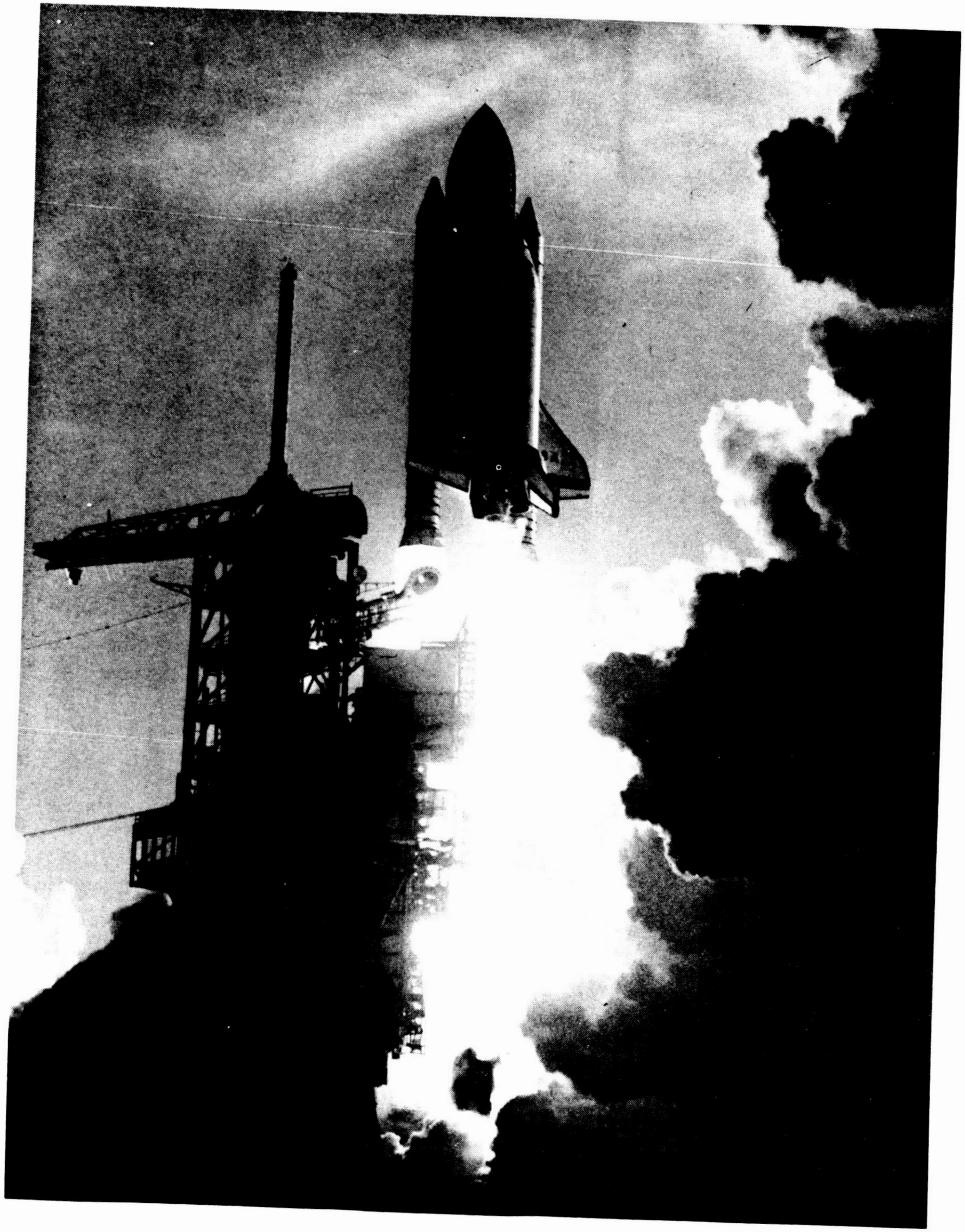

Zero-G Thermodynamic Vent System for Shuttle/Centaur

Presented by
Richard E. Niggemann

SUNDSTRAND

N88-15944
519-18
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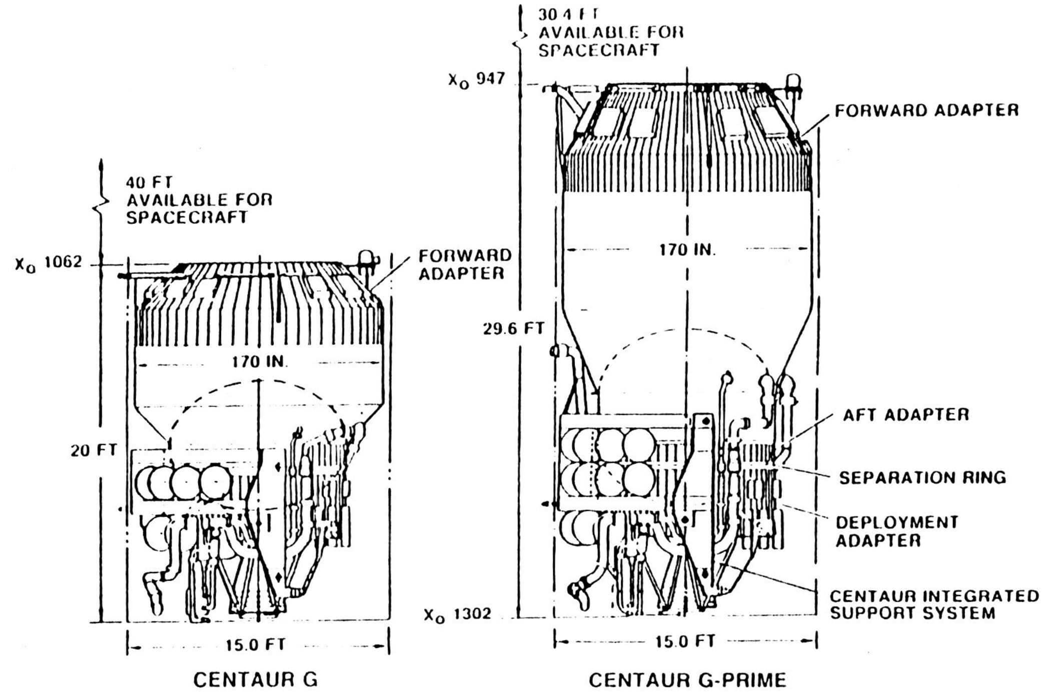
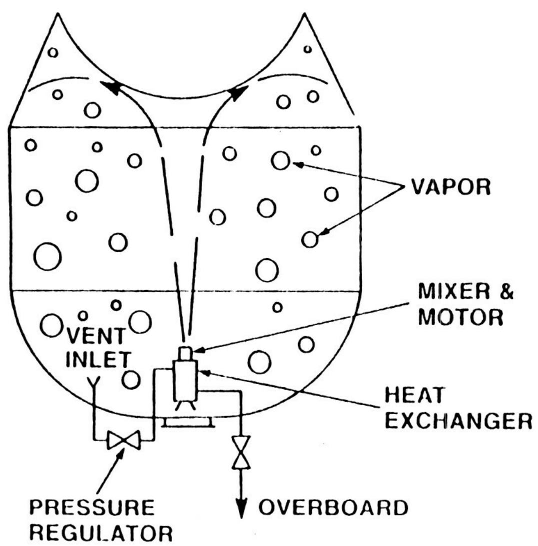
Centaur Configurations



Zero-G TVS

Requirement: Vent to Control Tank Pressure Rises Caused by Propellant Tank Heating



Component Design Requirements

Mixer

- To Provide: (a) Thermal Equilibrium Mixing of Bulk Propellants, and (b) Heat Exchange Mechanism Between Tank Fluid and Vent Fluid

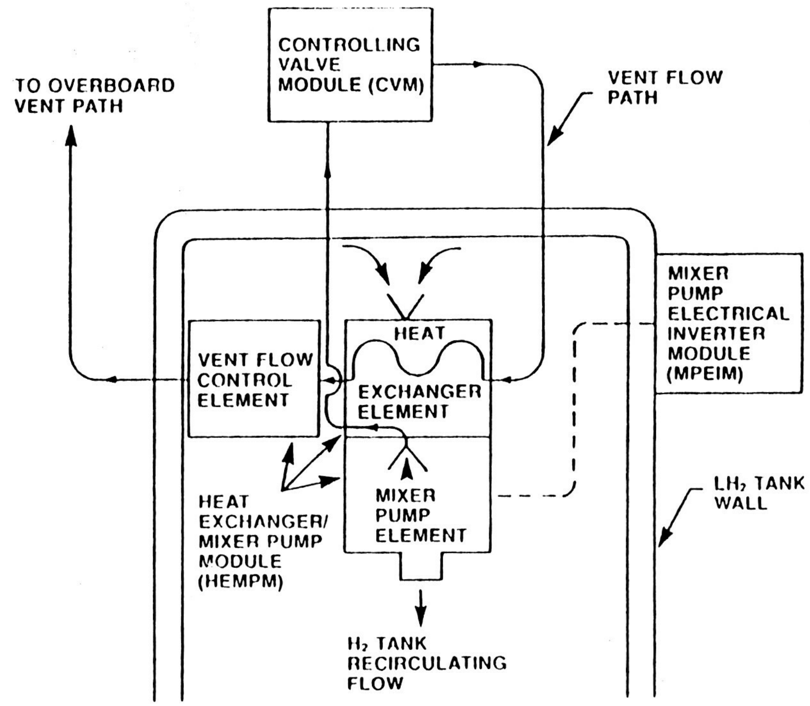
Heat Exchanger

- Lowers Bulk Energy Level
- Assures Pure Vapor Venting Regardless of Fluid Quality at System Inlet

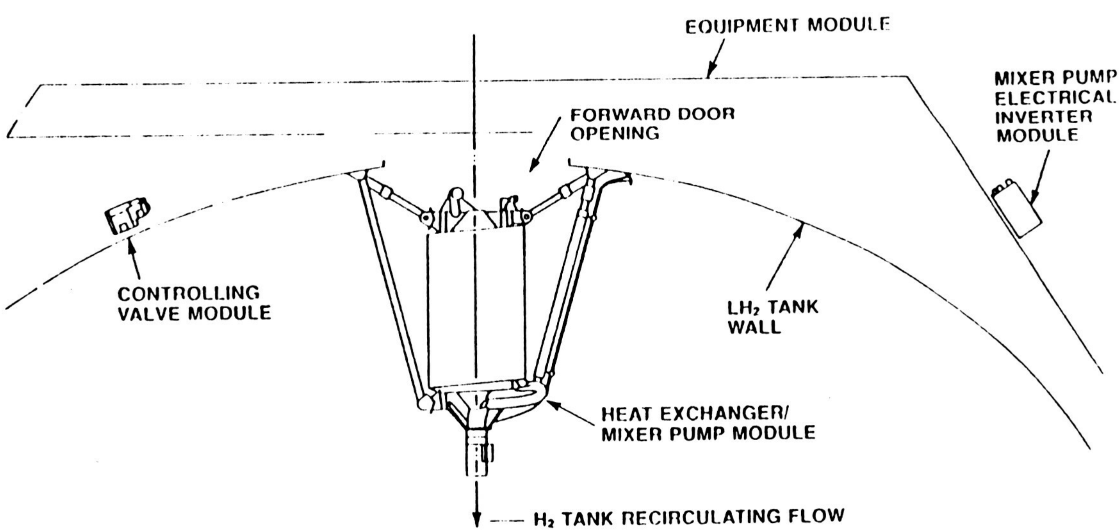
Pressure Regulator

- Controls Vent Side Fluid Pressure

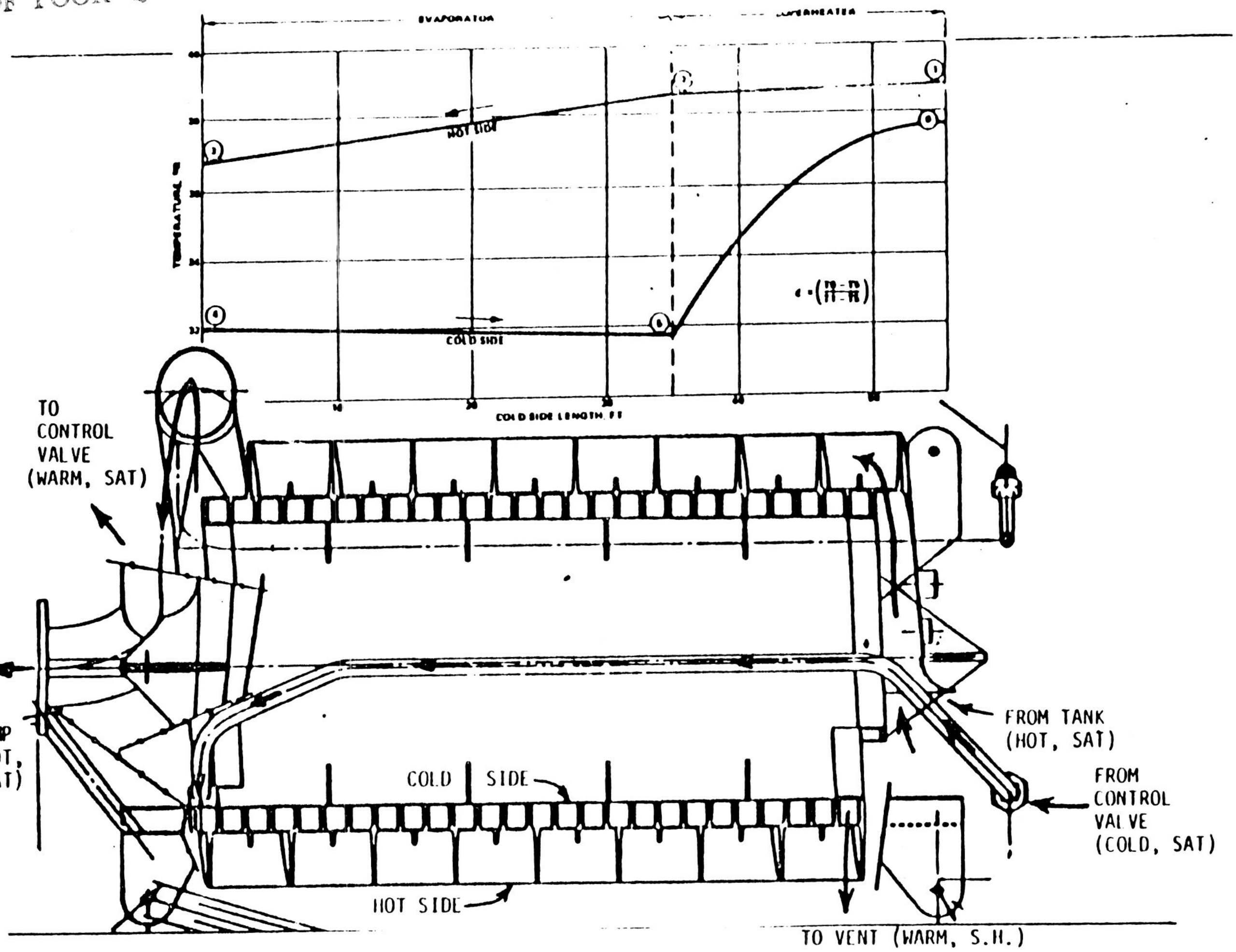
Zero-Gravity TVS Block Diagram



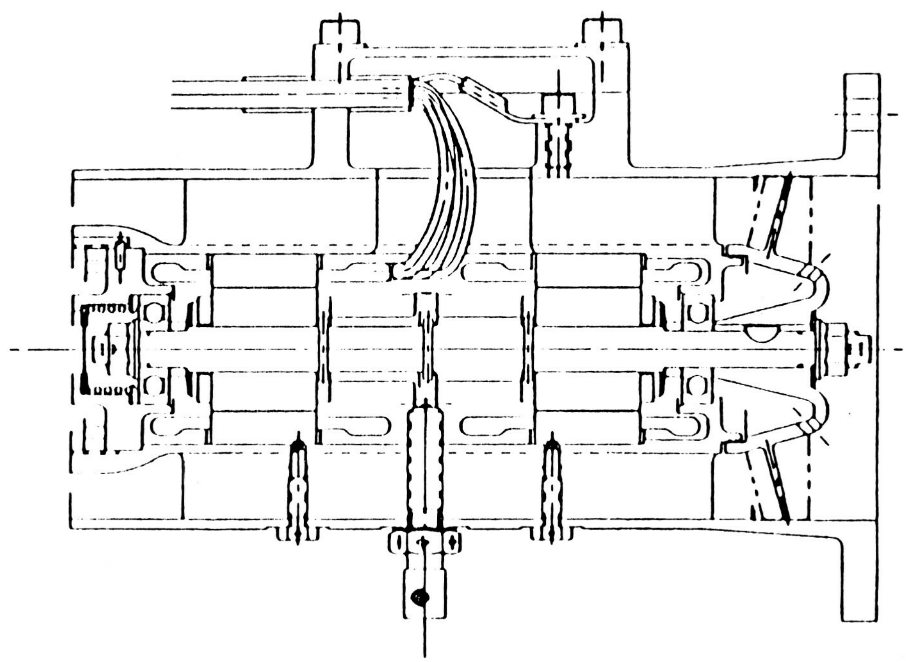
TVS System



HEAT EXCHANGER



Zero Gravity TVS Mixer Pump



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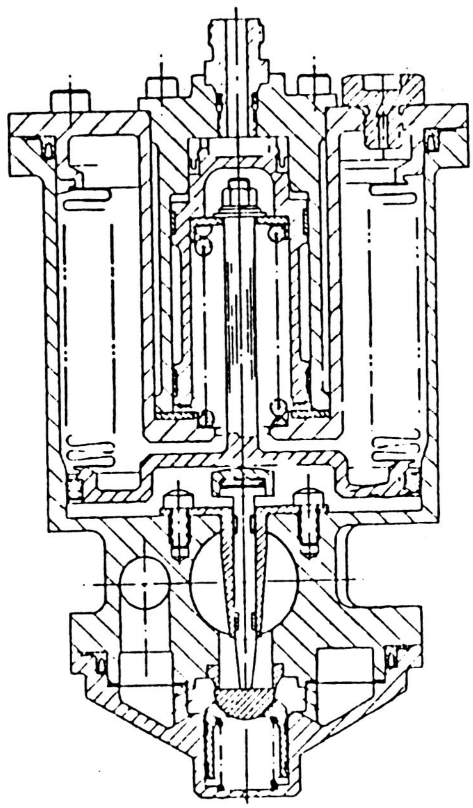
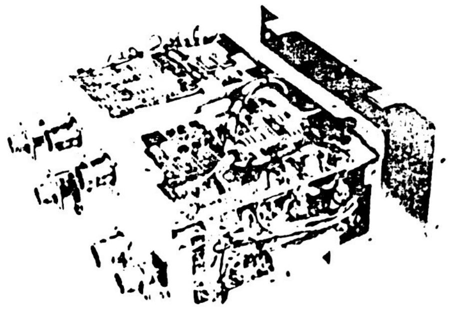
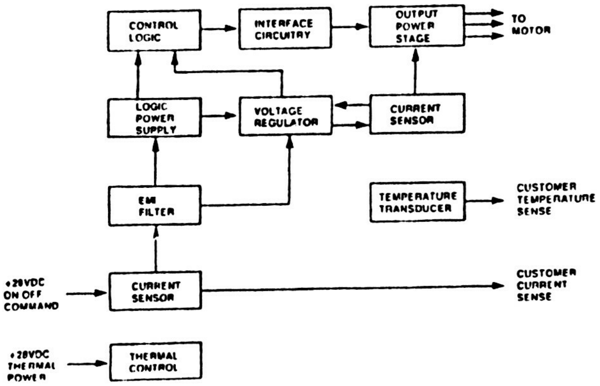
CVM



Shuttle Centaur - Hydrogen Vent Motor Pump Inverter

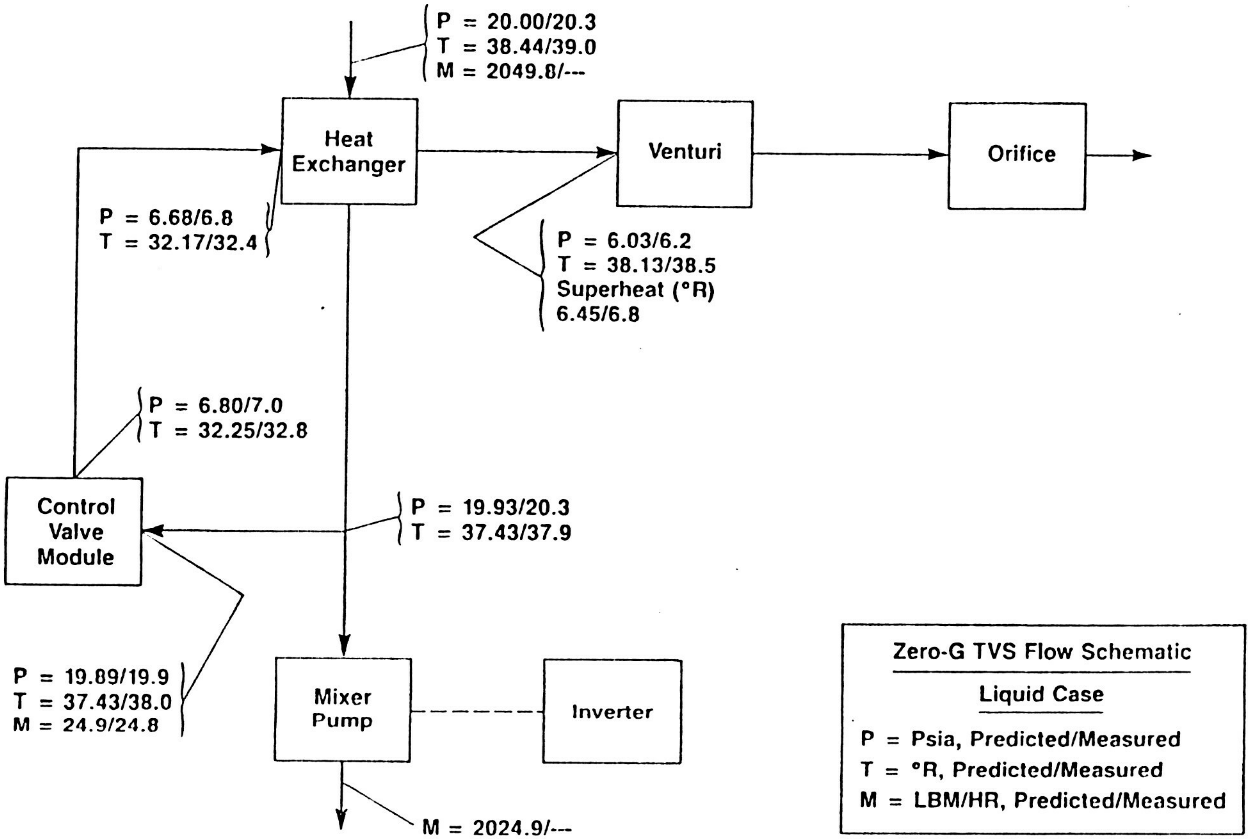


- Dual Redundant Inverters
- Built-In Thermal Control and Voltage/Current Protection
- Radiative Heat Dissipation
- 40 Watts Per Channel Max. 20 Watts Per Channel Nominal
- 28 Volts DC Input
- 7.5 Volts, 112 Hz, 3ϕ Output
- 7 Pounds Dual Inverter Packaged

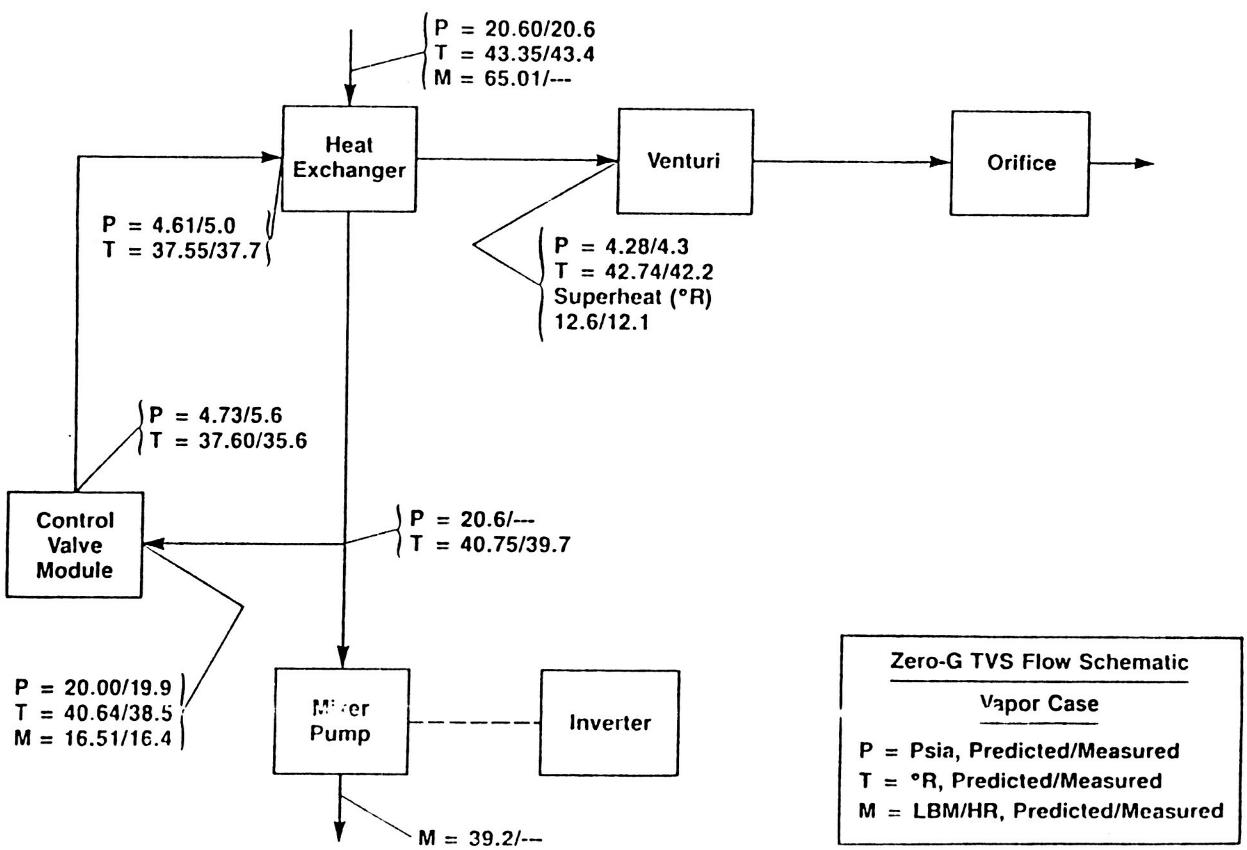


Inverter Block Diagram

TVS Liquid Flow Operation



TVS Vapor Flow Operation



Cryogenic Performance Summary

CVM Inlet Condition	CVM Outlet Pressure (Psia)		Vent Flow Rate (Lbm/Hr.)		Superheat (°R)		Liquid Carryover	
	Measured	Required	Measured	Required	Measured	Required (Min.)	Measured	Required
Liquid 20.2 psia	7.2	6.3-7.2	26.3	23-27	6.3	5	0	Less Than .06 Lbm per vent cycle
Liquid 24.8 psia	7.1	6.3-7.2	24.8	23-27	8.3	6.5	0	
Vapor 20.9 psia	6.7	6.3-7.2	19.7	18.7-22.7	10.2	7	0	
VR = .05-.15, P = 25.2 psia	6.5	6.3-7.2	22.5	21-25	9.3	7	0	
VR = .2-.35, P = 24.7 psia	6.5	6.3-7.2	22.2	21-25	9.5	7	0	
VR = .4-.6, P = 25.2 psia	6.5	6.3-7.2	22.1	21-25	9.5	7	0	
VR = .80-.95, P = 25.1 psia	6.3	6.3-7.2	21.5	21-25	9.7	7	0	
Vapor T = 252 °R T = 21.1 psia	6.5	6.3-7.2	7.3	7 Min.	N.A.	N.A.	N.A.	N.A.

V.R. = Vapor and Liquid Mixture Ratio, Vapor Volume/Total Volume
N.A. = Not Applicable

SPEAKER: RICHARD E. NIGGEMANN/SUNSTRAND CORPORATION

Harold Duncan:

How much power does the TVS motor require?

Niggemann:

I don't recall what the motor power was, but I think it was approximately 7.5 Watts. This was not a continuous vent system; this was an intermittent type system that was designed for the 25 pounds per hour vent rate when it was on.

David Chato/Lewis Research Center:

I was wondering on your test data whether that was one-G data or zero-G data?

Niggemann:

This was one-G data, and all the testing with hydrogen was done at Convair's Sycamore Canyon facility. I can say that the expected zero-G performance is good, based on a experiment that I was involved in about a week and a half ago on the K-bird down at NASA JSC. We flew a two phase thermal management system experiment on our 114 that utilized an evaporator that was based on curvilinear flow. We have data on how that performs in the two-G and the zero-G environments. We have not yet received all the data from Johnson, however, based on the experiments that we have done on that evaporator in several orientations in one-G, plus some other data that we've taken in cooperation with McDonnell Douglas Aircraft on a similar evaporator for high Gs, up to 9-Gs, we expect its performance to be very good and even better in zero-G.