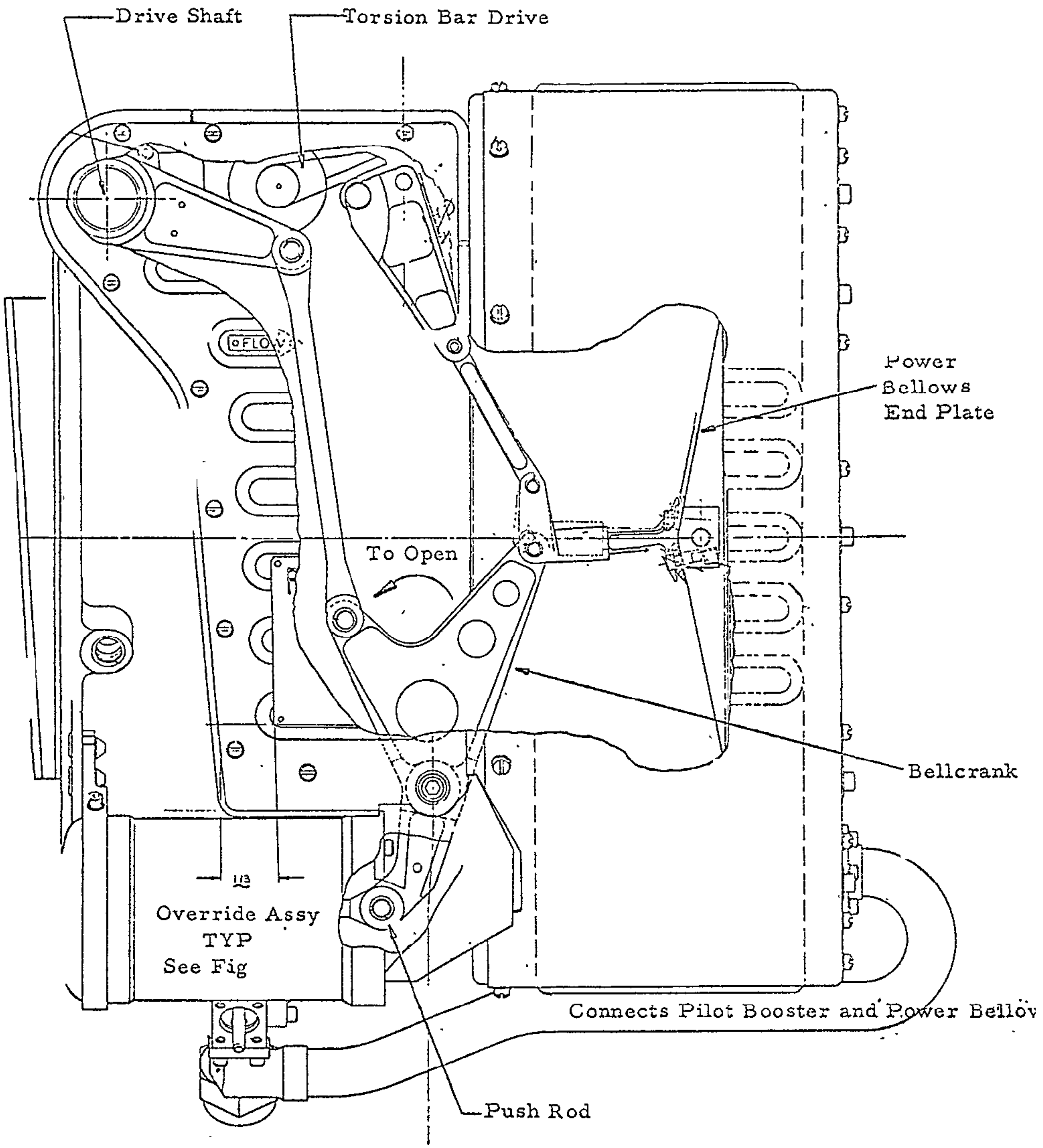


Figure 3. View of Valve Flapper Linkage

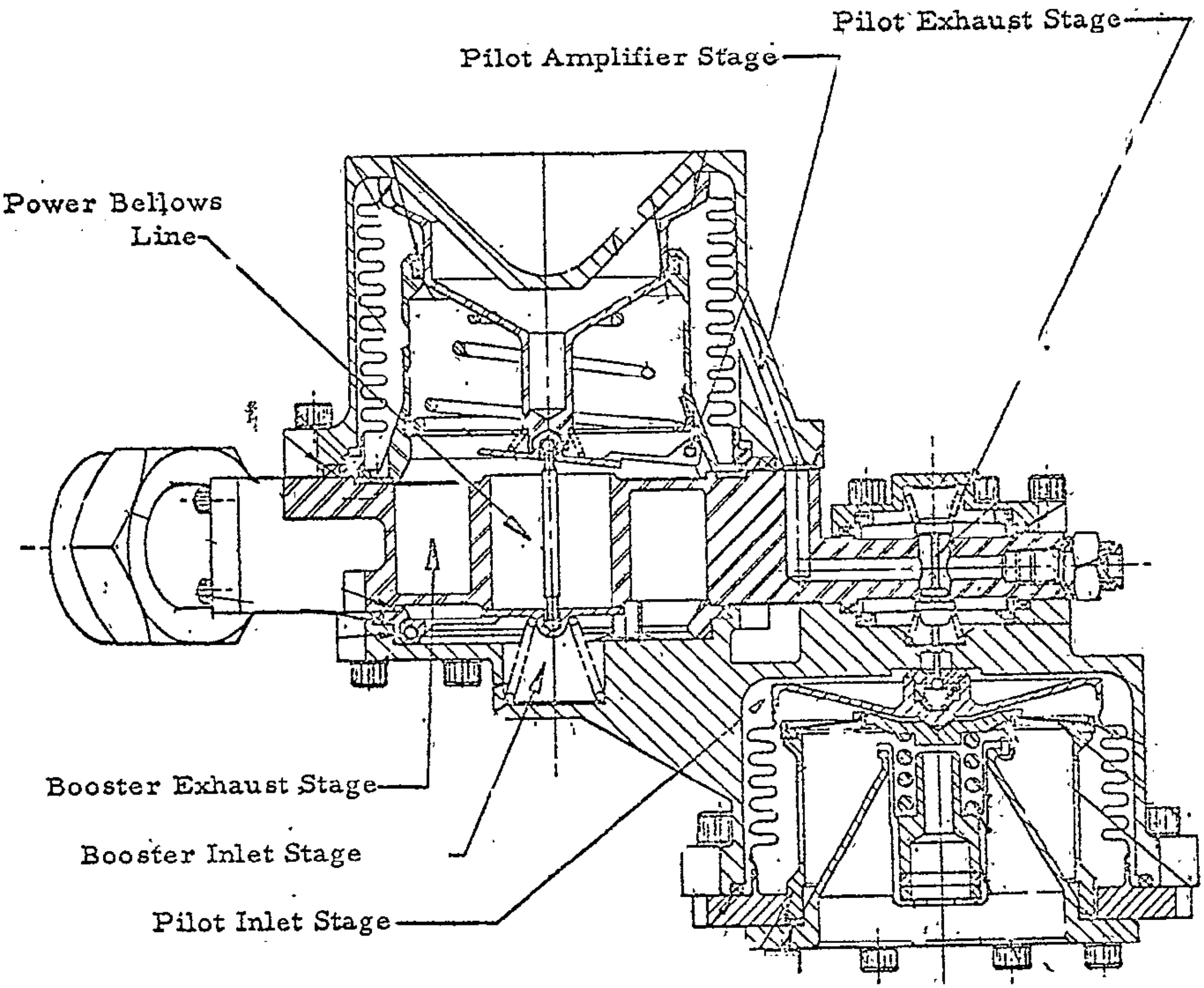


Figure 4. Cross-Section of Pilot & Booster Assy

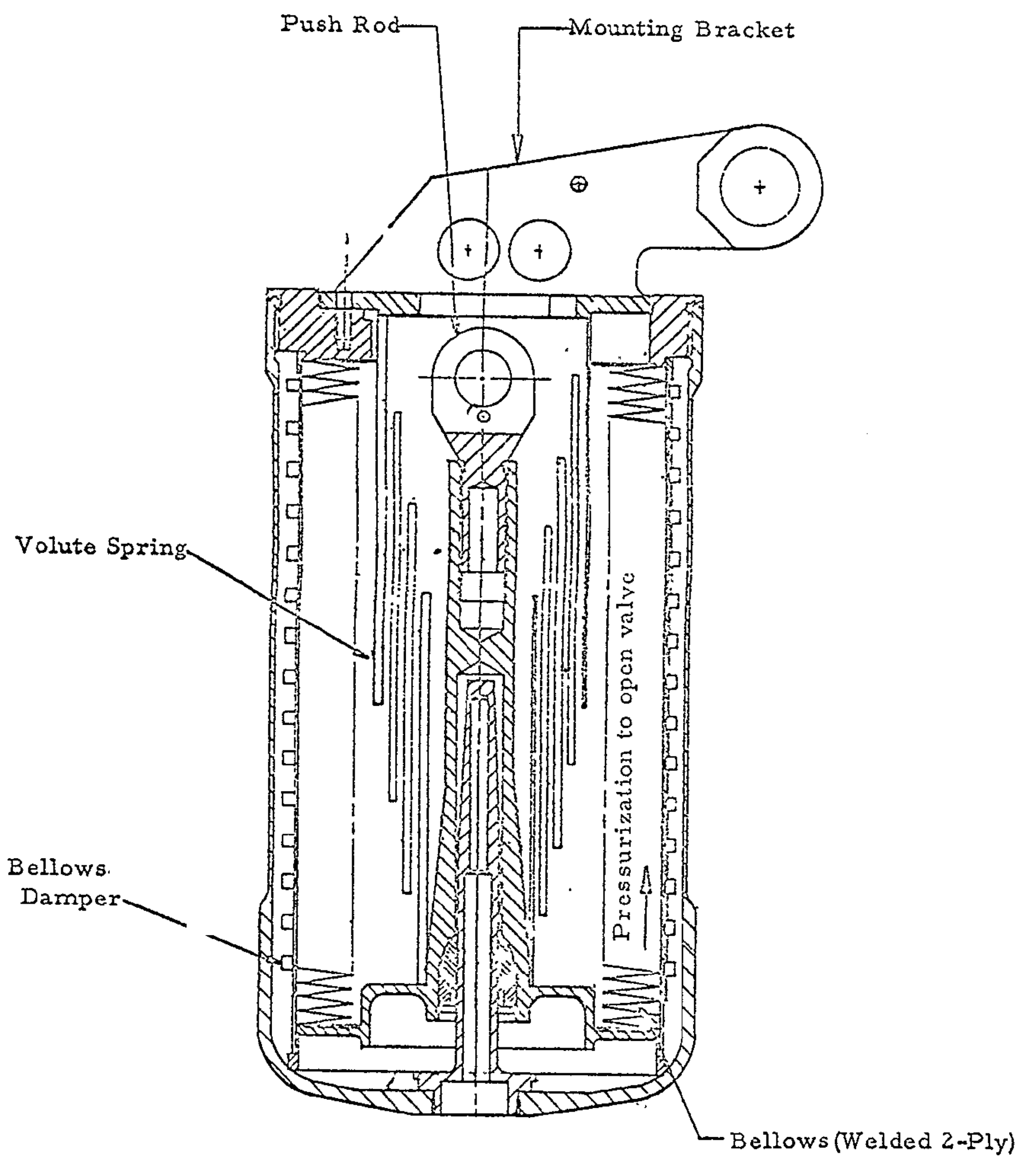
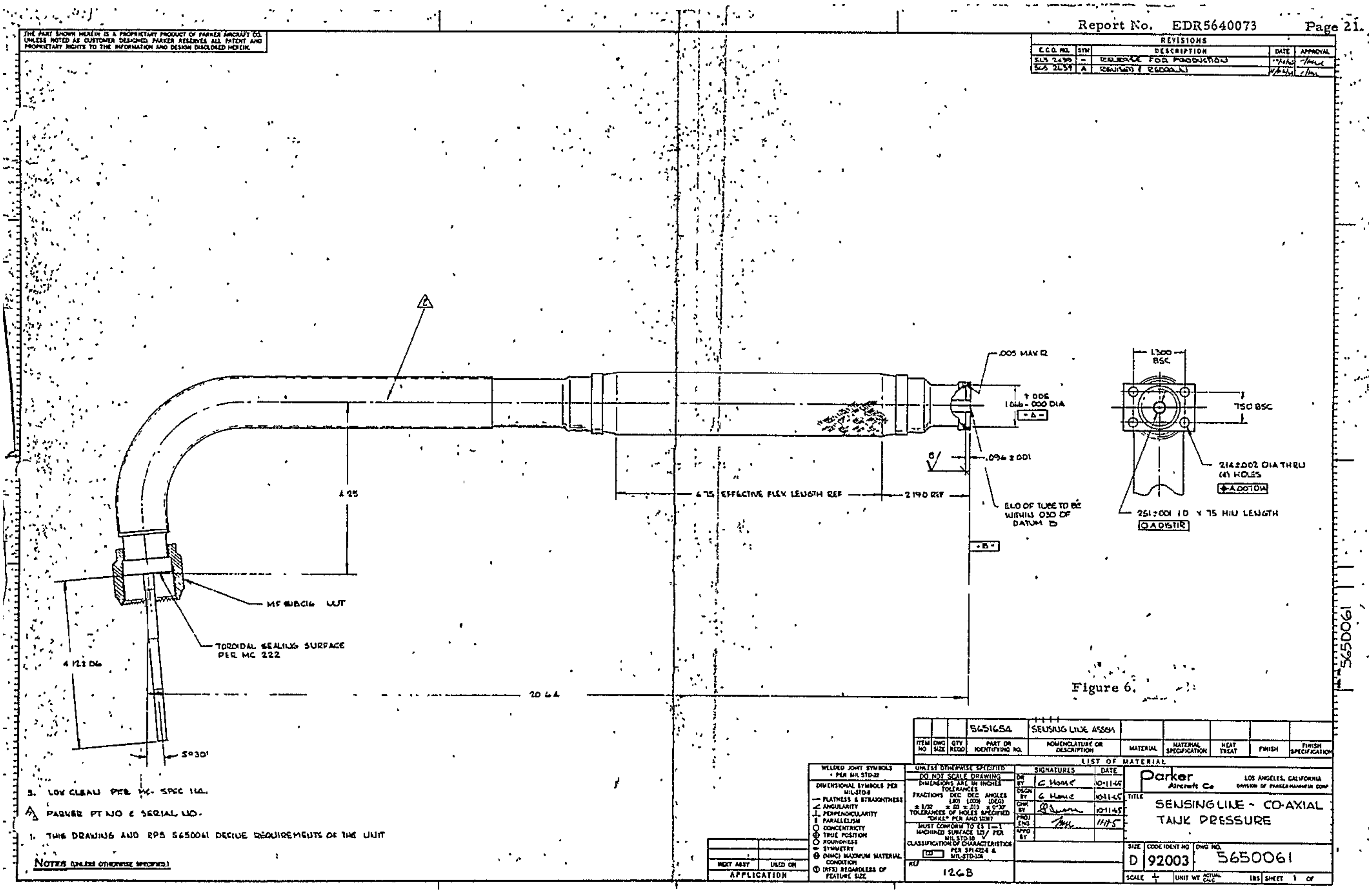


Figure 5. Cross-Section of Override Assy (TYP)
Shown in valve closed position.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REVISIONS
E.C.O. NO.
SYM
DESCRIPTION
DATE
APPROVAL
.005 MAX R
1.300 BSC
.750 BSC
.096 ±.001
.214±.002 DIA THRU (4) HOLES
4.25
4.75 EFFECTIVE FLEX LENGTH REF
2.190 REF
END OF TUBE TO BE WITHIN .030 OF DATUM B
.251±.001 I.D. X .75 MIN LENGTH
MS 21921-16 NUT
TOROIDAL SEALING SURFACE PER MC 222
4.123 DG
20.6A
5°30'
3. LOX CLEAN PER MC-SPEC 110.
2 PARKER PT NO & SERIAL NO.
1. THIS DRAWING AND RPS 5650061 DEFINE REQUIREMENTS OF THE UNIT
NOTES (UNLESS OTHERWISE SPECIFIED)
5651654
SENSING LINE ASSY
ITEM NO
DWG SIZE
QTY REQD
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL
MATERIAL SPECIFICATION
HEAT TREAT
FINISH
FINISH SPECIFICATION
LIST OF MATERIAL
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
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SENSING LINE - CO-AXIAL TANK PRESSURE
SIZE
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SHEET 1 OF
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Figure 6.

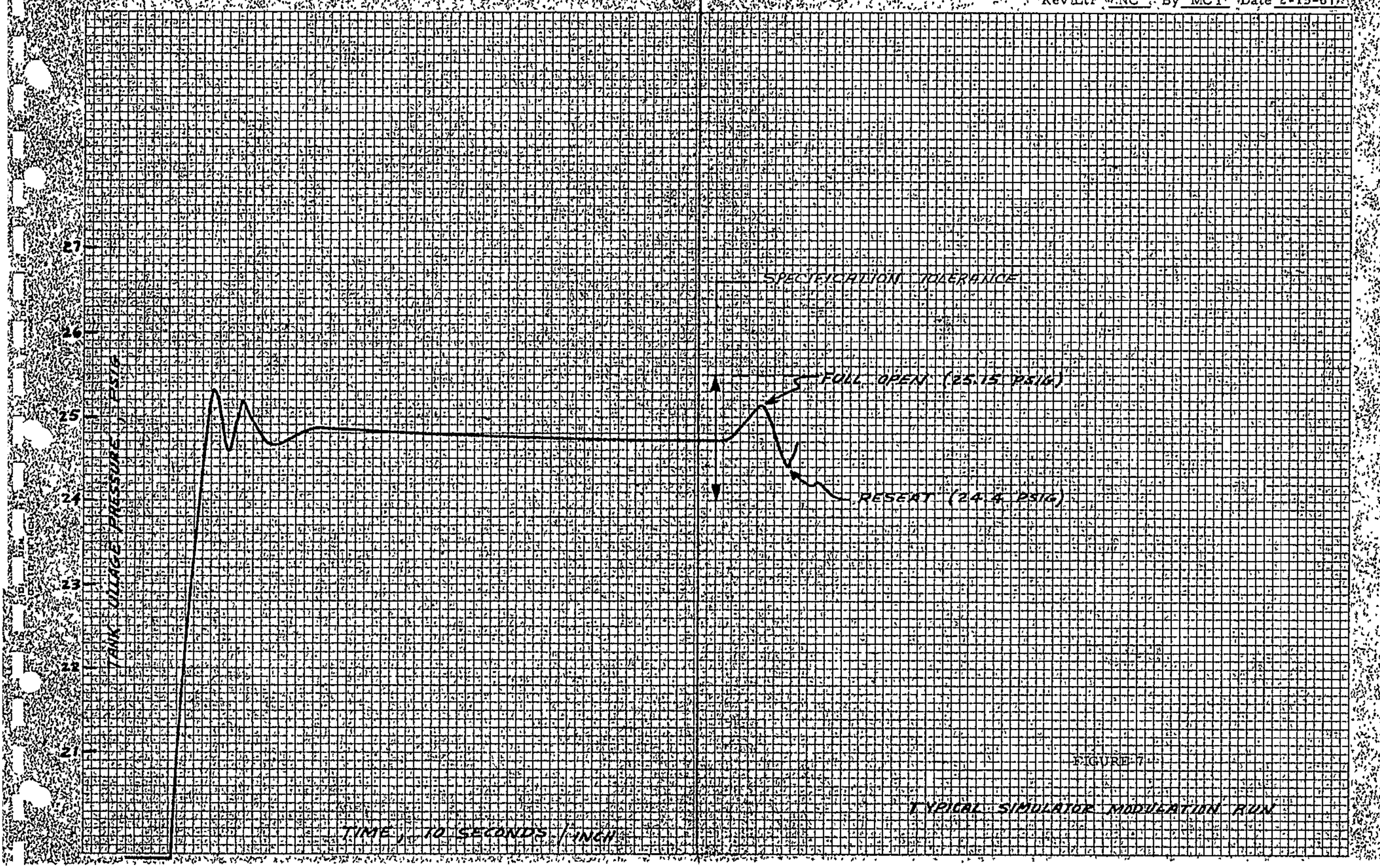

FIGURE 7

TYPICAL SIMULATOR MODULATION RUN

Parker AIRCRAFT CO. • 5827 W. CENTURY BOULEVARD, LOS ANGELES, CALIFORNIA 90009
A DIVISION OF PARKER-HANNIFIN CORPORATION