Models 902 & 903 - Atmospheric Gas Panel Interfaces

Instruction Manual

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1. DESCRIPTION

1.1. Overview

Models GPI-902 and GPI-903 are gas panel interfaces designed for semiconductor processes performed in diffusion furnaces under atmospheric conditions. This includes processes such as oxidation, anneal, dopant deposition and dopant drive-in. Both Models use the same circuit board, but the GPI-902 omits the Torch Interlock and the H2:O2 Ratio control and interlock circuits.

1.2. Features

- *Universal Power input for international operation.*
- *+/- 15 VDC Power Supply adequate for (6) MFC's.*
- *+24 VDC Power Supply for solenoids and sensors.*
- *Jumper-selectable Override Relays to provide positive MFC shutoff.*
- *Monitor circuit for Type 'K' Torch thermocouple.*
- *Selectable ratio circuit for slaving the Hydrogen set-point to the actual Oxygen flow.*
- *Hardware interlocks on Hydrogen flow for Low O2 and Torch Temperature.*
- *Status LEDs for all Digital Outputs and Digital Inputs.*
- *Remote Connector with Galvanically isolated control signals for use with a Tymkon Process Sequencer.*

1.3. Suggested Tymkon Configuration

Following is a recommended function template for installations in which these Gas Panel Interfaces are used with vertical Tymkon process sequencers. The Tymkon software allows front panel functions to be remapped to different hardware ports, but adherence to the suggested layout minimizes hardware remapping and simplifies installation. When Hydrogen is not required in the process, avoid using Digital Output 3, if possible, as that function is hardware interlocked to Digital Output 4 (O2 Sol), Digital Input 4 (Lo O2) and Digital Input 5 (Torch).

Outputs				Inputs	
0	Load	**8**		**0**	BIC
1	Unload	**9**	N2 Safe (NO)	**1**	BOC
2	N2 Sol	**A**	N2 MFC	**2**	TMP Fault
3	H2 Sol	**B**	H2 MFC	**3**	H2 Hi
4	O2 Sol	**C**	O2 MFC	**4**	O2 Lo
5	DCE[1] Sol	**D**	DCE[1] MFC	**5**	Torch
6	Lo O2 Sol	**E**	Lo O2 MFC	**6**	Ratio
7	DCE[1] > Tube	**F**		**7**	GPI Fault

[1] In this document, DCE is synonymous with TLC or any other oxidizing, gettering or doping agent that may be vaporized from a bubbler.

2. INSTALLATION

2.1. DDC[2] Interface Connector, J7

The GPI-902 and GPI-903 provide a 50-pin IDC ribbon cable connector for interface to a process controller. The pinout of the connector exactly matches that of the most common Tymkon I/O boards, but may be adapted to process sequencers from other manufacturers.

A typical ribbon-cable female mating connector is 3M P/N 3425-6000. The 3M part number for an optional strain relief is 3448-3050. These connectors may be used with standard flat ribbon cable (e.g. 3M P/N 3365-50) or with round, shielded ribbon cable (e.g. 3M P/N 3659F/50).

The pinout of the Interface Connector follows on the next page. The connector provides a generic interface that is shared by both atmospheric and LPCVD[3] gas panel interfaces.

The pins labeled "Digital Output" and those labeled "Analog Output" are signals from the process sequencer to the gas panel interface. Those labeled "Digital Input" and those labeled "Analog Input" are signals from the gas panel interface to the process sequencer.

Note that the (16) "Digital Output" pins expect to see either mechanical contact closures or solid-state relay closures to 24 Volt Return from the DDC or process sequencer. The 24 Volt Return signal is sent from the GPI to the DDC on pin 26 of the Interface Connector. Furthermore, the (8) "Digital Input" pins provide contact closures to 24 Volt Return to the DDC when the sensors are safe. Pin 49 of the Interface Connector provides +24 Volts to the DDC to power the opto-isolators usually found in the DDC.

Note also that the signals present on the "Analog Output" and "Analog Input" pins of the Interface Connector are generally 0 to 5 Volts DC.

[2]DDC: Direct Digital Control system - Computer-controlled system that sequences gas valves, furnace temperature, boat loaders etc. in response to time-based recipes and external sensors.
[3]LPCVD: Low Pressure Chemical Vapor Deposition.

DDC Interface Connector, J7

IDC Pin	Comm Pin	Function
1	1	ANALOG OUTPUT F
3	2	ANALOG OUTPUT E
5	3	ANALOG OUTPUT D
7	4	ANALOG OUTPUT C
9	5	ANALOG OUTPUT B
11	6	ANALOG OUTPUT A
13	7	ANALOG OUTPUT 9
15	8	ANALOG OUTPUT 8
17	9	ANALOG COMMON
19	10	DIGITAL GROUND
21	11	ALARM SILENCE INPUT
23	12	RUN INPUT
25	13	DIGITAL INPUT 7
27	14	DIGITAL INPUT 5
29	15	DIGITAL INPUT 3
31	16	DIGITAL INPUT 1
33	17	OUTPUT F (NO)
35	18	OUTPUT D (NO)
37	19	OUTPUT B (NO)
39	20	OUTPUT 9 (NO)
41	21	OUTPUT 7 (NO)
43	22	OUTPUT 5 (NO)
45	23	OUTPUT 3 (NO)
47	24	OUTPUT 1 (NO)
49	25	+ SUPPLY (+5 to +40 VOLTS)

IDC Pin	Comm Pin	Function
2	26	ANALOG INPUT F
4	27	ANALOG INPUT E
6	28	ANALOG INPUT D
8	29	ANALOG INPUT C
10	30	ANALOG INPUT B
12	31	ANALOG INPUT A
14	32	ANALOG INPUT 9
16	33	ANALOG INPUT 8
18	34	ALARM (-) OUTPUT
20	35	ALARM (+) OUTPUT
22	36	ABORT INPUT
24	37	RESET INPUT
26	38	- SUPPLY (-5 to -40 VOLTS)
28	39	DIGITAL INPUT 6
30	40	DIGITAL INPUT 4
32	41	DIGITAL INPUT 2
34	42	DIGITAL INPUT 0
36	43	OUTPUT E (NO)
38	44	OUTPUT C (NO)
40	45	OUTPUT A (NO)
42	46	OUTPUT 8 (NO)
44	47	OUTPUT 6 (NO)
46	48	OUTPUT 4 (NO)
48	49	OUTPUT 2 (NO)
50	50	OUTPUT 0 (NO)

Note: The numbers in the columns labeled “Comm Pin” refers to the respective pin numbers as they would appear if an attached ribbon cable were terminated in a communications connector as is sometimes used on process sequencers. The numbers in the columns labeled “IDC Pin” are the conductor numbers in a ribbon cable.

2.2. MFC Connectors, J1 through J6

20-conductor ribbon cables are used to connect the GPI to the Mass Flow Controllers. Following is the pinout of MFC 1 through MFC 6 (J1 through J6 respectively) on the Gas Panel Interface. (The numbers in the "IDC" columns are the ribbon cable conductor numbers.)

Card Edge	IDC		Card Edge	IDC	
1	1	Case GND	A	2	Setpoint
2	3	Power Common	B	4	Signal Common
3	5	Output (0-5v)	C	6	Signal Common
4	7	+15 VDC	D	8	Valve Test
5	9	N/C	E	10	N/C
6	11	N/C	F	12	-15 VDC
7	13	Keyway	G	14	Keyway
8	15	N/C	H	16	N/C
9	17	N/C	I	18	N/C
10	19	Common	J	20	Valve Off

Unless specified by the customer, the GPI's provide an ***MFC Override*** relay for each gas channel. These six relays are controlled by Digital Outputs 'A' through 'F'.

A jumper is provided for each override relay to select Normally Open or Normally Closed operation. This allows the relays to be used for MFC Override control when jumpered Normally Closed or as ON/OFF control signals when the MFC connectors are used to control other peripheral equipment.

When jumpered Normally Closed, the relays provide a set of normally closed contact to connect the appropriate *MFC Valve Off* pin to the *MFC Common* pin thereby forcing the MFC closed regardless of the analog setpoint. When the relay is energized, the override signal is released and the MFC is allowed to soft-start to the setpoint.

2.3. Solenoid Valves, J8

Either a 25-pin female 'D' connector or a 26-pin IDC header or both is provided to drive up to sixteen pilot valves or gas solenoids. If the valves are polarized, the positive side of the coil must be connected to one of the +24 Volts pins, while the negative side must be connected to one of the valve output signals.

> Note: Shorting any of the outputs on the Valve Connector may cause permanent damage to the GPI or to the process sequencer or DDC which drives the outputs.

Note that Digital Outputs 0 and 1 are not located on the first two pins as might be expected. Since these signals are normally not assigned to pilot valves, they have been relocated to provide better compatibility with pilot valve manifolds.

The pin-out is as follows:

J8 Pin IDC	J8 Pin 'D'	Function	Valve	Recommended Use
1	1	Output 2	1	N2 Sol
2	14	Output 3	2	H2 Sol
3	2	Output 4	3	O2 Sol
4	15	Output 5	4	TLC Sol
5	3	Output 6	5	Lo O2 Sol
6	16	Output 7	6	DCE > Tube Sol
7	4	Output 8	7	
8	17	Output 9	8	N2 Safe (N.O.)
9	5	Output A	9	
10	18	Output B	10	
11	6	Output C	11	
12	19	Output D	12	
13	7	Output E	13	
14	20	Output F	14	
15	8	Output 0	15	
16	21	Output 1	16	
17	9		24V Return	
18	22		+24 VDC	Sol Common
19	10		+24 VDC	Sol Common
20	23		+24 VDC	Sol Common
21	11		+24 VDC	Sol Common
22	24		+24 VDC	Sol Common
23	12		+24 VDC	Sol Common
24	25		+24 VDC	Sol Common
25	13		+24 VDC	Sol Common
26			+24 VDC	Sol Common

Note: If the process uses Hydrogen and Oxygen, proper interlock operation requires that the Hydrogen valve be assigned to Output 3 and that the Oxygen valve be assigned to Output 4. Otherwise, the function assignments are suggestions provided for reference only.

2.4. Sensors, J9

Either a 9-pin female 'D' connector or a 10-pin IDC header or both is provided for a Low O2 flow switch and/or other sensors. Any sensor that provides a relay contact or an NPN transistor output may be used to pull the sensor inputs to 24 Volt Return.

Sensors that provide a relay contact output should be wired "*closed when safe*" and must provide contact closures to 24-volt return. Sensors that provide NPN current sinking outputs should be configured "ON when Safe" and should be capable of 24-volt operation. A 24 Volts DC power supply is available on this connector to provide power for sensors. The emitter of the sensor's output transistor should be wired to 24-Volt Return and the collector of the sensor's output transistor should be wired to the appropriate Digital Input pin on J9.

J9 Pin IDC	J9 Pin 'D'	Function	Sensor
1	1	Digital Input 2	
2	6	+24 V	
3	2	Digital Input 3	
4	7	24 Volt Return	
5	3	Digital Input 4	O2 Flow
6	8	24 Volt Return	
7	4	Digital Input 5	Torch OK
8	9	24 Volt Return	
9	5	Digital Input 6	
10		24 Volt Return	

The circuit board in the GPI 902 & GPI-903 contains (3) jumpers, JP3, JP4 and JP5, which control the behavior of Digital Input 4 (Lo O_2), Digital Input 5 (Lo Temp). See page 15.

2.5. Loader, J10

Either a 15-pin female 'D' connector or a 16-pin IDC header or both is provided for connection to a boat loader.

J10 Pin IDC	J10 Pin 'D'	Function	
1	1	Digital Output 0	Load
2	9	+24 Volts	Output Common to Loader
3	2	Digital Output 1	Unload
4	10	Digital Input 0	BIC
5	3	24 Volt Return	Input Common to Loader
6	11	Digital Input 1	BOC
7	4	Speed Setpoint	Analog Output 8
8	12	Position	Analog Input 8
9	5	Analog Common	
10	13	LDR +24V	*
11	6	LDR 24V Return	*
12	14	LDR +24V	*
13	7	LDR 24V Return	*
14	15	LDR +24V	*
15	8	LDR 24V Return	*
16		LDR +24V	*

* Pins 10 through 16 on the IDC connector, or the corresponding pins on the 'D' connector, are provided for those applications in which the loader is powered from the GPI-902 or GPI-903. Note: Some boat loader boards, especially older versions, may require modification to be compatible with this pinout.

2.6. Remote, J11

Either a 9-pin female 'D' connector or a 10-pin IDC header or both is provided for connecting control signals from a remote control panel to the process sequencer. These signals are not used by the GPI directly; however, the GPI does provide a Solid State Relay to buffer an Alarm signal that may originate at the process controller. Generally, the RUN/HOLD/RESET signals would be isolated at the process sequencer. An external buzzer and any remote control switches may be powered by the internal 24-volt power supply or by an external +5 volt to +24 volt power supply.

J11 Pin IDC	J11 Pin 'D'	Function	
1	1	RUN	Switch to Ground to RUN
2	6	ALARM OUT (-)	ALARM -
3	2	RESET	Switch to Ground to RESET
4	7	+24 Volts	ALARM +
5	3	ALARM SILENCE	Switch to Ground to Silence
6	8	+24 Volts	Tie to Remote Common
7	4	ABORT	Switch to Ground to ABORT
8	9	REMOTE COMMON	+5VDC to +24VDC
9	5	24 Volt Return	
10		24 Volt Return	

2.7. Auxiliary, J12

Either a 15-pin female 'D' connector or a 16-pin IDC header or both is provided for access to various calibration and control signals. The signals available on this connector are used for:

- Analog and Digital I/O
- Torch monitoring and adjustment
- Ratio setpoint adjustment

J12 Pin IDC	J12 Pin 'D'	Function	
1	1	+24 VDC	
2	9	24V RETURN	
3	2	DIGITAL INPUT 7	
4	10	AUX 2, NC	
5	3	AUX 2, NO	
6	11	AUX COMMON	
7	4	AUX 1, NO	
8	12	AUX 1, NC	
9	5	LO TEMP SET	
10	13	TEMPERATURE	
11	6	RATIO SET	
12	14	ANALOG INPUT 9	
13	7	ANALOG OUTPUT 9	
14	15	ANALOG COMMON	
15	8	VREF (+5)	
16		ANALOG COMMON	

The circuit board for the GPI-903 provides circuitry for interlocking Hydrogen gas flow on Output 3 to Torch temperature and Oxygen flow on burnt Hydrogen systems. Connector J12 contains the signals required to set the LO TORCH setpoint. Both the torch setpoint on Pin 9 and the temperature display on Pin 10 are referenced to analog common on pin 14. When used with a Type 'K' thermocouple, the temperature signals are scaled such that 1 volt DC represents 100 degrees Celsius.

The circuit board in the GPI 902 & GPI-903 contains a jumper, JP7, to select the source of Digital Input 7. When JP7 is jumpered between Pin 1 and Pin 2, Digital Input 7 becomes a 'GPI Fault' sensor that informs the DDC when the GPI power supply has failed. When JP7 is jumpered between Pin 2 and Pin 3, Digital Input 7 is connected to J12 and is available for some alternate purpose.

2.8. Torch

A connector is provided for a Type K torch thermocouple. Using an AD595 IC inside the GPI-903, the thermocouple signal is amplified and compensated. The resulting signal is scaled such that each one-volt DC increment represents 100 degrees Celsius (for example, 6.5 volts = 650 degrees). This amplified signal is then compared to a user adjustable set point. The resulting digital signal is used in the Hydrogen interlock circuit. See page 11 for additional information.

In addition, installing a jumper across JP6 connects the amplified thermocouple signal to an analog input on the DDC. It is the responsibility of the DDC software to scale this signal for display purposes.

2.9. Power Input

The GPI-902 & GPI-903 operate on AC voltages ranging from 85 VAC to 264 VAC at frequencies ranging from 47 to 63 Hertz without the need for jumpers or selector switches. Operation on DC power sources is also specified. A standard IEC power receptacle is provided for connection to an AC power source. See page 18 for additional information.

Note: Do not connect the unit to AC power until the valves and sensors are connected.

3. CONFIGURATION AND OPERATION

3.1. Auxiliary Relays, JP8 & JP9

Two sets of relay contacts are provided on connector J12. One of the relays may be controller by either Output 0 or by Output 8 as selected by Jumper JP8. The second relay may be controller by either Output 1 or by Output 9 as selected by Jumper JP9. The default jumper settings link to two auxiliary relays to Outputs 8 and 9.

3.2. MFC Override Relays, JM1 to JM6

A relay is provided for each of the six Mass Flow Controller (MFC) connectors, J1 through J6. Most MFC's include an "Override" feature that forces the flow controller closed regardless of the analog setpoint. This feature is typically activated by a contact closure between the Override pin and the Digital Common pin on the MFC.

The Override relays in the Gas Panel Interface are typically jumpered to the "Normally Closed" contacts of the relay. In this configuration, the signal that energizes the relay permits gas to flow by releasing the Override command.

In the event that a particular MFC connector is used for some other peripheral, the associated relay may be jumpered "Normally Open". In this configuration, the signal that energizes the relay closes the contact thereby enabling the peripheral.

3.3. Torch Jumper, JP1

The Model 903 includes a torch interlock that monitors the torch temperature on systems that use burn Hydrogen to form water vapor.

3.3.1. Circuit Description

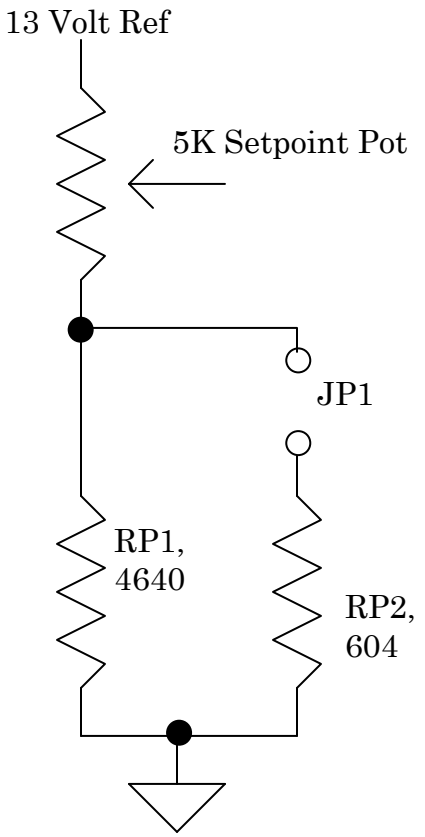
A resistor on the circuit board in the GPI-903 limits the lowest setting of the LO TEMP potentiometer to about 550 degrees Celsius for safety reasons. This resistor has a value of 4640 ohms. If you choose to use a type 'R' or 'S' thermocouple in place of type 'K' for which the circuit is designed, JP1 is provided to reduce the value of this resistor to 534 ohms to permit the torch setpoint to accommodate the lower output voltage of Type 'R' or Type 'S' thermocouples. Be aware that after this modification, if a type 'K' T/C is used, it will be possible to set the LO TEMP limit to an unsafe value.

Note: For normal operation with a Type "K" Torch Thermocouple, do not install a jumper on JP1.

With a 13 volt reference and a 534 ohm resistor in series with a 5000 ohm pot, the lowest possible setpoint voltage would be 1.25 volts corresponding to about 550 degrees with a Type 'R' thermocouple or 575 degrees with a Type 'S' thermocouple.

With JP1 removed and a 4640 resistor installed at R26, the lowest possible setting is 6.25 volts.

3.3.2. Torch Setpoint Diagram



3.3.3. Adjusting the Torch Setpoint for a Type 'K' Thermocouple

The signals required to adjust the LO TORCH setpoint are available on connector J11.

J12 Pin IDC	J12 Pin 'D'	Function	
9	5	Torch Setpoint	DC Voltage referenced to Analog Ground. Represents the current Torch setpoint (1.0 VDC per 100 degrees Celsius).
10	13	Torch Temp	DC Voltage referenced to Analog Ground. Represents the current Torch temperature. (1.0 VDC per 100 degrees Celsius)
14	15	Analog Ground	

3.3.4. Using a Type 'R' or Type 'S' Thermocouple

At a particular temperature, Type 'K' thermocouples output about 4 or 5 times the voltage of a Type 'R' thermocouple. The IC used in the GPI-903 is an Analog Devices AD595 that provides cold-junction compensation and amplification of Type 'K' T/C's. The AD595 is also available in a Type 'J' version (AD594), but not as a Type 'R' or Type 'S'. When used with the appropriate thermocouple type, the AD594 and the AD595 both output 1.0 volts DC per 100 degrees Celsius.

When using a Type 'R' or Type 'S' T/C, determining the LO TEMP setpoint limit is not quite as straightforward. Use the following procedure:

- Determine the setpoint temperature limit in degrees Celsius.
- Use the NIST Type 'R' or Type 'S' thermocouple tables to determine the output voltage of a Type 'R' (or Type 'S') T/C at the setpoint temperature.
- Use the NIST Type 'K' thermocouple tables to determine the temperature at which a Type 'K' thermocouple would produce that same output voltage.
- Using the 100 Degrees Celsius / 1 Volt conversion factor, determine the voltage at that temperature.

Tables on the following pages have been pre-calculated for some common setpoints for Type 'R' and Type 'K' thermocouples.

Following are some typical Type 'R' setpoints determined using the technique described above:

Setpoint Temperature	Type 'R' Voltage	Type 'K' Temperature	Setpoint Voltage
450	3.933 mV	96 °	0.96 VDC
475	4.200 mV	103 °	1.03 VDC
500	4.471 mV	108 °	1.08 VDC
525	4.744 mV	116 °	1.16 VDC
550	5.021 mV	123 °	1.23 VDC
575	5.300 mV	129 °	1.29 VDC
600	5.582 mV	136 °	1.36 VDC
700	6.741 mV	165 °	1.65 VDC
800	7.949 mV	194 °	1.94 VDC
1200	13.224 mV	324 °	3.24 VDC
1250	13.922 mV	341 °	3.41 VDC
1300	14.624 mV	358 °	3.58 VDC

Following are some typical Type 'S' setpoints determined using the technique described above:

Setpoint Temperature	Type 'S' Voltage	Type 'K' Temperature	Setpoint Voltage
450	3.742 mV	91 °	0.91 VDC
475	3.987 mV	97 °	0.97 VDC
500	4.233 mV	103 °	1.03 VDC
525	4.482 mV	109 °	1.09 VDC
550	4.732 mV	115 °	1.15 VDC
575	4.984 mV	121 °	1.21 VDC
600	5.239 mV	127 °	1.27 VDC
700	6.275 mV	153 °	1.53 VDC
800	7.345 mV	180 °	1.80 VDC
1200	11.951 mV	294 °	2.94 VDC
1250	12.554 mV	308 °	3.08 VDC
1300	13.159 mV	323 °	3.23 VDC

3.4. Hydrogen Interlock Jumpers, JP3, JP4 & JP5

The circuit board in the GPI-903 contains circuitry to interlock the Hydrogen valve in burnt Hydrogen (Pyrox) applications. The interlocks monitor the Hydrogen Valve control signal, the Oxygen Valve control signal, a Low Oxygen flow sensor and the output of the Torch monitor circuit.

Three jumpers, JP3 thru JP5, are provided to control the behavior of these interlocks.

Jumper	Label	Pins 1-2	Pins 2-3	
JP3	ILK Bypass	BYPASS		Bypasses all interlocks on the Hydrogen Valve
JP4	O_2 Flow	NORMAL	BYPASS	Determines whether the O2 Valve signal and the Low O2 sensor interlock the Hydrogen Valve
JP5	Torch	NORMAL	BYPASS	Determines whether the Torch OK signal interlocks the Hydrogen Valve

Note that the GPI-903 always expects sensors to be wired "Energized when Safe" for fail-safe operation.

3.5. H2/O2 Ratio Circuit

3.5.1. Ratio Jumper, JP2

The Model 903 provides a jumper to control the behavior of a Hydrogen/Oxygen ratio circuit.

When a jumper is installed between pins 1 and 2 of JP2 (labeled 'NORMAL' on the circuit board), the Hydrogen setpoint is not slaved to the actual O2 flow. In this mode of operation, the process sequencer is responsible for maintaining a safe H2/O2 ratio.

Note: In most installations, Pin 1 and Pin 2 of JP2 should remain jumpered together.

When a jumper is installed between pins 2 and 3 of JP2 (labeled 'RATIO' on the circuit board), the Hydrogen setpoint is slaved to the actual O2 flow. In this mode of operation, the H2/O2 ratio is controlled by a potentiometer, POT2, on the circuit board.

3.5.2. Adjusting the H2/O2 Ratio

When the H2/O2 ratio jumper, JP2, is jumpered for 'RATIO' mode, the ratio of the Hydrogen MFC setpoint to the actual O2 flow is determined by a potentiometer accessible through a hole at the top of the enclosure. A reference circuit is provided such that this ratio may be pre-adjusted without the need to have gases flowing.

A 'RATIO SET' signal is available on pin 11 of J12 (Pin 6 on the 'D' connector version). This signal represents the setpoint being sent to the H2 MFC (assuming that JP2 is jumpered for 'RATIO') and is referenced to 'ANALOG COMMON' on pin 14 of J12. Any Digital Volt Meter capable of accurately displaying a 0 to 5 volt DC signal may be used for adjusting or monitoring this signal.

In order to adjust the H2/O2 ratio setpoint, it is required to know the relative orifice sizes of the Hydrogen and Oxygen Mass Flow Controllers. Some examples follow:

- If the size of the Hydrogen MFC orifice equals the size of the Oxygen MFC orifice, the setpoint voltage sent to the Hydrogen MFC must not exceed 2x the voltage representing the actual Oxygen flow. That is, the ratio of (H2 Setpoint):(O2 Actual) in terms of voltages must not exceed 2:1. Assuming that the voltage ratio is 2:1, the gas flow ratio would be 2:1, the maximum safe limit.
- If the size of the Hydrogen MFC orifice is 2 times the size of the Oxygen MFC orifice, the setpoint voltage sent to the Hydrogen MFC must not exceed the voltage representing the actual Oxygen flow. That is, the ratio of (H2 Setpoint):(O2 Actual) in terms of voltages must not exceed 1:1. Assuming that the voltage ratio is 1:1, the gas flow ratio would be 2:1, the maximum safe limit.

A formula for determining the ratio of the Hydrogen setpoint voltage to the actual Oxygen voltage using actual flow rates is as follows:

$$\frac{\text{(Desired H2 flow in LPM) / (size of H2 MFC orifice in LPM)}}{\text{(Desired O2 flow in LPM) / (size of O2 MFC orifice in LPM)}}$$

A formula for determining the ratio of the Hydrogen setpoint voltage to the actual Oxygen voltage using target flow ratios is as follows:

$$\frac{\text{(Desired H2:O2 flow ratio) * (size of O2 MFC orifice in LPM)}}{\text{(size of H2 MFC orifice in LPM)}}$$

Once this voltage ratio is determined, multiply this number times the Oxygen flow to obtain the required Hydrogen setpoint.

A pushbutton switch is provided on the Model 903 to allow the ratio to be adjusted while no gases are flowing. This is the preferred way to adjust the ratio. When the pushbutton is depressed and the Oxygen flow is off, a 5-volt reference signal is provided to the ratio-adjust potentiometer. Multiply the target voltage ratio determined above times 5 volts to determine the target setpoint voltage as would be read on pin 11 of J12 with respect to pin 14 of J11.

A practical example follows:

A Hydrogen flow of 4 LPM is desired in a system with an Oxygen flow of 3 LPM. The Hydrogen MFC orifice is 20 LPM and the Oxygen MFC orifice is 10 LPM.

Using the formula (4 LPM) / (20 LPM) stated above, the desired voltage ratio is determined to be 67% as follows:

(3 LPM) / (10 LPM)

With the ratio pushbutton switch depressed, 5.0 volts would be applied to the ratio potentiometer. The desired RATIO SETPOINT would be 67% x 5 volts or 3.33 volts.

4. SPECIFICATIONS

4.1. Physical

Dimensions:	10.05 in. high x 6 in. wide x 4 in. deep
Weight:	4 lbs. maximum
Finish:	Cardinal, high bake, water-based paint, medium texture.

4.2. AC Power Requirements

AC Frequency:	47 to 63 Hertz
AC Voltage:	85 to 264 Volts AC
DC Voltage:	120 to 370 Volts DC
Power:	100 watts maximum
Efficiency:	75-85% Typical

5. JUMPER SUMMARY

5.1. Jumper Definition

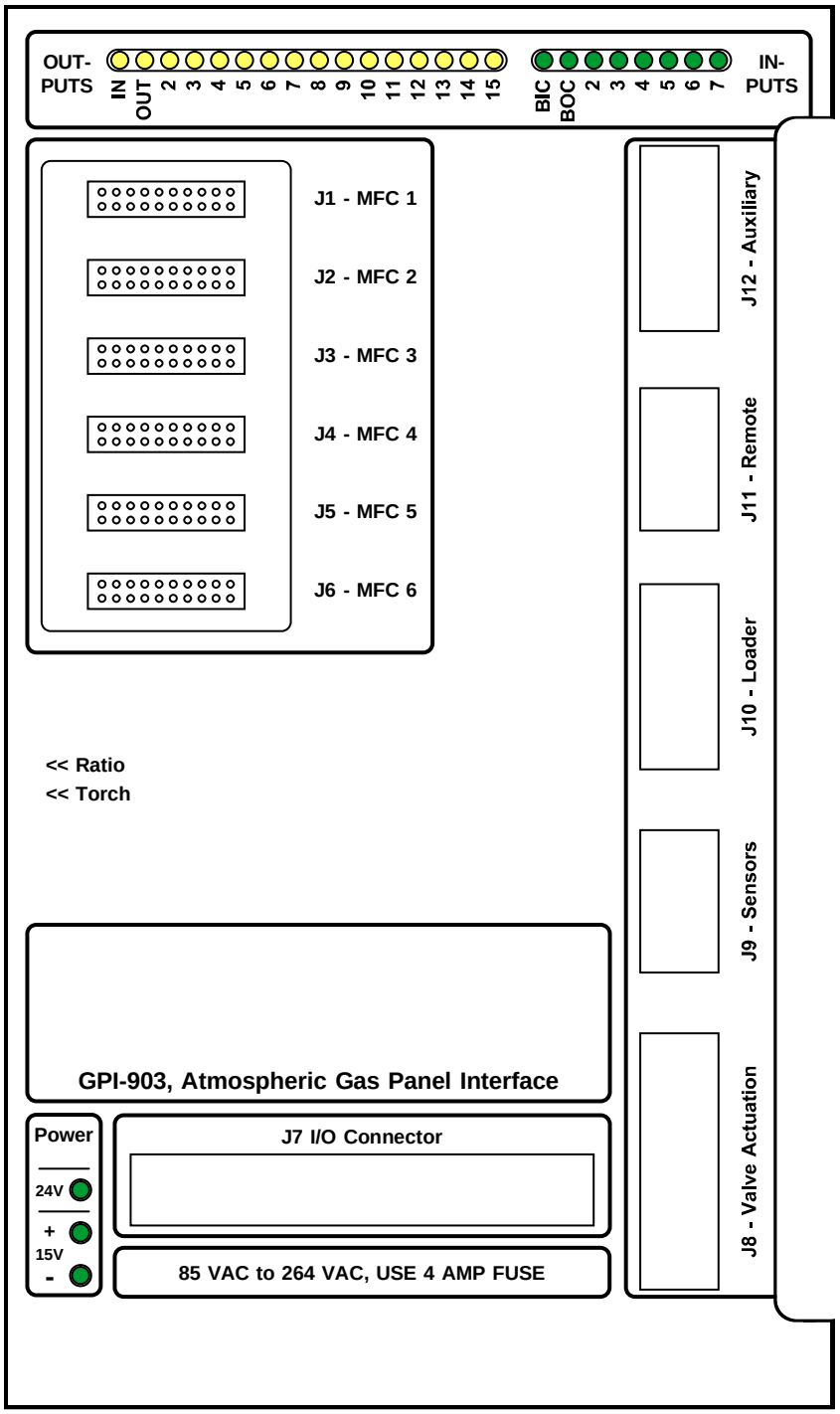
Jumper	Function	Pins 1-2	Pins 2-3	
JP1	Type 'R'	ENABLE	----------	Enables shunt resistor for Type 'R' Torch Monitor
JP2	H2:O2 Ratio	NORMAL	RATIO	RATIO position slaves H2 Setpoint to O2 Actual
JP3	ILK Bypass	BYPASS	----------	Bypasses all interlocks on the Hydrogen Valve
JP4	O_2 Flow	NORMAL	BYPASS	Determines whether the O2 Valve signal and the Low O2 sensor interlock the Hydrogen Valve
JP5	Torch	NORMAL	BYPASS	Determines whether the Torch OK signal interlocks the Hydrogen Valve
JP6	Torch	ENABLE		Connects Torch Thermocouple to Analog Input 9
JP7	Digital Input 7	24V Return	INP 7	Determines source of Digital Input 7 signal
JP8	Aux 1	Dig Out 0	Dig Out 8	Determines source of control signal for Aux 1 relay
JP9	Aux 2	Dig Out 1	Dig Out 9	Determines source of control signal for Aux 2 relay
JM1 to JM6	MFC OR	N.C.	N.O.	Selects Normally Closed/Normally Open contacts on MFC relays

5.2. Default Jumper Settings

Jumper	Function	GPI-902	GPI-903
JP1	Type 'R'	No Jumper	No Jumper
JP2	H2:O2 Ratio	NORMAL	NORMAL
JP3	ILK Bypass	BYPASS	No Jumper
JP4	O_2 Flow	BYPASS	NORMAL
JP5	Torch	BYPASS	NORMAL
JP6	Torch	No Jumper	No Jumper
JP7	Digital Input 7	INP 7	INP 7
JP8	Aux 1	Dig Out 8	Dig Out 8
JP9	Aux 2	Dig Out 9	Dig Out 9
JM1 to JM6	MFC Override	N.C.	N.C.

6. APPENDIX

6.1. Front Panel Artwork



6.2. Bottom View