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TITLE		
EVALUATION OF PNEUMATIC CHECK VALVES		
REPORT NO.	DATE	MODEL NO.
LMSD-4064	3 MARCH 1958	W3 117L
SUBMITTED UNDER (CONTRACT, SPEC., ETC.)		
AF 04(647)-97		

MSD 8726

LOCKHEED AIRCRAFT CORPORATION, MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION

REPORT DED-4061

EVALUATION OF PNEUMATIC CHECK VALVES

TEST LABORATORIES DEPT. (51-62)

DATE: 3 March 1958

MECHANICAL AND FLUID DYNAMICS TEST GROUP

REQUESTED BY: XA Propulsion Section
Vehicle Department

REFERENCE: S/N 14 1453

SUBMITTED UNDER: Contract AF 64 (647)-97.

PREPARED BY: H. A. Swanfor: L. A. Kramer

CHARGE: 3-6102-8769-08

APPROVED BY:

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Acting Group Engineer

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R. C. GeigerR. C. Geiger
Section EngineerOBJECTIVE

To evaluate various pneumatic check valves for the purpose of determining parts acceptable for weapon system usage.

Specifically, this investigation required evaluation of pneumatic check valves supplied by the Val-Aero Division of Barco Industries, James-Pond-Clark, Parker Aircraft Company and Sealol Corporation. These items were to be subjected to pneumatic and environmental conditions including proof pressure, flow calibration, cracking pressure, seating pressure, vibration, acceleration, low temperature, corrosion and life cycle.

CONCLUSION

The trend of testing indicated that none of the valves fulfilled all the requirements, but that generally the James-Pond-Clark valves were far superior to the others evaluated.

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISIONREPORT LMSD-1061TEST SPECIMENS1. Oxidizer valves LMSD Number 1060518-1.

a. Darcy Industries, Val-Aero Division

El Segundo, California

Model 30139 (1/2 inch tube size)

Serial No's. 1001 and 1002.

b. James-Pond-Clark (Circle Seal)

Pasadena, California

Model 840A-8TT (1/2 inch tube size)

Serial No's. 1 and 2.

c. Fairbanks Aircraft Company

Los Angeles, California

Model 1111-578350 (1/2 inch tube size)

Serial No's. 1 and 2.

d. Sealol Corporation

Providence, Rhode Island

Model C0900T02H (1/2 inch tube size)

Serial No's. 3 and 4.

2. Fuel valves LMSD Number 1060552.

a. James-Pond-Clark (Circle Seal)

Pasadena, California

Model 869A-6TT (3/8 inch tube size)

Serial No's. 3 and 4.

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Providence, Rhode Island

Model C0900T6M (3/8 inch tube size)

Serial No's. 1 and 2.

PROCEDURE AND RESULTS

Pursuant to Paragraph "D" of the test request, "Detailed Requirements and Mandatory Procedures" (Reference 1), the following operations were performed and the indicated results were recorded:

1. Disassembly, Inspection and Reassembly.

- a. Procedure: Each check valve was disassembled, inspected, cleaned as necessary, and reassembled. Exploded views of typical valves are shown by Figures 10 through 14.

b. Results:

VALVE	SERIAL NO.	CONDITION
Darco Ind.	S/N 1001	Contaminated
Darco Ind.	S/N 1002	Contaminated
James-Pond-Clark	S/N 1	Clean
James-Pond-Clark	S/N 2	Clean
James-Pond-Clark	S/N 3	Contaminated
James-Pond-Clark	S/N 4	Contaminated
Parker Aircraft	S/N 1	Contaminated
Parker Aircraft	S/N 2	Contaminated
Sealol Corp.	S/N 1	Contaminated
Sealol Corp.	S/N 2	Contaminated
Sealol Corp.	S/N 3	Contaminated
Sealol Corp.	S/N 4	Contaminated

Contamination consisted of oil, water and dirt.
 The Sealol valves exhibited poor workmanship, i.e., tool marks, rough threads, burrs, etc.

LOCKHEED AIRCRAFT CORPORATION
 MISSILE SYSTEMS DIVISION
REPORT **LXSD-4064****2. Proof Pressure**

a. Procedure: The outlet port was capped and 240 psi pneumatic pressure was applied to the inlet port for 5 minutes. Leakage was checked by submergence. Equipment used: pneumatic test bench and a 0 - 200 psi pressure gauge.

b. Results:

VALVE	SERIAL NO.	HELIUM LEAKAGE: Bubbles/min.
Danco Ind.	S/N 1001	None
Danco Ind.	S/N 1002	None
James-Pond-Clark	S/N 1	None
James-Pond-Clark	S/N 2	None
James-Pond-Clark	S/N 3	None
James-Pond-Clark	S/N 4	None
Parker Aircraft	S/N 1	None
Parker Aircraft	S/N 2	None
Sealol Corp.	S/N 1	None*
Sealol Corp.	S/N 2	None*
Sealol Corp.	S/N 3	None*
Sealol Corp.	S/N 4	None*

* After lapping seat and poppet of valve.

3. Flow Calibration.

a. Procedure: Helium was used as the working fluid and conversion factors were utilized to convert flow meter readings from nitrogen to helium values. The temperature tapping point, indicated on the orifice barrel (Index T1, Figure 1), was incorrectly located and a factor of 10°F was added to all temperature readings i. an attempt to emulate upstream temperature at the upstream pressure tapping location. Standard

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conditions imposed on ΔP were 59°F and 14.7 psi pressure.

b. Results: Refer to Figures 2 through 9.

4. Cracking and Reseating.

a. Procedure: Pressure (helium) was applied at the inlet port until the second bubble of continuous leakage was observed, then the pressure reading was recorded. Pressure was reduced until the poppet reseated and leakage stopped, then this pressure reading was recorded.

b. Results:

VALVE	SERIAL NO.	AVERAGE CRACKING PRESSURE (INCH H ₂ O)	AVERAGE RESEATING PRESSURE (INCH H ₂ O)
Darco Inc.	S/N 1001	1.8	0.9
Darco Inc.	S/N 1002	2.3	2.1
James-Fond-Clark	S/N 1	7.5	6.3
James-Fond-Clark	S/N 2	7.7	6.1
James-Fond-Clark	S/N 3	5.6	5.0
James-Fond-Clark	S/N 4	4.3	1.0
Parker Aircraft	S/N 1	1.5	1.1
Parker Aircraft	S/N 2	1.1	1.0
Sealol Corp.	S/N 1	1.3	1.1
Sealol Corp.	S/N 2	1.5	1.2
Sealol Corp.	S/N 3	0.9	0.9
Sealol Corp.	S/N 4	2.2	1.2

5. Back Pressure and Leakage.

a. Procedure: Helium was applied in the check (reverse flow) direction and

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Leakage was determined by observing bubbler action (the bubbler used was a Meriam Company, Model C-12H1). Pressure (ΔP in inches of H_2O) was measured by a water manometer across the specimen, and by a pressure gauge in the line when pressures exceeded the range of the manometer and the manometer was locked-out of the system.

b. Results:

VALVE	MODEL & SERIAL NO.	ΔP PRESSURE	LEAKAGE: BUBBLES/MIN.
Darco Ind.	30400 S/N 1001	1 to 24 in. H_2O 0.865-80 psig	25 0
Darco Ind.	30400 S/N 1002	1 to 24 in. H_2O 0.865-80 psig	25 0
James-Pond-Clark	840A-8TT S/N 1	1 to 24 in. H_2O 0.865-80 psig	15 0
James-Pond-Clark	840A-8TT S/N 2	1 to 24 in. H_2O 0.865-80 psig	15 0
James-Pond-Clark	869A-6TT S/N 3	1 to 24 in. H_2O 0.865-80 psig	5 0
James-Pond-Clark	869A-6TT S/N 4	1 to 24 in. H_2O 0.865-80 psig	5 0
Parker Aircraft	1111-578350 S/N 1	1, 2, 6, & 18 in. H_2O 0.865-80 psig	164, 200, 400, & 450 0
Parker Aircraft	1111-578350 S/N 2	1, 2, 6, & 18 in. H_2O 0.865-80 psig	68, 114, 82, & 12 0
* Sealol Corp.	CO900T6MN S/N 1	1, 2, 6, & 18 in. H_2O 10, 20, & 60 psig	0, 0, 2, & 7 122, 187 & 75 cc/min
* Sealol Corp.	CO900T6MN S/N 2	1, 2, 6 & 18 in. H_2O 10, 20, & 60 psig	0, 2, 13 & 50 50, 100, & 550 cc/min
* Sealol Corp.	CO900T6MN S/N 3	1, 2, 6 & 18 in. H_2O 10, 20, & 60 psig	0, 0, 0, & 1 54, 77 & 146 cc/min
* Sealol Corp.	CO900T6MN S/N 4	1, 2, 6, 18 in. H_2O 10, 20, & 60 psig	0, 2, 11 & 39 238, 75 & 300 cc/min

* Tested after Sealol valve seat and poppet were lapped and polished three times.

6. Vibration.

- a. Procedure: Each specimen was mounted in a fixture which in turn was bolted to a shaker. Pressurized helium was applied to the outlet port before vibration commenced. Imposed ΔP was started at 1 inch of H₂O across the valve. If leakage occurred, the vibration frequency sweep was stopped and additional pressure applied until leakage, indicated by bubbling, ceased; at which point the sweep was continued. Leakage was indicated in a bubbler. Vibration was conducted through a constant 0.027- inch displacement for 10 to 85 cps where a constant 10 g acceleration was applied to 2000 cps.
- b. Results: See Page 8.

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b. Results:

VALVE	LONGITUDINAL		TRANSVERSE		LONGITUDINAL EXITATION LEAKAGE AT ΔP VARIOUS PRESSURES	TRANSVERSE EXITATION LEAKAGE AT ΔP VARIOUS PRESSURES
	EXITATION LEAKAGE 80 psig	EXITATION LEAKAGE 80 psig	EXITATION LEAKAGE 80 psig	EXITATION LEAKAGE 80 psig		
Durco Ind. S/N 1001	1 Bubble at 700 cps	0	0	0	1-inch H ₂ O, Excessive from 10-2000 cps. 6-inches H ₂ O stopped leakage	1-inch H ₂ O, 3 Bubbles at 350 cps; no other leakage
Durco Ind. S/N 1002	0	0	0	0	1-inch H ₂ O, Excessive at 150 cps, 8-inches H ₂ O stops until 1300 cps, 9-inch H ₂ O stops to 2000 cps	1-inch H ₂ O, 1 Bubble at 150 cps; no additional leakage
James-Pond-Clark S/N 1	0	0	0	0	1-inch H ₂ O, no leakage	1-inch H ₂ O, no leakage
James-Pond-Clark S/N 2	0	0	0	0	1-inch H ₂ O, 1 Bubble at 150, 200, 450 & 1300 cps	No leakage
James-Pond-Clark S/N 3	0	0	0	0	1-inch H ₂ O, 2 Bubbles at 100 and 200 cps; Steady stream at 400 cps.	1-inch H ₂ O, 3 Bubbles at 300 cps. No other leakage
James-Pond-Clark S/N 4	0	0	0	0	1-inch H ₂ O, no leakage	1-inch H ₂ O, no leakage
Parker Aircraft S/N 1	0	0	0	0	8-inches H ₂ O, many bubbles at 170, 330, 1000 & 1500 cps; 2 psig stops leakage	1-inch H ₂ O, many bubbles, at 70, 100, 170, 320, 450, 600, 1100, 1300 & 1700 cps. 12-inches H ₂ O, few bubbles 150, 250, 350, & 1900 cps.
Sealed S/N 1	Excessive	Excessive	Excessive	Excessive	1-inch H ₂ O, many bubbles 300 to 1600 cps. 3-inch ΔP , excessive leakage	1-inch H ₂ O, many bubbles 200 to 1250 cps. 6-inches H ₂ O, excessive leakage
Sealed S/N 3	Very Excessive	Very Excessive	Very Excessive	Very Excessive	1-inch H ₂ O, no leakage 16-inch H ₂ O, very excessive leakage	1-inch ΔP , 1 Bubble 350 cps 6-inch ΔP , excessive leakage

NOTE

On the recommendation of the cognizant department, evaluation of the Sealal valves was discontinued because of persistent excessive leakage.

7. Acceleration Test.

- a. Procedure: Each specimen was mounted on a fixture secured to the acceleration table. Pressure (helium) was applied to the outlet port and the inlet port was connected to a bubbler through the pressure system of the acceleration table. The valve, in each case, was pressurized prior to the 10 g test acceleration. The test consisted of five runs per valve in five dissimilar positions. The five positions used in the acceleration test were: (1) specimen perpendicular to plane of rotation, (2) specimen in the plane of rotation and perpendicular to the revolving arm of the table with the free flow in the direction of rotation, (3) same as position 2 except that free flow was in the direction opposite to rotation, (4) specimen in the plane of rotation and parallel to the revolving arm of the table with free flow away from the center of rotation, (5) same as position 4 except that free flow was toward the center of rotation.

- b. Results: See Page Nos. 10 and 11.

ACCEPTANCE COMPLETION																
VALVE	NO. 1			NO. 2			NO. 3			NO. 4			NO. 5			
	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
Danco Inc. S/N 1001	Δ P			inches H ₂ O			Bubbles/min.			Leakage			Rate			
	4	4	4	3	1	3	3	5	8	11	18	24	2	5	3	4
	0			0			0			0			A			
Danco Inc. S/N 1002	Δ P			inches H ₂ O			Bubbles/min.			Leakage			Rate			
	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	7	3	5	6	0	0	1	3	10	12	28	7	0	3	6	3
James-Pond-Clark S/N 3	Δ P			inches H ₂ O			Bubbles/min.			Leakage			Rate			
	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	0	1	0	0	1	0	0	4	0	0	0	4	0	0	0	0
James-Pond-Clark S/N 2	Δ P			inches H ₂ O			Bubbles/min.			Leakage			Rate			
	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	0	0	0	0	0	1	6	2	0	0	0	4	0	0	0	1
James-Pond-Clark S/N 3	Δ P			inches H ₂ O			Bubbles/min.			Leakage			Rate			
	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	0	0	0	0	0	1	6	2	0	0	0	4	0	0	0	1
This valve did not seal under any condition. Possibly attributable to mercury found internally, or possibly a cocked poppet seal.																

This valve did not seal under any condition. Possibly attributable to mercury found internally, or possibly a coated poppet seal.

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VALVE		ACCELERATION CONFIGURATION															REMARKS
		NO. 1			NO. 2			NO. 3			NO. 4			NO. 5			
James-Paul-Clark S/E 1	ΔP inches H ₂ O	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	Bubbles/min.	1	1	1	0	0	1	1	0	0	1	3	0	1	3	0	3
	Leakage 0-56-80 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perrier Aircraft S/E 1	ΔP inches H ₂ O	This valve did not seal under any condition with no apparent reason.															
	Bubbles/min.																
	Leakage 0-80 psi																
Perrier Aircraft S/E 2	ΔP inches H ₂ O	1	2	6	18	1	2	6	18	1	2	6	18	1	2	6	18
	Bubbles/min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Leakage 0-56-80 psi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sealol		Not tested															

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8. Low Temperature (also includes "Leakage after Low Temperature").

- a. Procedure: Each specimen was subjected to the temperature environment by being placed in a temperature chamber for a reasonable soak period and then tested for check (reverse flow) leakage. The order of testing was identical for each test conducted. The valve was subjected to a free flow of helium gas to assure poppet movement, and then the flow was applied in the reverse direction in a range from $\Delta P = 1$ inch of H_2O to $\Delta P = 80$ psig.

Leakage was observed in a bubbler and the amount checked for two minutes at each pressure.

- b. Results: See Page No. 13.

5. Corrosion.

a. Procedure: The 1/2-inch diameter James-Pond-Clark, Darco, and Parker valves were subjected to IRFMA internally for a period of seven days.

The 3/8-inch diameter James-Pond-Clark valves were subjected to JP-4 internally for seven days (see Figures 16, 17, 18 and 19).

b. Results:

- (1) James-Pond-Clark, 1/2-inch, S/N 1. No visible internal damage.
- (2) Darco Ind., 1/2-inch, S/N 1001. The "Kel-F" (elastomer) seal ring on the poppet valve was observed to be loose and was easily removed, due to the action of the sealant on the adhesive or on the ring itself.
- (3) Parker Aircraft, 1/2-inch, S/N 1. The flapper seat, of "Kel-F" (elastomer), was observed to be affected as it had a wavy configuration after the test.
- (4) No damage was evidenced by the James-Pond-Clark 3/8-inch diameter valves either during or after subjection to JP-4.

10. Leakage After Low Temperature Test (No. 8).

a. Procedure: This test was performed on all specimens, except the Sealol units, concurrently with the low temperature test (No. 8).

b. Results: There was no difference between the results for this test and the results obtained at ambient temperature in the low temperature test (No. 8).

11. Proof Pressure, After Low Temperature and Corrosion Tests.

a. Procedure: The outlet port was capped and helium was applied at 240 psi pressure to the inlet port for five minutes. Leakage was checked by submergence.

- b. Results: These two tests caused no visible nor physical damage to the external seals. This is substantiated by proof pressure result observations, of no leakage, which were identical to the results obtained from Test No. 2 (Proof Pressure) on valves from Darco Industries, James-Pond-Clark and Parker Aircraft.

12. Life Cycle.

Procedure: The check valve test set-up enabled helium flow through two units simultaneously (see Figure 15). Solenoid valves were arranged to allow pressurization of the system to 55 psi and then to allow release of the pressure on the upstream side, thereby trapping the 55 psi pressure on the downstream side of the check valves. The downstream pressure was then released and the cycle was repeated. Each valve was subjected to 1000 cycles.

- b. Results: No failures nor malfunctions were evidenced during or after the test.

13. Leakage After Life Test.

- a. Procedure: The valves were subjected to free flow (helium), to assure poppet movement, and then flow was applied in the reverse direction in a range from $\Delta P = 1$ inch of H_2O to $\Delta P = 80$ psig. Leakage was observed in the bubbler and the amount checked at each pressure as indicated in the following paragraph.

- b. Results: See Page 16.

Leakage After Life Test in Bubbles-Per-Minute at Various Pressures						
Valve	ΔP in inches of H ₂ O					ΔP (psig)
	1	2	6	18	24	80
Danco Industries S/N 1002	24	44	103	128	200	All valves: Too many bubbles to count.
James-Pond-Clark S/N 1	6	12	36	109	125	
James-Pond-Clark S/N 3	2	8	24	62	83	
Parker Aircraft S/N 2	67	84	67	128	143	

14. Disassembly and Inspection.

After disassembly, the interior of the valves showed no deleterious matter with one exception, the James-Pond-Clark 3/8-inch diameter (S/N 3) had Mercury globules on the threads and on the various internal surfaces (see Figure 11). This may account for the odd results obtained in the low temperature tests.

DISCUSSION

The test results presented herein represent the data obtained from an extensive evaluation program conforming to the Job Request 2-0150 submitted with the test specimens.

The requirement of zero leakage was unobtainable by any one valve of the entire requested test applications.

Although the James-Pond-Clark valves showed generally the best results, it is believed that the Val-Aero-Darco Industries valve was not designed for the critical requirements of sealing a ΔP of one inch of water. However, if a stronger spring were used, the valve could still meet the cracking pressure requirement and would then be improved sufficiently to be considered as a second choice to the James-Pond-Clark check valves, from a pressure sealing viewpoint.

Since all valves appear to have inadequate flow rates, it may be necessary to reevaluate the flow requirements or redesign the valve configuration. The flow curves for the James-Pond-Clark valves indicate separate characteristics for each constant upstream pressure. This separation was attributed to the variable flow area brought about by the movement of the poppet relative to the seat.

Evaluation of the Sealel Corporation valves was abandoned during the program upon the recommendation of the cognizant department. The valves leaked excessively after numerous attempts to reduce the leakage by machining and lapping the seat and poppet combination. Tests to which the Sealel valves were not subjected are as follows: acceleration, low temperature, corrosion, leakage after low temperature, proof pressure, life cycle, and leakage after life test.

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISIONREPORT **MSD-1061****REFERENCES**

1. EA Weapons System Branch Job Request 2-0150 (Service Number 1453) dated September 9, 1957.
2. Interoffice Notebook Pages IN 15702 through IN 15729.
3. Lockheed MSD Blueprint Number 1060518-1 and 1060552-1 for Oxidizer and Fuel Check Valves, respectively.
4. Information transmitted to Vehicle Department by 24 February 1958.

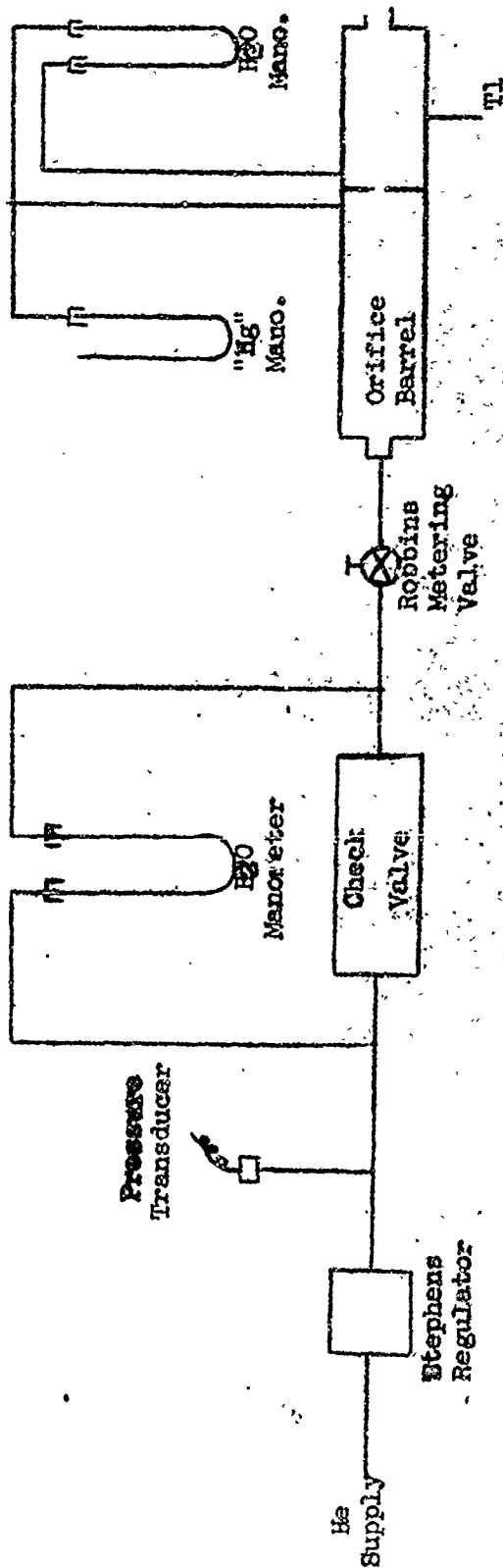


Figure 1. Check Valve Flow Test Schematic

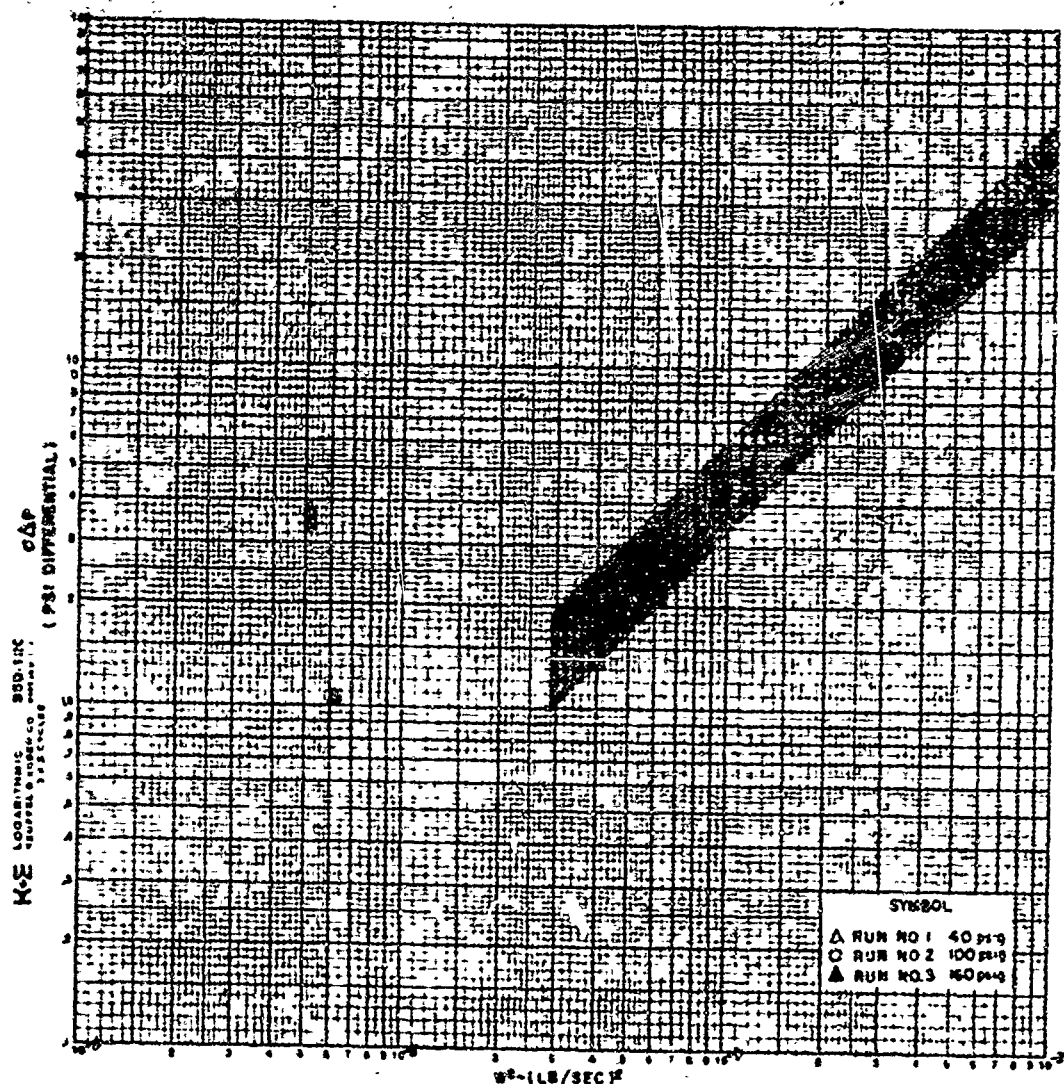


FIGURE 2. CHECK VALVE FLOW CHARACTERISTICS. 1/2" DIA. DARCO INDUSTRIES SERIAL NO. 1001.
PRESSURE DIFFERENTIAL VS MASS FLOW RATE SQUARED CORRECTED TO STANDARD
CONDITIONS; TEMPERATURE 59°F, PRESSURE 14.7 psi WORKING FLUID-HELIUM

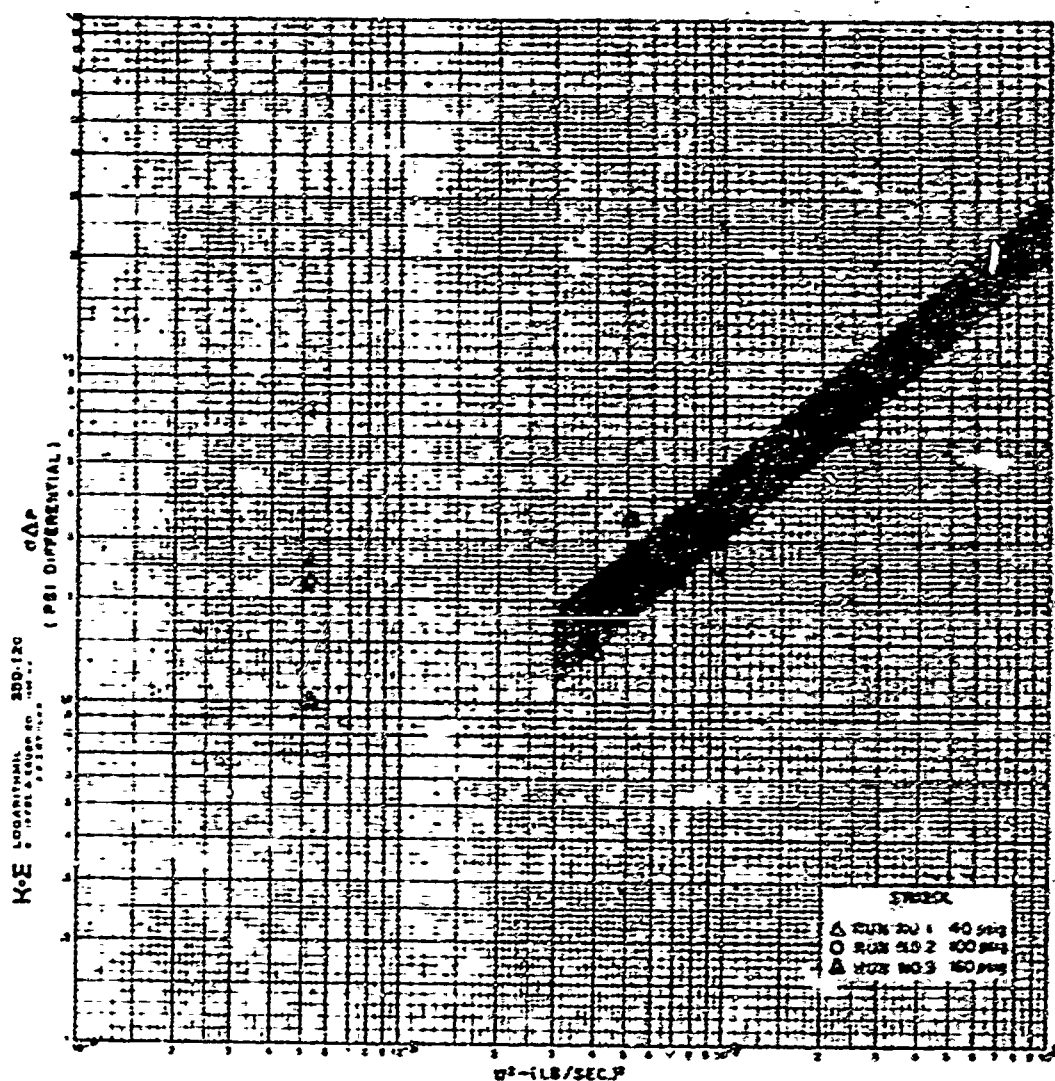
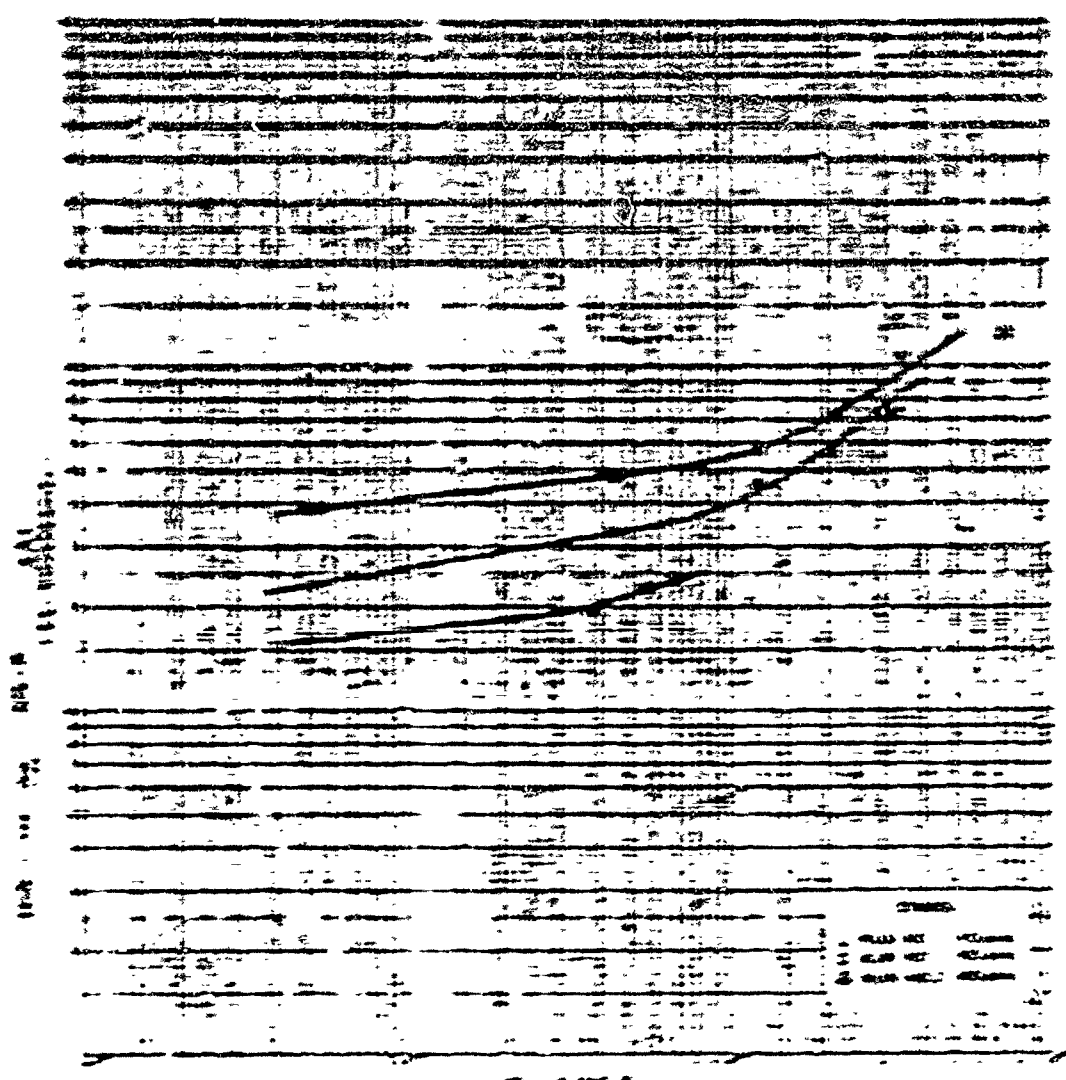
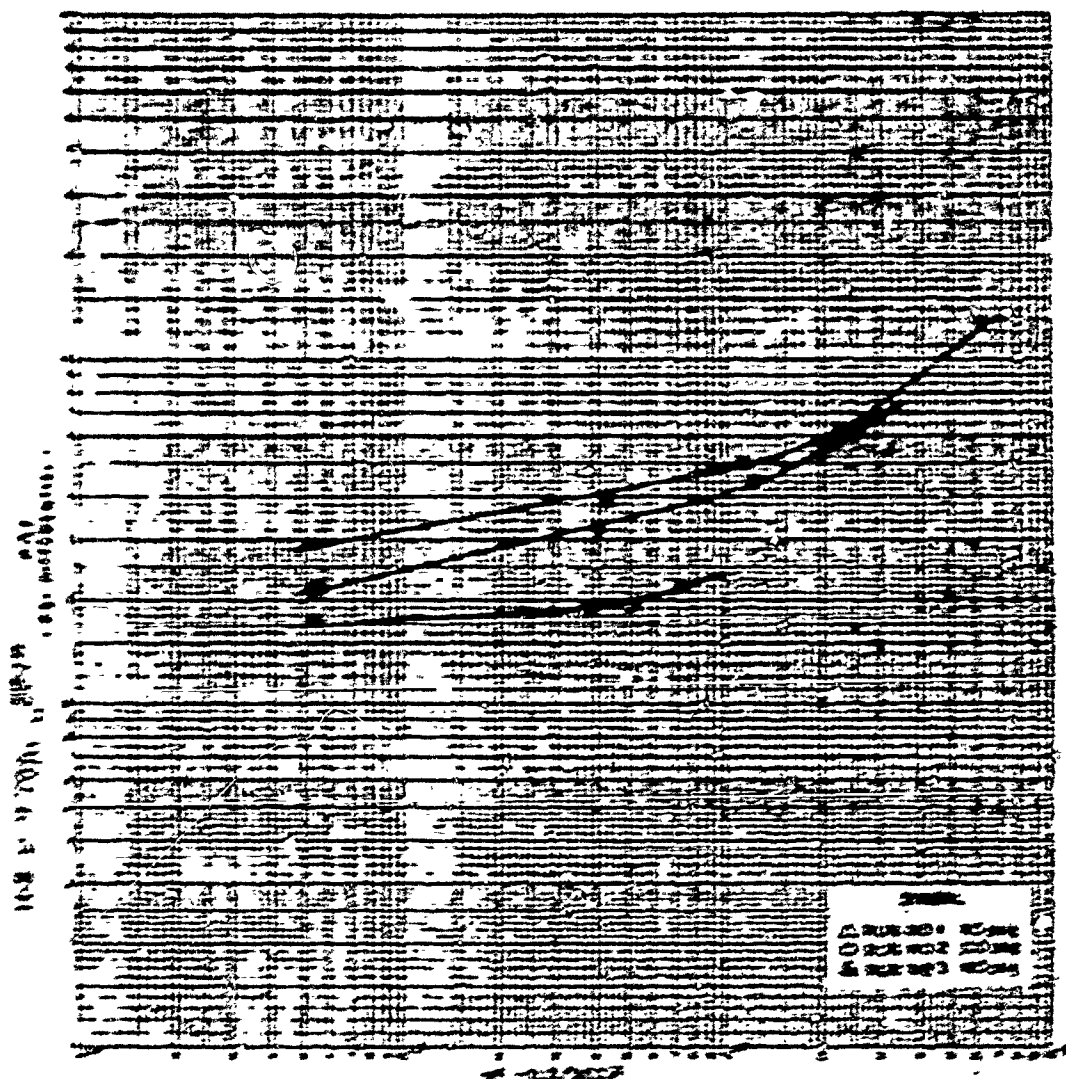
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REPORT ~~DEST-1061~~

FIGURE 3. CHECK VALVE FLOW CHARACTERISTICS 1/2" DIA DANCO INDUSTRIES SERIAL 02,0002
 PRESSURE DIFFERENTIAL VS MASS FLOW RATE SQUARED CORRECTED TO STANDARD
 CONDITIONS, TEMPERATURE 59°F, PRESSURE 14.7 psi WORKING FLUID-HELIX

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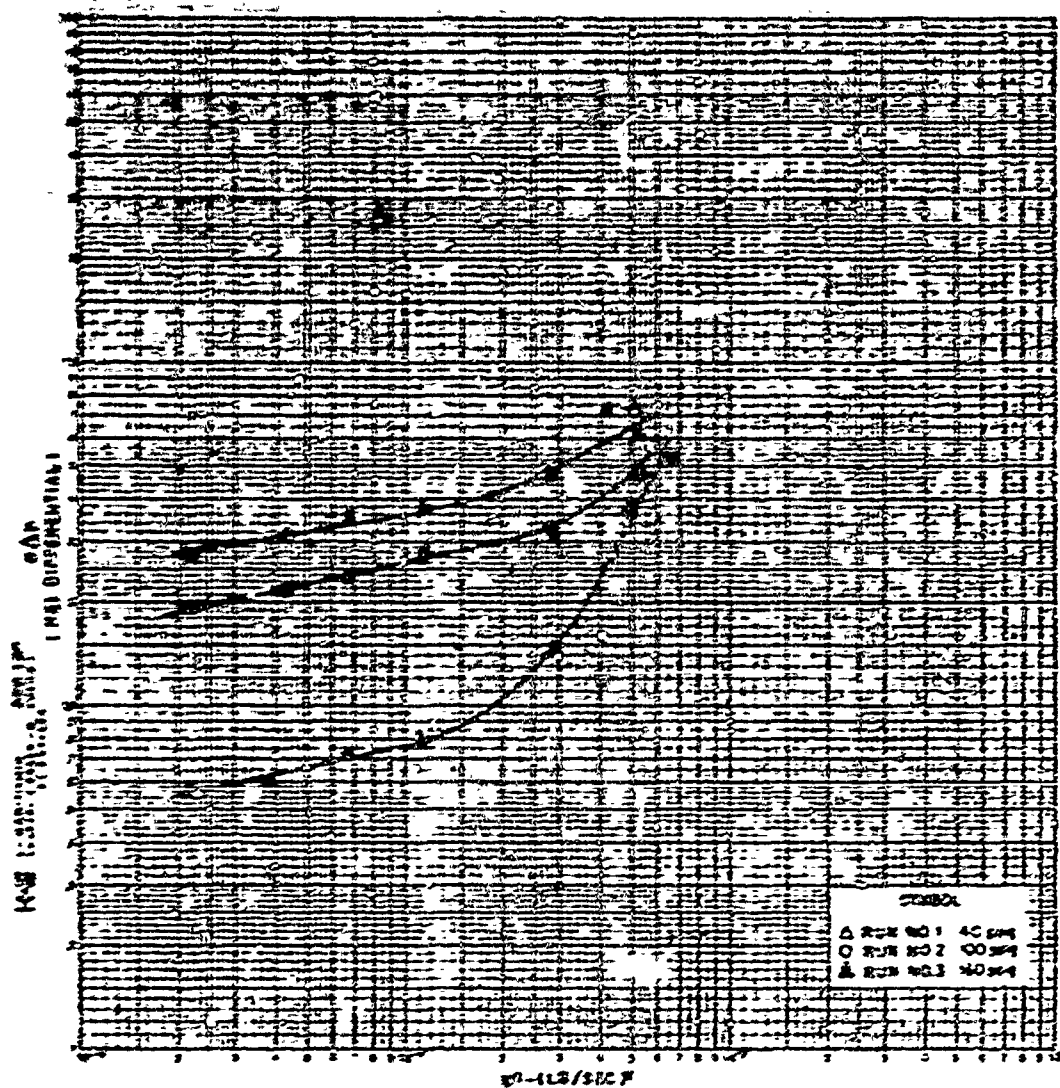


FIGURE 4. CHECK VALVE FLOW CHARACTERISTICS 1/2" DIA. JAMES, JORD, CLARK SIGNAL NO. 1
PRESSURE DIFFERENTIAL VS MASS FLOW RATE CORRECTED TO STANDARD
CONDITIONS TEMPERATURE 59°F PRESSURE 14.7 PSI WORKING FLUID-HELIUM

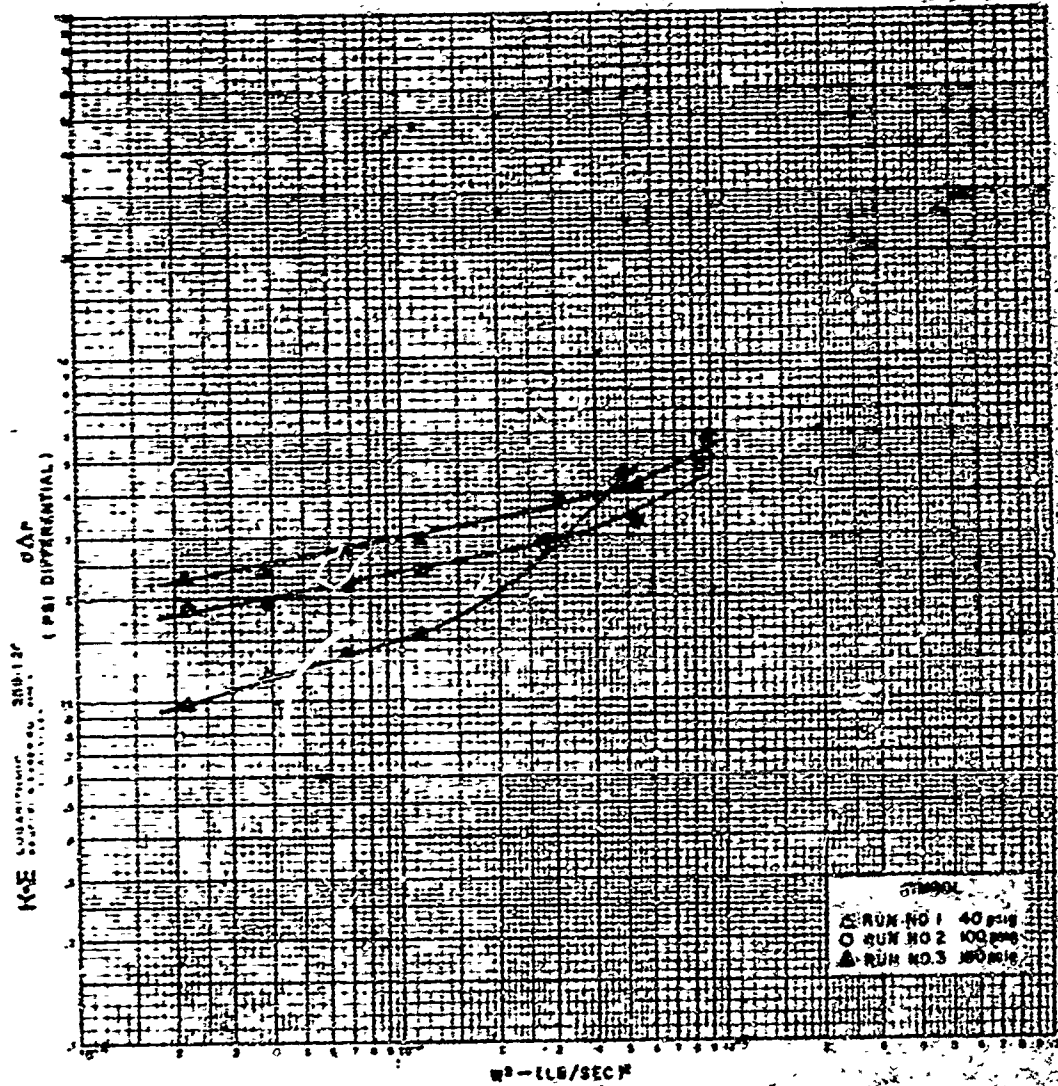


FIGURE 7. CHECK VALVE FLOW CHARACTERISTICS. 1/8" DIA. JAMES, FORD, CLARK, SERIAL NO. 4. PRESSURE DIFFERENTIAL VS MASS FLOW RATE SQUARED CORRECTED TO STANDARD CONDITIONS, TEMPERATURE 55°F, PRESSURE 14.7 PSI WORKING FLUID-HELIUM.

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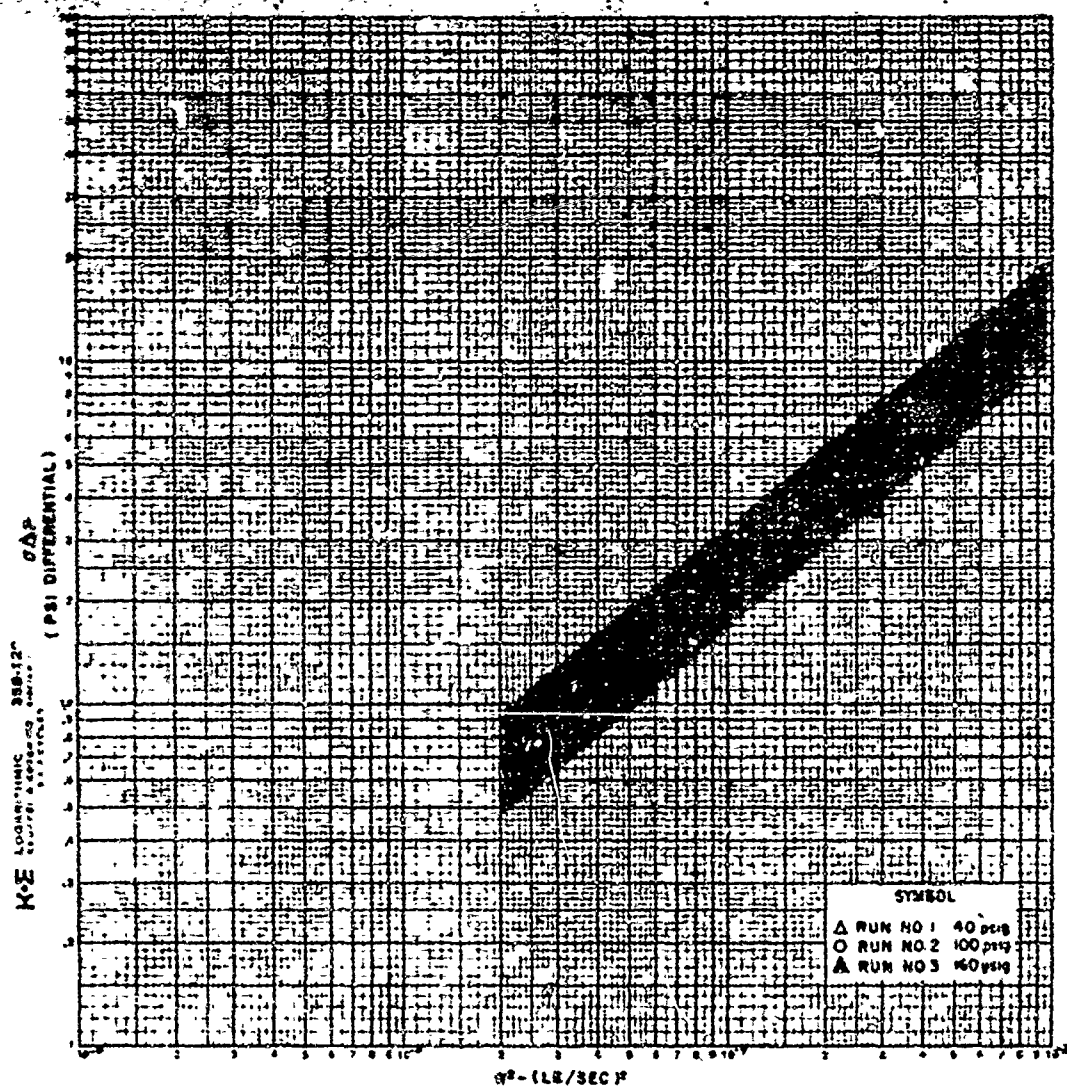


FIGURE 8. CHECK VALVE FLOW CHARACTERISTICS. 1/2" DIA PARKER SERIAL NO 1
 PRESSURE DIFFERENTIAL VS MASS FLOW RATE SQUARED CORRECTED TO STANDARD
 CONDITIONS, TEMPERATURE 59°F, PRESSURE 14.7 psi WORKING FLUID HELIUM

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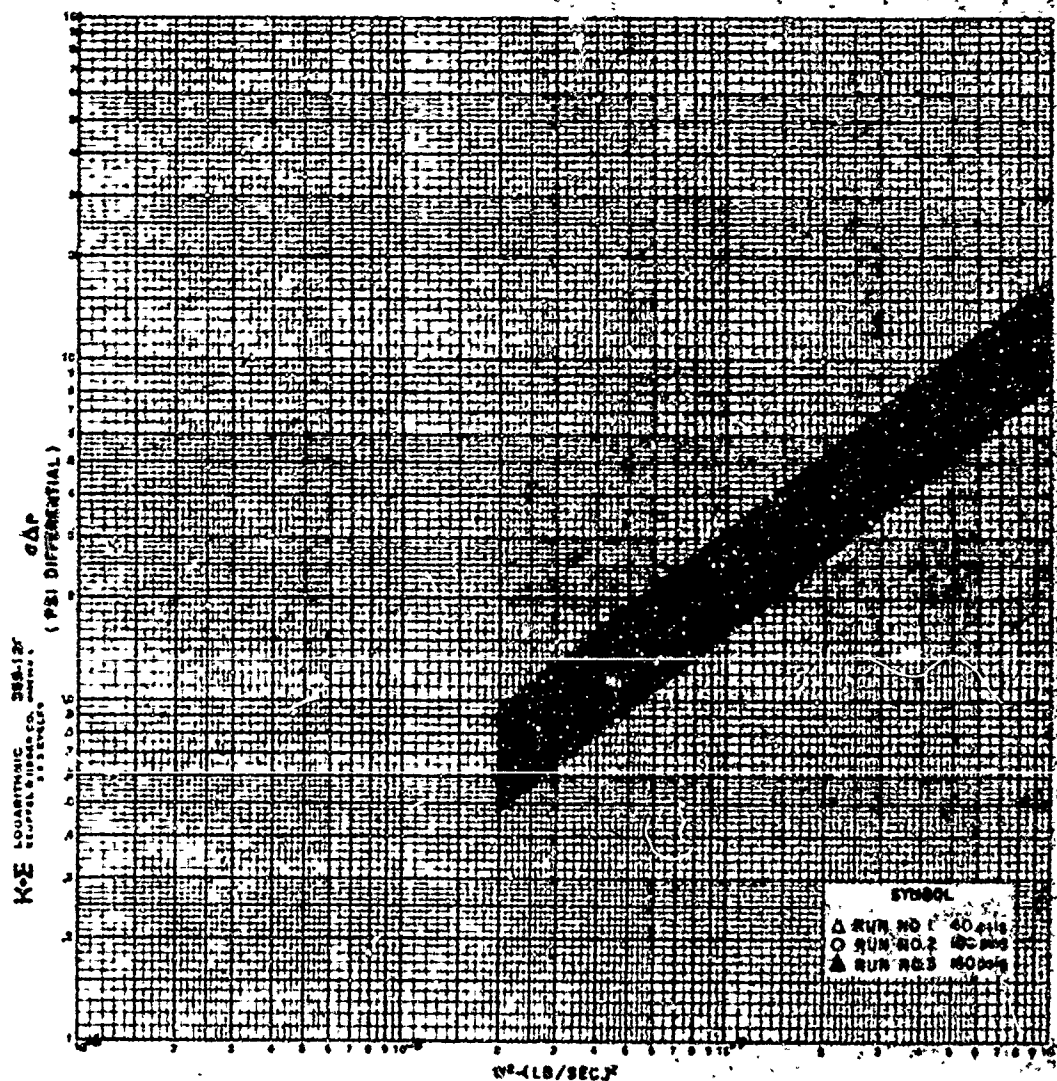


FIGURE D. CHECK VALVE FLOW CHARACTERISTICS, 1/2" DIA. PARKER SERIES NO. 2.
 PRESSURE DIFFERENTIAL VS W^2 FLOW RATE SQUARED CORRECTED TO STANDARD
 CONDITIONS, TEMPERATURE 58°F, PRESSURE 14.7 psi WORKING FLUID-HELIUM

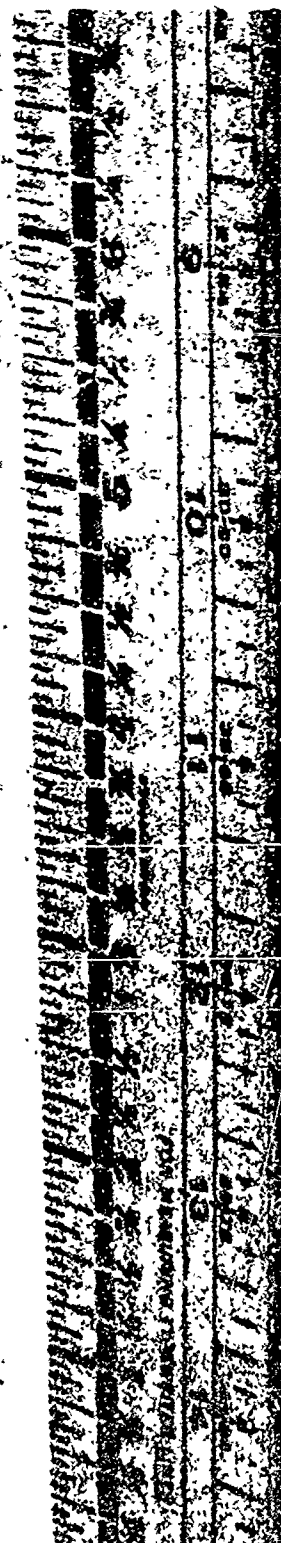
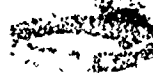
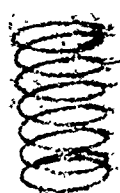


FIGURE 10. CHECK VALVE EXPLODED VIEW, CIRCLE SEAL 1/2 INCH DIA.

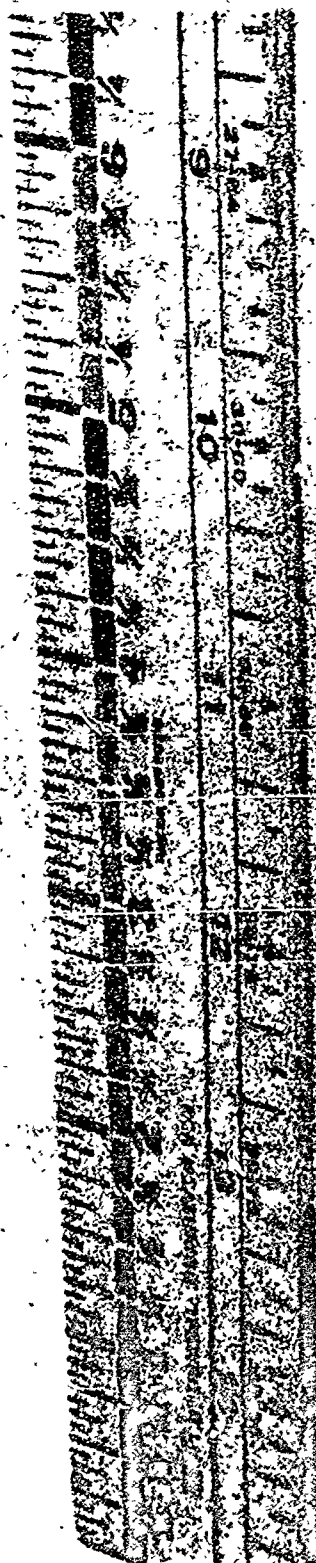
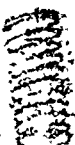


FIGURE 11. CHECK VALVE EXPLODED VIEW, CIRCLE SEAL .36 INCH DIA. (30/71) SHOWING MERCURY ON THREADS

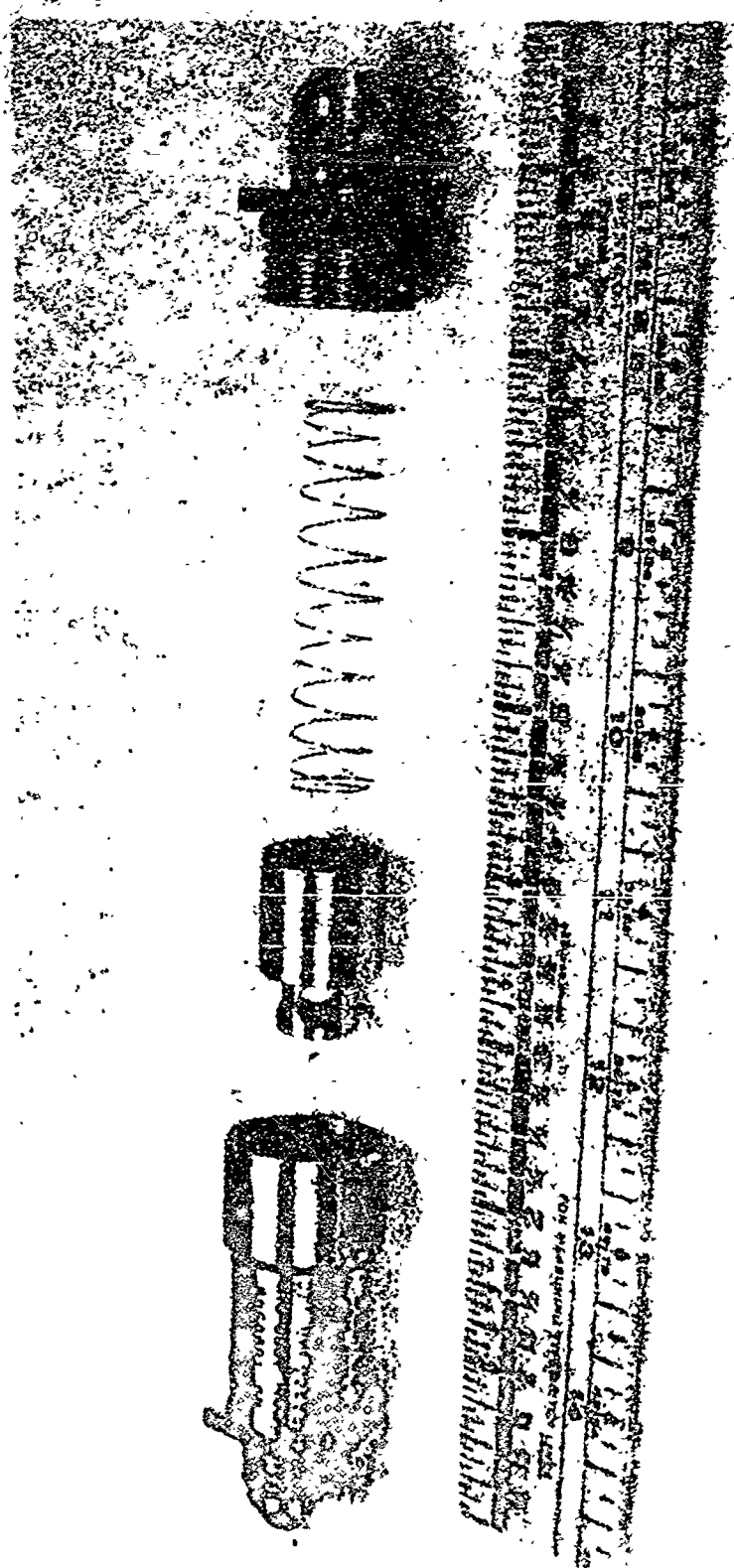


FIGURE 12. CHECK VALVE EXPLODED VIEW, DARCO 1/2 INCH DIA.

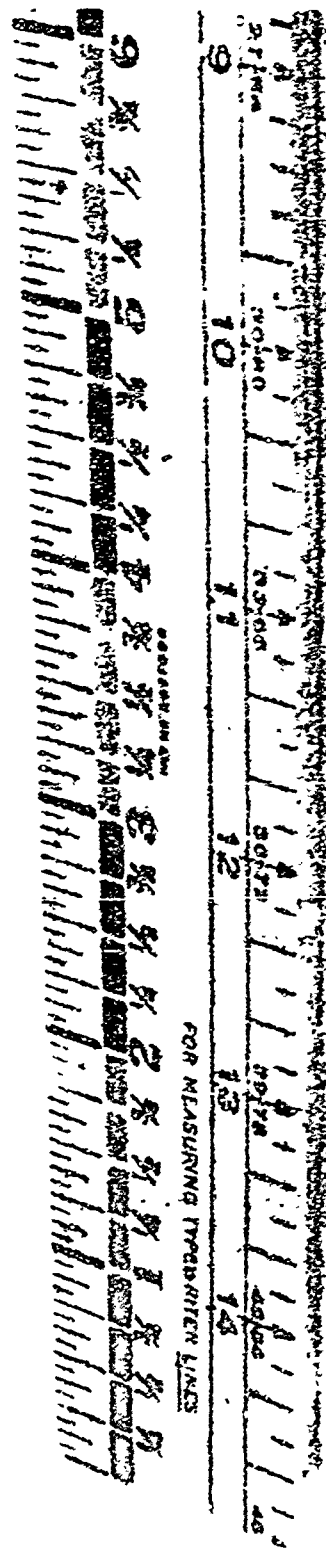


FIGURE 13. PARKER CHECK VALVE, 1/2 INCH DIA.

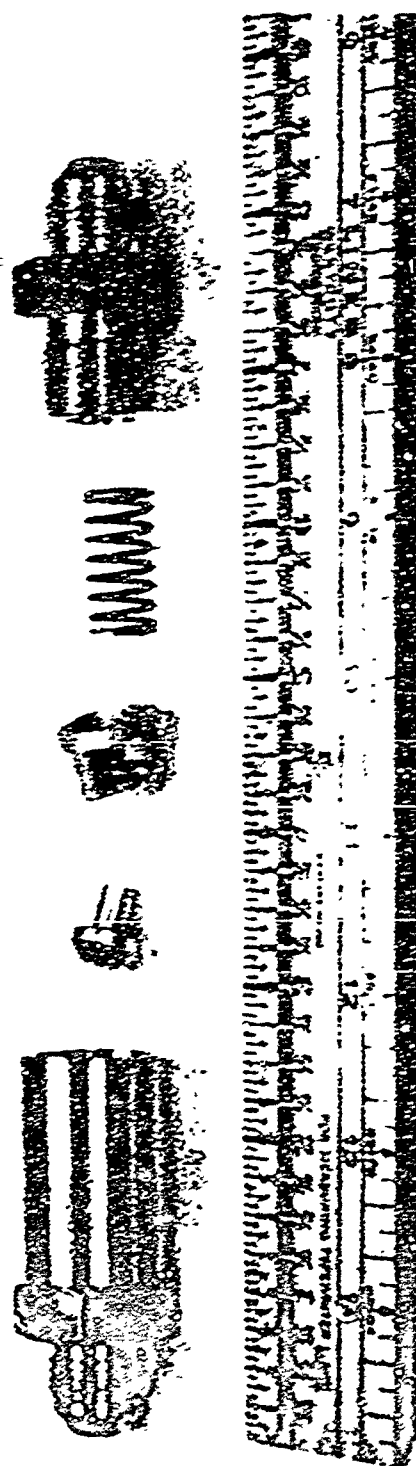


FIGURE 1A CHECK VALVE EXPLODED VIEW, SEAL O.D. 1/2 INCH DIA.

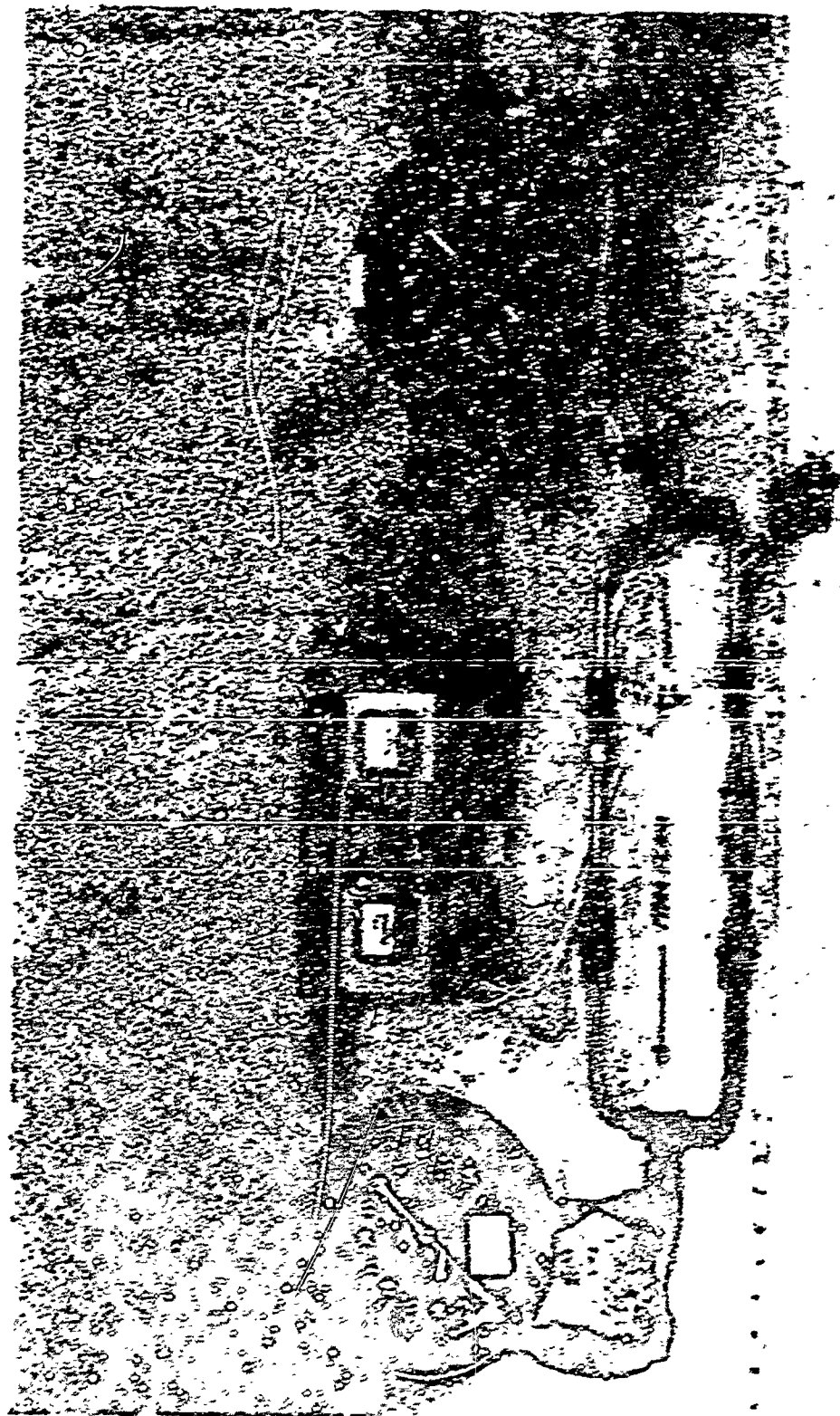
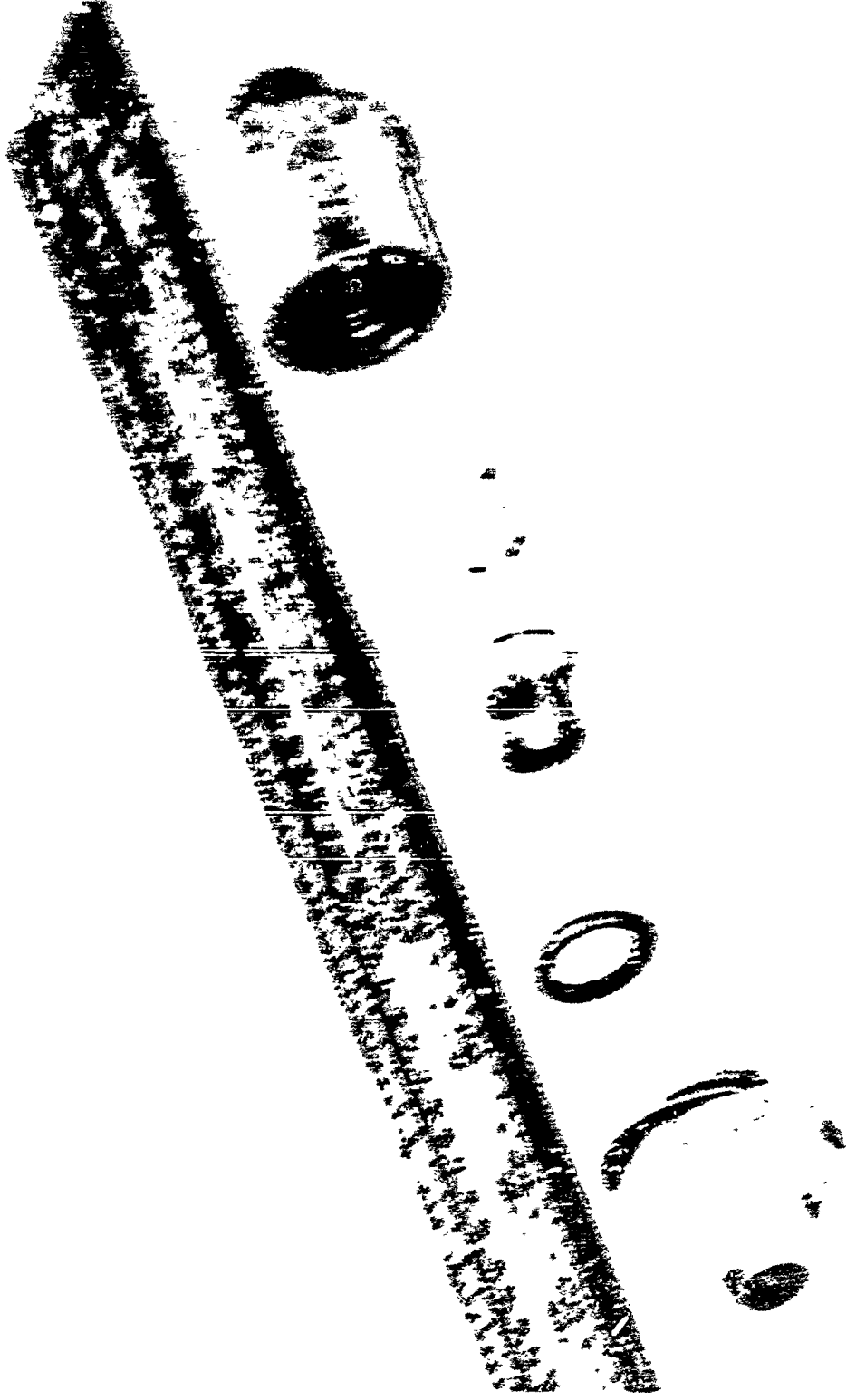


FIGURE 10. EQUIPMENT SET-UP FOR LIFE TEST, ALL VALVES



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FIGURE 14. GUNION VALVE EXPLODED VIEW, J. A. GLAHN II/INBIDIA, AFTER INTERNAL FUEL CORRUPTION TEST

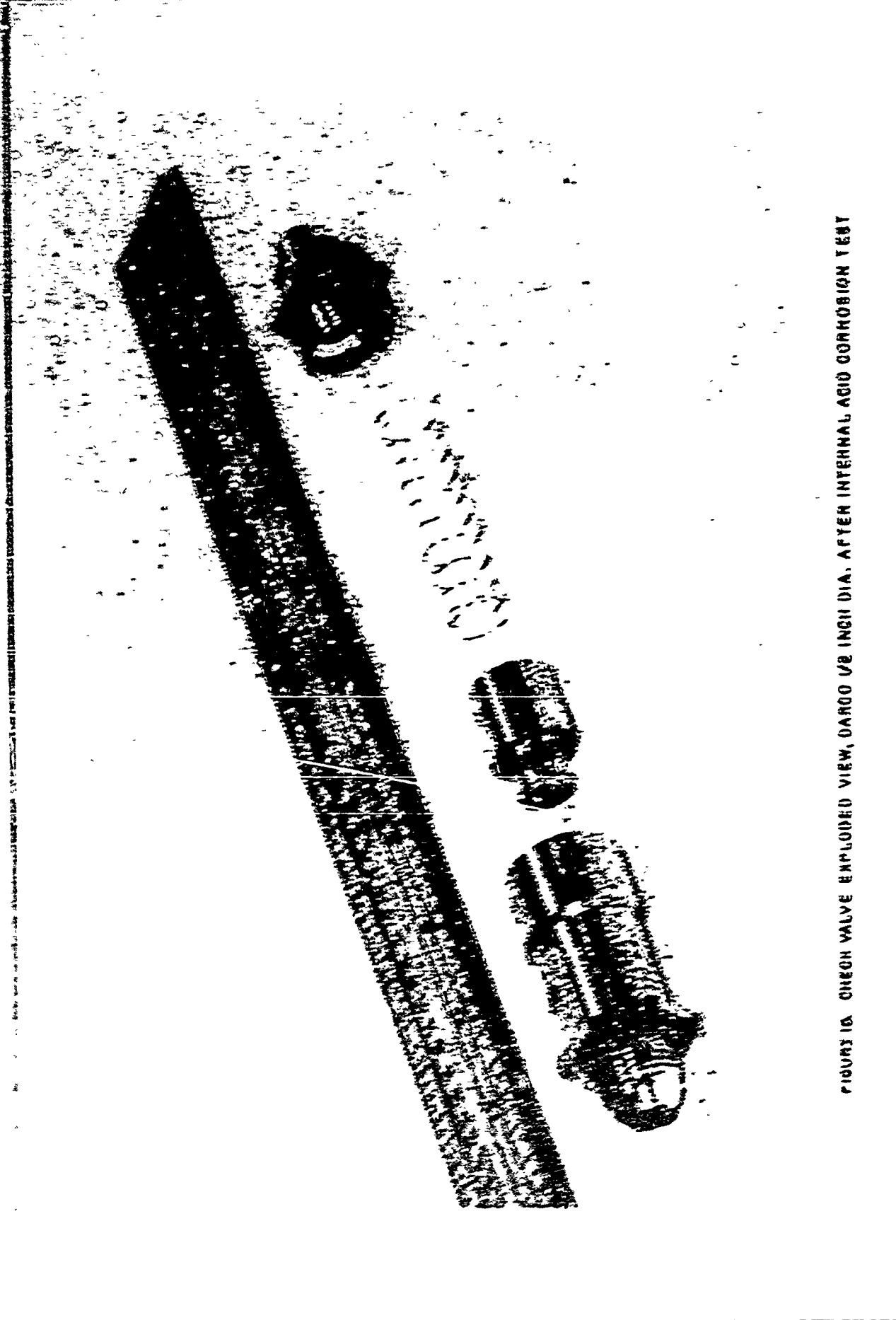


FIGURE 10. CHECK VALVE EXPLODED VIEW, DARGO 1/2 INCH DIA. AFTER INTERNAL ACID CORROSION TEST



FIGURE 1A CHECK VALVE EXPLODED VIEW, PARKER 1/2 INCH DIA, AFTER INTERNAL ACID CORROSION TEST.
SHOWING DETERIORATION OF SEAL ON FLAPPER GATE. VALVE SAVED IN HALF DUE TO BINDING
OF THREADS AND RESULTANT FREEZING REFER TO FIGURE 1B FOR CONDITION BEFORE
CORROSION TEST