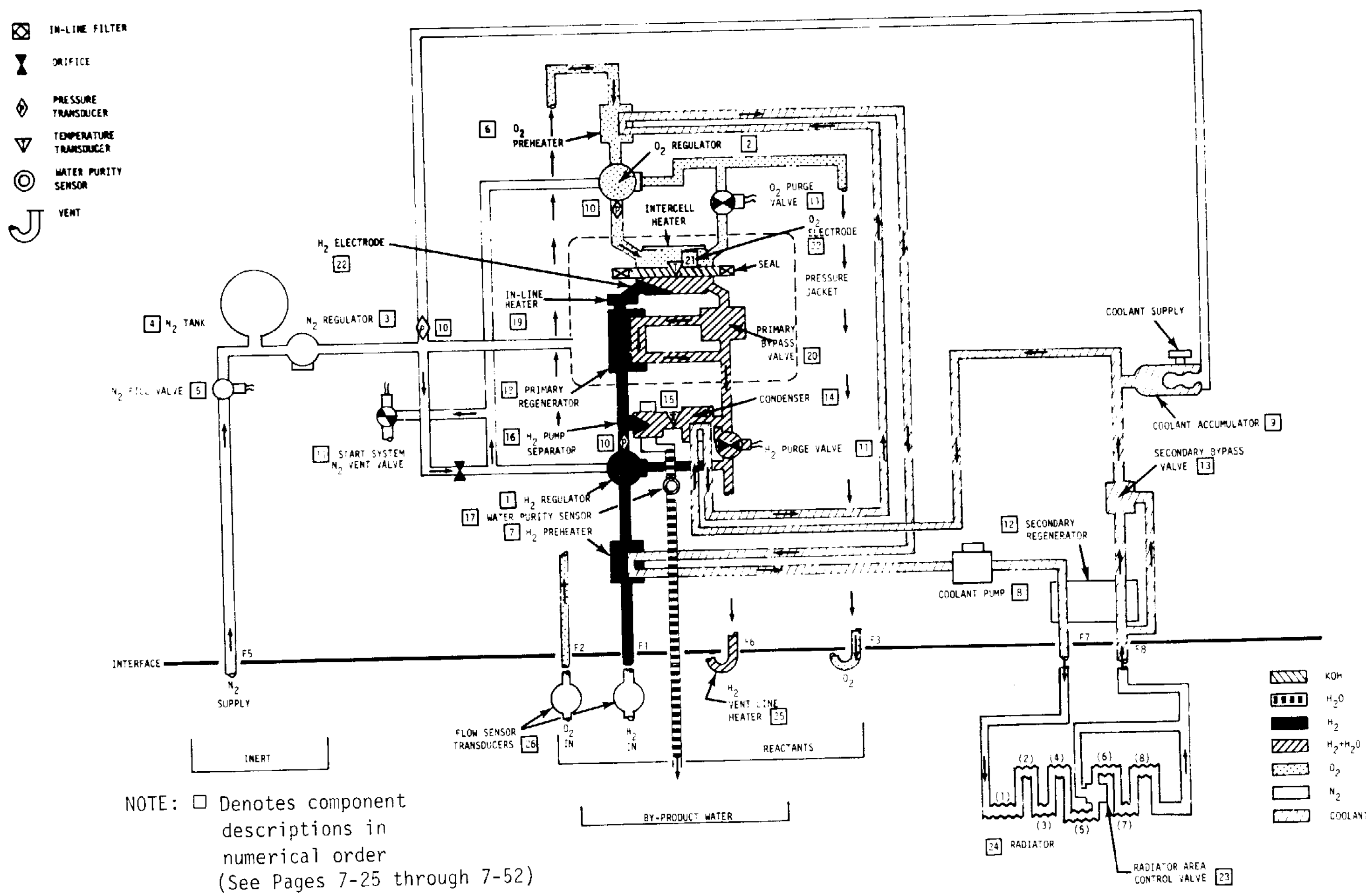
7.2 FUEL CELL COMPONENT DESCRIPTIONS

FUEL CELL SCHEMATIC



NOTE: □ Denotes component descriptions in numerical order (See Pages 7-25 through 7-52)

7.3 CRYOGENIC GAS STORAGE SYSTEM COMPONENT DESCRIPTIONS

CRYOGENIC STORAGE SYSTEM SCHEMATIC

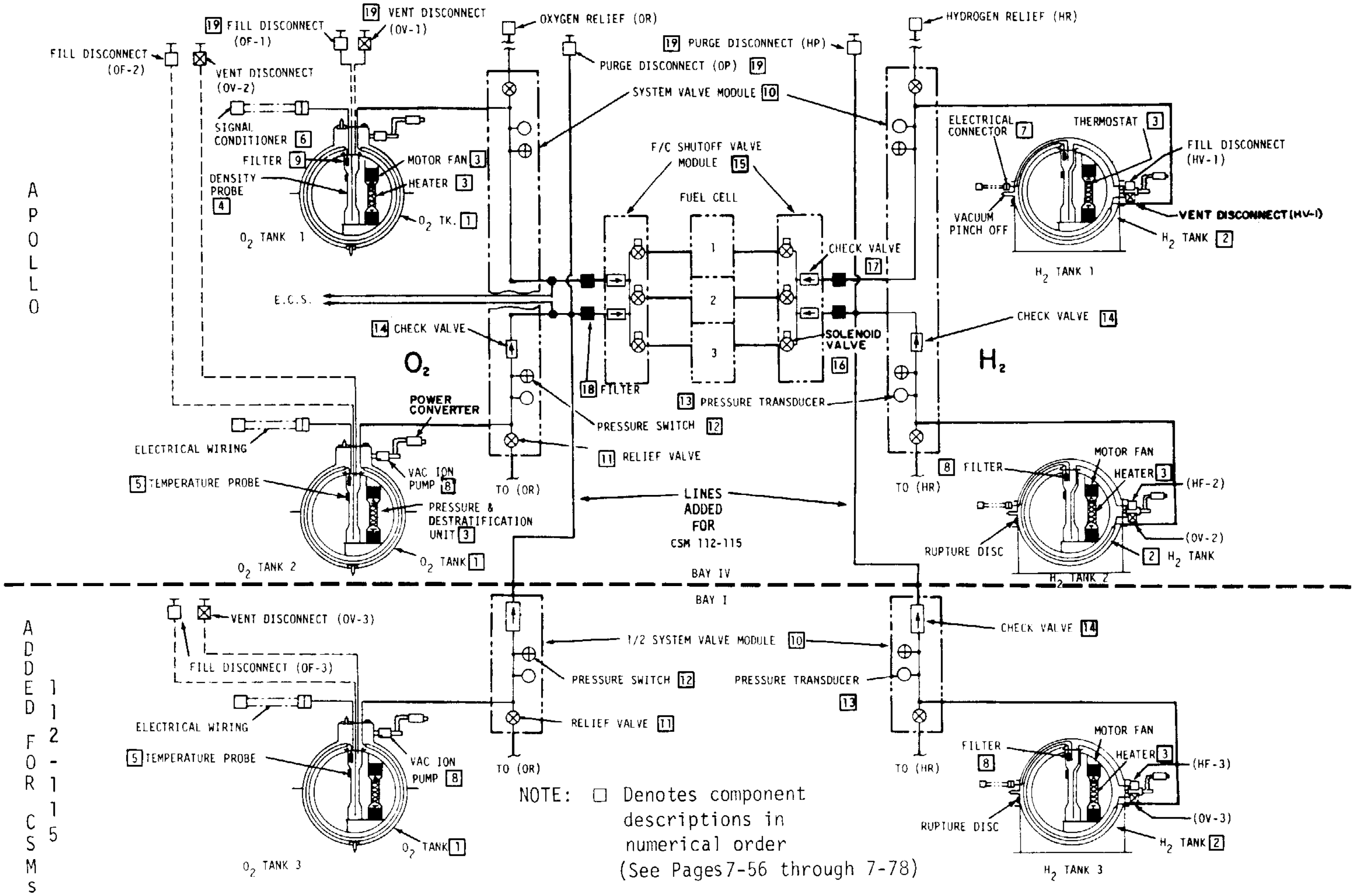
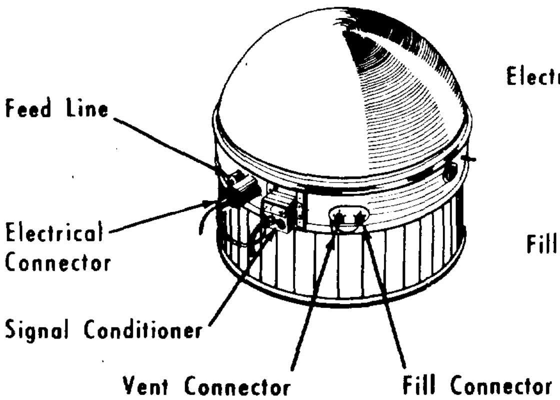


TABLE 7.3.1

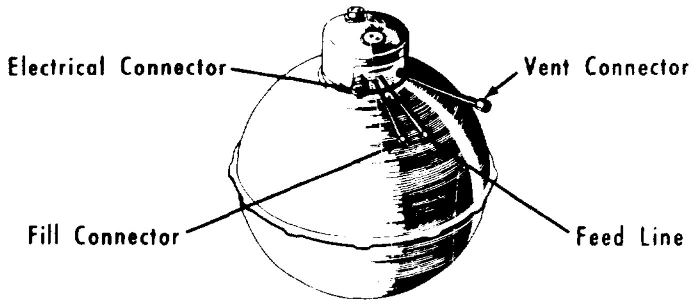
CRYOGENIC GAS STORAGE SYSTEM INTERFACES

CGSS INTERFACES		
ELECTRICAL INTERFACE		
Valve Modules	Pigtails	Pigtails
Tank Connectors	Hermetically sealed pin receptacle	Hermetically sealed pin receptacle
TANK INTERFACE LINE SIZES		
Fill Connections	1/4" O.D. (0.015 wall)	3/8" O.D. (0.022 wall)
Vent Connections	1/4" O.D. (0.015 wall)	3/4" O.D. (0.028 wall)
Relief Connections	3/16" O.D. (0.022 wall)	3/16" O.D. (0.022 wall)
Feed Connections	1/4" O.D. (0.015 wall)	1/4" O.D. (0.022 wall)
CRYOGENIC VALVE MODULE		
Feed Connections	1/4" O.D. (0.015 wall)	1/4" O.D. (0.022 wall)
F/C Supply Connections	1/4" O.D. (0.022 wall)	1/4" O.D. (0.022 wall)
Relief Valve Outlet	1/4" O.D. (0.022 wall)	1/4" O.D. (0.022 wall)
FUEL CELL VALVE MODULE		
Feed Connections (2)	1/4" O.D. (0.022 wall)	1/4" O.D. (0.022 wall)
F/C Supply Connections (3)	1/4" O.D. (0.022 wall)	1/4" O.D. (0.022 wall)

[1] & [2] OXYGEN AND HYDROGEN STORAGE TANK



[2] H_2 STORAGE TANK



[1] O_2 STORAGE TANK

Each storage tank consists of two concentric spherical shells. The annular space between them is evacuated and contains the thermal insulation system, pressure vessel support, fluid lines and the electrical conduit. The inner shell, or pressure vessel is made from forged and machined hemispheres. The pressure vessel support is built up on the pressure vessel from subassemblies and provides features which transmit pressure vessel loads to the support assembly. The fluid lines and the electrical lead line exit the pressure vessel at its top, traverse the annular space and exit the outer shell as follows: O_2, top of tank coil cover; H_2, girth ring equator.

Structural and physical parameters are listed in Tables 7.3.2 and 7.3.3, respectively. Tank volumes, with expansion and contraction data, are listed in Table 7.3.4. Tube sizing is listed in Table 7.3.5.

TABLE 7.3.2 CRYOGENIC TANK STRUCTURAL LIMITS

	Hydrogen	Oxygen
Material	5 Al-2.5 Sn ELI Ti	Inconel 718
Ultimate Strength, psi	105,000	180,000
Yield Strength, psi	95,000	145,000
Young's Modulus, psi	17×10^6	30×10^6
Creep Stress, psi	71,200	No creep at 145,000
Poisson's Ratio	0.30	0.29
Safety Factors -		
Ultimate	1.5	1.5
Yield	1.33	1.33
Creep	1.33	N.A.
Design Stress Level, psi	53,000	110,000
Proof Pressure, psia	400 psia	1357 psia
Burst Pressure, psia	450 psia	1537 psia

TABLE 7.3.3 CRYOGENIC TANK PHYSICAL PARAMETERS

Parameter	Hydrogen	Oxygen
Pressure Vessel		
Material	5Al-2.5 Sn ELI Ti	Inconel 718
Inside Diameter - Inches	28.24	25.06
Wall Thickness - Inches	$.044 \pm^{.004}_{.000}$	$.059 \pm^{.004}_{.000}$
Outside Diameter - Inches	28.328	25.178
Outer Shell		
Material	5Al-2.5 Sn ELI Ti	Inconel 750
Inside Diameter - Inches	31.738	26.48
Outside Diameter - Inches	31.804	26.52
Wall Thickness - Inches	.033 ± .002	.020 ± .002
Support		
Flange Diameter - Inches	37.966	28.228
Flange Thickness - Inches	.070 ± .010	.080 ± .010
Bolt Circle Diameter - Inches	32.216	27.50
Number of Bolts	8	12
Annulus		
Annular Space - Inches	1.705"	.653"
Insulation	Vapor-cooled and passive radiation shields.	Vapor-cooled shield with preloaded insulation.
Vacuum Level (TORR) - MM Hg	5×10^{-7}	5×10^{-7}
Average Pump Down Time	24 Days	24 Days
Burst Disc		
Burst Pressure	90 psi $\pm^{10}_{20}$	75 psi ± 7.5
Weight (Empty)		
Spec	75.0 lb.	93.5 lb.
Actual (Maximum)	80.0 lb.	90.8 lb.
Electrical/Instrumentation		
Beech/NAA Interface	Pigtails & Hermetically sealed pin receptacle	Hermetically sealed pin receptacle

TABLE 7.3.4 CRYOGENIC TANK VOLUMES
(With Expansion and Contraction Data)

		INTERNAL VOLUME (Less .02 ft^3 for components	
		O_2 Tank	H_2 Tank
Ambient Pressure	Max. tol.	4.7528 ft^3	6.8314 ft^3
Ambient Temperature	Max. tol.	4.7471 ft^3	6.8045 ft^3
Full Ambient Pressure -297°F O_2 -423°F H_2	Max. tol.	4.7213 ft^3	6.777 ft^3
	Min. tol.	4.7156 ft^3	6.7698 ft^3
Full 935 psia (O_2) -294°F	Max. tol.	4.7532 ft^3	N/A
	Min. tol.	4.7497 ft^3	N/A
Full 865 psia (O_2) -294°F	Max. tol.	4.7508 ft^3	N/A
	Min. tol.	4.74705 ft^3	N/A
Full 260 psia (H_2) -418°F	Max. tol.	N/A	6.805 ft^3
	Min. tol.	N/A	6.80048 ft^3
Full 225 psia (H_2) -418°F	Max. tol.	N/A	6.8014 ft^3
	Min. tol.	N/A	6.7963 ft^3
Full 935 psia (O_2) + 80°F	Max. tol.	4.7848 ft^3	N/A
	Min. tol.	4.7812 ft^3	N/A
Full 260 psia (H_2) -200°F	Max. tol.	N/A	6.8597 ft^3
	Min. tol.	N/A	6.8550 ft^3

Volumes Used for Tank Calculations

	O_2 Tank	H_2 Tank
Average Size Cold 835 psia O_2 225 psia H_2	4.74892 Ft^3	6.7988 Ft^3
Average Size Warm 935 psia O_2 260 psia H_2	4.7830 Ft^3	6.8573 Ft^3

TABLE 7.3.5 CRYOGENIC TANK TUBE SIZING

	Hydrogen	Oxygen
Vent Tube	1/4 O.D. x .015 wall 304 L SST	1/2 O.D. x .015 wall (Inside coil cover) 3/4 O.D. x .028 wall (Outside coil cover) Inconel 750 AMS 5582
Fill Tube	1/4 O.D. x .015 wall 304L SST	3/8 O.D. x .022 wall Inconel 750 AMS 5582
Feed Tube*	Common with vent line	1/4 O.D. x .015 wall Inconel 750 AMS 5582
Electrical Tube	1/2 O.D. x .015 wall 304L SST	1/2 O.D. x .015 wall Inconel 750 AMS 5582
Vapor Cooled* Shield Tube	1/4 O.D. x .015 wall 304L SST	3/16 O.D. x .015 wall Inconel 750 AMS 5582
Pressure Vessel to Vapor* Cooled Shield Tube	- - - - - - - - - -	1/4 O.D. x .015 wall Inconel 750 AMS 5582

* Three tubes joined to provide a single feed line for the oxygen tank only.

3 PRESSURIZATION AND DESTRATIFICATION UNIT

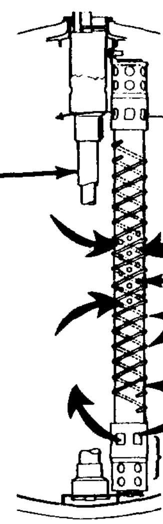
Each of the storage tanks contains a forced convection pressurization and destratification unit.
Each unit consists of the following:

a. A 2.0 inch diameter support tube approximately 3/4 the tank diameter in length.

b. Two heaters.

c. Two fan motors.

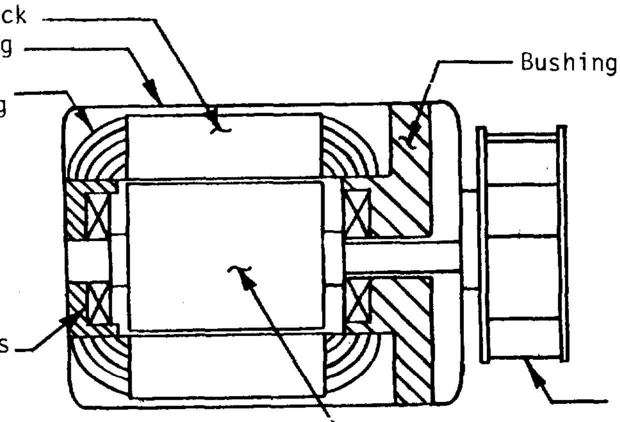
d. Two thermostats. Eliminated for H_2 on CSM 113 and on and eliminated for O_2 on CSM 114 and on.



The tube provides a large surface area for efficient heat transfer, and is small enough to be installed through the pressure vessel neck. The heaters are placed along the tube's outer surface and brazed in place. A motor-fan is mounted at the upper and lower ends of the tube, which draw fluid through the inlet ports located along the tube, force it across the heat transfer surface and expel it near the top and bottom of the vessel.
Block II tanks utilize separate sets of lead wires for each heater element and for each motor fan through the electrical connector interface.

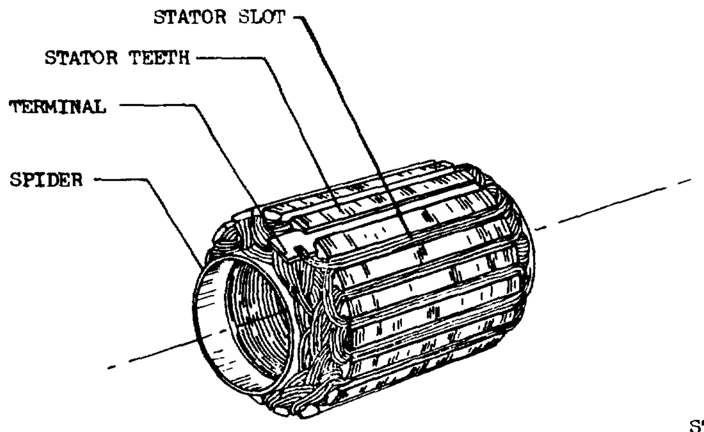
FAN MOTORS

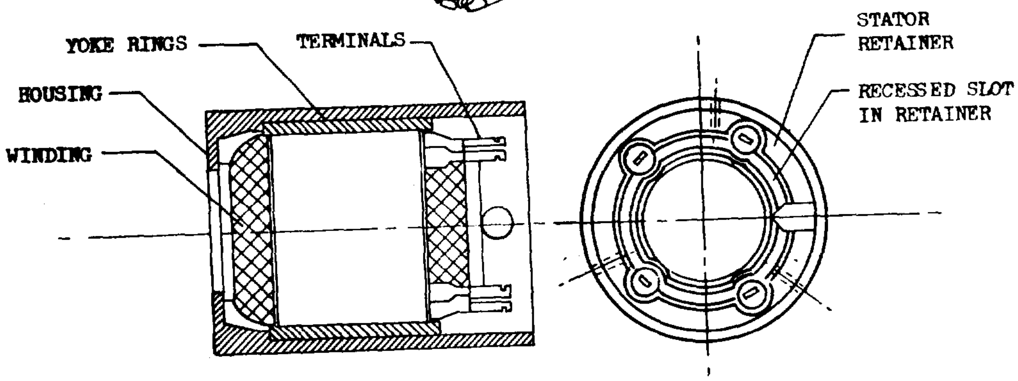
The motors are three phase, four wire, 200 volts A.C. line to line, 400 cycles miniature induction type with a centrifugal flow impeller. The minimum impeller speed of the oxygen unit in fluid is 1800 rpm with a torque of 0.90 in. oz., and the hydrogen unit is 3800 rpm with a torque of 0.45 in. oz.. Two fans and motors are used in each vessel.

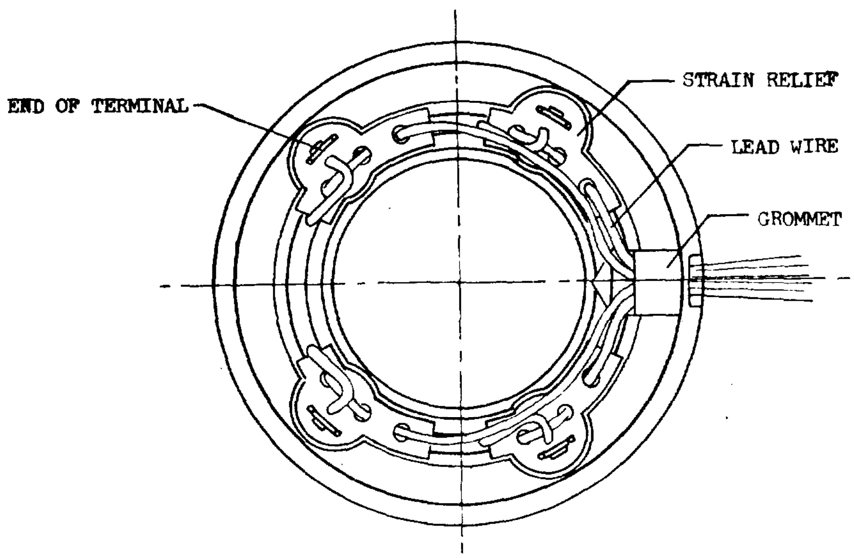


MOTOR FAN

3 PRESSURIZATION AND DESTRATIFICATION UNIT (CONTINUED)

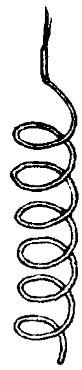




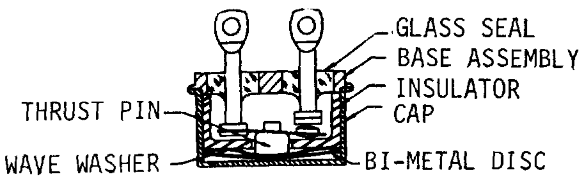


HEATERS

The heaters are a nichrome resistance type, each contained in a thin stainless steel tube insulated with powered magnesium oxide. The heaters are designed for operation at 28 volts DC during in-flight operation, or 65 volts DC for GSE operation to provide pressurization within the specified time. The heaters are spiralled and brazed along the outer surface of the tube. The heaters are wired in parallel to provide heater redundancy at half power. The heaters have small resistance variation over a temperature range of + 80°F to -420°F.



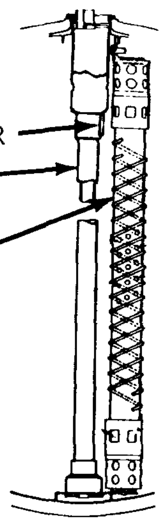
THERMOSTATS



The thermostats are a bimetal type unit developed for cryogenic service. They are in series with the heaters and mounted inside the heater tube with a high conducting mounting bracket arranged so that the terminals protrude through the tube wall. When the heater tube reaches 80 ±10°F, the thermostats open cutting power to the heaters to prevent over heating of the pressure vessel. When the tube reaches -200°F in the hydrogen tank or -75°F in the oxygen tank the thermostats close allowing power to be supplied to the heaters.

[4] DENSITY SENSOR PROBE

The density sensor consists of two concentric tubes which serve as capacitor plates, with the operating media acting as the dielectric between the two. The density of the fluid is directly proportional to the dielectric constant and therefore probe capacitance. The gage is capable of sensing fluid quantity from empty to full during fill and flight operation. The accuracy of the probe is 1.5% of full scale.



	Hydrogen	Oxygen
Quantity Gaging System		
Range	0-100% full (.17-4.31 $\#/ft^3$)	0-100% full (1.39-69.5 $\#/ft^3$)
Accuracy	±2.68 % full range	±2.68 % full range
Output Voltage	0-5 V DC	0-5 V DC
Output Impedance	500 ohms	500 ohms
Power	2-1/2 watts 115 V 400 cps	2-1/2 watts 115 V 400 cps

[5] TEMPERATURE SENSOR

The temperature sensor is a four-wire platinum resistance sensing element mounted on the density sensor (see photograph of density sensor probe). It is a single point sensor encased in a Inconel sheath which only dissipates 1.5 millivolts of power per square inch to minimize self-heating errors. The resistance of the probe is proportional to the fluid temperature and is accurate to within 1.5%.

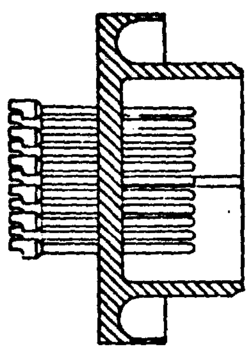
	Hydrogen	Oxygen
Temperature Gaging System		
Range	-420^oF to -200^oF	-320^oF to $+80^oF$
Accuracy	+2.68 % full range	+2.63 % full range
Output Voltage	0-5 VDC	0-5 V DC
Output Impedance	5000 ohms	5000 ohms
Power	1.25 watts 115 V 400 cps	1.25 watts 115 V 400 cps

[6] SIGNAL CONDITIONER

The temperature and density amplifiers are separate modules, contained in the same electrical box. The density module functions as an infinite feedback balancing bridge and utilizes solid state circuitry. The temperature module also uses solid state circuits and amplifies the voltage generated across the sensor which is linearly proportional to the resistance of the sensor. The output in both cases is a 0-5 volt DC analog voltage which is fed into the NR interface. The voltage required to run the signal conditioner is 115 V, 300 cycle single phase, and draws a total of 3.75 watts of power. The accuracy of the unit is 1.0% of full scale.

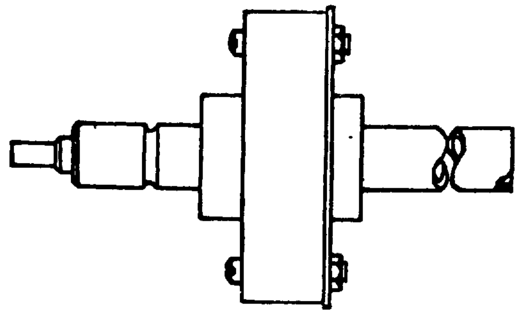
The modules are encased in Emerson-Cumings epoxy potting and the unit is hermetically sealed.

[7] ELECTRICAL CONNECTOR



The electrical receptacle is a hermetically sealed device capable of withstanding system pressures and temperature. It contains straight pins with solder cups attached to facilitate the soldering of lead wires from the temperature and density probes, the destratification units and the heaters. The pins are sealed in a ceramic material which has the same coefficient of thermal expansion as the shell and pin material.

[8] VAC-ION PUMP



DESCRIPTION

The vac-ion pump is attached directly to the vacuum annulus of the oxygen tank which maintains the insulation space at reduced pressure required for adequate insulation. Pumping action results from bombarding the titanium cathode with ionized gas molecules which become chemically bound to the titanium. The impacting ions sputter titanium from the cathode. The sputtered titanium particles also contribute pumping by gettering action. The pump can be used as a vacuum readout device since the input current to the pump is directly proportional to pressure. The unit is powered by a DC-DC converter capable of putting out the required amounts of power.

CONSTRUCTION

Vac-ion pumps have no moving parts. The pumps consist of two titanium plates spot welded to a vacuum tight stainless steel enclosure with an anode structure mounted between the plates connected to a copper-gold brazed electrical feedthrough. A permanent magnet maintains a magnetic field between the electrodes causing the ions to follow spiral paths thus increasing transit time.

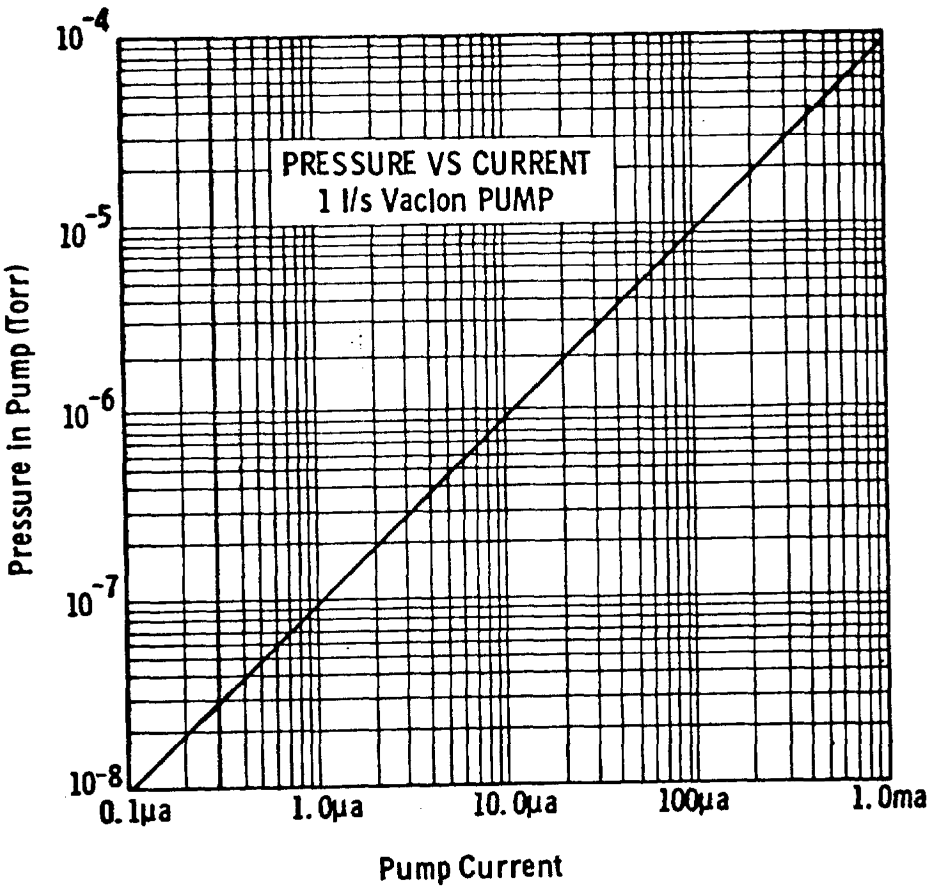
POWER SUPPLY (CONVERTER)

The converter is a solid state device capable of supplying power to the vac-ion pump over a large range of pressure. The unit is emergized by a 28 V DC source and is current limited to 350 ma. The unit is capable of putting out 4.2 ma at 10 Volts DC and 1 ma at 4000 volts. The unit employs a square wave inverter, a toroid transformer and a quadrupler circuit on the output. Choke filters are supplied on the 28 volt DC input to keep to acceptable limits the amount of conducted interference being fed back from the output. The metal case is well bonded to reduce to acceptable limits radiated interference. The circuits are enclosed in Emerson-Cumings stycast 2850 Ft.

[8] VAC-ION PUMP (CONTINUED)

PERFORMANCE

The pumping rate of the pump is constant at 1 liter per second. Pump current is related to pressure as shown by the graph below.

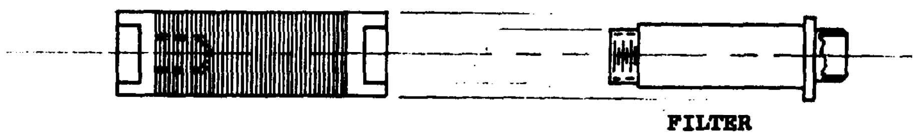


LIFE SPAN

The practical life span of a vac-ion pump while pumping in the various pressure ranges is as follows:

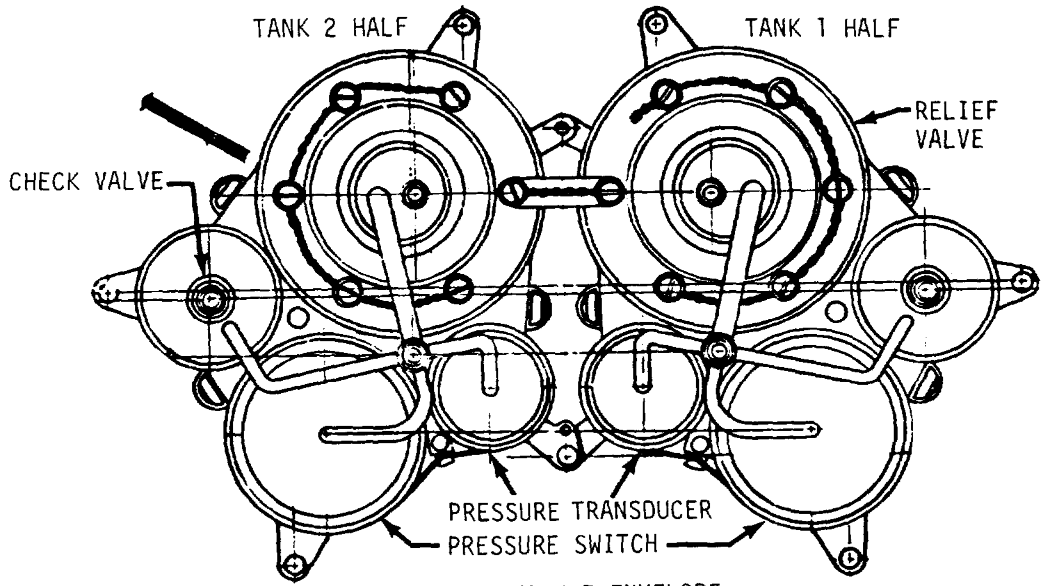
1×10^{-6} region	-	10,000 hours
1×10^{-5} region	-	1,000 hours
1×10^{-4} region	-	100 hours
1×10^{-3} region	-	10 hours

[9] FILTER

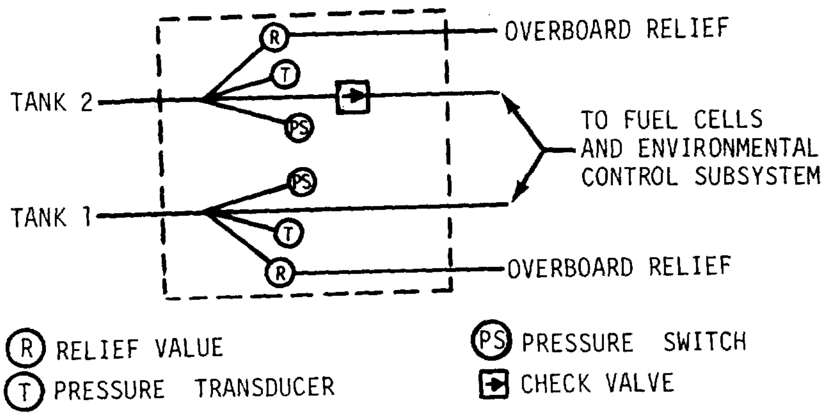


The filter is a multiple disc type element rated at 175 microns absolute. The discs are stacked on a mandrel-like cartridge. The filter is used to trap fibers and particles which could get downstream of the tank and hinder valve module and fuel cell operation. The filter is mounted inside the density probe adapter and is welded onto the feed and vent line.

10 SYSTEM (TANK) VALVE MODULE

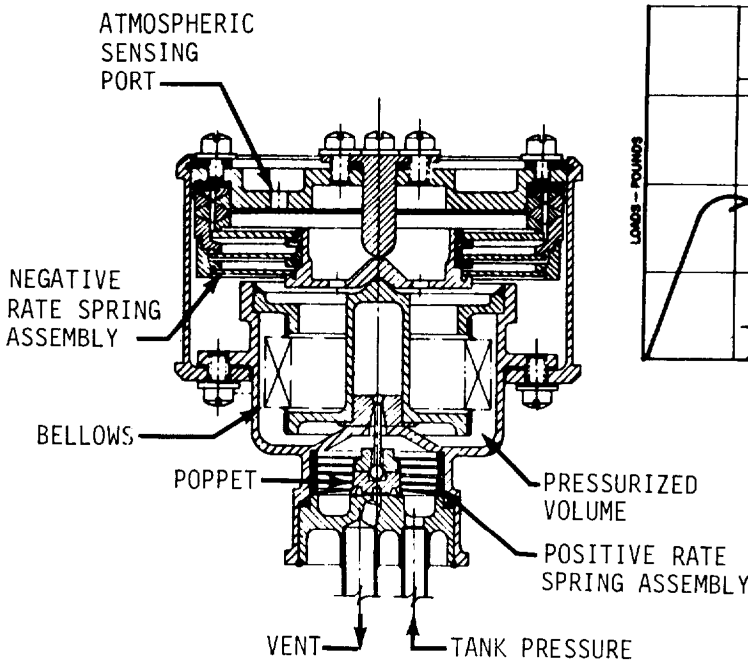


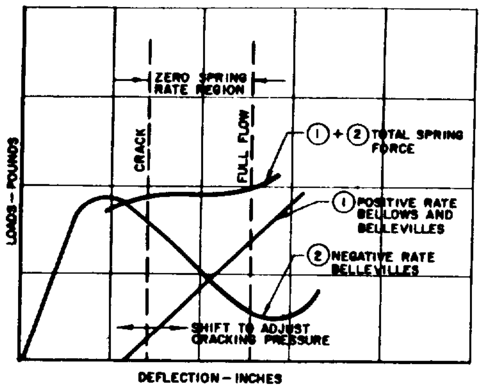
VALVE MODULE ENVELOPE



The system (tank) valve module for the hydrogen system and oxygen system are functionally indentical. Each module contains two relief valves, two pressure transducers, two pressure switches, and one check valve. These module components are each separately described on the following pages.

11 RELIEF VALVES



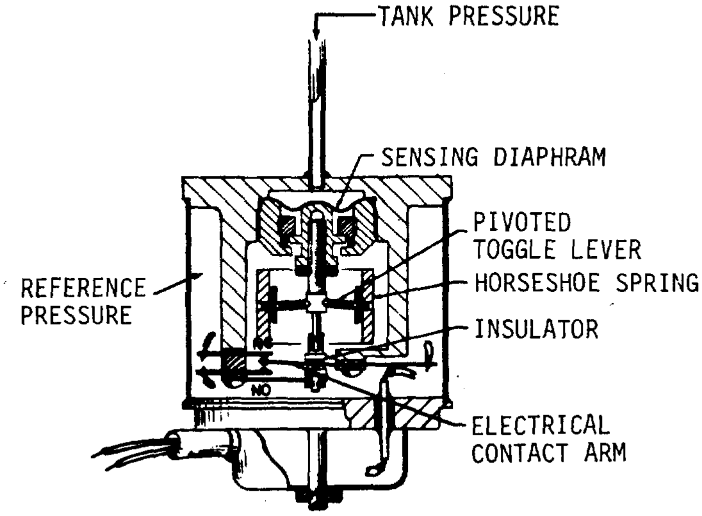


The relief valve, part of the system valve module, is differential type designed to be unaffected by back pressure in the downstream plumbing. The valve has temperature compensation and a self-aligning valve seat. The valve consists of an ambient pressure sensing bellows preloaded with a belleville spring, which operates a poppet valve. Virtually zero pressure increase between crack and full flow is obtained by cancelling out the positive spring rate of the pressure sensing element with a negative-rate belleville spring (see above right). The large sensing element and small valve produces large seat forces with a small crack-to-reseat pressure differential assuring low leakage at the reseat pressure. The Belleville springs are made of 17-4 PH and 17-7 PH stainless steels. The bellows is a three-ply device designed to prevent fractures due to resonant vibrations.

The relief crack pressure is 273 psig minimum for hydrogen tanks and 983 psig minimum for oxygen tanks. The valve is atmospheric sensing; therefore, relief crack pressure in space is 273 psia minimum for hydrogen and 983 psia minimum for oxygen.

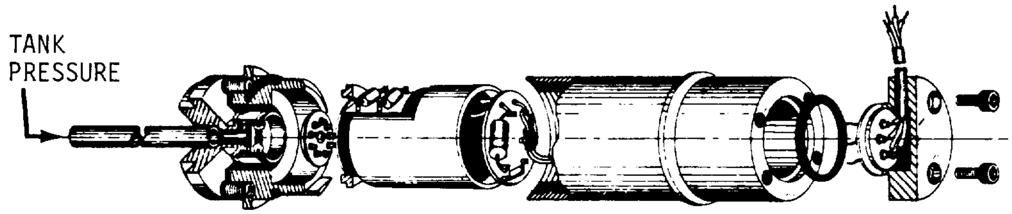
	Oxygen	Hydrogen
Full Flow Pressure	1010 psig (max.)	285 psig (max.)
Reseat Pressure	965 psig (min.)	268 psig (min.)

12 PRESSURE SWITCH



The pressure switch, part of the system valve module, is a double pole, single throw absolute device. A positive reference pressure (less than atmospheric) is used to trim the mechanical trip mechanism to obtain the required absolute switch actuation settings. The reference pressure is typically between 4 to 10 psia. A circular convoluted diaphragm senses tank pressure and actuates a toggle mechanism which provides switching to drive motor switch (Cryogenic Electrical Control Box Assembly). The motor driven switch controls power to both the tank heaters and destratification motors. The pressure switch body is 302 stainless steel and the diaphragm is 17-7 stainless steel. This unit is capable of carrying the current required by the motor driven switch without any degradation. The convoluted diaphragm actuates the switch mechanism in a positive fast manner which eliminates bounce and the resultant voltage transients.

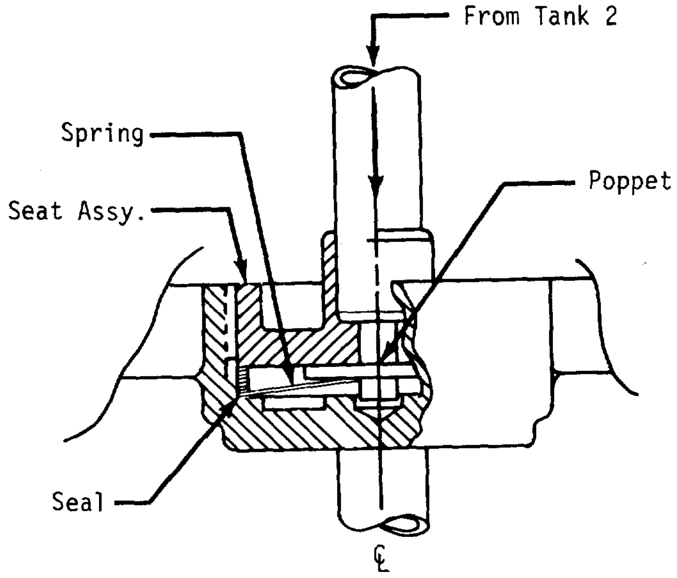
13 CRYOGENIC PRESSURE TRANSDUCER



The pressure transducer, part of the system valve module, is an absolute (vacuum reference) device. The transducer consists of a silicon pickup comprised of four sensors mounted on a damped edge diaphragm and an integral signal conditioner. The unit senses tank pressure through the discharge line from the tank. The signal conditioner output is a 0-5 VDC analog output which is linearly proportioned to tank pressure.

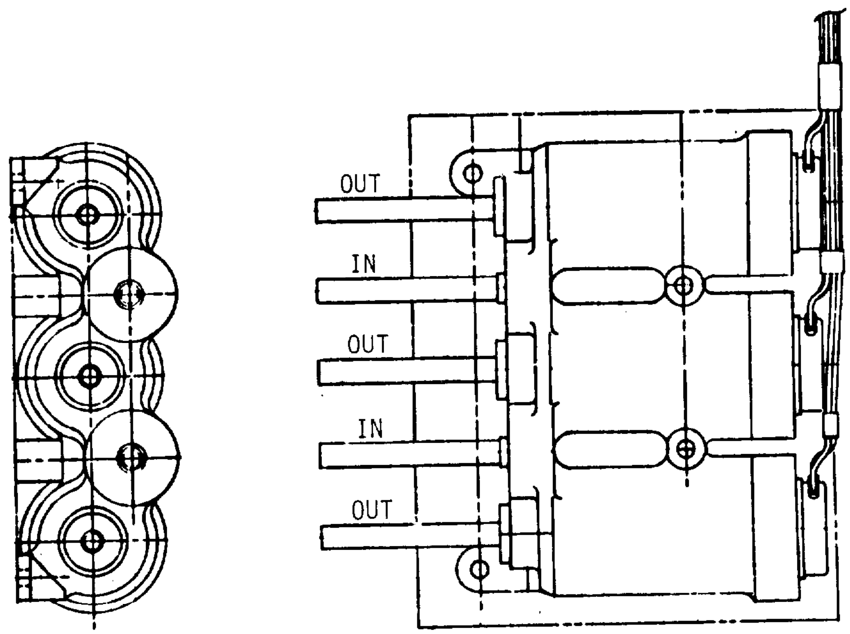
	Hydrogen	Oxygen
Range	0 to 350 psia	50 to 1050 psia
Accuracy	± 2.68 % full range	± 2.68 % full range
Output Voltage	0-5 V DC	0-5 V DC
Output Impedance	500 ohms	500 ohms
Power	1.5 watts	1.5 watts
Voltage	28 V DC	28 V DC

[14] CHECK VALVE (SYSTEM MODULE)

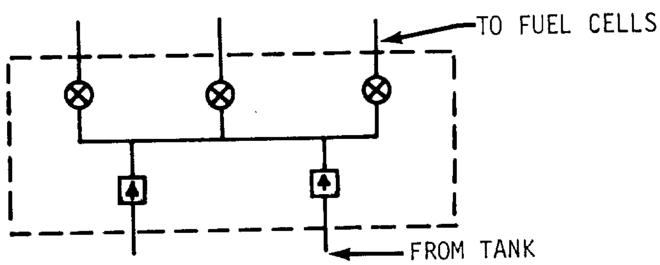


The check valve, part of the system valve module, is designed to open at a differential pressure of approximately 1 psia. The single poppet is spring loaded and has a large area to prevent chattering during flow in the normal direction. This large area also helps in obtaining a positive seal if pressurized in the reverse direction.

15 FUEL CELL VALVE MODULE



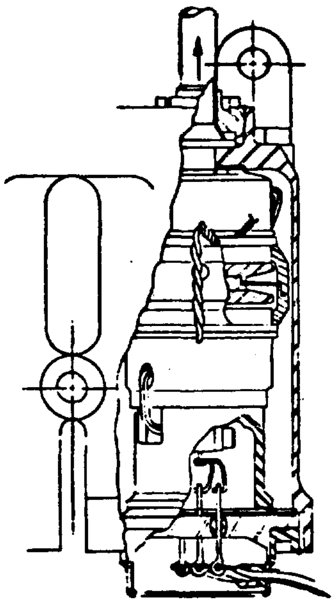
VALVE MODULE ENVELOPE

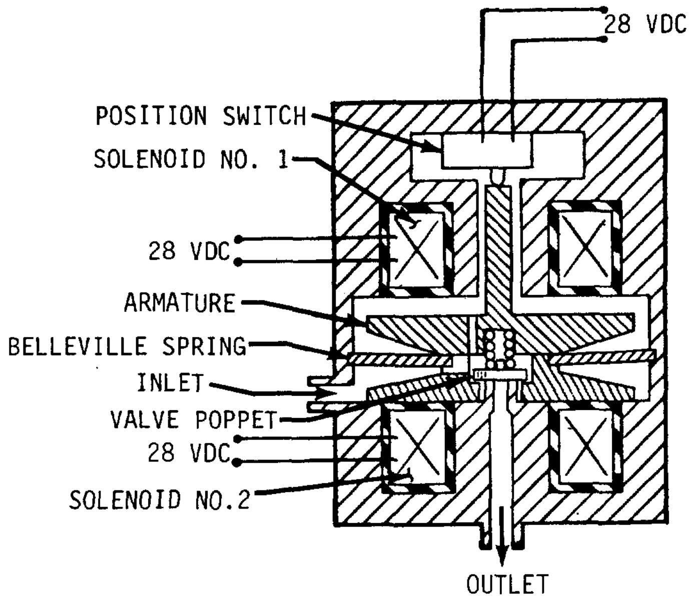


FLOW SCHEMATIC

The fuel cell valve module consists of two check valves and three solenoid shutoff valves contained in a cast body. The separate hydrogen and oxygen modules are functionally identical. Individual valve module components are described on succeeding pages.

16 SOLENOID VALVES

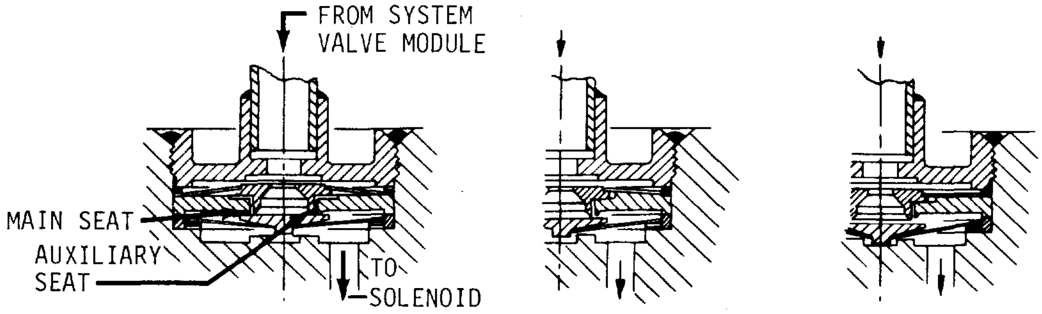




SIMPLIFIED

The solenoid valves, part of the fuel cell valve module, employ a poppet-seat arrangement. This poppet is actuated by a magnetic armature which is suspended on a Belleville spring. The upper solenoid is used to open the valve; the lower to close it. The snap-over-center belleville spring both guides the armatures and latches the valve open or closed. A switch to indicate valve closed position is incorporated. The valve opens against pressure and pressure helps seal the valve against leakage in the normal flow direction. The valve body is 321 stainless steel. The maximum in-rush current is 10 amps with steady state current at 2 amps. The solenoid coil circuit has diode noise suppression.

17 CHECK VALVE (FUEL CELL MODULE)



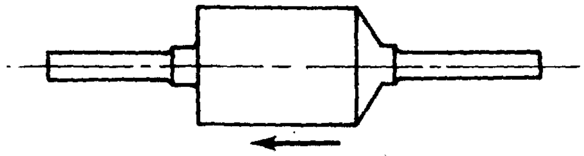
Seated - both main and auxiliary seats are closed.

Cracked - at low flows the auxiliary seat is barely open and catches contaminant particles, the main seat is wide open and protected from contaminants.

Full flow - both main and secondary seats are wide open; the high flow velocities carry particles through the valve without fouling the seat.

The check valve, part of the fuel cell module, is designed to open at a differential pressure of approximately 1 psia. The valve consists of a main seat and auxiliary seat operating as shown pictorially above. A large seat area provides a positive low leakage seal if pressurized in the reverse direction.

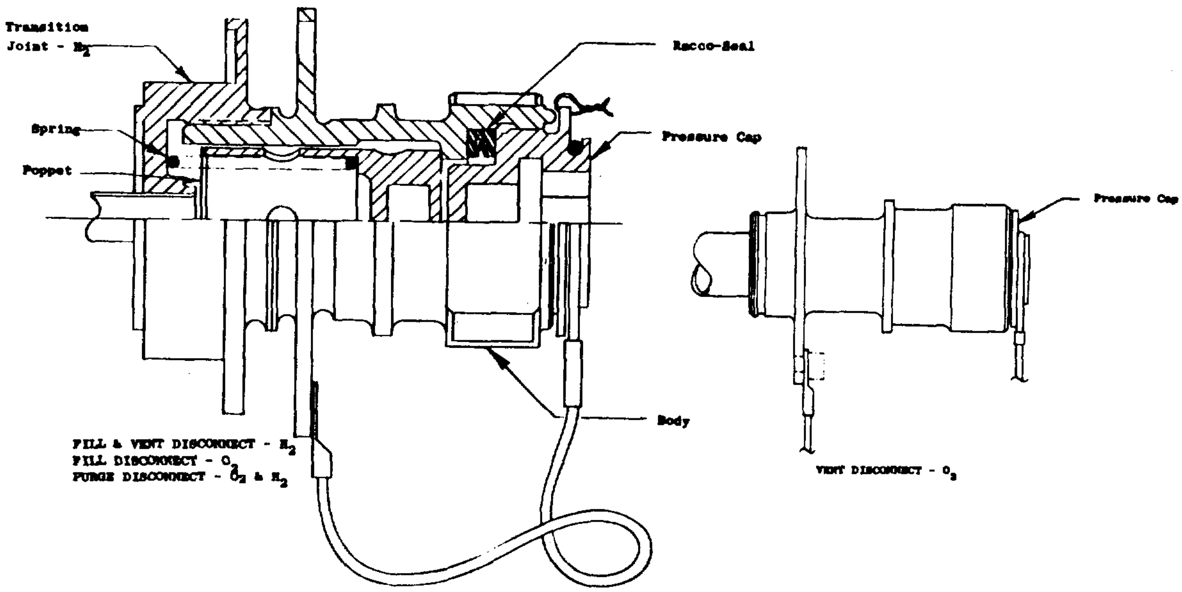
18 H_2-O_2 INLINE FILTER



FLOW DIRECTION

The hydrogen and oxygen reactant filter consists of a multiple of chemically etched discs. The discs are stacked on a mandrel-like cartridge. The filter is used to trap contamination which could get downstream of the reactant tank valve modules. The filter is rated at 5μ nominal and 12μ absolute with a dirt holding capacity of .25 grams. The filter design does not allow it to generate system contamination and provides closer adherence to specified filter rating.

19 FILL AND VENT DISCONNECTS - AIRBORNE



Each vent and fill disconnect utilizes a spring loaded poppet and a pressure cap that can be locked into place. The ground unit is connected by aligning grooves on the ground sleeve with keys on the airborne body, pushing until a stop is reached (about 40 lbs. force is required), and turning the ground sleeve until engagement is complete. The spring loaded poppets can be self opening on installation of mating ground disconnects, or can be opened subsequent to installation of the ground disconnect, depending on the type of ground unit that is used. The poppet is self closing on removal of the ground unit regardless of the type used.

7.4 FUEL CELL/CRYOGENIC SYSTEM FILTRATION

TABLE 7.4.1
FUEL CELLS/CRYOGENICS - FILTRATION

CRITICAL COMPONENT	MINIMUM CLEARANCE	FILTER PROTECTION		OTHER CHARACTERISTICS
		RATING - SIZE	LOCATION	
Secondary Bypass Valve	0 to 0.006 in. annulus tapered pintle depending on travel	-	No filter	-
Water/Glycol Pump		75μ nom. 100μ absolute Area = 6.6 in^2	Internal to Pump Inlet	Non Bypassing Type
Water Separator Check Valve	Hole Size = 0.030 in. dia Stem Clearance = 0.013 in. Max. Stroke = 0.048 in.	40μ absolute Area = 0.076 $in.^2$	Internal to Water Separator Pump	Made from Sinter Cd Powder
H_2 Pump		5μ nom. 12μ absolute Holding capacity = .25 grams [1]	Between H_2-O_2 Valve Module & H_2-O_2 Fuel Cell Module [1]	Chem Milled Stacked Disc Filter Element
Primary Bypass Valve	Bi-Metalic Flapper Stroke = 0.040 in. Clearance (min) at full regeneration = 0.013 in.	5μ nom. 12μ absolute Holding capacity = .25 grams [1]	Between H_2-O_2 Valve Module & H_2-O_2 Fuel Cell Module [1]	Chem Milled Stacked Disc Filter Element
H_2 Regulator	Valve seat clearance open = 0.008 in. Min. radial sliding clearance exposed to gas = 0.006 inches [2]	10μ nom. 25μ absolute Area 0.076 in^2	Internal to Regulator Inlet	Made from Sinter Powder

[1] Filtration also provided by filter at the H_2 Regulator Inlet (see H_2 Regulator)

[2] Valve open seat clearance is based on regulator flow conditions at 2200 watts plus purge for Apollo 8 regulator.

TABLE 7.4.1
FUEL CELLS/CRYOGENICS - FILTRATION (Continued)

CRITICAL COMPONENT	MINIMUM CLEARANCE	FILTER PROTECTION		OTHER CHARACTERISTICS
		RATING - SIZE	LOCATION	
H_2 Purge Valve	Ball travel from seat = 0.020 in. to 0.025 in. Min diametric clearance = 0.005 in.	6μ nom. 18μ absolute Area 0.35 in.^{2}	Internal to Valve Inlet	Cylindrical-Shaped Screen, Bypassing Type
1. H_2 Purge Valve Orifice (Valve exit)	0.0305 in. dia.	Protective screen (perforated cap) hole size = 0.008 in.	Internal and Upstream of Orifice @ Valve Exit	Lee Jet Size 0.0305 in. orifice, 750 LOHM
O_2 Regulator	Valve Seat clearance open = 0.005 in. Min. radial sliding clearance exposed to gas = 0.0035 in. [2]	10μ nom. 25μ absolute Area = 0.076 in^2	Internal to Regulator Inlet	Made from Sinter Powder
O_2 Purge Valve	Ball Travel from Seat = 0.020 in. to 0.025 in. Min. diametric clearance = 0.005 in.	6μ nom. 18μ absolute Area = 0.35 in^2	Internal to Valve Inlet	Cylindrical-Shaped Screen, Bypassing Type
1. O_2 Purge Valve Orifice (Valve exit)	0.0120 in. dia.	Protective screen (perforated cap) hole size = 0.008 in.	Internal and Upstream of Orifice @ Valve Exit	Lee Jet Size = 0.0120 in. orifice, 4500 LOHM

[2] Valve open seat clearance is based on regulator flow conditions at 2200 watts plus purge for Apollo 8 regulator.

TABLE 7.4.1

FUEL CELLS/CRYOGENICS - FILTRATION (Continued)

CRITICAL COMPONENT	MINIMUM CLEARANCE	FILTER PROTECTION		OTHER CHARACTERISTICS
		RATING - SIZE	LOCATION	
N_2 Vent Valve	Ball seal .020 to .025 inches from seat. Valve pintle travel from sealing seat is .010-.012 in. Maximum diametric clearance .006 inches.	6μ nom. 18μ absolute Area = 0.35 $in.^2$	Internal to Valve Inlet	Cylindrical-Shaped Screen, Bypassing Type
1. N_2 Vent Valve Orifice	0.0186 in. dia.	Protective screen (perforated cap) hole size = 0.008 in.	Internal and Upstream of Orifice @ Valve Exit	Lee Jet Size = 0.0186 in. orifice, 2000 LOHM
2. N_2 Vent Valve Vent Port Plug		6μ nom. 18μ absolute Area = 0.15 $in.^2$	Internal to Valve Exit	Cylindrical Screen
N_2 Fill Valve	Ball seal .020 to .025 inches from seat. Valve pintle travel from sealing seat is .010-.012 in. Minimum diametric clearance .005 inches.			
1. Inlet Port		6μ nom. 18μ absolute Area = 0.034 $in.^2$ (Min)	Internal to Valve Inlet	Disc-shaped Screen
2. Interstage 3. Exit Port		6μ nom. 18μ absolute Area = 0.074 $in.^2$ (Min)	Internal to Valve at Interstage and Exit Port	Cylindrical Screen
N_2 Regulator	Valve Seat Clearance Open, 0.0015 in. Min. radial sliding clearance exposed to gas = 0.0035 in. [2]	10μ nom. 25μ absolute Area 0.076 $in.^2$	Internal to Regulator Inlet	Made from Sinter Powder

[2] Valve open seat clearance is based on regulator flow conditions at 2200 watts plus purge for Apollo 8 regulator.

TABLE 7.4.1
FUEL CELLS/CRYOGENICS - FILTRATION (Continued)

CRITICAL COMPONENT	MINIMUM CLEARANCE	FILTER PROTECTION		OTHER CHARACTERISTICS
		RATING - SIZE	LOCATION	
N_2 Regulator Overboard Vent Port Plug		200 MESH screen 0.0018-0.0026 in. dia. wire	Internal to Regulator Exit	Screen Twill or Plain
Metering Orifice	0.0215 in. dia.	Protective screen (perforated cap) hole size = 0.008 in.	Between N_2 Regulator and O_2 & H_2 Regulators	None
Radiator Bypass Valve Main Valve Bypass Valve Orifice/Stroke Main Valve Bypass Valve	 0.0015 to 0.003 in. 0.002 to 0.004 in. 0.156 in/0.060 in. 0.420 in/0.018 in.	None at Valve Provided by Pump Inlet Filter	Filtration Filter at Coolant Pump Inlet	
Valve Module, H_2 (Consists of 2 relief valves, 2 press. switches, 2 press. transducers, and one check valve)		175μ absolute Area = 0.97 in^2	Internal to H_2 Cryogenic Tanks Outlet	Chem Milled Stacked Disc Filter Element
Valve Module, O_2 (Consists of 2 relief valves, 2 press. switches, 2 press. transducers, and one check valve)		175μ absolute Area = 0.97 in^2	Internal to O_2 Cryogenic Tanks Outlet	Chem Milled Stacked Disc Filter Element

TABLE 7.4.1

FUEL CELLS/CRYOGENICS - FILTRATION (Continued)

CRITICAL COMPONENT	MINIMUM CLEARANCE	FILTER PROTECTION		OTHER CHARACTERISTICS
		RATING - SIZE	LOCATION	
H_2-O_2 Fuel Cell Valve Module (Consist of 2 check valves and 3 solenoid valves each)		5μ nom. 12μ absolute Holding capacity = .25 grams	Between H_2-O_2 Valve Module and H_2-O_2 Fuel Cell Module	Chem Milled Stacked Disc Filter Element