

**IBM**

HAROLD F. VAN SLYKE  
IBM DEPT 906  
**Saturn IB/V - Instrument Unit**

**Technical Manual**

MSFC No. III-5-509-5  
IBM No. 66-966-0009

# **Environmental Control System Description**



**MSFC No. III-5-509-5**

**IBM No. 66-966-0009**

**TECHNICAL MANUAL**

**SATURN IB/V INSTRUMENT UNIT  
ENVIRONMENTAL CONTROL SYSTEM  
DESCRIPTION**

Prepared under Contract

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Federal Systems Division

Huntsville, Alabama

**15 March 1966**



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## PREFACE

This manual provides system-level information on the Environmental Control System for the Saturn Launch Vehicle Instrument Unit.

Information is presented for familiarization purposes in the following areas:

- Description of the system
- Principles of operation
- Removal and replacement of components
- General servicing instructions
- Spare parts list

This edition contains data on Instrument Unit SA-203. Design changes, updating information, and coverage of subsequent Instrument Units will be added as new data becomes available.



## LIST OF RELATED DOCUMENTS

The following manuals have been published under NASA contracts as source and reference information on IU systems and/or components.

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit Structure Repair Manual	65-966-0011H	III-5-510-1	1 September 1965	1 January 1966
Auxiliary Power Distributors	65-966-0013H	III-5-510-2	1 October 1965	
Power Distributor	65-966-0014H	III-5-510-3	1 October 1965	
Emergency Detection System Distributor	65-966-0015H	III-5-510-4	1 October 1965	
Control Distributor	65-966-0016H	III-5-510-5	1 October 1965	
Measuring Distributors	65-966-0017H	III-5-510-6	1 October 1965	
56 Volt Power Supply	65-966-0018H	III-5-510-7	1 October 1965	
5 Volt Measuring Voltage Supply	65-966-0019H	III-5-510-8	1 October 1965	
Saturn IB/V Instrument Unit Switch Selector, Model II	66-966-0001	III-5-510-9	1 February 1966	
Saturn IB/V Instrument Unit Component Handling Equipment, Description and Operating Instructions	66-966-0005	III-5-510-10	1 February 1966	
Saturn IB/V Instrument Unit C-Band Radar Transponder Set SST-135C	66-966-0008	III-5-510-11	31 July 1964	1 March 1966
Saturn IB/V Instrument Unit Control-EDS Rate Gyro Package	66-966-0013	III-5-510-13	1 March 1966	
Saturn IB/V Instrument Unit Control Signal Processor	66-966-0014	III-5-510-14	1 March 1966	
Saturn IB/V Instrument Unit Flight Control Computer	66-966-0015	III-5-510-15	15 March 1966	
Saturn IB/V Instrument Unit Instrumentation System Description	65-966-0021H	III-5-509-1	1 April 1966	
Saturn IB/V Instrument Unit Navigation, Guidance, and Control System	66-966-0003	III-5-509-2	1 February 1966	

LIST OF RELATED DOCUMENTS (Cont)

Title	Number		Published Date	Changed Date
	IBM	MSFC		
Saturn IB/V Instrument Unit System Test Reference Manual Volume I Control System Volume II Guidance System Volume III ST-124M-3 Inertial Stabilizer System	66-966-0004	III-5-509-3	1 March 1966	
Saturn IB/V Instrument Unit System Description and Component Replacement Data	66-966-0006	III-5-509-4	1 March 1966	
Saturn IB/V Instrument Unit Environmental Control System Description	66-966-0009	III-5-509-5	15 March 1966	
Apollo-Saturn Emergency Detection System Description	66-966-0010	III-5-509-6	1 March 1966	

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## SECTION I

# INTRODUCTION AND DESCRIPTION

### 1-1 SYSTEM INTRODUCTION

An Environmental Control System (Figure 1-1) is provided in the Instrument Unit and the S-IVB Stage of the Saturn IB and V Launch Vehicles. The relative location of the Environmental Control System within the Instrument Unit is shown in Figure 1-2. With the exception of ducting, manifolds, and mounting and thermal conditioning panels, the major components of the system are located at panels 6 and 22. The ducting, manifolds, and mounting and thermal conditioning panels are installed around the entire inside circumference of the Instrument Unit and S-IVB Stage.

Because of the functions required, the system is composed of three separate systems which serve three distinct and separate purposes.

- The Thermal Conditioning System cools the Astrionics equipment during prelaunch and flight by maintaining the coolant in the system at  $15^{\circ} \pm 0.5^{\circ}\text{C}$  ( $59^{\circ} \pm 1^{\circ}\text{F}$ ).
- The Gas Bearing Supply System furnishes gaseous nitrogen ( $\text{GN}_2$ ) at a regulated temperature and pressure to lubricate the gas bearings in the ST-124M-3 Inertial Platform Assembly.
- The Preflight Air/ $\text{GN}_2$  Purge System maintains an inert environment in the Instrument Unit and S-IVB Stage by furnishing a temperature and pressure regulated supply of filtered air and gaseous nitrogen to these compartments.

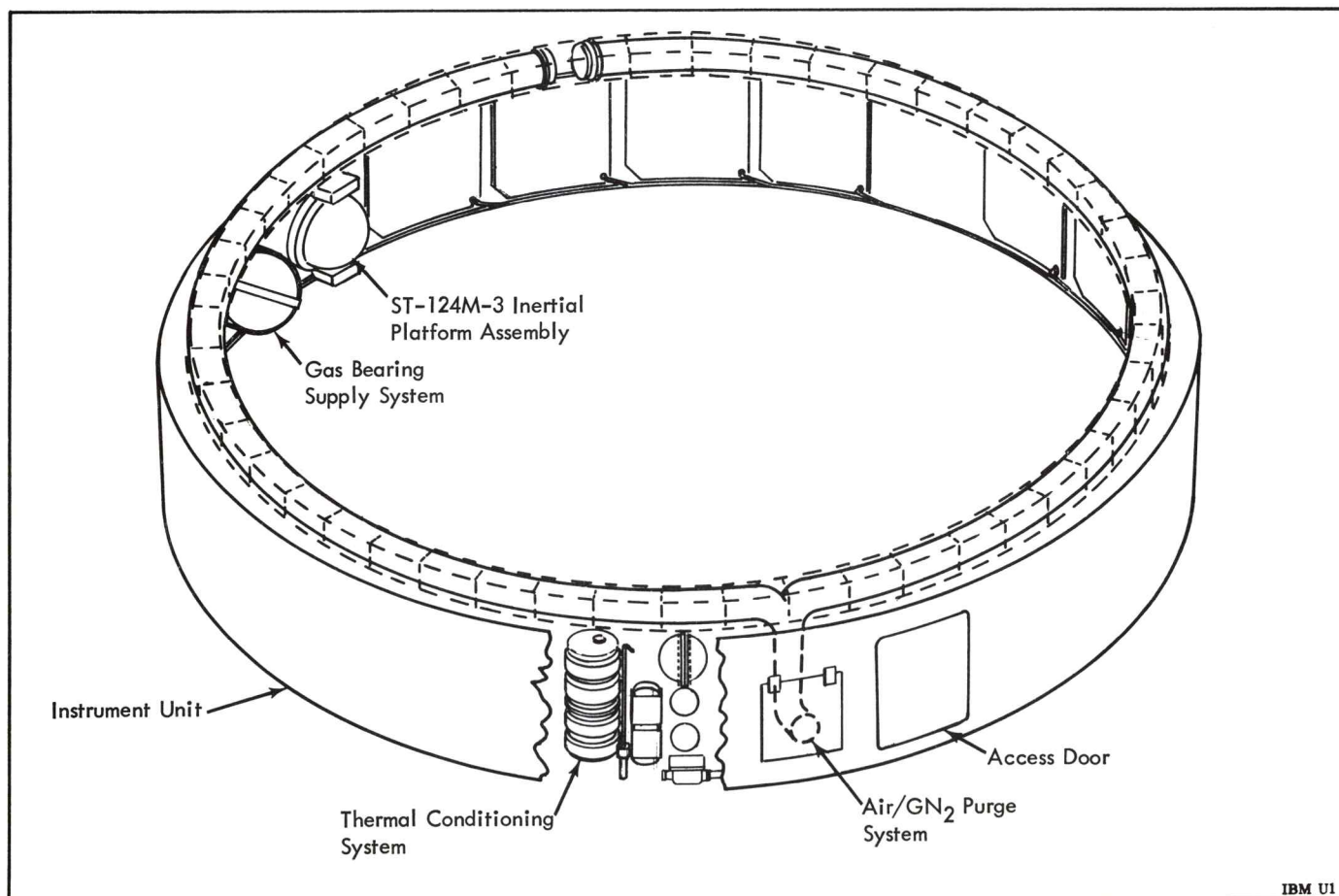
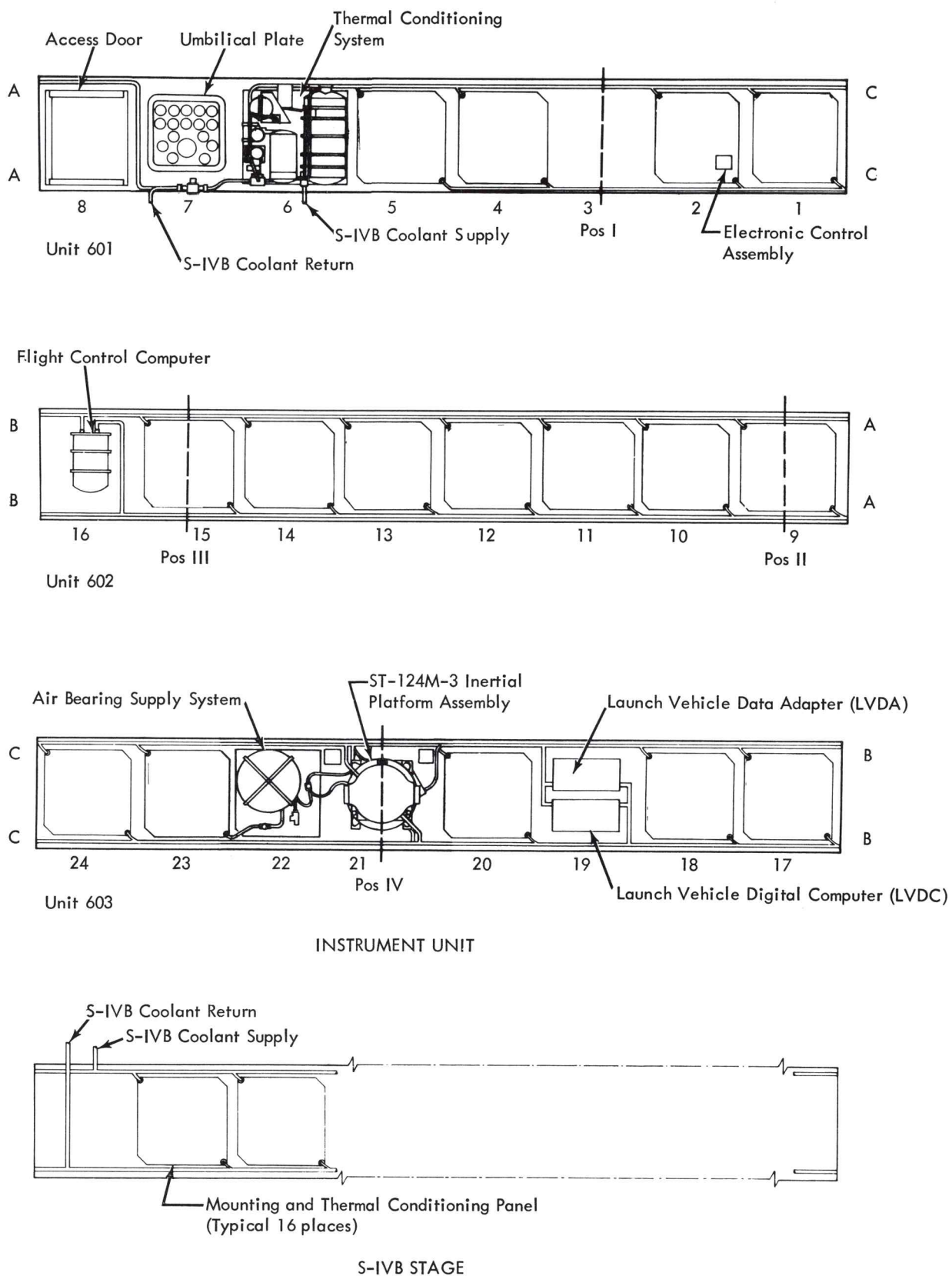


Figure 1-1. Environmental Control System



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Figure 1-2. Thermal Conditioning System and Gas Bearing System Location

Although the Thermal Conditioning and the Gas Bearing Supply Systems are separate systems, they do not operate independently of each other. The Thermal Conditioning System does not rely on the Gas Bearing Supply System and could operate independently; however, gaseous nitrogen is heated or cooled as required when it passes through the Gas Bearing Heat Exchanger prior to entry into the ST-124M-3 Inertial Platform Assembly. The Preflight Air/GN<sub>2</sub> Purge System is a separate system and functions independently of either the Thermal Conditioning or the Gas Bearing Supply System. All three systems operate concurrently during prelaunch.

## 1-2 SYSTEM DESCRIPTION

The three separate systems which make up the Environmental Control System are composed of methanol/water coolant, gaseous nitrogen, distilled water, manifolds, ducting, mounting and thermal conditioning panels, and the operating components identified in Figures 1-3 and 1-4. Details of the components that comprise the complete system are given in Tables 1-1, 1-2, and 1-3.

## 1-3 THERMAL CONDITIONING SYSTEM

The Thermal Conditioning System is a closed-loop system utilizing a coolant mixture of 60 percent methanol and 40 percent water by weight. The closed-loop system, through which the coolant circulates, is composed of the mounting and thermal conditioning panels, operating components, and equipment having integral coolant passages. The Launch Vehicle Digital Computer, the Launch Vehicle Data Adapter, the Flight Control Computer, and the ST-124M-3 Inertial Platform Assembly are not components of the system, but are integrally cooled units connected directly into the closed-loop system by quick disconnects. These units are cooled by the circulating coolant while serving as a flow channel in the closed-loop system.

The Thermal Conditioning System consists of the items listed in Table 1-1 plus the associated plumbing necessary to complete the system.

The manually operated shut-off valve has no in-flight function and is used only during filling of the

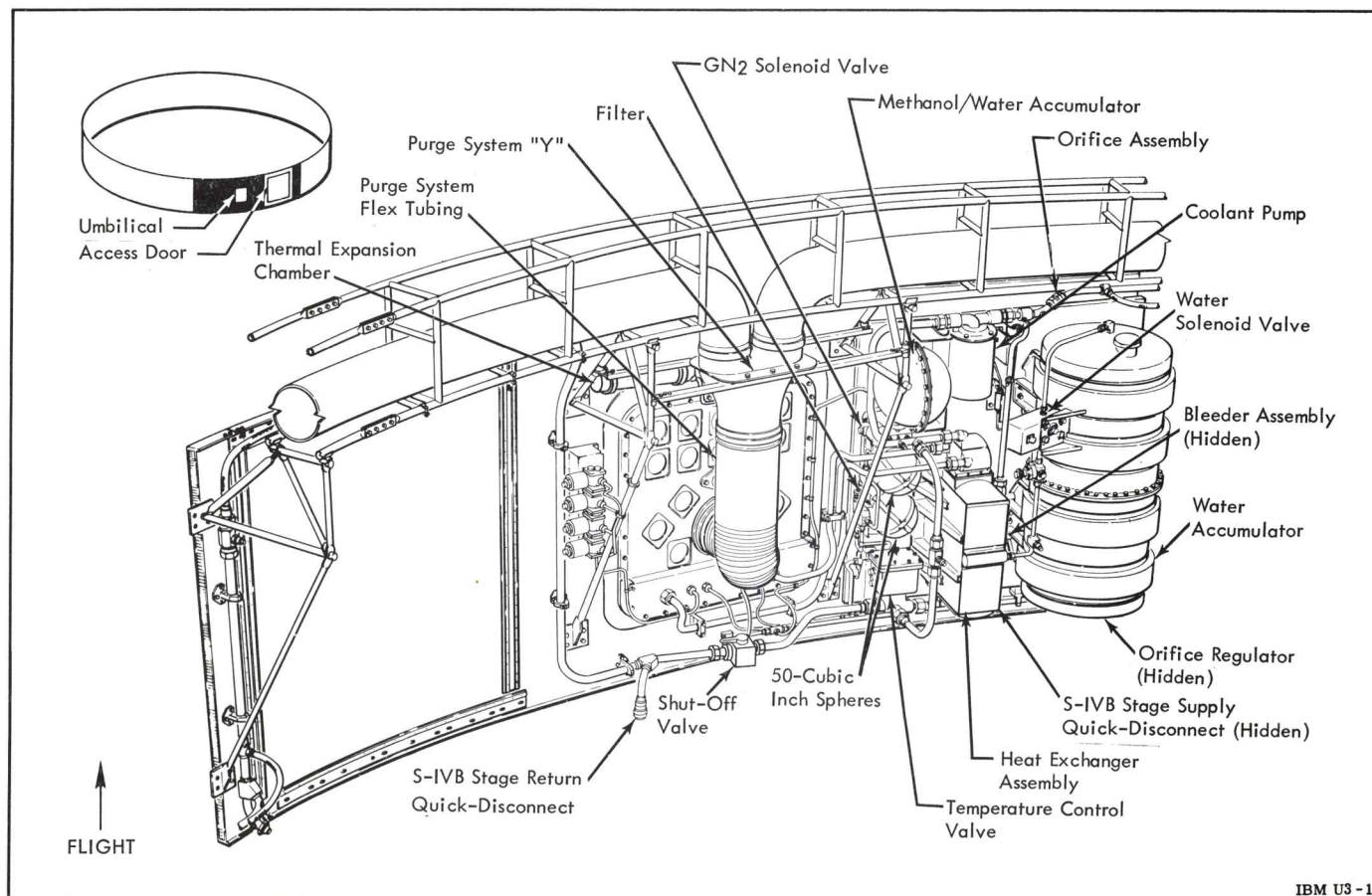


Figure 1-3. Major Components of Thermal Conditioning and Air/GN<sub>2</sub> Purge Systems (Sheet 1 of 2)



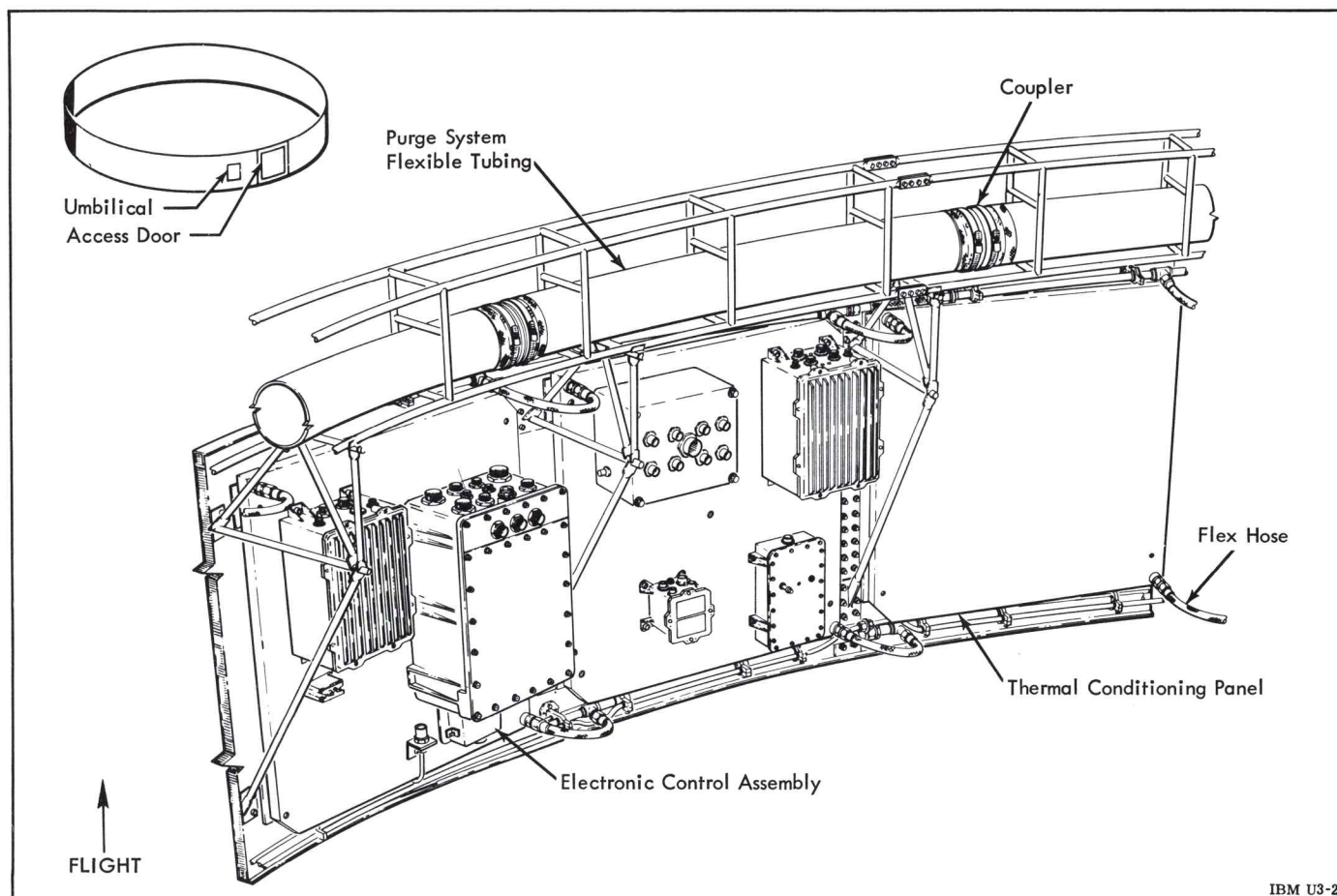


Figure 1-3. Major Components of Thermal Conditioning and Air/GN<sub>2</sub> Purge Systems (Sheet 2 of 2)

system. It is located on the manifold coolant return line near the quick disconnect that is just inside the umbilical panel.

The preflight heat exchanger has two separate circulatory sections, and two separate sources of coolant circulating through each section to perform the basic cooling function during prelaunch. A temperature controlled methanol/water mixture supplied by the ground support equipment is circulated through one section thus cooling the closed-loop coolant that flows through the other section.

The mounting and thermal conditioning panels, which are known as "cold plates", form a mounting surface for most of the electronic equipment that requires cooling. The system contains 16 cold plates in the Instrument Unit and 16 in the S-IVB Stage. Figure 1-5 shows a cold plate mounted in place on the Instrument Unit structure. Figure 1-6 illustrates a cutaway view of the cold plate showing the honeycomb back-up structure and the details for coolant flow and component mounting.

The holes on the face of the cold plate are located on a 2-inch-square grid pattern.

Each item in the system through which the coolant or the GN<sub>2</sub> flows has the direction of flow or inlet and outlet ports plainly marked.

#### 1-4 GAS BEARING SUPPLY SYSTEM

The Gas Bearing Supply System consists of the components listed in Table 1-2 plus the associated plumbing necessary for the flow of GN<sub>2</sub> to the using assembly. Most of the Gas Bearing Supply System components are mounted on the Gas Bearing Supply System mounting panel, which is located at panel 22 within the Instrument Unit. The Gas Bearing Heat Exchanger is located on panel 21 (Figure 1-4). The Gas Bearing Heat Exchanger is constructed of coiled-loop tubing inside an enclosed shell-like structure. Methanol/water coolant at a constant temperature circulates through the shell and cools or heats the GN<sub>2</sub> flowing through the coiled-loop tubing.

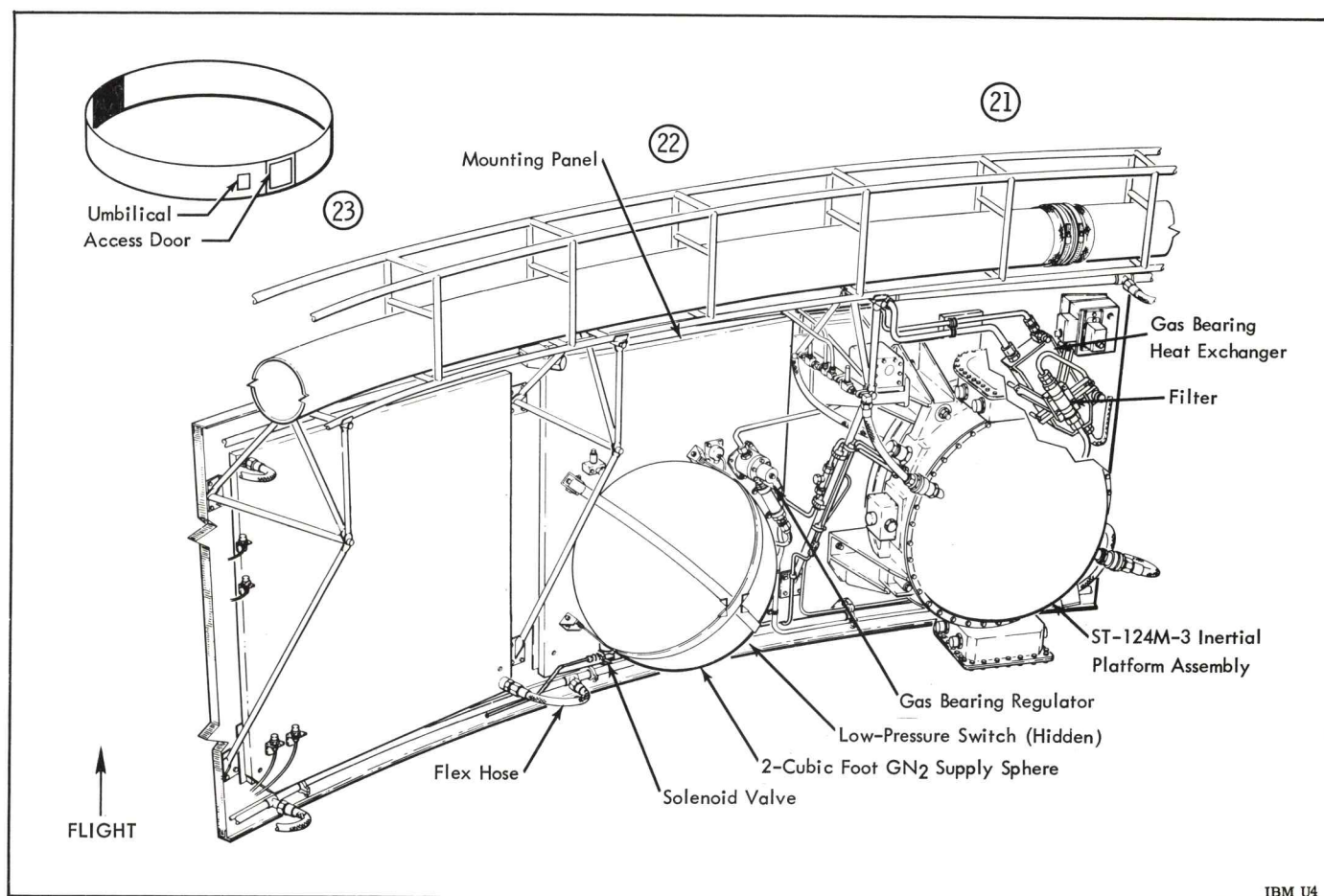


Figure 1-4. Major Components of Gas Bearing Supply System

The ST-124M-3 Inertial Platform Assembly is not a component of the Gas Bearing Supply System, but it uses the  $\text{GN}_2$  that is furnished, therefore its relationship is one of completion of the system.

#### 1-5 PREFLIGHT AIR/ $\text{GN}_2$ PURGE SYSTEM

The items which comprise the Preflight Air/ $\text{GN}_2$  Purge System are listed in Table 1-3. System ducting is supported by a bridge-type structure attached to the Instrument Unit. Segments of the ducting routed both ways from a system "Y", are joined together by connectors to form a broken circle around the inside of the upper edge of the Instrument Unit. Both ends are capped to force distribution of air or  $\text{GN}_2$  out through the regularly spaced holes in the ducting. Ventilating air is provided through the

ducting during preflight checkout of the Instrument Unit. During fueling operations the system maintains an inert  $\text{GN}_2$  atmosphere in the Instrument Unit and the upper S-IVB Stage, thus preventing an accumulation of dangerous and corrosive gases which might affect operation and safety.

#### 1-6 LEADING PARTICULARS

Detail descriptions and leading particulars of the individual components which comprise the Environmental Control System of the Instrument Unit and the S-IVB Stage are given in Tables 1-1, 1-2, and 1-3. These tables are not intended to be a listing of every detail part in the system; only the major components which can be described easily by tabular presentation are listed.



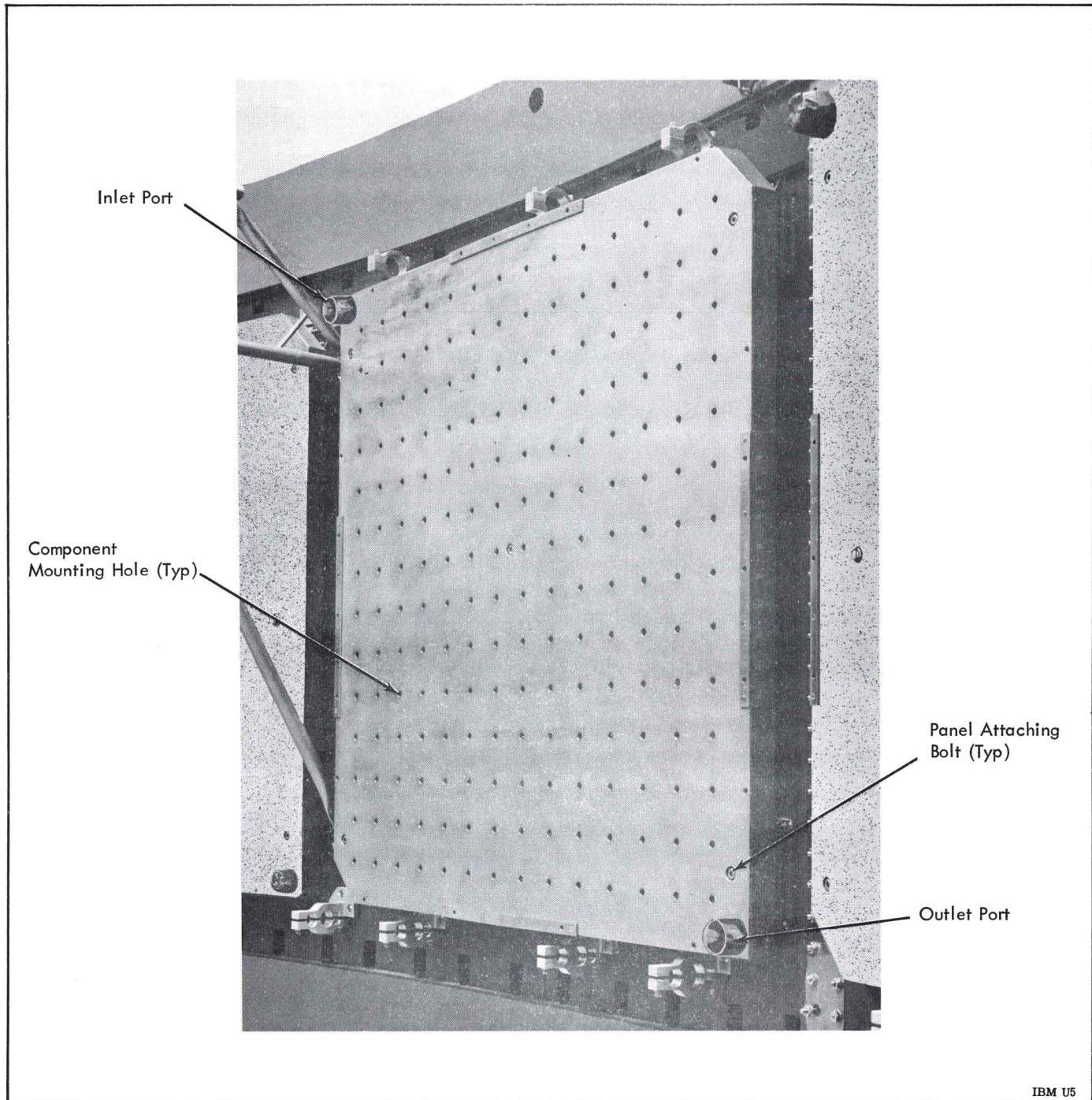


Figure 1-5. Mounting and Thermal Conditioning Panel Installed in IU



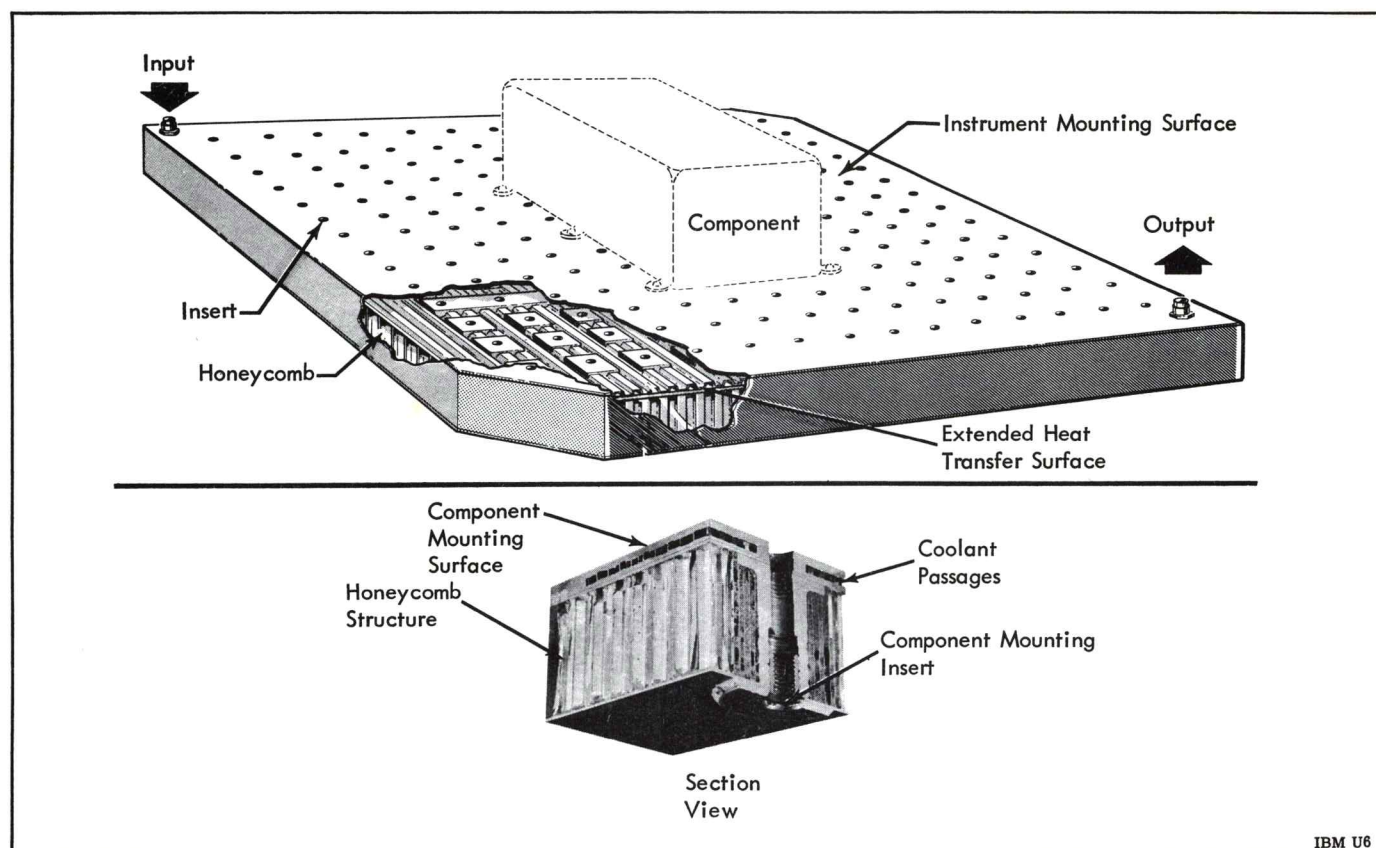


Figure 1-6. Thermal Conditioning Panel Details

Table 1-1. Leading Particulars of Thermal Conditioning System Components

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs.)	Design Characteristics	No. Req.	Fig. Ref.
Mounting and Thermal Conditioning Panel	20Z4200-1	30 x 30 x 1.25 in.	31.5	Aluminum reinforced honeycomb structure; Service Media, water/methanol	16	1-5 1-6
Coolant Pump	20M42001-1	10 x 12 x 5 dia in.	23	Electrically driven 28 Vdc; Service Media, water/methanol; Operating Pressure, 16 psia inlet, 28 psia outlet	1	1-3
Quick Disconnects	20M42006-1	1.0 in. ID	1.5	Corrosive resistant alloy; Service Media, water/methanol; Operating Pressure, 50 psia	10	1-3
	20M42006-5	0.75 in. ID	1.0		1	
	20M42006-7	0.50 in. ID	0.55		1	
Temperature Control Valve	20M42007-1	6.49 x 3.33 x 6.5 in	4.75	Three-way; Motor driven, dc actuated	1	1-3
Electronic Control Assembly	20M42007-3	6.75 x 4.75 x 2.5 in.	2.0	Hermetically sealed unit; dc power	1	1-3

Table 1-1. Leading Particulars of Thermal Conditioning System Components (Cont)

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs.)	Design Characteristics	No. Req.	Fig. Ref.
Coolant Temperature Sensor	20M42007-5	2.0 x 0.813 in. dia	0.06	Hermetically sealed thermistor; Temperature Control Point, 59° F	1	
Pressure Regulator	20M42013-1	3.0 x 2.0 in dia	1.5	Operating Pressure, 3200 to 200 psig inlet; 16.5 ± 0.5 psia outlet; Service Media, GN <sub>2</sub> ; Internal relief, Relieve — 38 psig max, Reseat — 28 psig min.	1	
50 In. <sup>3</sup> Sphere	20M42014-1	4.785 OD x 5.5 in. (Including boss)	6.6	Titanium alloy; Service Media, gaseous nitrogen; Operating Pressure, 3000 psig	2	1-3
Valve	20M42034-1	4.3 x 2.5 x 2.5 in.	1.5	Two-way; poppet type; spring loaded to open position; solenoid operated, 28 Vdc	1	1-3
Orifice Assembly	20M42037-1	2.24 x 1.0 in. dia	0.619	Union type; flow restriction pressed into one end; Operating Pressure, 50 psia	1	1-3
Methanol/Water Accumulator	20M42040-1	3.65 in. radius	2.5	Aluminum alloy; Urethane rubber diaphragm; Service Media, GN <sub>2</sub> on one side, methanol/water on the liquid side; Operating Pressure, 50 psia on liquid side, 16.5 on GN <sub>2</sub> side	1	1-3
Valve	20M42079-1	4.1 long x 1.9 in. dia	3.0	Poppet type; two-position; normally closed; Solenoid operated, 28 Vdc; Operating Pressure, 3200 psig; Service Media, GN <sub>2</sub>	1	1-3
Bleeder Assembly	20M42098-1	3.0 x 1.75 x 0.75 in.	0.117	Operating Pressure, 16.5 psia; Service Media, GN <sub>2</sub>	1	1-3
Filter	20M42119-1	4.38 x 1.12 in. hex	0.9	Corrosion resistant alloy; stainless steel element; Service Media, GN <sub>2</sub> ; Operating Pressure, 3000 psig; Filtration, 20 microns	1	1-3
Water Accumulator	20M42122-3	32.2 high x 32.0 in. dia	26.0	Aluminum construction; Urethane diaphragm; Service Media, water/gaseous nitrogen; Operating Pressure, 3.7 to 6.0 psia	1	1-3
Orifice Regulator	20M42122-5	2.25 x 0.7 in. dia	0.15	Aluminum housing; internal vent port; Service Media, GN <sub>2</sub> ; Operating Pressure, 17 psia inlet to 3.7 psia internal pressure	1	1-3
Flex Hose Assembly	20Z42133-1 thru -57	1/2, 3/4, and 1/0 in. dia; 9-1/2 to 48 in. length	varies with size and length	Operating Pressure, 50 psig; Service Media methanol/water; Pull-back fittings; Rubber hose, woven metal covering	63	1-4

Table 1-1. Leading Particulars of Thermal Conditioning System Components (Cont)

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs.)	Design Characteristics	No. Req.	Fig. Ref.
Shut-Off Valve	20M42155-1	5.5 x 2.5 x 3.38 in.	4.0	Manually operated; ball type; Operating Pressure, 0-50 psig; Service Media, methanol/water	1	1-3
Heat Exchanger Assembly	20M42159-1	20.0 x 7.5 x 11.0 in.	55.0	Corrosion resistant alloy; hot and cold loop construction; Service Media, methanol/water for hot loop of flight heat exchanger and hot and cold loop of preflight heat exchanger, distilled water and steam for cold loop of flight heat exchanger; Operating Pressure, hot loop of heat exchanger assembly 21 psia internal pressure, cold loop of flight heat exchanger 3.7 to 6.0 psia internal pressure, cold loop of preflight heat exchanger 65 psia max. internal pressure	1	1-3
Thermal Expansion Chamber	20M42163-1	10.8 long x 2.75 in. dia	1.13	Aluminum alloy; Service Media, methanol/water; Operating Pressure, 50 psi; Burst Pressure, 100 psi	1	1-3
Coolant Supply and Return Manifold	20Z42024-1 thru 20Z42033-1 20Z42055-1	1/2 and 3/4 in. outside dia; length varies	Varies with size and length	Aluminum alloy; Service Media, methanol/water; Operating Pressure, 50 psig	11	1-3

Table 1-2. Leading Particulars of Gas Bearing Supply System Components

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs.)	Design Characteristics	No. Req.	Fig. Ref.
2 Ft. <sup>3</sup> Sphere	20M32013-1	19.5 dia x 21.0 in. (Including boss)	45.5	Titanium alloy; Service Media, GN <sub>2</sub> ; Operating Pressure, 3200 psig	1	1-4
Pressure Regulator	20M42012-1	4.5 long x 2.5 in. dia	3.5	Corrosion resistant alloy; Internal relief, Relieve — 70 psig Max; Reseats — 50 psig min; Service Media, GN <sub>2</sub> ; Operating Pressure, 3200 to 300 psig inlet; Reference pressure, 12 to 22 psia; Outlet pressure 10 to 20 psia greater than reference	1	1-4
Low-Pressure Switch	20M42016-1	3.4 x 3.0 x 2.5 in	1.0	Single-pole, double-throw; absolute pressure type; actuating setting, 1000 psia; Service Media, GN <sub>2</sub> ; Working Pressure 3200 psig	1	1-4



Table 1-2. Leading Particulars of Gas Bearing Supply System Components

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs.)	Design Characteristics	No. Req.	Fig. Ref.
Gas Bearing Heat Exchanger	20M42048-1	5.0 x 4.5 x 1.5 in.	3.5	Liquid-cooled condenser type; Service Media for Tube, GN <sub>2</sub> ; Service Media for Shell, methanol/water; Operating Pressure for Tube and Shell, 50 psig	1	1-4
Gas Bearing Mounting Panel	20M42108-1	30.0 x 28.0 x 1/0 in.	7.3	Anodized aluminum alloy with aluminum honeycomb core	1	1-4
Valve	20M42079-1	4.1 long x 1.9 in. dia	3.0	Poppet type; two-position; normally closed; Solenoid operated 28 Vdc; Operating pressure, 3200 psig, Service Media, GN <sub>2</sub>		1-4
Filter	20M42119-1	4.38 in. long x 1.2 in. hex	0.9	Corrosion resistant alloy; stainless steel element; Filtration, 20 microns; Service Media, GN <sub>2</sub> ; Operating pressure, 3000 psig	2	1-4

Table 1-3. Leading Particulars of Preflight Air/GN<sub>2</sub> Purge System Components

Item	Drawing Number	Dimensions L x W x D (Maximum)	Weight (lbs)	Design Characteristics	No. Req.	Fig. Ref.
Purge System "Y"	20M42100-1	12.0 x 9.6 x 8.6 in.	2.0	Low-pressure glass fiber laminated; beaded for connecting	1	1-3
Flex Tubing Assembly	20M42101-1	5.1 in. dia length as required	Varies with length	Treated canvas cloth over collapsible spring type wire frame	10	1-3
Flex Tubing	20M42102-1	21.0 x 6.0 x 6.0 in.	0.5	Treated canvas cloth over collapsible spring type wire frame	1	1-3
Flex Tubing Coupler	20M42103-1	3.0 x 5.0 x 5.0 in.	0.1	Glass fiber laminated	8	1-4
End Cap	20M42104-1	2.5 x 5.0 x 5.0 in.	0.115	Glass fiber laminated	2	



## SECTION II

# PRINCIPLES OF OPERATION

### 2-1 GENERAL OPERATION

The Environmental Control System is functionally divided into three systems: a Thermal Conditioning System, a Gas Bearing Supply System, and a Preflight Air/GN<sub>2</sub> Purge System. These three systems perform the following environmental control functions, respectively:

- Preflight and flight thermal conditioning of Astrionics equipment located in the Instrument Unit and S-IVB Stage to maintain a stable, acceptable temperature.
- Preflight and flight lubrication of gas bearings in the ST-124M-3 Inertial Platform Assembly.
- Preflight purging of the Instrument Unit and S-IVB compartment.

Preflight and flight thermal conditioning of electronics equipment is by the conduction of component heat into a circulating coolant fluid which acts as a heat sink and carries the heat away for removal from the coolant system. Preflight and flight lubrication of gas bearings is by the flow of temperature and pressure regulated gaseous nitrogen (GN<sub>2</sub>) through the ST-124M-3 Inertial Platform Assembly. Preflight purging of the Instrument Unit and S-IVB compartment is accomplished by the exhaust of regulated and filtered air or GN<sub>2</sub> into the compartment.

### 2-2 DETAILED OPERATION

#### 2-3 THERMAL CONDITIONING SYSTEM

The Thermal Conditioning System provides cooling for the Astrionics equipment located in the Instrument Unit and the S-IVB Stage of the Saturn IB and Saturn V vehicles. The system is a closed-loop, circulating coolant system which operates during both preflight and flight. Most of the electronic equipment which requires cooling is mounted on

thermal conditioning panels (cold plates) which have passages for coolant flow. Each cold plate is capable of dissipating approximately 420 watts with a fluid temperature rise of 5.5 °C (10 °F). A simplified schematic of coolant flow in a cold plate is shown in Figure 2-1.

Basically, the Thermal Conditioning System operates as follows: a coolant fluid of 60 percent methanol and 40 percent demineralized water by weight is circulated through the cold plates and through equipment having integral cooling passages. Heat generated by the electronic components is absorbed and carried away by the circulating coolant. The heat is removed from the coolant either by a preflight heat exchanger or by a sublimator during flight to maintain the coolant at  $15 \pm 0.5$  °C ( $59 \pm 1$  °F).

#### Preflight Operation (See Figure 2-2)

During preflight operation, the sublimator is inactive because to operate the sublimator requires a freezing process attained in space. The flow of cooling water from the water accumulator to the sublimator is controlled by normally open solenoid valve C. This valve is energized (closed) during preflight operations and it remains closed until approximately 150 seconds after lift-off. The preflight heat exchanger operates during preflight operation to cool the closed-loop coolant. A Ground Support Cooling Unit (GSCU) circulates a temperature controlled methanol/water mixture through the heat exchanger. This ground supplied coolant flows

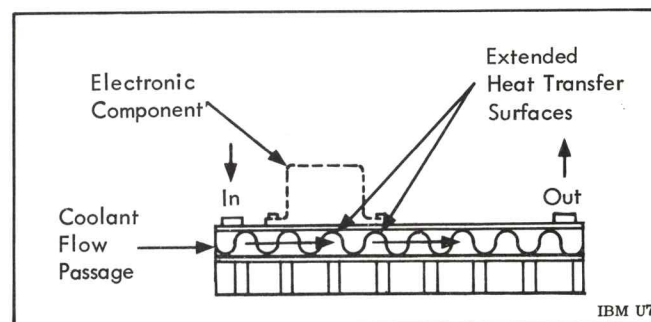


Figure 2-1. Thermal Conditioning Panel Simplified Coolant Flow Schematic

through one section of the preflight heat exchanger, thus cooling the closed-loop coolant that flows through the other section.

The electrically driven pump continuously circulates the closed-loop coolant through the system. From the supply side of the pump, the coolant flows through the coolant temperature sensor, through orifice A, and then through the supply manifold to the cold plates and integrally cooled equipment within the Instrument Unit. Orifice A diverts coolant to the supply line for the S-IVB Stage cold plates. A decrease in the diameter of the coolant piping causes coolant to flow through the gas bearing heat exchanger. Orifice B, in the outlet line of the Flight Control Computer, maintains the proper coolant flowrate through the computer.

The coolant in the return manifold flows through the open shutoff valve to the modulating flow control valve which either diverts coolant through the sublimator and preflight heat exchanger to the return side of the pump, or allows coolant to bypass to the pump. The modulating flow control valve, the electronic control assembly, and the temperature sensor at the pump outlet are electrically interconnected and provide coolant temperature control. An electrical signal is supplied by the sensor to the electronic control assembly which controls the positioning motor of the flow valve. The flow valve diverts varying amounts of coolant through the sublimator and preflight heat exchanger if the coolant requires cooling. If no cooling is required, the flow valve will divert the coolant through the bypass directly to the pump.

The methanol/water accumulator, located immediately before the pump inlet, provides damping of pressure fluctuations, maintains a constant pump inlet pressure, compensates for thermal expansion of the coolant, and provides a limited supply of coolant should any be lost from the system.

The methanol/water accumulator and the water accumulator are pressurized with GN<sub>2</sub> that is stored at  $20.7 \times 10^6 \text{ N/m}^2\text{g}$  (3000 psig) in two 819.4-cubic centimeter (50-cubic inch) storage spheres. The GN<sub>2</sub> is filtered by filter A and reduced to approximately  $103.5 \times 10^3 \text{ N/m}^2\text{a}$  (15 psia) by the pressure regulator. This regulated pressure is applied to the methanol/water accumulator and to the orifice assembly at the water accumulator. The orifice assembly reduces the regulator pressure to  $34.5 \times 10^3 \text{ N/m}^2\text{a}$  (5 psia) which pressurizes the water accumulator. The water accumulator internal

pressure varies (3.7 to 6.0 psia) depending on the temperature and pressure of the inlet gaseous nitrogen as well as the amount of water being consumed by the sublimator during flight operation. The orifice assembly also vents excess pressure to the Instrument Unit compartment to prevent overpressurizing the water accumulator. Both accumulators have internal flexible membranes which provide a barrier that prevents mixing of the GN<sub>2</sub> and liquid.

The hand-operated bleeder assembly in the GN<sub>2</sub> line and the hand-operated shutoff valve in the coolant return line are used only during servicing of the system. The bleeder assembly is closed during operation of the system and the shutoff valve is lockwired in the open position. During servicing, the bleeder assembly is opened to vent air from the GN<sub>2</sub> system and to allow the flexible membrane in the methanol-water accumulator to retract as the system is filled with coolant. The shutoff valve is closed and opened during servicing to assure complete methanol/water filling or draining of the system.

Normally closed solenoid valve A is energized during servicing of the system and controls the filling of the GN<sub>2</sub> storage spheres. A pressure transducer indicates when the spheres are pressurized to the proper value. At this time, solenoid valve A is de-energized (closed). The solenoid valve also provides for the venting of the system during preflight operations, if required.

As previously mentioned, the sublimator is inactive during preflight operation and serves only as a passage for the coolant through the preflight heat exchanger to the pump. Ground supplied coolant flowing through one side of the heat exchanger cools the closed-loop coolant until umbilical separation and vehicle lift-off. The preflight heat exchanger is then inactive.

#### Flight Operation (See Figure 2-2)

During flight, the system operation is the same as described under preflight operation except the sublimator is active and the preflight heat exchanger is inactive. However, the sublimator does not operate until approximately 150 seconds after lift-off, at which time the ambient pressure is low enough to sustain sublimation. Calculations indicate that during the transient phase, the thermal capacity of the electronics equipment and thermal conditioning system is sufficient to prevent overheating of the equipment.



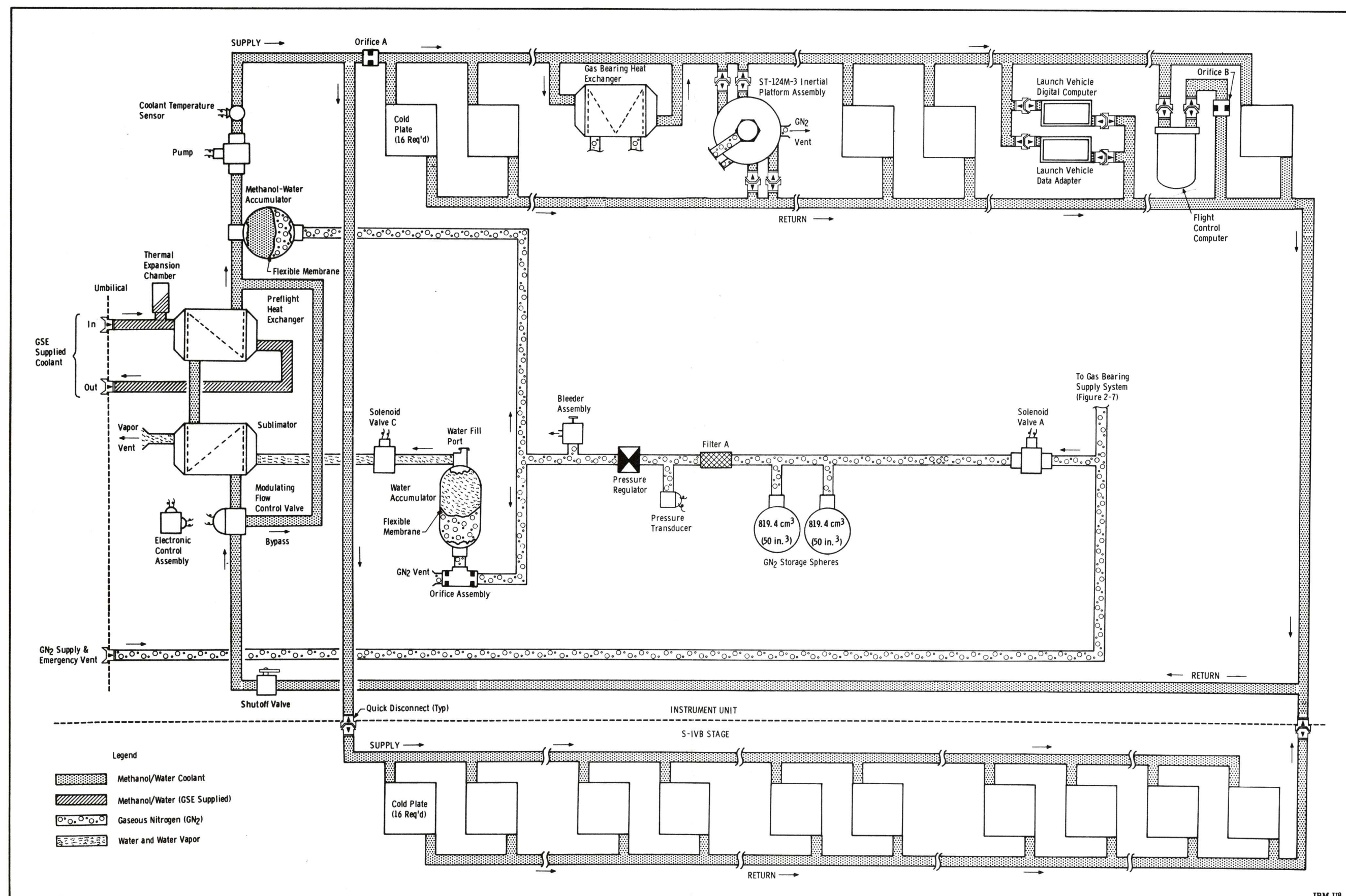


Figure 2-2. Thermal Conditioning System Simplified Schematic



Some of the methanol/water coolant, which was circulated by the GSCU, is entrapped between the umbilical quick disconnects and preflight heat exchanger at the time of umbilical separation. A thermal expansion chamber, connected into the preflight heat exchanger inlet line, provides for the thermal expansion of this entrapped coolant.

When the ambient pressure is low enough for sublimation, solenoid valve C is de-energized (opens) permitting water to flow from the water accumulator to the sublimator where the sublimation process takes place. The water cools the closed-loop coolant with a resultant venting of water vapor or ice from the sublimator. The sublimator vents into the Instrument Unit compartment.

#### Sublimation Process

A simplified schematic of the flow of closed-loop coolant and water through the sublimator is

shown in Figure 2-3. The water, under pressure, enters the sublimator and flows into the pores of the porous plate. As the water in the pores encounters the space vacuum at a temperature and pressure below the triple point of water, an ice layer forms at the outer water surface and continues to build up back towards the water passage. The heat absorbed by the closed-loop coolant during its flow through the thermal conditioning system is transferred to the water by conduction. As heat is transferred through the water passage and ice layer, the outer surface sublimates and vents into the Instrument Unit. As the heat level increases, the ice sublimates at a faster rate, thus increasing the water flow rate.

Another theory of sublimator operation exists based on the premise that two modes of heat transfer occur in the sublimator. This theory — sublimation and evaporation — is as follows: As the water in the large pores encounters the space vacuum, freezing occurs and an ice plug is formed. In the small

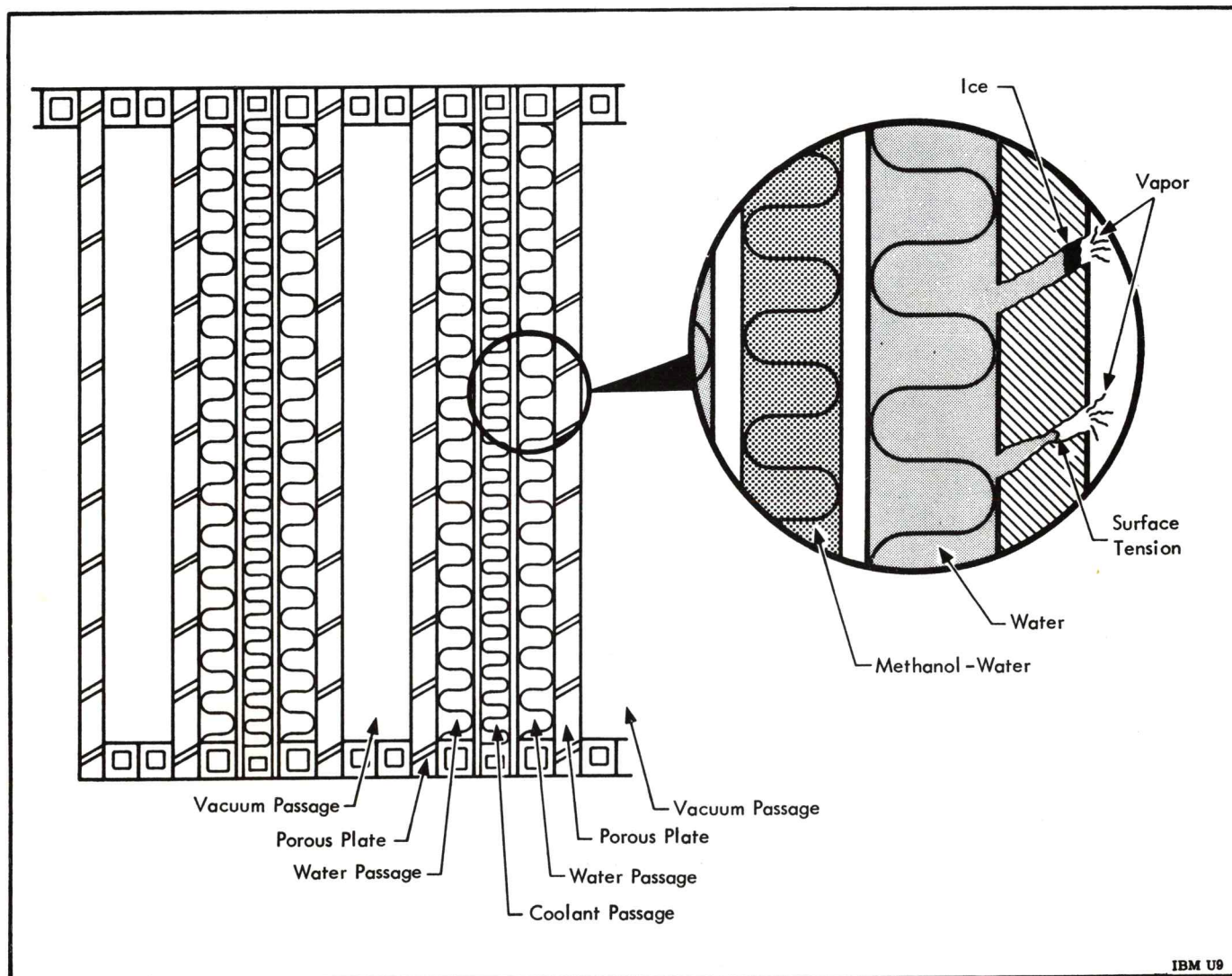


Figure 2-3. Simplified Schematic of Sublimator Coolant and Water Flow



pores which are non-wetted and can retain water by surface tension, the water fills the pores to a distance where the restriction is small enough to retain water at the inlet pressure. As the heat flux increases, the ice in the large pores sublimates at the solid-vapor interface and is formed at the liquid-solid interface. The vapor or steam is vented. When the heat flux becomes great enough to prevent all ice from existing, any further increase in the heat load will raise the evaporation temperature. The heat load reaches a maximum when no ice exists and the heat sink temperature is  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ).

The sublimator has an advantage over a heat exchanger in that the flow of water is self-regulating. As the heat flux decreases ice plugs are formed in the pores and the flow of water also decreases.

#### Temperature Control System

A block diagram of the Thermal Conditioning System temperature control loop is shown in Figure 2-4. A temperature control system, consisting of a temperature sensor, an electronic control assembly, and a modulating flow control valve, maintains the Thermal Conditioning System's methanol/water coolant at a temperature of  $15 \pm 0.5^{\circ}\text{C}$  ( $59 \pm 1^{\circ}\text{F}$ ). An electrical signal is supplied by the temperature sensor to the electronic control assembly which controls the positioning motor of the flow control

valve. The flow valve diverts varying amounts of coolant through the heat sink if the coolant requires cooling, or it will bypass the coolant directly to the pump if no cooling is required.

The thermistor temperature sensor is energized in a dc bridge circuit and provides continuous medium temperature signals to the electronic control assembly. A temperature error is converted to a dc output voltage by the bridge, and this voltage is integrated by an operational amplifier circuit in the electronic control assembly. When a particular level of voltage is reached, a voltage comparator provides a pulse to the motor controller. The motor controller then provides a proper sequence of pulses to the flow valve motor to drive it in a direction which will reduce the error signal. The directional logic is a function of the direction of temperature error, resulting in a particular voltage sign from the dc bridge. This results in either positive or negative integration and the eventual pulsing of the clockwise or counterclockwise voltage comparator which is interpreted in the motor controller providing a clockwise or counterclockwise sequence of pulses to the flow valve motor.

The average valve speed is a function of the rate of valve motor pulses. Figure 2-5 shows that the rate of valve pulses are approximately proportional to bridge voltage or temperature error.

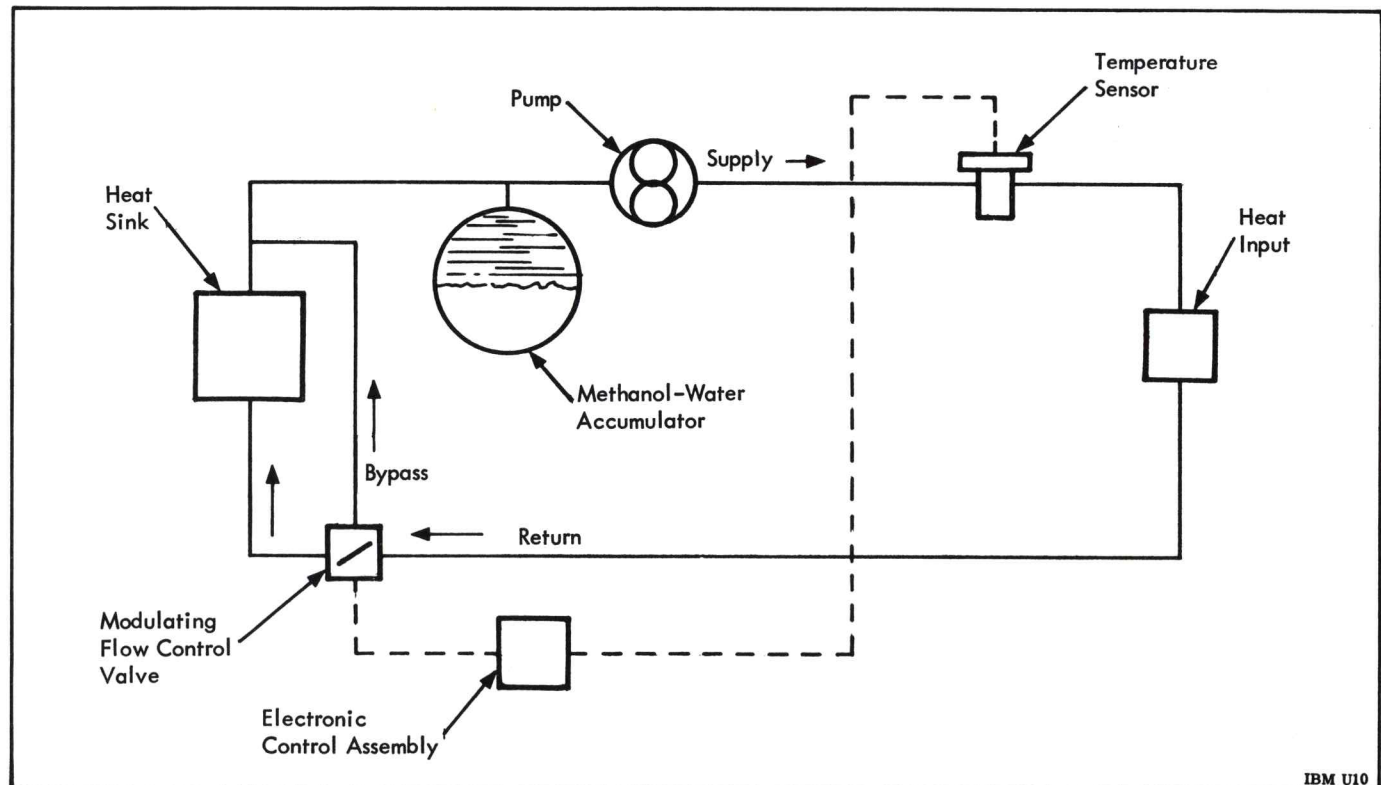


Figure 2-4. Thermal Conditioning System Temperature Control Loop

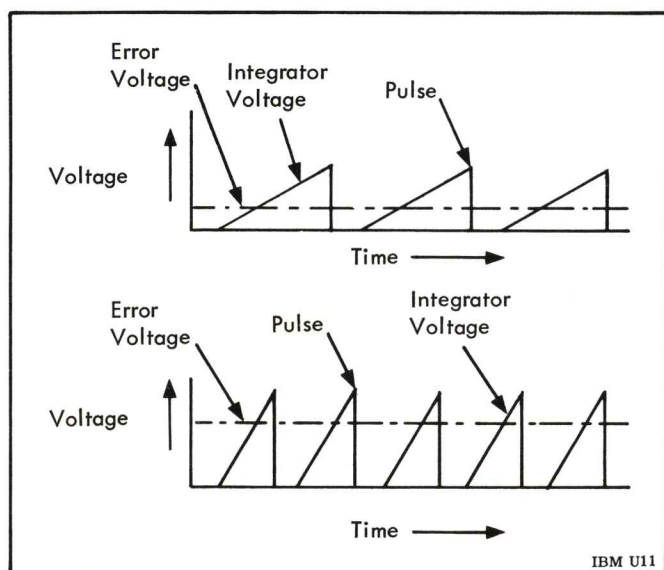


Figure 2-5. Error Voltage - Pulse Rate Relationship

Rate damping and use of a deadband are provided as means of control stabilization. Figure 2-6 shows how the effective control point shifts to anticipate the lag in the control loop and to stop valve movement before control temperature is actually reached. The rate feedback then tends to decay at approximately the same rate as the thermistor temperature changes as a result of system control loop lag. The result is that the thermistor temperature comes within the deadband when both the feedback and the temperature changes approach zero.

The system operates on 28 Vdc power. The flow valve has a potentiometer for feedback indication of valve gate position and has adjustable limit switches for the presetting of any desired range between full

heat sink flow and full bypass flow. A small check valve on the valve housing permits air to be forced into the valve housing and retained at 20 psig. A green and red pin, extending through the valve housing, indicates when pressure is normal (green), or abnormal (red). Both the temperature sensor and the electronic control assembly are hermetically sealed units.

#### 2-4 GAS BEARING SUPPLY SYSTEM

The Gas Bearing Supply System (Figure 2-7) operates during prelaunch and flight. The system furnishes gaseous nitrogen ( $\text{GN}_2$ ) at a regulated temperature and pressure for lubrication of the gas bearings in the ST-124M-3 Inertial Platform Assembly. The  $\text{GN}_2$  permits the ST-124M-3 gyros to operate in a nearly frictionless environment.

The system is filled through the  $\text{GN}_2$  supply and emergency vent quick disconnect from a ground supplied source. A pressure transducer indicates when the pressure in the 0.056-cubic meter (2-cubic foot) storage sphere in approximately  $20.7 \times 10^6 \text{ N/m}^2\text{g}$  (3000 psig). At this time, normally closed solenoid valve B is de-energized (closed) and the  $\text{GN}_2$  source can be removed. The solenoid valve also provides for the venting of the system during preflight operations, if required. The pressure switch indicates when the pressure in the sphere decreases below approximately  $6.9 \times 10^6 \text{ N/m}^2\text{g}$  (1000 psig). Should a pressure decrease occur during prelaunch operations, the inertial platform would be shut down until the sphere could be repressurized. Under normal flight conditions a drop in pressure should not occur unless a leak or malfunction is present in the system.

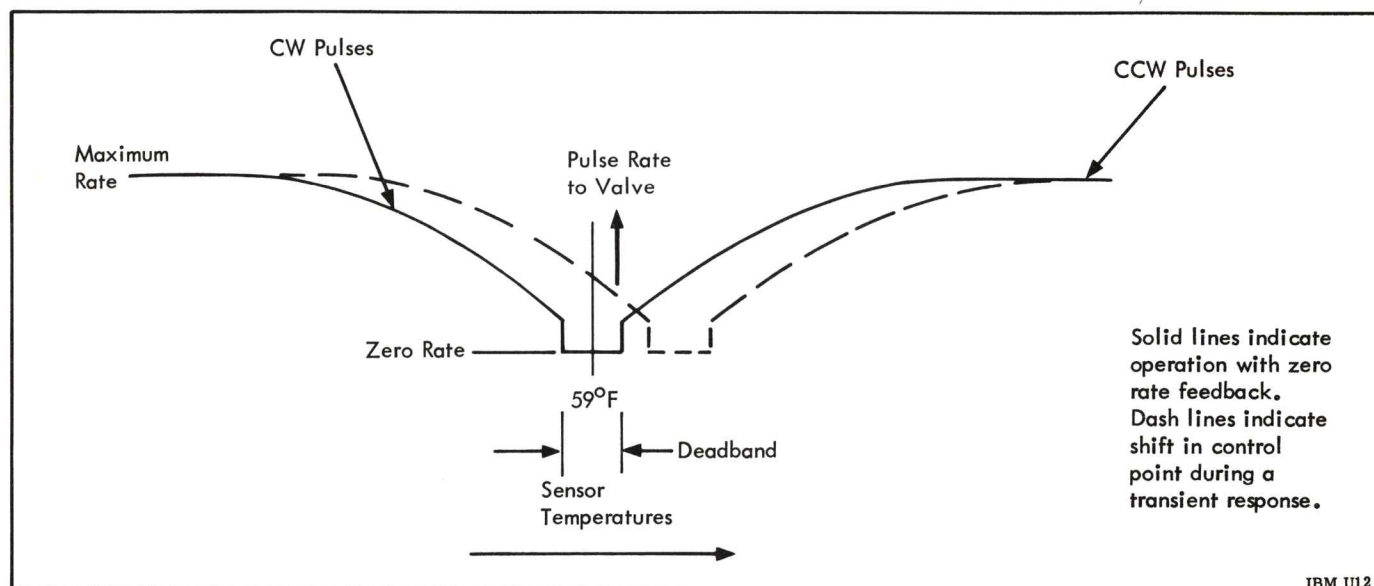


Figure 2-6. Electronic Controller Assembly Characteristic



Gaseous nitrogen flows from the storage sphere through filter B to the pressure regulator where the pressure is reduced to an acceptable value for lubrication of gas bearings. The GN<sub>2</sub> is cooled or heated as required as it passes through the gas bearing heat exchanger; it is then filtered by filter C before it is applied to the gas bearings in the platform. After lubricating the bearings, the GN<sub>2</sub> is vented into the Instrument Unit compartment.

A reference pressure feedback from the platform to the pressure regulator, maintains a constant pressure in the gas bearings by controlling the pressure regulator output, e.g., a decrease in pressure in the gas bearings causes the pressure regulator output to increase.

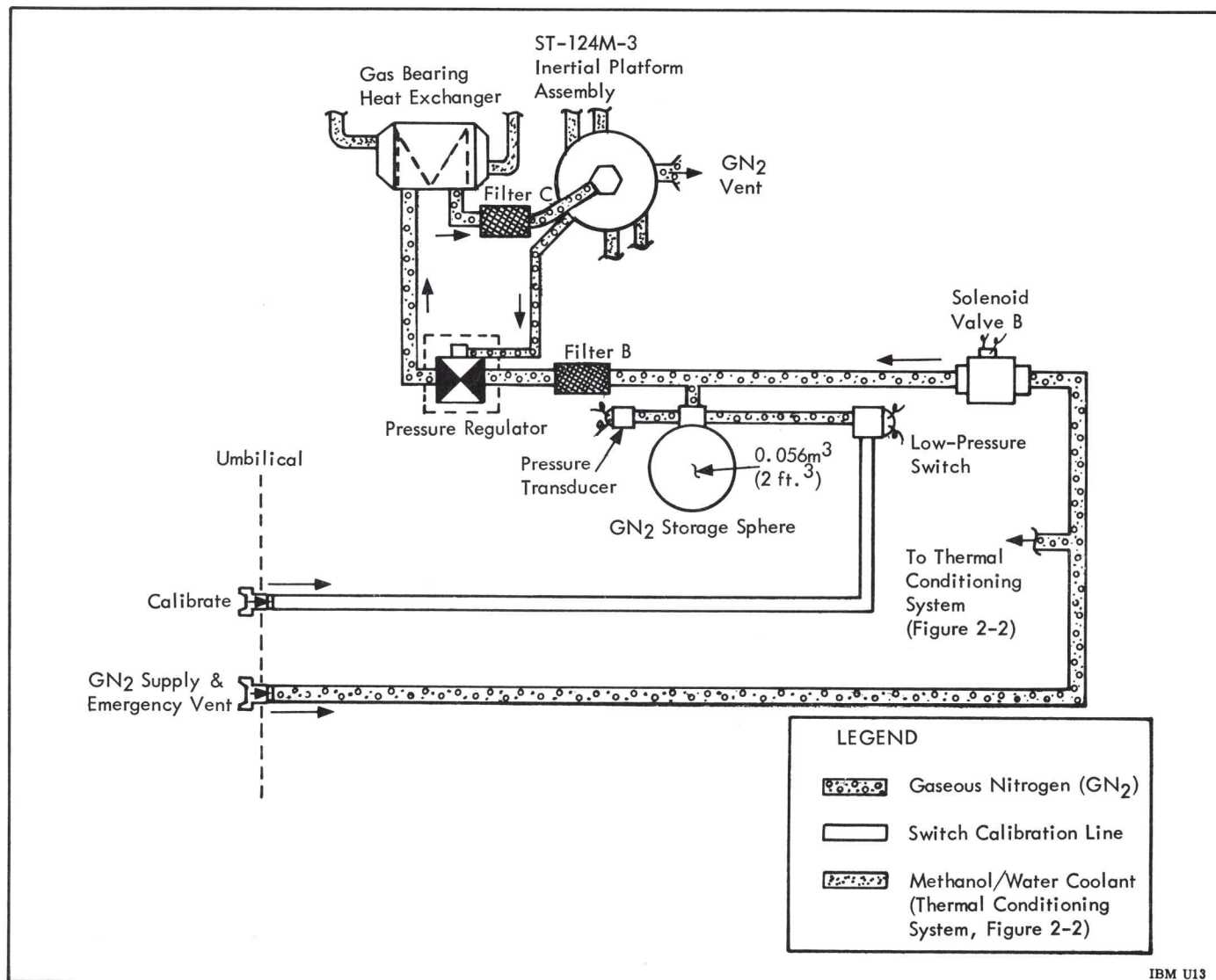


Figure 2-7. Gas Bearing Supply System Simplified Schematic

2-5 PREFLIGHT AIR/ $\text{GN}_2$  PURGE SYSTEM

The Preflight Air/ $\text{GN}_2$  Purge System (Figure 2-8) consists primarily of flexible ducting located above the Instrument Unit payload interface. The system operates only during preflight operations to maintain an inert environment in the Instrument Unit

and S-IVB compartment. The system distributes temperature and pressure regulated, ground supplied filtered air or  $\text{GN}_2$  through openings in the ducting. During preflight phases ventilating air is furnished. During fueling, inert  $\text{GN}_2$  is furnished to prevent accumulation of a hazardous and corrosive atmosphere.

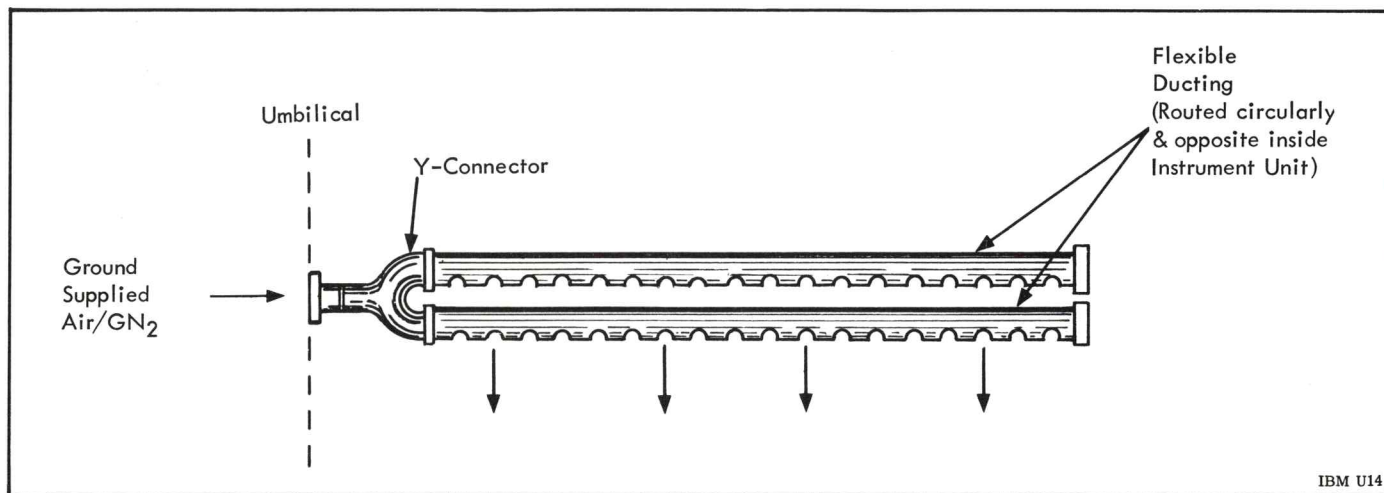


Figure 2-8. Preflight Air/ $\text{GN}_2$  Purge System Schematic



## **SECTION III**

# **COMPONENT REMOVAL AND REPLACEMENT**

(To be supplied)

## SECTION IV

# GENERAL SERVICING INFORMATION

### 4-1 INTRODUCTION

This section presents general servicing information for the Environmental Control System. Service points, manual controls, and filling, draining and purging procedures are given for familiarization purposes.

### 4-2 SERVICING POINTS AND MANUAL CONTROLS

The servicing points and hand-operated controls of the Environmental Control System are shown in Table 4-1.

### 4-3 FILLING WATER ACCUMULATOR

The water accumulator is filled with distilled water through the water fill port on top of the accumulator. The normally open water solenoid valve is energized (closed) prior to filling the accumulator.

The water accumulator can be filled manually by pouring water through the water fill port or it can be filled and drained using a ground support servicing cart. (Detailed procedures on servicing the water accumulator using the ground support cart will be furnished at a later date.

### 4-4 FILLING, DRAINING, AND PURGE DRYING OF METHANOL/WATER SYSTEM

The servicing of the Instrument Unit and S-IVB Stage methanol/water system is accomplished using the Ground Support Cooling Unit. The detailed procedures for servicing the system using the Ground Support Cooling Unit are contained in MSFC Drawing 20M42200. This document covers (1) filling,

- (2) contamination and air entrainment checking,
- (3) draining, and (4) drying.

The manifolds, methanol/water accumulator, cold plates and other components in the Instrument Unit system are filled with coolant through either of the Instrument Unit quick-disconnect couplings at the IU/S-IVB system interface connections. The S-IVB system manifolds and cold plates are likewise filled through the S-IVB quick-disconnect couplings. As coolant enters through one coupling, the air in the system is vented through the other coupling. The couplings are also used for draining and purging operations.

The GN<sub>2</sub> bleeder assembly in the methanol/water accumulator GN<sub>2</sub> line is opened to vent trapped air from the methanol/water accumulator and GN<sub>2</sub> lines as the coolant fills the accumulator. The methanol/water shutoff valve in the coolant return line is closed and opened during servicing to assure complete filling, draining, or purging of the system.

### 4-5 PRESSURIZATION (GN<sub>2</sub>)

The storage spheres, which supply GN<sub>2</sub> to the Gas Bearing Supply System, the methanol/water accumulator, and the water accumulator are pressurized through the GN<sub>2</sub> supply and emergency vent quick-disconnect coupling on the umbilical plate. Two solenoid valves, one in the Gas Bearing Supply System and one in the GN<sub>2</sub> Supply System for the accumulators, control the filling of each system's spheres. The normally closed valves are energized (opened) by ground control to pressurize the spheres. When the pressure in the spheres is adequate, the solenoid valves are closed. The valves can be opened to depressurize the GN<sub>2</sub> systems, if required.

Table 4-1. Servicing Points and Manual Controls

Servicing Point or Control	Location	Remarks
Water Accumulator (Water Fill)	IU Position No. 6	Service medium: Distilled water, approximately 66.7 kilograms (147 pounds) at $15.56 \pm 11^{\circ}\text{C}$ ( $60 \pm 20^{\circ}\text{F}$ ); water fill port with screw type cap located at top of accumulator
M/W System Quick-Disconnect Couplings	IU/S-IVB interface, IU Position No. 6 and 7	Service medium: 60 percent methanol and 40 percent demineralized water by weight; Filling, draining, and purging of methanol/water system accomplished through two IU system and two S-IVB system interconnect couplings (quick-disconnects)
GN <sub>2</sub> Supply Quick-Disconnect Couplings	Umbilical Plate	Service medium: Gaseous nitrogen; Purpose: Pressurizing of Gas Bearing Supply System, and methanol/water and water accumulators
GN <sub>2</sub> Bleeder Assembly	GN <sub>2</sub> supply line to methanol/water and water accumulators, IU Position No. 6	Manually opened prior to filling of methanol/water system to vent air from GN <sub>2</sub> lines (closed during system operation). Also provides for manual venting of pressurized methanol/water and water accumulator GN <sub>2</sub> supply system, if required
Methanol/Water Shut-off Valve	Methanol/water coolant return line, IU Position No. 7	Manually operated for filling, draining, and purging of methanol/water system. (Safety wired to open position after servicing)



## **SECTION V**

### **SPARE PARTS**

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