HAMILTON STANDARD Division of UNITED TECHNOLOGIES

SVHSER 7222

OPERATION AND MAINTENANCE MANUAL

FOR A PREPROTOTYPE SABATIER

CARBON DIOXIDE REDUCTION SUBSYSTEM

BY

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PREPARED UNDER CONTRACT NO. NAS 9-15470

BY

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JANUARY 1981

ABSTRACT

The Preprototype Sabatier Carbon Dioxide Reduction Subsystem Operation and Maintenance Manual delineates the procedures, precautions and necessary sequences of steps required to prepare the package for test, provide troubleshooting information and perform required maintenance by the operating crew.

The manual is divided into five (5) sections: Installation, Checkout, Operation, Failure Detection/Isolation and Maintenance.

FOREWORD

This manual has been prepared by the Hamilton Standard Division of United Technologies Corporation for the National Aeronautics and Space Administration's Lyndon B. Johnson Space Center in accordance with Contract NAS 9-13624, "Development of a Preprototype Sabatier CO_2 Reduction Subsystem."

Appreciation is expressed to the NASA Technical Monitor, Mr. Robert J. Cusick of the NASA, Johnson Space Center, for his guidance and advice.

List of Applicable Documents

Schematic	SVSK 96498
Package Assembly Drawing	SVSK 96500
Installation Drawing	SVSK 97823
Driver Box Drawing	SVSK 97813
Electrical Harness Drawing	SVSK 100140
Controller and Display Block Diagram	SVSK 96463
Analog Conditioning Circuit Drawing	SVSK 101113
Output Drive Circuit Drawing	SVSK 101115
TIMES Controller (Common item, used to operate the Sabatier subsystem)	SVSK 97811

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INTRODUCTION

The Preprototype Sabatier Carbon Dioxide Reduction Subsystem Operation and Maintenance Manual delineates the procedures, precautions and necessary sequences of steps required to prepare the package for test, provide troubleshooting information and perform required maintenance by the operating crew.

The manual is divided into five (5) sections as described herein.

Section 1 - Installation

This section defines the steps required in installing the subsystem prior to checkout. Included are procedures for making fluid and electrical connections, techniques for charging and purging and precautions to be taken.

Also, procedures are provided for preparing the subsystem for shipment and/or storage.

Section 2 - Checkout

This section defines the procedure to be used to checkout the subsystem prior to subsystem test.

Section 3 - Operation

This section presents the method used to control this subsystem, evaluate instrumentation data during each operating mode, and perform shutdown subsequent to a failure.

Section 4 - Failure Detection/Isolation

This section describes the component or subsystem malfunctions identified automatically by the controller and other procedures for troubleshooting to isolate, to the repair level, an out-of-limits condition identified during subsystem operation.

Section 5 - Maintenance

This section provides maintenance instructions for every replaceable item. For each item, its location is described and a photograph of its installed position in the subsystem is provided. Also, the tools needed, steps required before maintenance such as safety checks, bleeds, etc., maintenance steps for removal and installation are provided. In addition, any special checkout steps or precautions are listed.

Section 1

INSTALLATION

Section 1

INSTALLATION

1.0 Scope

This section is divided into two parts. The first part will discuss the installation and commissioning operation to ready the package for test. The second part will delineate the necessary preparations required prior to shipment and/or storage.

The Sabatier Subsystem consists of the following assemblies:

- Sabatier, Package Assembly
- Sabatier, Driver Box
- TIMES, Controller
- TIMES, Display and Keyboard
- Interconnecting Harnesses

The TIMES items are used to operate the Sabatier subsystem, to reduce program costs and to demonstrate the common capability of these items. Figure 1 defines the basic subsystem interfaces and the preprototype system.

Electrical, fluid and mechanical requirements for the package interfaces are defined by the Hamilton Standard Sabatier Installation Drawing SVSK 97823 and the Sabatier Electrical Harness Drawing SVSK 100140.

The Sabatier package assembly, driver box and TIMES controller will be installed in the NASA test racks in close proximity to one another while the TIMES display and keyboard will be located remotely in the laboratory control center. A 10 meter transmission line is provided to permit the remote location. A 10 meter line is also provided to permit the NASA to install a remote discrete shutdown switch. Figure 2 defines a recommended test setup for monitoring inlet and outlet parameters.

1.1 Commissioning

1.1.1 Interfaces

1.1.1.1 Cooling Air From Cabin

This interface is the source of cooling air for the Sabatier Reactor (Item 91) and Condenser/Separator (Item 51). No interface connections are required. Air is drawn in from the cabin ambient.

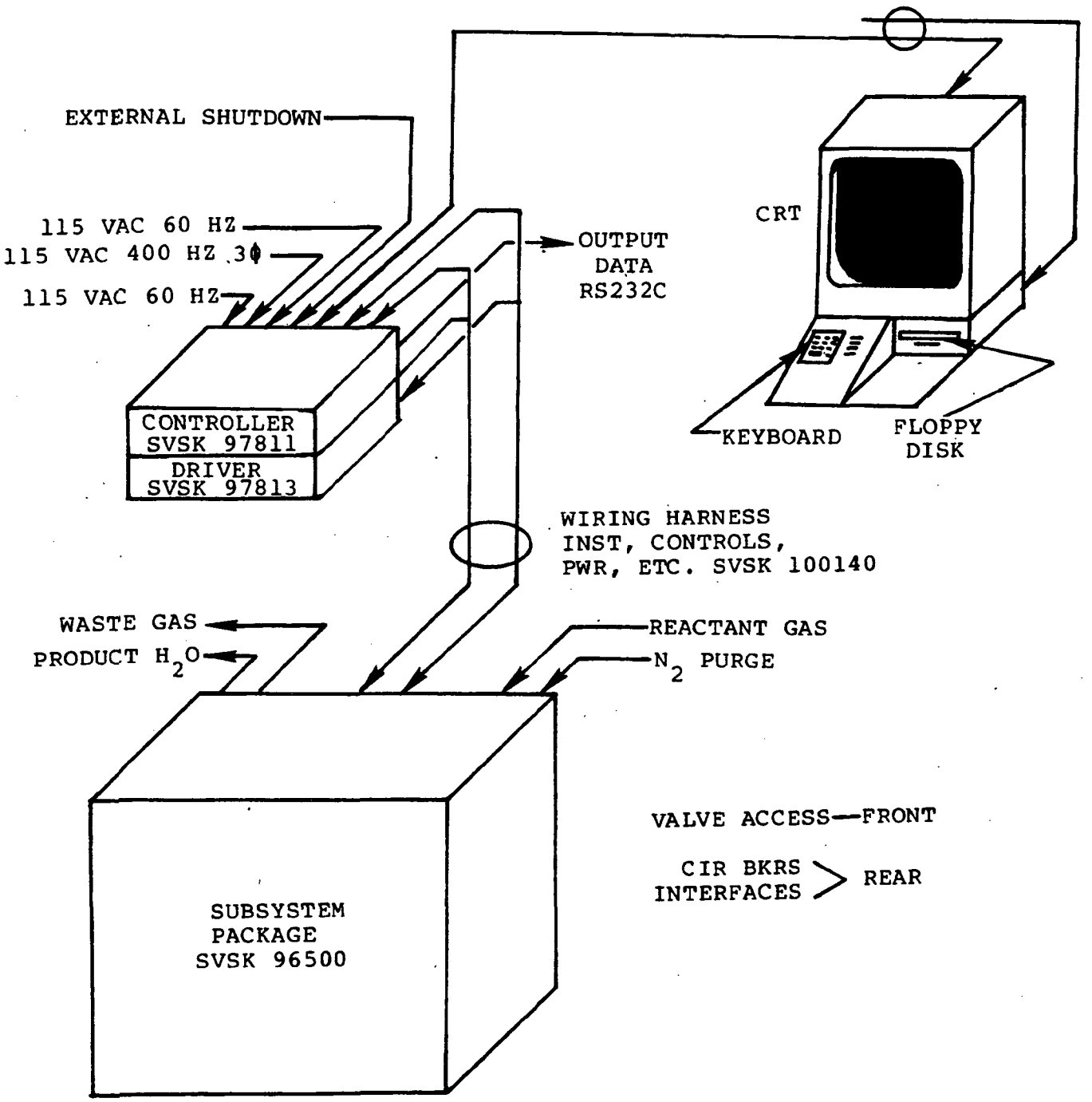


FIGURE 1

PREPROTOTYPE SABATIER SUBSYSTEM INSTALLATION

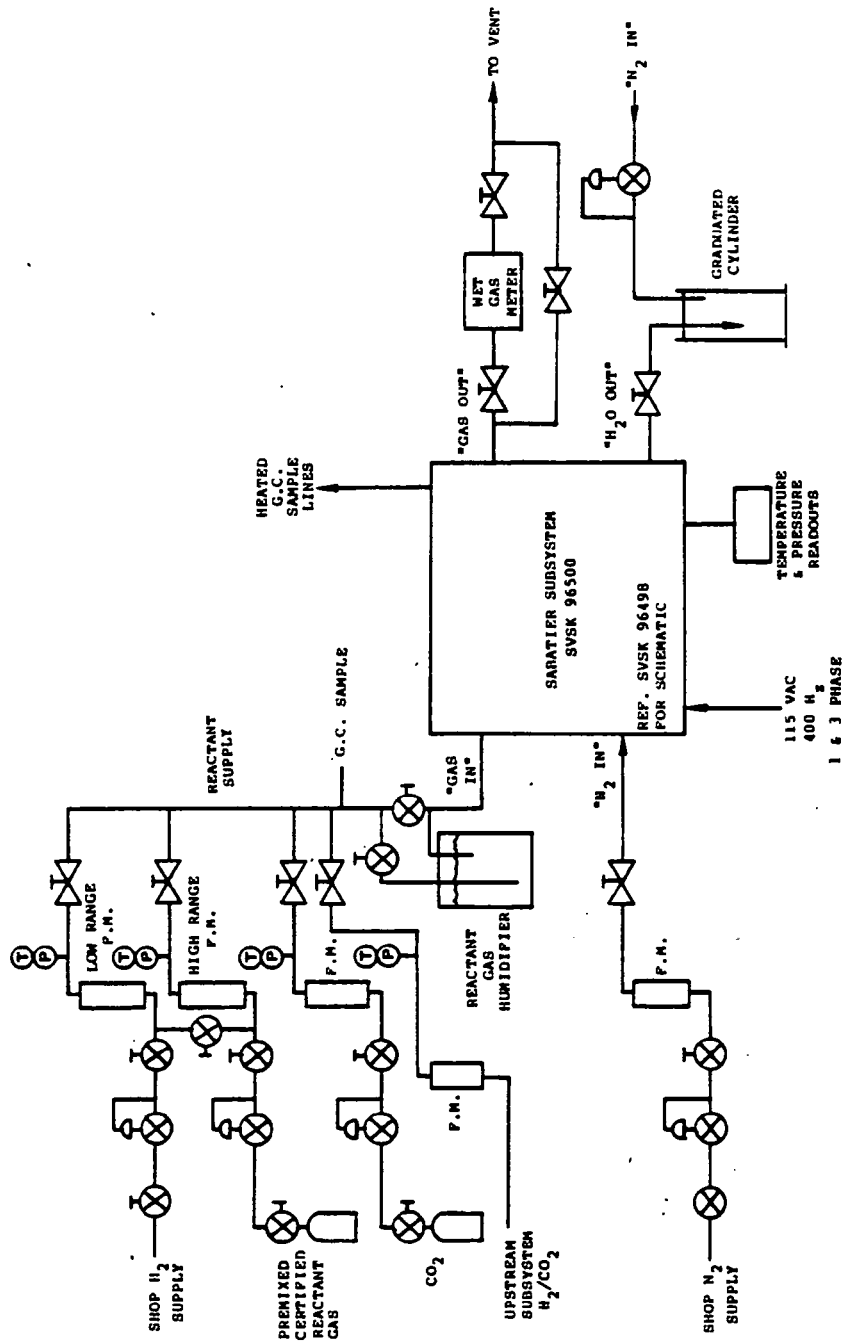


FIGURE 2

RECOMMENDED TEST INSTALLATION

1.1.1.2 Cooling Air To Cabin

This interface is the outlet for cooling air for the Sabatier reactor (Item 91) and Condenser/Separator (Item 51). No interface connections are required. Air is exhausted to cabin ambient.

1.1.1.3 Nitrogen (N_2) In (Purge)

This interface is to be connected to a dry nitrogen (-65°F, (-18°C) dewpoint) supply pressure not to exceed 30 psia. Be sure that the Electrical Shutoff Valve Item (306-3) is in the closed position prior to connection. There should be a shutoff valve upstream of the package interface (GSE), left in the closed position, until Package Checkout, as defined in Section 2, is complete.

1.1.1.4 Gas In (CO_2 and H_2)

This is the process flow supply line. Be sure that the Electrical Shutoff Valve (Item 306-1) is in the closed position prior to connection. There should be a shutoff valve upstream of the package interface left in the closed position until Package Checkout, as defined in Section 2, is complete.

1.1.1.5 Gas Out (Waste)

This interface provides a connection for the reacted gases to be exhausted. This line should be connected to an outside ambient pressure vent or a vacuum supply to assure that reacted gases are eliminated from the test area. Be sure that the Electrical Shutoff Valve (Item 306-2) is in the closed position prior to connection.

1.1.1.6 Water (H_2O) Out

This interface is the outlet for process water collected in the Accumulator (Item 61). The outlet line should be located no higher than thirty (30) inches above the interface connection to prevent too high a back pressure from developing in the subsystem outlet line when purging the water pump (Item 545). The maximum back pressure on the water outlet line should not exceed 30 psig to prevent too high a back pressure on the subsystem which will exceed the pumping capacity of the pump (Item 545) system.

1.1.1.7 Electrical Interface

Three electrical interfaces are required for subsystem operation. Two additional electrical interfaces are supplied for NASA use.

1 - 115 VAC 60 Hz power to the Sabatier Driver Box, Item 71 (SVSK 97813)

2 - 120 VAC 400 Hz 30 power to the Sabatier Driver Box, Item 71 (SVSK 97813)

3 - 115 VAC 60 Hz power to the TIMES Controller (SVSK 97811)

4 - Shut down discrete signal. Enables the subsystem to be shutdown remotely.

5 - Analog output - Permits NASA to monitor or record data displayed on CRT.

These lines must be wired as follows:

1 - Earth ground must be common to all circuits.

2 - 115 VAC supplies should be common.

3 - Shut down discrete relay must be completely isolated (i.e. use isolated relay contacts).

1.1.4 Subsystem Preparation

1.1.4.1 Vacuum Line (If Used)

With the vacuum line connected to the "GAS OUT" port the subsystem should be evacuated back to this outlet. Be sure 507-4 is in the open position. Open 306-5 and 306-4. These are manual operations. Wait approximately five (5) minutes and then close 306-5 and 306-4 manually. Leave 507-4 in the open position.

1.1.2 GSE Precautions

1.1.2.1 Gas Out Vent

When the subsystem is operational with or without other subsystems, the gas out vent line or vacuum source must be open.

1.1.2.2 Nitrogen

The nitrogen source should be on line and the GSE valve to the packages open.

1.1.2.3 Combustible Gas Protection

1.1.2.3.1 Installation

The subsystem shall be installed for test purposes in such a way as to be subjected to constant ventilation at a minimum flow velocity of 25 ft/min. by circulation of room air. This may require external fans to accomplish this circulation.

Potential ignition sources should be isolated from the subsystem by distance or other means, except when the potential ignition source is essential to the chemical or combustion process for which the hydrogen is intended.

1.1.2.3.2 Shutdown

The subsystem shall be shutdown (including purge in the normal manner) if the circulation of cabin air fails.

1.1.2.3.3 Repair

No repairs of any hydrogen containing component or line should be done without first shutting down and purging the subsystem.

1.2 Preparations for Shipment or Storage

The following procedure is recommended to prepare the Preprototype Sabatier Carbon Dioxide Reduction package assembly (SVSK 96500) for shipment or storage.

1.2.1 Water Line Evacuation

The water lines between the Condenser/Separator (Item 51), the Accumulator (Item 61) and the "WATER OUT" interface should be drained by removing Item 806 cap. These lines shall then be evacuated before storage or shipment. Replace the Item 806 cap. Connect a vacuum source to "WATER OUT" port of 1.0 psia or less for approximately four (4) hours with 503-61 in the open position.

1.2.3 Interface Connections

Disconnect all interfaces and cap the lines at the package.

Section 2

CHECKOUT

Section 2

CHECKOUT

2.0 General

This section describes a series of tests designed to verify the functional integrity of the electro-mechanical operation and malfunction equipment. The successful completion of the dry checks outlined in this section will provide the necesary confidence to commit this subsystem to performance testing.

Checkout of this subsystem is performed in four parts: a) subsystem leakage test, b) electro-mechanical functional check out, c) nitrogen purge test and d) pump test.

2.1 Subsystem Leakage Test

Subsystem circuit segments should be leak tested as described below:

Test	Tube/Duct Segment	Leakage Method	Allowable Limit
Leakage	Pressurize "GAS IN", with 5 psig N_2. Cap all other ports. Open all subsystem valves.	Decay at 5 psig Nitrogen	No less than 4 psig in 10 min.

2.2 Electro-Mechanical Functional Check Out

The test sequence described in this section was selected to demonstrate the electro-mechanical functional requirements of this subsystem. The tests described herein are dry checks, that is, the subsystem is not pressurized except when specifically noted.

Prior to initiating the test series, Section 3 - Operation, should be reviewed. Presented in Section 3 is a description of system operation, mode control selection method, and a definition of the controller limits and instrumentation.

The valves should be visually inspected and placed in the following configuration before initiating the test series and applying power to the subsystem.

2.2 Continued

306-1 Optional	507-1 Open
306-2 Optional	507-2 Open
306-3 Optional	507-3 Open
306-4 Optional	507-4 Open
306-5 Optional	

The N_2 and H_2/CO_2 supply should either not be connected or be shut off at the source except as specifically noted. The subsystem tests should be performed with power "on" in the "step" sequence presented below. For each of the steps, the expected output of each item as displayed on the CRT and the resultant valve positions are noted. After each malfunction check the subsystem will go into an automatic purge mode, indicate the type of malfunction and display a visual and audible alarm which will continue for a period of 10 minutes. The subsystem cannot be restarted, nor will it accept any-other instructions during this time period. The audible alarm can be shut off by pushing the "CLEAR" button.

2.2.1 Valve Position (Items 306)

Step 1 - With power on the subsystem, the CRT display should indicate the Shutdown Mode and the Item 306 valves should assume the positions noted in Table 1. The subsystem parameters as displayed on the CRT Performance Table 1 shall be as noted on Table 1.

Step 2 - Valve 306-1 is manually positioned to the close position to verify operation of the valve. The override must be retained for approximately 10 seconds to keep the valve in the open position. This action will initiate an emergency shutdown sequence and light a red flashing display and an audio signal and indicate the valve was in the wrong position. The subsystem will assume a purge mode which will continue for 10 minutes. Until then the subsystem cannot be restarted. When the override is removed, the valve will return to the open position.

Step 3 - Valve 306-2 is manually positioned to the open position to verify operation of the valve. The override must be retained for approximately 10 seconds to keep the valve in the closed position. This action will initiate an emergency red flashing and an audio signal and display the valve was in the wrong position. When the override is removed the valve will return to the closed position.

Table 1

CHECKOUT - "SHUTDOWN" MODE

Item No.	Name	CRT Reading
083-1	HEATER 1 CURRENT (amps)	0
083-2	HEATER 2 CURRENT (amps)	0
046	FAN PHASE 1 CURRENT (amps)	0
545	PUMP PHASE 1 CURRENT (amps)	0
081-2	CONDENSER OUTLET TEMPERATURE (°F)	Room Temp. ± 10°
081-1	REACTOR OUTLET TEMPERATURE (°F)	Room Temp. ± 10°
082-1	REACTOR TEMPERATURE - BED (°F)	Room Temp. ± 10°
	REACTOR TEMPERATURE - SHELL (°F)	Room Temp. ± 10°
178-1	COMBUSTIBLE GAS (percent)	<25
178-2	COMBUSTIBLE GAS (percent)	<25
178-3	COMBUSTIBLE GAS (percent)	<25
178-4	COMBUSTIBLE GAS (percent)	<25
902-1	REACTANT PRESSURE (psig)	0 ± .2
902-2	REACTOR INLET PRESSURE (psig)	0 ± .2
907	LIQUID SENSOR (seconds before timeout)	Dry
306-5	OUTLET VALVE	Open
061	PRODUCT WATER QUANTITY (percent)	0
268	WATER PRODUCTION RATE (pph)	0
		Visual Inspection
306-1	INLET VALVE	Closed
306-2	BYPASS VALVE	Open
306-3	PURGE VALVE	Closed
306-4	OUTLET VALVE, REACTOR	Closed
306-5	OUTLET VALVE	Open

2.2.1 Continued

Step 4 - Valve 306-3 is manually positioned to the open position to verify operation of the valve. The override must be retained for approximately 10 seconds to keep the valve in the closed position. This action will initiate an emergency red flashing and an audio signal and display the valve was in the wrong position. When the override is removed, the valve will return to the closed position.

Step 5 - Valve 306-4 is manually positioned to the close position to verify operation of the valve. The override must be retained for approximately 10 seconds to keep the valve in the open position. This action will initiate an emergency shutdown sequence and light a red flashing display and an audio signal and indicate the valve was in the wrong position. The subsystem will assume a purge mode which will continue for 10 minutes. Until then the subsystem cannot be restarted. When the override is removed, the valve will return to the open position.

Step 6 - Valve 306-5 is manually positioned to the close position to verify operation of the valve. The override must be retained for approximately 10 seconds to keep the valve in the open position. This action will initiate an emergency shutdown sequence and light a red flashing display and an audio signal and indicate the valve was in the wrong position. The subsystem will assume a purge mode which will continue for 10 minutes. Until then the subsystem cannot be restarted. When the override is removed, the valve will return to the open position.

2.2.2 Combustible Gas Indication (Items 178)

Step 7 - Expose the Item 178-1 combustible gas sensor to a 2 percent hydrogen gas mixture. This will initiate an emergency shutdown sequence and a red flashing light and an audio signal and display the items number and name of the sensor. The CRT Performance Table will indicate the percent combustible gas present.

2.2.2 Continued

Step 8 - Expose the Item 178-2 combustible gas sensor to a 2 percent hydrogen gas mixture. This will initiate an emergency shutdown sequence and a red flashing light and an audio signal and display the item number and name of the sensor. The CRT Performance Table will indicate the percent combustible gas present.

Step 9 - Expose the Item 178-3 combustible gas sensor to a 2 percent hydrogen gas mixture. This will initiate an emergency shutdown sequence and a red flashing light and an audio signal and display the items number and name of the sensor. The CRT Performance Table will indicate the percent combustible gas present.

Step 10- Expose the Item 178-1 combustible gas sensor to a 2 percent hydrogen gas mixture. This will initiate an emergency shutdown sequence and a red flashing light and an audio signal and display the items number and name of the sensor. The CRT Performance Table will indicate the percent combustible gas present.

2.2.3 Heater Control (Item 82-1)

Step 11- Place the subsystem into the Processing Mode, and note the time the fan should run as indicated by the noise level and air flow out of the muffler. The fan phase 1 current should read <1 and >0 ($\approx$.25) as noted on the CRT Performance Table. The subsystem parameters as displayed on the CRT Performance Table shall be as noted in Table 2.

Step 12- The heater wire shall appear red on the CRT Performance and Operations schematics and the Item 83-1 and 83-2 heater current should be >0 and <1.0.

Step 13- Item 82-1 and 85-1 temperatures shall rise as can be noted on the CRT Performance Table. These temperature values can be compared with the Item 86 temperatures which can be manually monitored. As soon as the bed temperature reaches 375°F (196°C) the heater will shut off as evidenced by the heater wire in the display timing to blue on the CRT Performance and Operation schematic. The Item 83-1 and

Table 2

CHECKOUT - "PROCESSING" MODE

Item No.	Name	CRT Reading
083-1	HEATER 1 CURRENT (amps)	<1.0
083-2	HEATER 2 CURRENT (amps)	<1.0
046	FAN PHASE 1 CURRENT (amps)	<1.0
545	PUMP PHASE 1 CURRENT (amps)	0
081-2	CONDENSER OUTLET TEMPERATURE (°F)	<100
081-1	REACTOR OUTLET TEMPERATURE (°F)	<300
082-1	REACTOR TEMPERATURE - BED (°F)	<1200
	REACTOR TEMPERATURE - SHELL (°F)	<1100
178-1	COMBUSTIBLE GAS (percent)	<25
178-2	COMBUSTIBLE GAS (percent)	<25
178-3	COMBUSTIBLE GAS (percent)	<25
178-4	COMBUSTIBLE GAS (percent)	<25
902-1	REACTANT PRESSURE (psig)	0 ± .2
902-2	REACTOR INLET PRESSURE (psig)	0 ± .2
907	LIQUID SENSOR (seconds before timeout)	Dry
306-5	OUTLET VALVE	Open
061	PRODUCT WATER QUANTITY (percent)	0
268	WATER PRODUCTION RATE (pph)	0
		Visual Inspection
306-1	INLET VALVE	Open
306-2	BYPASS VALVE	Close
306-3	PURGE VALVE	Close
306-4	OUTLET VALVE, REACTOR	Open
306-5	OUTLET VALVE	Open

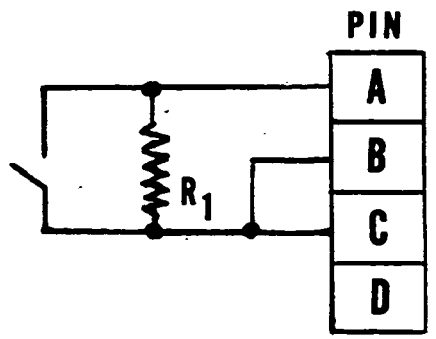
2.2.3 Continued

83-2 heater currents will read 0 on the CRT Performance Table. Note: The reactor temperature must rise above 325°F (163°C) in less than ten minutes or the system will be automatically shut down. Note with normal reactant flow, temperatures will rise much quicker than with no gas in the system. Caution: Do not exceed 500°F (260°C) at any time with no gas flow into the reactor.

Step 14- Place the subsystem into the shutdown mode and allow the subsystem to shut down completely as evidenced by the fan motor coming to a complete stop.

2.2.4 Reactor Overtemperature (Item 85-1)

Step 15- Disconnect the Item 85-1 temperature probe connector and connect a thermal simulator to the electrical harness connector which mates to the Item 85-1 connector. The simulator schematic and the appropriate pin connections is shown below:



R_1 = 325 ohms
The switch should be closed.

Step 16- Open the thermal simulator switch and Item 85-1 temperature will read 1150 + 10°F (621 + 3°C) on the CRT Performance Table. A heater overtemperature signal will be indicated and a malfunction shutdown sequence will be initiated.

2.2.4 Continued

Step 17- After the subsystem has shutdown, remove the thermal simulator and reconnect Item 85-1 to the mating subsystem connector.

2.2.5 Low Reactor Temperature (Item 82-1)

Step 18- Disconnect both Item 83 heater connectors.

Step 19- Repeat Step 11 and note the time. Heater currents will read zero on the CRT Performance Table.

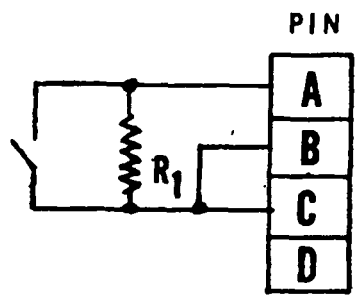
Step 20- Observe the reactor temperature which will remain constant. After ten minutes, since the reactor temperatures will not have reached 325°F (163°C), a malfunction shutdown sequence will be initiated.

Step 21- After the subsystem has shutdown, reinstall the electrical heater connector to the proper mating subsystem connector.

2.2.6 High Condenser Output Temperature (Item 81-2)

Step 22- Disconnect Item 82-1 temperature probe connector and connect a thermal simulator to the electrical harness connector which mates to the Item 81-2 connector. The simulator schematic and the appropriate pin connections are shown below:

$R_1 = 120\Omega$



The switch should be closed.

2.2.6 Continued

Step 23- Open the thermal simulator switch and Item 81-2 temperature will read 125 ± 10°F (52 ± 3°C) on the CRT Performance Table. A overtemperature malfunction will be indicated and an emergency shutdown sequence will be initiated.

Step 24- After the subsystem has shut down, remove the thermal simulator and reconnect the Item 82-2 connector to the proper mating subsystem connector.

2.2.7 Purge Overpressure (Item 902-2)

Step 25- Remove Item 802 port cap and install a low pressure dry nitrogen supply line.

Step 26- Slowly raise the nitrogen pressure to 6 psig (Note: Do not exceed 10 psig) as indicated on test instrumentation or by observing Item 902-2 reactant pressure reading on the CRT Performance Table. As soon as the pressure exceeds 5.5 psig, an overpressure condition will be indicated and a malfunction shutdown sequence will be initiated.

Step 27- After the subsystem has shut down, remove the nitrogen supply and allow the nitrogen pressure to be reduced. Immediately reinstall the Item 802 port cap.

2.2.8 Reactant Overpressure (Item 902-1)

Step 28- Remove the "GAS IN" port cap and install a dry nitrogen supply line.

Step 29- Slowly increase the nitrogen pressure to 6 psig (Note: Do not exceed 15 psig as indicated on test instrumentation or by observing Item 902-1 reactant pressure reading on the CRT Performance Table. As soon as the pressure exceeds 5.5 psig, an overpressure condition will be indicated and a malfunction shutdown sequence will be initiated.

Step 30- After the subsystem has shut down, remove the nitrogen pressure to be reduced. Reinstall the "GAS IN" cap.

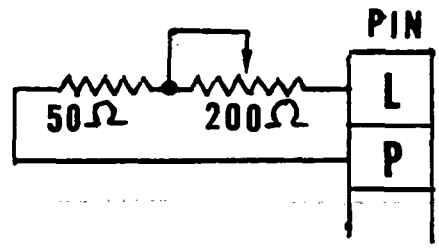
2.2.9 Liquid Sensor (Item 907)

Step 31- Expose the Item 907 liquid sensor to water containing carbon dioxide or a trace of salt (NaCl). This will initiate an emergency shutdown sequence and light a red flashing display, an audio signal, and display the item number and name of the sensor. The CRT Performance Table display will indicate the liquid sensor is wet.

Step 32- After the subsystem has shutdown, clean the tip of the sensor in distilled water, dry and reinstall back into the duct.

2.2.10 High Fan Current (Item 46)

Step 33- Disconnect the fan electrical connector located on top of the fan body and connect an overcurrent simulator to the electrical harness connector which mates to the Item 46 connector. The overcurrent simulator and pin callouts are shown below:



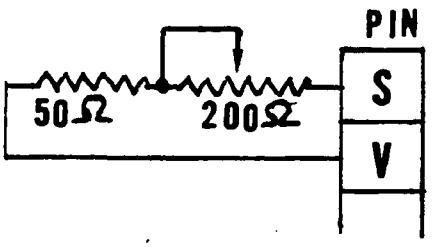
Step 34- Slowly decrease the variable resistance to approximately 58 ohms (1 amp). The current for Item 046 can be monitored on the CRT Performance Table. Within 30 seconds after the current reaches 1 amp a malfunction shutdown sequence will be initiated.

2.2.10 Continued

Step 35- After the subsystem has shutdown, remove the overcurrent simulator and reconnect the Item 46 electrical harness connector to the Item 46 fan.

2.2.11 High Pump Current (Item 545)

Step 36- Disconnect the pump electrical connector and connect an overcurrent simulator to the electrical harness connector which mates to the Item 545 connector. The overcurrent simulator and pin callouts are shown below:



Step 37- Slowly decrease the variable resistance to approximately 58 ohms (1 amp). The current for Item 545 can be monitored on the CRT Performance Table. Within 30 seconds after the current reaches 1 amp a malfunction shut-down sequence will be initiated.

Step 38- After the subsystem has shutdown, remove the overcurrent simulator and reconnect the Item 545 electrical harness connector to the Item 545 pumps.

2.3 Nitrogen Purge Test

The test sequence defined below is performed to verify operation of the nitrogen purge sequence including the pressure transducer Item 902-2; orifice Item 703; the back pressure regulator Item 310-1 and electrical valves Item 306-3 and 306-1.

A 30 psig nitrogen supply source is installed to the "N_2 IN" and the "GAS OUT" interface is uncapped. Remove Item 802 cap and install a 0-30 psia gage.

Step 1 - Place the subsystem into the purge mode the subsystem parameters as displayed on the CRT Performance Table should be as noted on Table 3. Item 902-1 reactor inlet pressure should read 5.5 $\pm$ .2 psig and the Item 306-3 valve should be open.

Step 2 - Place the subsystem into the shutdown mode. Turn off the nitrogen gas supply.

2.4 Accumulator and Pump Test

The purpose of this test is to check the accumulator, acumulator quantity limits, and pump operation. Note: This test can only be conducted with an external supply of pressurized (8-12 psig) distilled filtered (5 microns) water.

Step 1 - Place the subsystem in the "Maintenance" mode.

Step 2 - Remove the "WATER OUT" port cap and connect to a suitable water reservoir which can be back pressurized. Remove the Item 806 port and connect a filtered (5 microns) distilled water supply line. Loosen the Item 805 port cap.

Step 3 - Slowly feed water into the system until the air is removed from the Item 805 port cap. Retighten the cap. Continue to feed water into the system until water is discharged from the water outlet port. The position of the water in the accumulator will be displayed in green on the CRT Performance Display and in the Performance Table.

Table 3

CHECKOUT - "PURGE" MODE

Item No.	Name	CRT Reading
083-1	HEATER 1 CURRENT (amps)	0
083-2	HEATER 2 CURRENT (amps)	0
046	FAN PHASE 1 CURRENT (amps)	1.0 max
545	PUMP PHASE 1 CURRENT (amps)	0.5 max
081-2	CONDENSER OUTLET TEMPERATURE (°F)	100 max
081-1	REACTOR OUTLET TEMPERATURE (°F)	300 max
082-1	REACTOR TEMPERATURE - BED (°F)	1200 max
	REACTOR TEMPERATURE - SHELL (°F)	1100 max
178-1	COMBUSTIBLE GAS (percent)	25 max
178-2	COMBUSTIBLE GAS (percent)	25 max
178-3	COMBUSTIBLE GAS (percent)	25 max
178-4	COMBUSTIBLE GAS (percent)	25 max
902-1	REACTANT PRESSURE (psig)	0
902-2	REACTOR INLET PRESSURE (psig)	5.5 max
907	LIQUID SENSOR	Dry
306-5	OUTLET VALVE	Open (by inspection)
061	PRODUCT WATER QUANTITY (percent)	0.0 - 90.0
268	WATER PRODUCTION RATE (pph)	0.0 - 0.5
		Visual Inspection
306-1	INLET VALVE	Close
306-2	BYPASS VALVE	Open
306-3	PURGE VALVE	Open
306-4	OUTLET VALVE, REACTOR	Open

2.4 Continued

Step 4 - Back pressure the water outlet port to 10 psig. Slowly increase the water supply pressure and note the CRT display. As the water level in the accumulator reaches approximately 80 percent full, the pump will turn on as noted by the sound and the pump current reading on the CRT Performance Table. Note: If the pump does not empty the accumulator or reduce the level, it is still air bound and must be repurged as discussed in Step 2 and 3 above. Care should also be taken not to empty the accumulator completely in order not to introduce air into the pump. If the water feed is faster than the pump or the pump is air bound, a yellow warning display will appear. If water continues to be put into the system, a red warning will be displayed. During normal process mode operation this would result in an automatic malfunction shutdown sequence. By proper adjustment of inlet water flow and pressure the accumulator and pump operation can be verified.

Step 5 - Place the subsystem into the "SHUTDOWN" mode. Remove the water inlet line and cap the water outlet port. Remove the water inlet line and filter and cap the Item 806 port.

2.5 Summary

With the exceptions listed below, the preceding check out tests verify the operation at the package interface of all the major components in the CO_2 reduction subsystem.

Condenser, Item 51
Sabatier Reactor, Item 91
Charcoal Canister, Item 31
Verification of the above components will be performed in Section 3 - Operation.

Section 3

OPERATION

Section 3

OPERATION

3.0 SCOPE

This section describes the method of operating, controlling and monitoring of this subsystem.

3.1 Controller and Display

Figure 3 is a photograph of the control keyboard and display. This portion of the subsystem utilizes an advanced microprocessor-based controller and display that provides automatic control, 24-hour monitoring of subsystem water output, automatic shutdown, subsystem performance and flow monitoring, and maintenance servicing and checkout provisions.

A multi-colored Cathode Ray Tube (CRT) display format shown in Figure 4 provides a continuous readout of system mode, any subsystem anomolies or advice system status, and operations instructions. Any one of six visual displays of appropriate data can be selected. These are:

- Mode Selection Table (Figure 5)
- Operation Diagram (Figure 6)
- Performance Diagram (Figure 7)
- Performance Table With Normal Operating Limits (Table 4)
- Performance Plot of Water Production
- Maintenance Diagram

In addition, an anomaly readout together with an anomaly light, either white, yellow or red can be displayed. White for a low level indication of abnormal occurrence, yellow for a caution and red for a warning and indicating the fact that the system is automatically being shutdown. An audible alarm accompanies the red anomaly light. In addition, the status of the electrical heaters, either on or off, is indicated by having the heater wire in the schematic glow red if on; and if off, blue. The status of the height of water in the accumulator is also visibly displayed in green in real time.

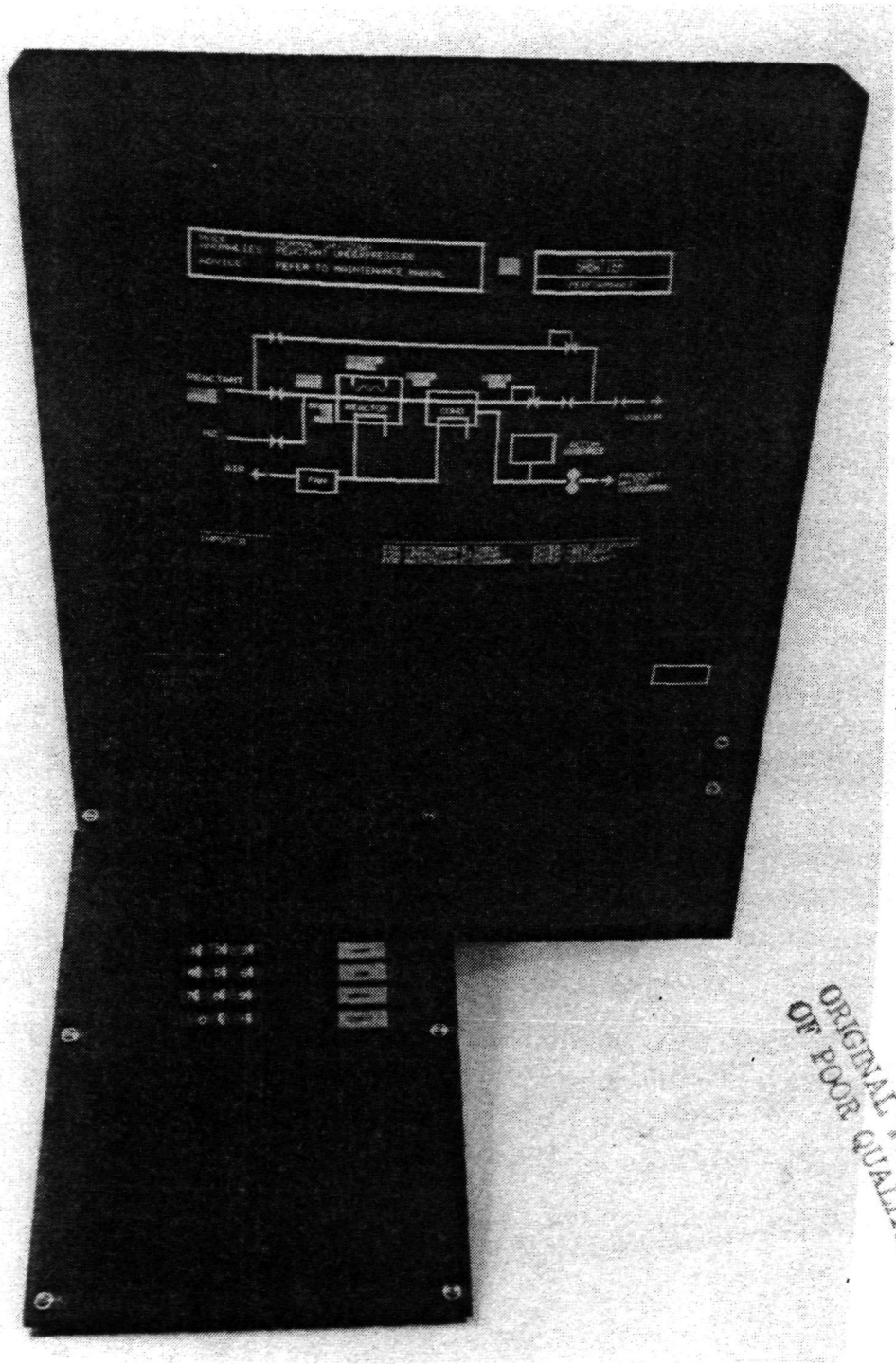


FIGURE 3
DISPLAY AND KEYBOARD

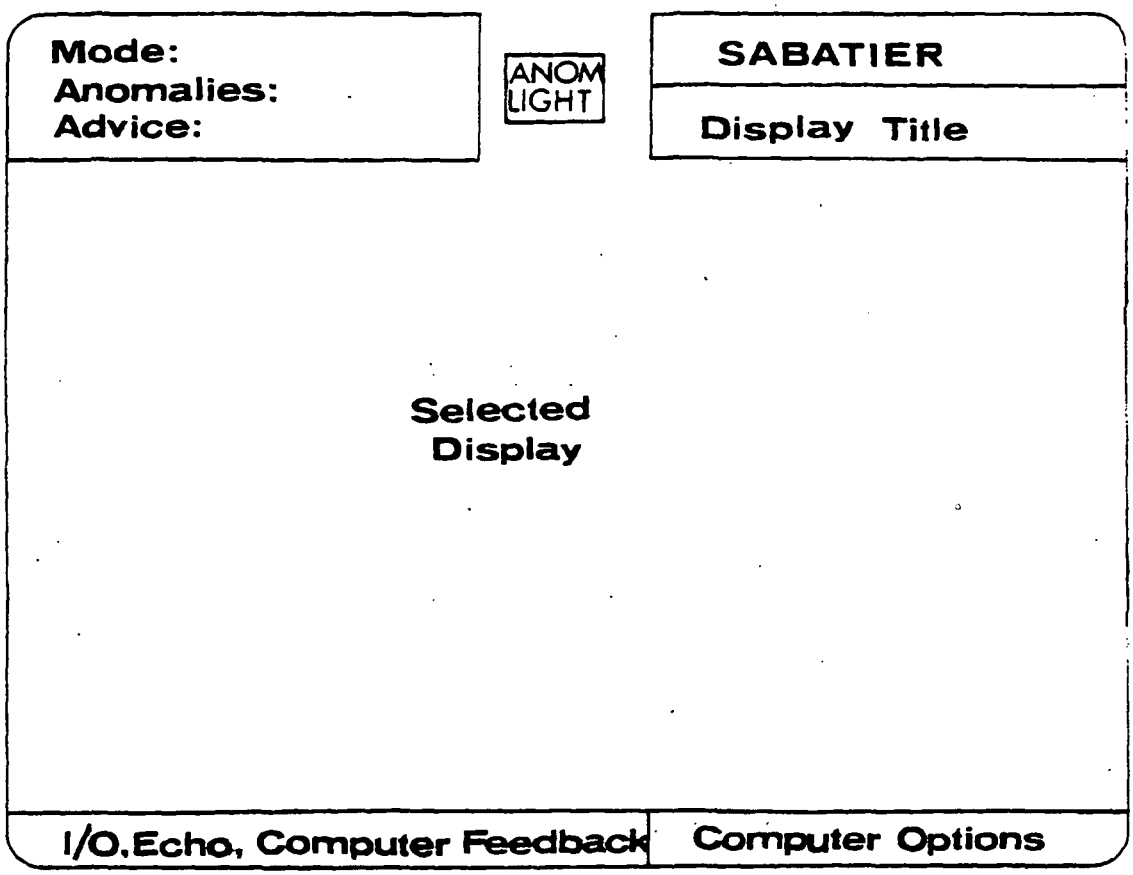


FIGURE 4
SABATIER CRT DISPLAY FORMAT

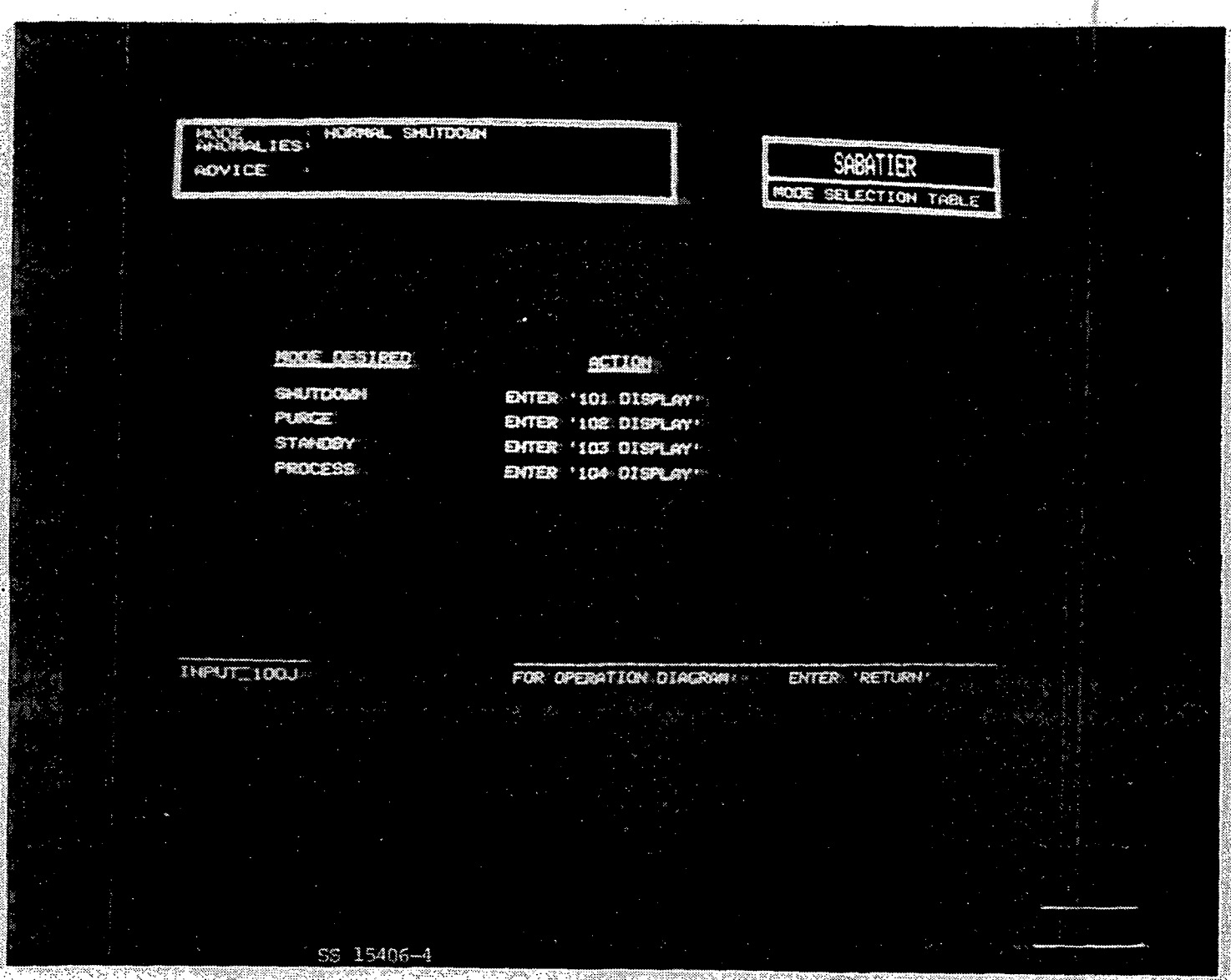


FIGURE 5
SABATIER MODE SELECTION TABLE

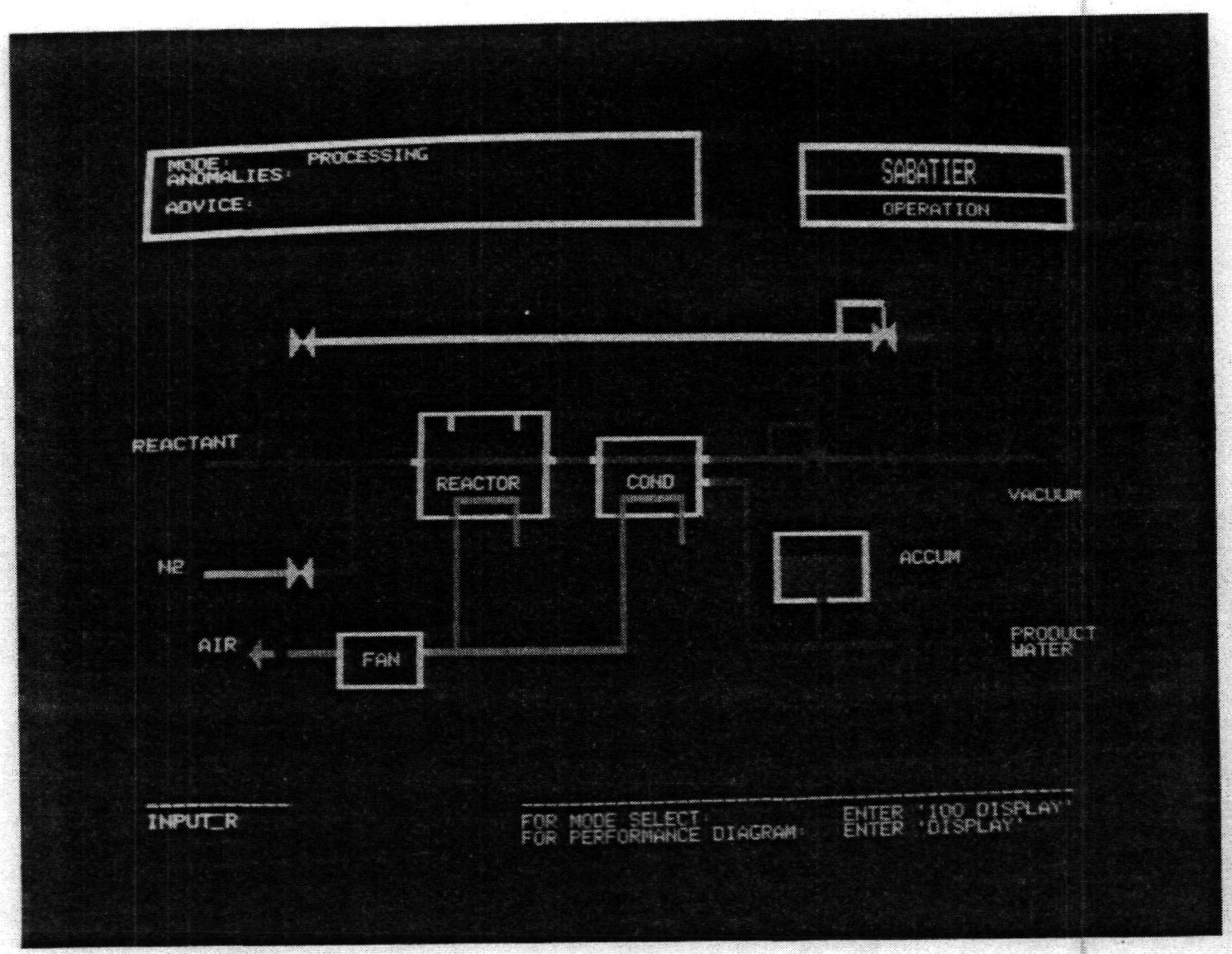


FIGURE 6
SABATIER OPERATION DIAGRAM

Table 4

CRT Performance Table

Item No.	Name	CRT Reading
083-1	HEATER 1 CURRENT (amps)	1.0 max
083-2	HEATER 2 CURRENT (amps)	1.0 max
046	FAN PHASE 1 CURRENT (amps)	1.0 max
545	PUMP PHASE 1 CURRENT (amps)	0.5 max
081-2	CONDENSER OUTLET TEMPERATURE (°F)	100 max
081-1	REACTOR OUTLET TEMPERATURE (°F)	300 max
082-1	REACTOR TEMPERATURE - BED (°F)	1200 max
	REACTOR TEMPERATURE - SHELL (°F)	1100 max
178-1	COMBUSTIBLE GAS (percent)	25 max
178-2	COMBUSTIBLE GAS (percent)	25 max
178-3	COMBUSTIBLE GAS (percent)	25 max
178-4	COMBUSTIBLE GAS (percent)	25 max
902-1	REACTANT PRESSURE (psig)	2.0 - 5.5 max
902-2	REACTOR INLET PRESSURE (psig)	0.0 - 5.5 max
907	LIQUID SENSOR	Dry
306-5	OUTLET VALVE	Open
061	PRODUCT WATER QUANTITY (percent)	0.0 - 90.0
268	WATER PRODUCTION RATE (pph)	0.0 - 0.5

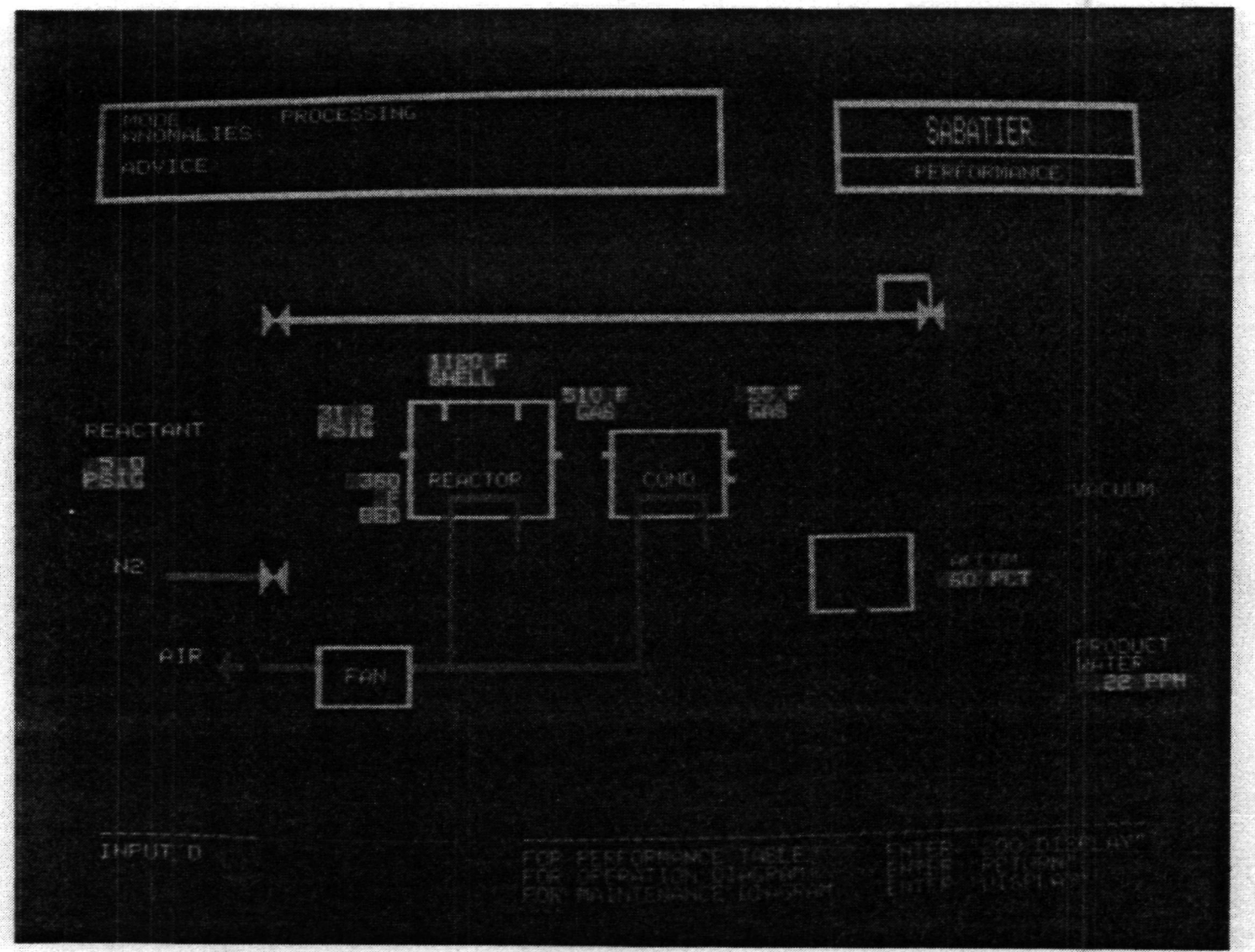


FIGURE 7
SABATIER PERFORMANCE DIAGRAM

3.1 Continued

The display provides maximum essential information at a glance and requires minimum interpretation and training for monitoring or subsystem control. The microprocessor controller provides automatic sequencing, dynamic control, failure detection and isolation, processes instrumentation signals, calculates water production rate and provides ground test instrumentation interfaces.

3.2 Subsystem Start-up

After the subsystem has been installed and set-up as described in Section 1 of this manual, the following procedure is used to operate the subsystem:

Step 1 - Check to see that NASA installed external switch is in "ON" position and all subsystem Item 507 manual valves (4) are "OPEN".

Step 2 - Swtich circuit breakers CB701, CB702, and CB703 located on the driver box to the "ON" position.

Step 3 - Install the floppy disk into the floppy disk drive and push cover closed. Handle the disk with care and keep it within its folder when not in use.

Step 4 - Apply 120 VAC 400 Hz 30 power to the subsystem.

Step 5 - Apply 115 VAC 60 Hz power to both inputs. At this point the CRT will light up and the Sabatier Operation Diagram (Figure 6) will be displayed. The Item 306 electrical valves will automatically assume their proper position. The display will indicate the subsystem mode is normal shutdown. The subsystem can now be operated or the status determined by following the computer options noted in the lower right hand corner of the CRT display.

Step 6 - The performance diagram of the subsystem can be monitored by pressing the "DISPLAY" key on the keyboard as noted in the lower right hand portion of the CRT screen. This area is noted as "Computer Options" in Figure 4. It defines the keyboard instructions required to select the information or subsystem control desired.

3.3 Subsystem Mode Selection

Four operating modes, shutdown, purge, standby and process, and a maintenance checkout mode are available. The logic summary for these modes is shown in Table 5. Also shown are the malfunction shutdowns and the modes during which they are initiated.

To select a subsystem operating mode enter "RETURN" on the keyboard and the Operation Diagram will appear. Enter "100 DISPLAY" on the keyboard as noted in the Computer Option display and the Mode Select Table (Figure 5) will appear. Any one of four subsystem operating modes can now be selected by entering on the keyboard the mode action displayed. The subsystem will automatically drive the valves to the proper position and accomplish the action directed. The subsystem flow schematic on the Operations diagram will indicate the operating fluid flow paths. From this point on, no further action is required unless it is desired to change the operating mode. The controller will provide:

- Automatic Sequencing
- Dynamic Control
- Failure Detection and Isolation
- Process Instrumentation Signals
- Calculate Performance Parameters
- Display Information
- Record Reaction Running Time
  (Time is accumulated whenever a mode requiring the cooling fan to operate is selected)

To obtain the information desired refer to the CRT Computer Options section of the display screen and enter the action noted on the keyboard.

3.4 Subsystem Shutdown

Step 9 - To charge the subsystem mode enter "RETURN" or "JUMP" to the Operation Diagram. Enter "100 DISPLAY" on the keyboard to obtain the Mode Select Table. To shutdown the subsystem enter "101 DISPLAY". The subsystem will automatically enter a 10 minute purge cycle and then shut down. This operation can be monitored by observing the Operation or Performance Diagram on the CRT.

3.4 Continued

Three subsystem shutdowns are possible: a) Normal discussed above, b) Emergency, and c) Manual.

a) Normal shutdown is an automatic shutdown sequence effected through the controller upon receipt of a command from the keyboard as noted above.

b) Emergency shutdown is an automatic sequence which will be accomplished by the controller when a pre-defined out-of-limits condition exists.

c) Manual shutdown is used when a power failure occurs or the controller does not provide proper controller. In this case, close manual valve 507-1 and open electrical valve 306-3 manually for ten minutes, then shut this valve. Note in the event of a power failure the subsystem will continue to function, but "the fan and pump will not operate and no leakage of combustible gases or other malfunctions will be detected if they should occur." It is recommended that the subsystem be shut down immediately in this situation. Table 5 summarizes the types of shutdowns possible and the conditions under which they would occur.

Step 10- If the subsystem is to be shutdown for any appreciable time (greater than an hour), remove the floppy disk from the floppy disk drive by pushing in the door. Place the disk in its folder and store in a clean dry place.

Step 11- Remove the 115 VAC 60 Hz power from both inputs.

Step 12- Remove the 120 VAC 400 Hz power.

3.5 Controller Limits

The operational and malfunction controller logic limits are shown in Table 6.

Table 5

Controller Modes and Malfunction Shutdowns

	Manually Selected Mode	Shutdown	Purge	Standby	Process			Maintenance
	Controller-Selected Sub-Mode					Shutdown (Purge)	Shutdown (Post Purge)	
	Sub-Mode Selection Parameter		-Select Shutdown -Select Standby or Process			Malfunction	+10 Min	Enter "107 Display' From Shutdown Mode
	Functions							
	. Heater Logic	Off	Off	On	On	Off	Off	Off
	. Condensate Deliver	Off	On	On	On	On	Off	Off
	. Fan	Off	On	On	On	On	Off	Off
	. Pump	Off	On*	On*	On*	On*	Off	Off**
	. Valve Sequence							
	306-1 (Process In)	Closed	Closed	Closed	Open	Closed	Closed	Closed**
	306-2 (Bypass)	Open	Open	Open	Closed	Open	Open	Open**
	306-3 (N_2)	Closed	Open	Closed	Closed	Open	Closed	Closed**
	306-4 (Process Out)	Closed	Open	Open	Open	Open	Closed	Closed**
	306-5 (System Out)	Open	Open	Open	Open	Open	Open	Open**
	Malfunction Shutdowns							
Item	Name							
178	Combustible Gas Indication (4)	Yes	Yes	Yes	Yes	No	No	Yes
306-5	Outlet Valve (306-5) Closed (Discrete)	↓	↓	↓	↓	Yes	Yes	No
902-1	Reactant Over Pressure	↓	↓	↓	↓	No	No	Yes
902-2	Purge Over Pressure	↓	↓	↓	↓	↓	↓	Yes
81-2	High Condenser Outlet Temperature	↓	↓	↓	↓	↓	↓	Yes
82-1	Low Reactor Temperature	No	No	↓	↓	↓	↓	No
61	Accumulator Level	Yes	Yes	↓	↓	↓	↓	No
907	Liquid Sensor Wet (Discrete)	↓	↓	↓	↓	↓	↓	Yes
46	High Fan Current	↓	↓	↓	↓	↓	↓	Yes
545	High Pump Current	↓	↓	↓	↓	↓	↓	Yes
85-1	Reactor Over Temperature	Yes	↓	↓	↓	Yes	Yes	Yes
306 (all 5)	Electrical Valves Wrong Position	Yes	Yes	Yes	Yes	↓	↓	No

*Pump will operate depending on water head in accumulator.
**Items can be operated using the controller keyboard.

TABLE 6
OPERATIONAL AND MALFUNCTION LOGIC LIMITS

Item Name	Item No.	Alarm Audio and Color	Response Time	Data Range	Trip Point	Applicable Mode
Heater Current - 1	83-1	-	-	0-1.99 amps	-	Display only
Heater Current - 2	83-2	-	-	0.199 amps	-	Display only
Fan Current -01	046	Red	30 sec.	0-1.99 amps	>1.0 amps	4, 3, 2
Pump Current -02	545	Red	30 sec.	0-1.99 amps	>0.5 amps	4, 3, 2
Temperature, Reactor Out	81-2	Yellow	0 sec.	0-304°F	>115°F	4, 3, 2, 1
		Red	30 sec.		>100°F	4, 3, 2
Temperature, Condenser Out	81-1	-	-	0-304°F	-	Display only
Temperature, Reactor Control	82-1	-	-	0-1300°F	>10 minutes*	4.3 >375 heater off
		-	-		-	4.3 <325 heater on
Temperature, Reactor Overtemperature	85-1	Red	3 sec.	0-1300°F	>1100°F	5, 4, 3, 2, 1
Combustible Gas Sensor	178-1	Red	3 sec.	0-34%	>25%	5, 4, 3, 2, 1
Combustible Gas Sensor	178-2	Red	3 sec.	0-99%	>25%	5, 4, 3, 2, 1
Combustible Gas Sensor	178-3	Red	3 sec.	0-99%	>25%	5, 4, 3, 2, 1
Combustible Gas Sensor	178-4	Red	3 sec.	0-80%	>25%	5, 4, 3, 2, 1
Pressure Subsystem Inlet	902-1	Yellow	0 sec.	0-21.6 psig	<2.0 psig	5, 4, 3, 2, 1
		Red	3 sec.		>5.5 psig	5, 4, 3, 2, 1
Pressure Reactor Inlet	902-2	Red	3 sec.	0-24.9 psig	>5.5 psig	5, 4, 3, 2, 1
Sensor Liquid	907	Red	10 sec.	Dry/wet	Wet	5, 4, 3, 2, 1
Accumulator Level	061	Yellow	0 sec.	0-127%	>80%	4, 3, 2, 1
		Red	30 sec.		>90%	4, 3, 2
Electrical Valve Position	306 valves	Red	0 sec.	Open/close	Wrong Valve Position	4, 3, 2, 1

*In Process Mode If 325°F Not Reached

MODES:

1 Shutdown
2 Purge
3 Standby
4 Process
5 Maintenance

3.6 Maintenance Mode

The maintenance mode permits operation of selected components for checkout and gas purging. It can only be entered after the system is completely purged and shutdown. To enter this mode, the Maintenance Diagram must first be displayed on the CRT by entering the action noted in the CRT "Computer Option" instructions. The maintenance mode is then entered by entering "107 DISPLAY" on the keyboard. This action will define in the "Computer Options" the actions required to operate the electrical valves (Item 306) and the pump (Item 545).

Operation of the pump, while clean filtered water is fed into the subsystem upstream of the condenser outlet (sample point 806), will permit purging of gas from the pump during the initial start-up of the subsystem. This pump operation will also permit observation of the accumulator fill and dump cycle diagramatically on the screen. Caution: "Operation of the pump without an external supply of water will pump the water subsystem dry and result in the pump becoming air bound. While in the Maintenance mode, the malfunction indicators for the items noted in the Applicable Mode Column in Table 5 are still applicable. To take the subsystem out of the Maintenance Mode, refer to Step 8 of paragraph 3.3.

3.7 Other Instrumentation and Data

The subsystem has provisions for measuring the temperature profile in the center of the reactor bed, Items 86-1 through 86-8, and along the reactor wall, Items 86-9 through 86-11. These are chromel-alumel thermocouples which utilize extremely fine wire leads. Care must be exercised while installing or handling the connectors. Two other chromel-alumel thermocouples, Item 87-1 and 87-2 are provided which can be used to measure the reactor coolant air flow temperatures. Pressure taps, Items 801 and 802, 803, and 804 are available for monitoring gas pressure or gas composition. It is recommended that the Item 804 port be utilized for gas outlet sampling as the gas will be drier at this point which will facilitate analysis.

3.7 Continued

Subsystem performance data is provided as shown in Table 4. In addition, a Performance Plot of Water Production over a 24-hour period can be displayed on the CRT. Subsystem operating time is recorded by an total time indicator mounted in the driver box. The timer is actuated upon subsystem power application and selection of a mode that requires fan operation. This prevents accumulation of "Operating Time" on a shutdown system when only power is supplied. An 0-5 VDC analog output of all input parameter suitable for interfacing with the NASA Data Acquisition System is provided. A general purpose communication link for remote display, recording, or for transmitting information to other subsystems is also provided.

3.8 Initial Start-up

The first time the subsystem is started up after the condenser has been dried out requires that the porous plate condenser become completely wet. This can be accomplished by operating the subsystem in the Process Mode at a 3-man molar ratio with no back pressure on the water outlet line. The subsystem must be operated long enough to completely fill the subsystem as evidenced by water appearing at the water outlet port. It is possible to trap air in the system at the pump inlet during this start-up process. If this occurs, the subsystem should be shut down and the accumulator and pump test noted in paragraph 2.4 conducted. Once the porous plate condenser is filled with water and the pump purged of air, the system can be started up and shut down at will with no further need for the above action.

Note: Operation of the pump in the Maintenance Mode requires an external supply of makeup water as the pump capacity is so great that it is virtually impossible to empty the accumulator without pumping the subsystem dry.

Section 4

FAILURE DETECTION/ISOLATION

Section 4

FAILURE DETECTION/ISOLATION

4.0 Scope

This section describes the component or subsystem malfunctions identified automatically by the controller and other procedures for troubleshooting to isolate, to the repair level, an out-of-limits condition identified during subsystem operation.

4.1 Automatic Shutdown

The malfunctions or failures shown in Table 7 will be detected automatically by the subsystem controller. A red flashing flag and an audio signal will indicate a malfunction and the item which initiated the failure. The subsystem will automatically purge itself and shutdown.

Operation assumes that a correct command was issued as described in Section 3, Operation. Note the controller will not accept faulty commands if operating properly.

Prior to initiating repair, the subsystem should be purged and shutdown as described in Section 3.4 of this manual.

4.2 Visual Malfunction Checks

Other malfunctions can be detected by observing performance data or subsystem operation. These are listed in Table 8.

Automatic Failure Detection & Shutdown

Sensor Item No.	Malfunction	Failure Detected	Comment
46	Fan	High Current Draw	
545	Pump	High Current Draw	
85-1	Reactor Overtemperature	Heater(s) failed	Check heater current.
178-1, 178-2, 178-3, 178-4	Subsystem Combustible Gas Leak	Combustible Gas Leak	Display will indicate sensor number. Maintenance Diagram shows location. Check for loose tube fittings.
306	Electrical Valve (5)	Wrong position for Mode selected	Display will indicate valve number. Maintenance Diagram or visual inspection will show location.
81-2	High Condensor Outlet Temperature	Indicates possibility of high abnormal flow through subsystem or loss of cooling flow	Check reactant flow, clean condensers air inlet filter and reactors coolant orifices.
902-1	Subsystem Overpressure or Underpressure	High gas inlet pressure. Yellow display to indicate pressure is low.	Check supply pressure. Subsystem can operate but cannot remove water.
902-2	N_2 Overpressure	High purge gas pressure.	Check supply pressure.
907	Liquid Carryover	Condenser not operating properly, excessive gas flow, pump not operating properly.	Pump probably airbound.
061	Accumulator not dumping properly.	Either Pump Air Bound, Failed Diaphragm or open Item 41-1 check valve.	Yellow display when 80% full, Red display and shutdown when 90% full.

Table 7 (Con't)

Automatic Failure Detection & Shutdown

Sensor Item No.	Malfunction	Failure Detected	Comment
82-1	Reactor did not start up.	Failed heater(s).	Upon startup, reactor temperature must reach 350°F within 10 minutes, or system will shut down.

Table 8

Visual Malfunction Checks

Sensor Item No.	Malfunction	Comment
83-1 83-2	Heater Failure -1 Heater Failure -2	Performance table will indicate operation of heaters during start-up. Note start-up can be accomplished with only one heater and in less than five minutes under some operating conditions.
82-1 85-1	Reactor Temperature Sensors	Inspection of these two temperature plus comparison with Item 86 thermocouples will indicate proper operation. An abnormal high or low reading relative to the others indicate a problem with the sensor or the leads.
—	Clogged Item 41-1 Check Valve (Open)	Overpressure of the water system can be detected by observing the water pressure at Port 806. Pressure at this point should be independent of the water outlet port back-pressure. If not, valve is open.
545 061	Pump Air Bound	Operation of the pump as noted by a current draw (or sound) and no corresponding removal of water from the accumulator indicates pump is air bound. Excessive long operation (2-3 minutes) of the pump also indicates air in the system.
—	Controller/Display Inoperative	Check circuit breaker positions, should be "ON". Check power supplies and that NASA's external switch is "ON". Check installation of floppy disk. Refer to Section 3.2 of this manual.

Section 5

MAINTENANCE

5.0 Scope

This section lists the limited life components, the tools required for maintenance, and the maintenance steps for removal and installation of the principal components within the Sabatier subsystem.

5.1 Limited Life Components

Limited life components in the Sabatier subsystem are noted in Table 9.

5.2 Tools Required

The tools required for maintenance of the Sabatier subsystem are noted in Table 10.

5.3 Maintenance

Maintenance steps for the items noted in Table 11 are described in the following paragraphs. Also noted in the table is the part name, the quantity per subsystem, the part number, maintenance paragraph number, the figure number showing the item and the find number shown in Figure 8, 9, 10, 11, and 12.

5.3.1 Item 46 - Fan, Sabatier Air Cooling

5.3.1.1. Location - Front Access--See Figure 8, Find No. 1

5.3.1.2 Tools Required

3/16" Allen Wrench
Screwdriver
7/8" Open End Wrench (2)

5.3.1.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off. Silencer (Item 26) and Fan Housing Adapter should be removed with Fan.

5.3.1.4 Maintenance Steps - Removal

1. Remove one (1) electrical connector on top of the Fan Housing Adapter.

2. Disconnect the inlet coolant tube fittings using two 7/8" Open End Wrenches.

Table 9

Limited Life Components

Item Number	Name	Remarks
178-1	Sensor, H_2	Calibrate every 30 days
178-2	Sensor, H_2	Calibrate every 30 days
178-3	Sensor, H_2	Calibrate every 30 days
178-4	Sensor, H_2	Calibrate every 30 days

Table 10

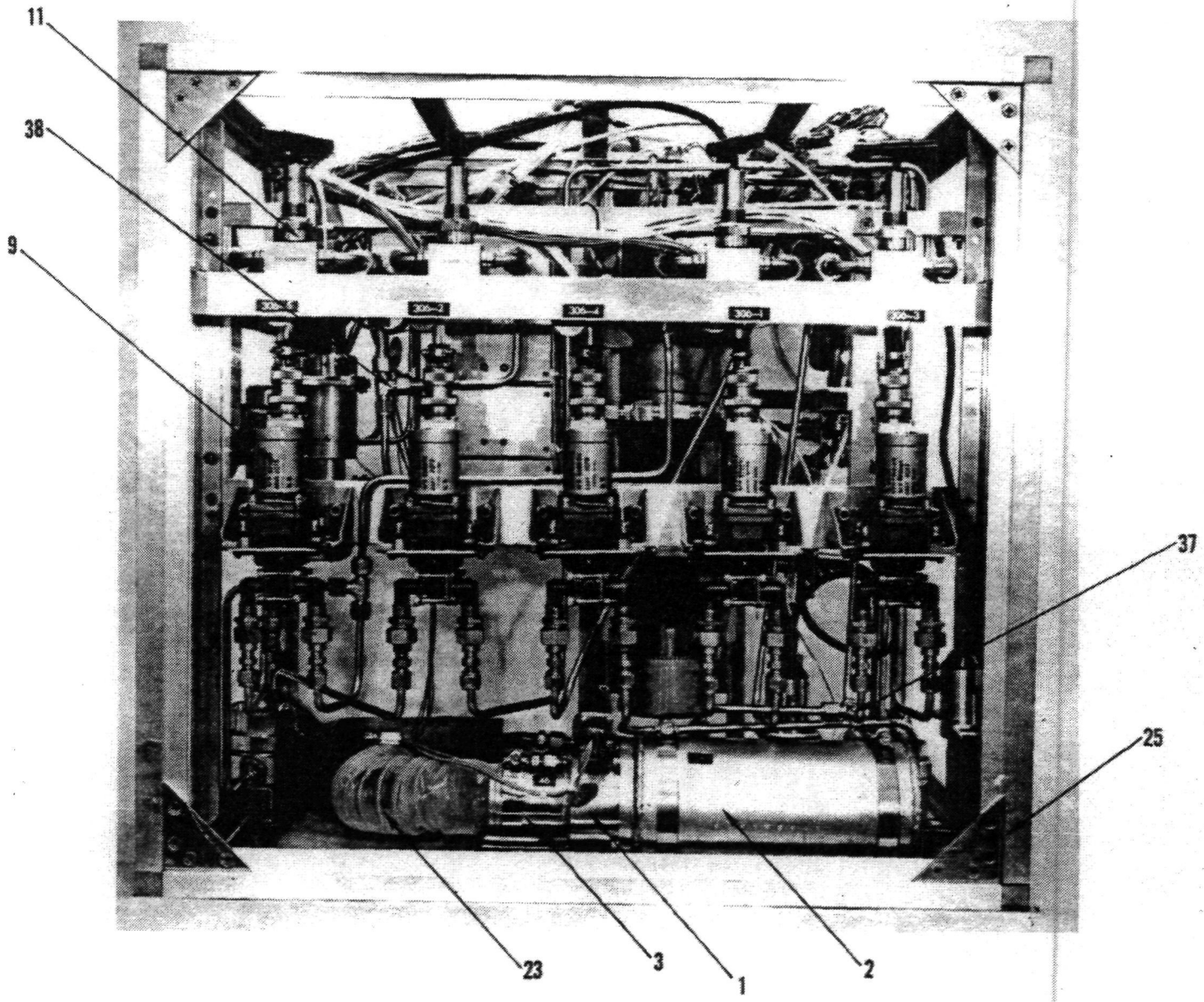
Tools Required For Maintenance

General Tools		
Name	Type	Quantity
Allen Wrench	1/8"	1
Allen Wrench	-3/16"	1
Socket Wrench with Extension	-3/8"	1
Open End Wrench	-3/8"	1
Open End Wrench	-9/16"	2
Open End Wrench	-11/16"	2
Open End Wrench	-7/8"	2
Open End Wrench	-1.0"	1
Screw Driver	-.25" flat head	1
Screw Driver	-Phillip #2	1

Table 11

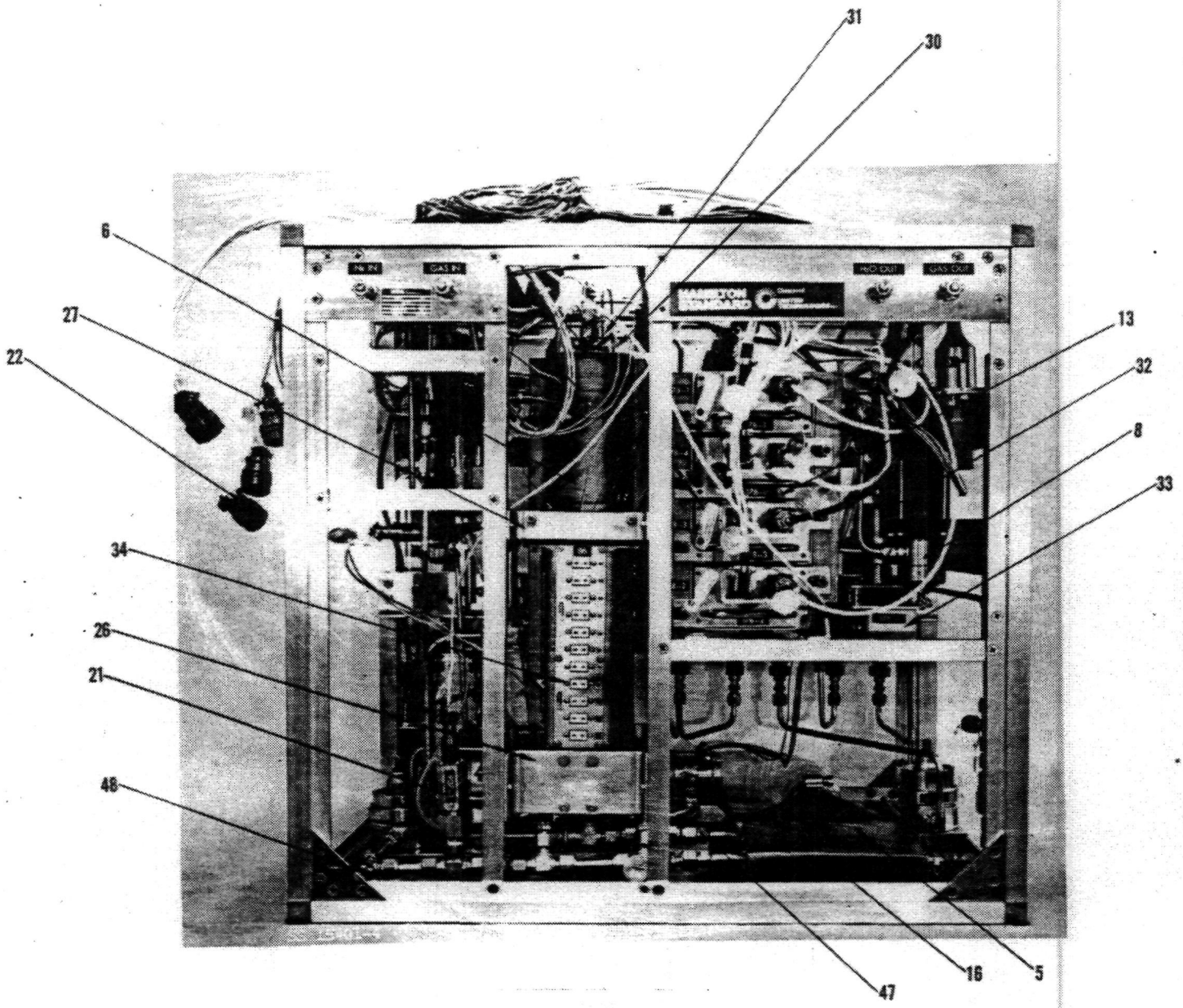
MAINTAINABLE ITEMS

ITEM NO.	PART NAME	QTY. PER ASSY.	PART NO.	MAINTENANCE STEP PARAGRAPH NO.	FIGURE NO.	FIND NO.
ITEM 46	FAN, SABATIER AIR COOLING	1	SVSK 96467	5.3.1	8	1.
ITEM 26	SILENCER, FAN	1	SVSK 96471	5.3.2	8	2.
ITEM 61	ACCUMULATOR ASSEMBLY	1	SVSK 96490	5.3.3	12	4.
ITEM 51	CONDENSER, SABATIER	1	SVSK 96349	5.3.4	9	5.
ITEM 91	REACTOR, SABATIER	1	SVSK 96482	5.3.5	9	6.
ITEM 31	CANISTER, CHARCOAL	1	SVSK 96470	5.3.6	11	7.
ITEM 545	PUMP	1	SVSK 86329-2	5.3.7	9	8.
ITEM 306	VALVE, ELECTRICAL S.O.	5	SVSK 84424	5.3.8	8	9.
ITEM 310	REGULATOR, BACK PRESSURE	2	SVSK 84412	5.3.9	11&12	10.
ITEM 507	VALVE, MANUAL S.O.	4	SVSK 84530	5.3.10	8	11.
ITEM 178	SENSOR-COMBUSTIBLE GAS	4	SVSK 84456-100	5.3.11	10,11&12	12.
ITEM 178	SENSOR, MONITOR ASSEMBLY	4	SVSK 84456-200	5.3.12	9	13.
ITEM 41	VALVE, CHECK	1	SVSK 96466	5.3.13	10	14.
ITEM 42	VALVE, CHECK	1	SVSK 101124	5.3.14	12	15.
ITEM 81-1	SENSOR, TEMPERATURE, CONDENSER INLET	1	SVSK 96465-1	5.3.15	11	17.
ITEM 81-2	SENSOR, TEMPERATURE, CONDENSER OUTLET	1	SVSK 96465-2	5.3.16	11	18.
ITEM 902-1	TRANSDUCER, PRESSURE-GAGE, PACKAGE INLET	1	SVSK 101128-1	5.3.17	9	19.
ITEM 902-2	TRANSDUCER, PRESSURE-GAGE, REACTOR INLET	1	SVSK 101128-2	5.3.18	9	20.
ITEM 907	DETECTOR, LIQUID WATER	1	SVSK 101129	5.3.19	9	21.
ITEM 82	SENSOR, TEMPERATURE, REACTOR CONTROL	1	SVSK 96499	5.3.20	10	28.
ITEM 83	HEATER - REACTOR	2	SVSK 96486	5.3.21	10	29.
ITEM 85	SENSOR, TEMPERATURE, REACTOR OVERTEMPERATURE	1	SVSK 86465	5.3.20	9	30.
ITEM 701	ORIFICE, CONTROL, .070" DIA	1	—	5.3.23	10	35.
ITEM 702	ORIFICE, CONTROL, .120" DIA	1	—	5.3.23	11	36.
ITEM 703	ORIFICE, CONTROL, .035" DIA	1	—	5.3.24	9	37.
ITEM 704	ORIFICE, CONTROL, .024" DIA	1	—	5.3.25	8	38.
ITEM 705	ORIFICE, CONTROL, .040" DIA	1	—	5.3.25	10	39.



FRONT VIEW

FIGURE 8
FRONT VIEW--SABATIER SUBSYSTEM PACKAGE



BACK VIEW

FIGURE 9
BACK VIEW--SABATIER SUBSYSTEM PACKAGE

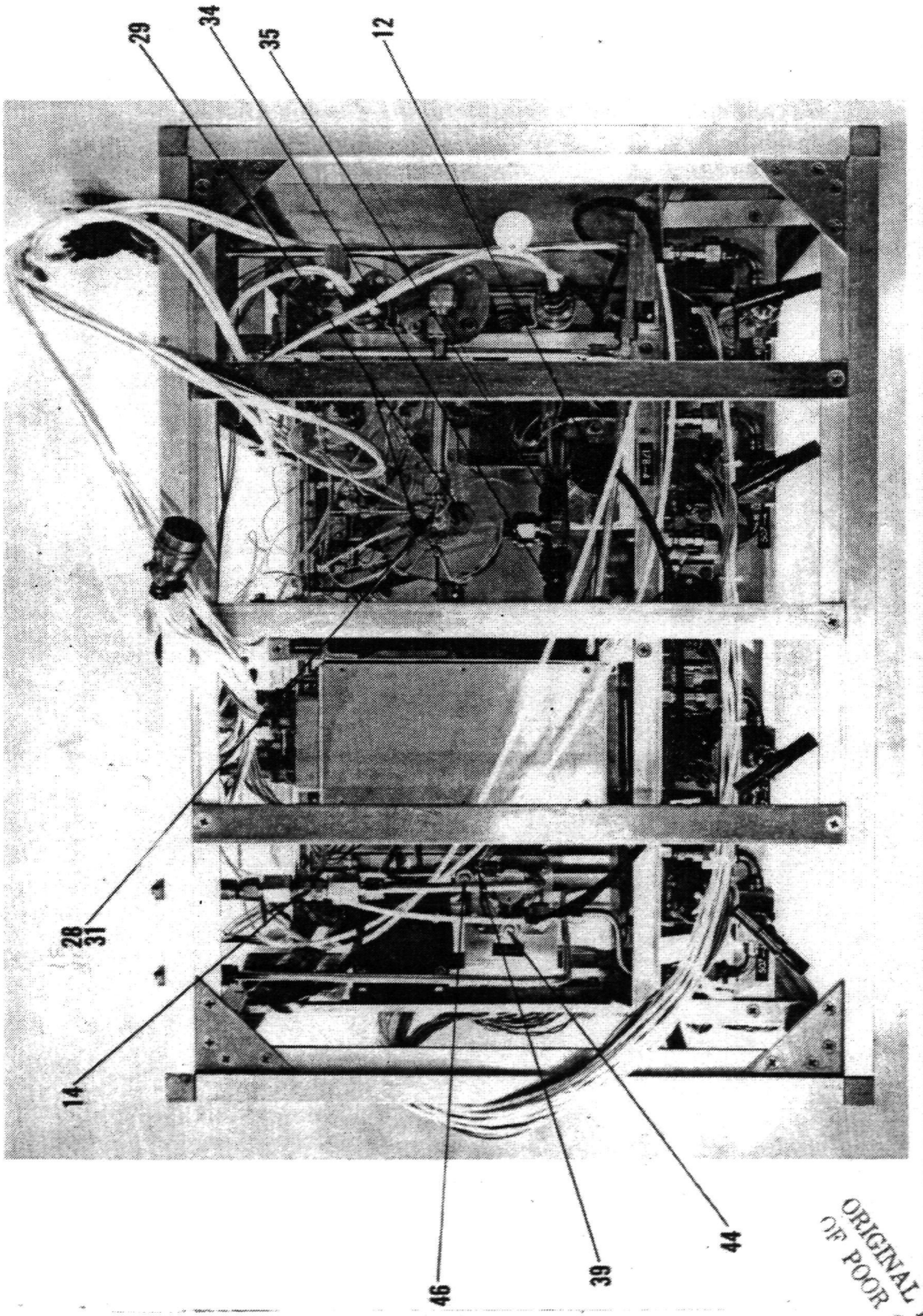
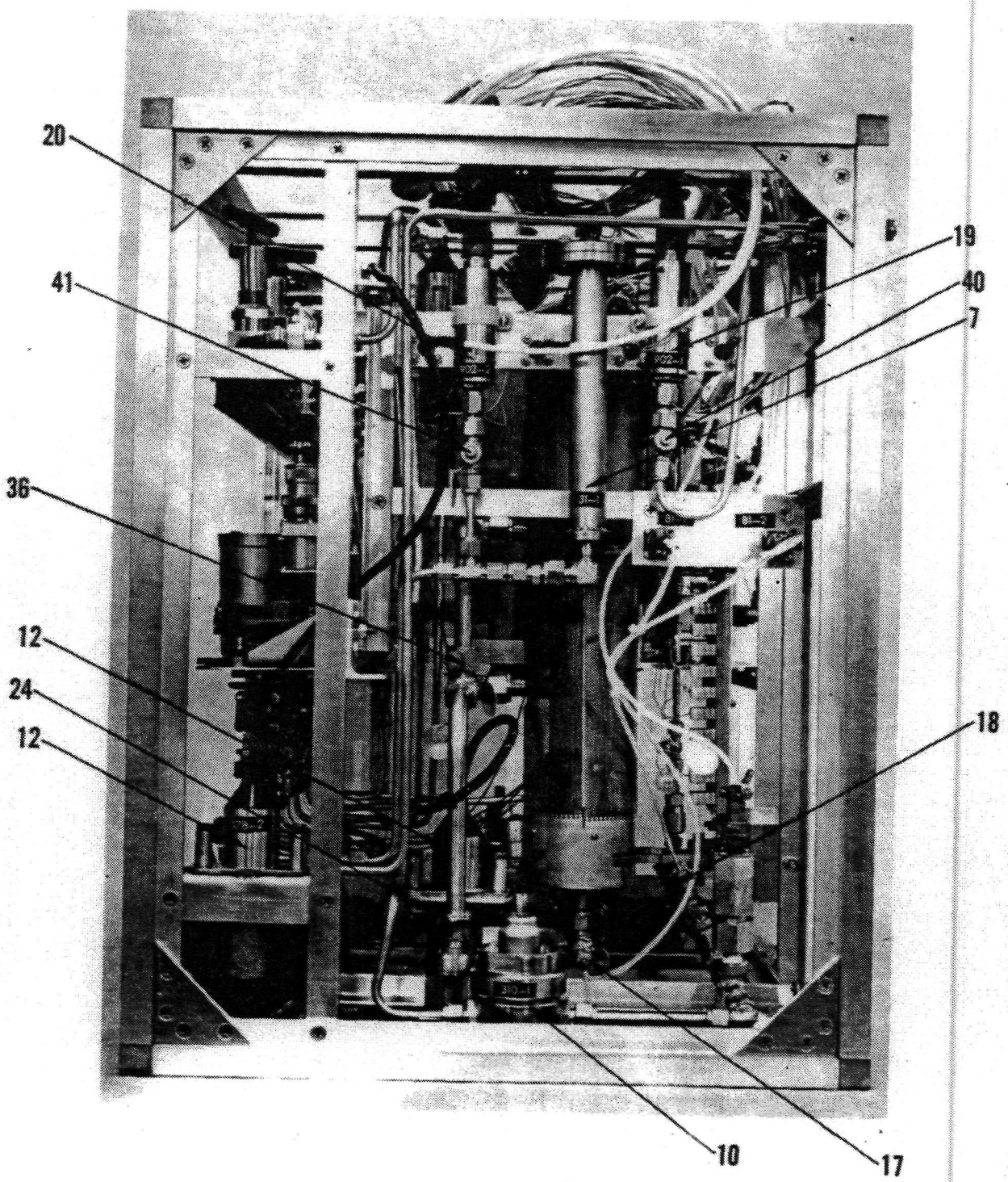
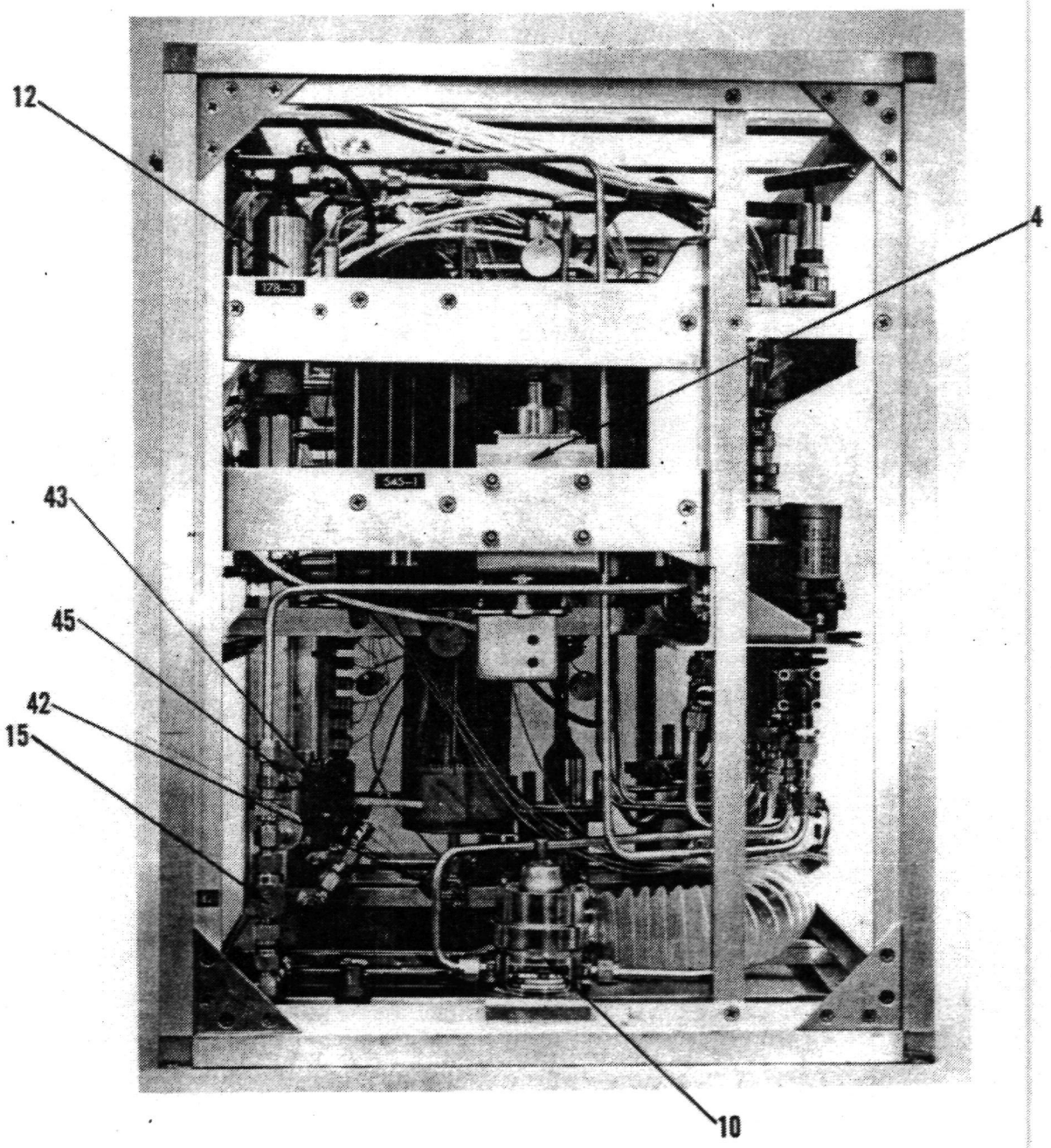


FIGURE 10
TOP VIEW--SABATIER SUBSYSTEM PACKAGE



RIGHT SIDE VIEW

FIGURE 11
RIGHT SIDE VIEW--SABATIER SUBSYSTEM PACKAGE



LEFT SIDE VIEW

FIGURE 12
LEFT SIDE VIEW--SABATIER SUBSYSTEM PACKAGE

5.3.1.4 Continued

3. Loosen clamp (1) on Fan Housing Adapter Housing using a screwdriver.

4. Remove clamps (2) on fan silencer using a screwdriver.

5. Slip flexible hose duct off Fan Housing inlet duct.

6. Lift out assembly.

7. Remove four (4) bolts holding silencer to Fan Housing Adapter using a 3/16" Allen wrench.

8. Remove fan electrical connector.

9. Remove three (3) screws holding fan inside Fan Housing Adapter, slip fan out of Fan Housing, guide wire leads so as not to damage them.

5.3.1.5 Maintenance Step - Installation

1. Insert wire leads into Fan Housing Adapter and position Fan Housing flange and insert three #8-32 NC screws into Housing Adapter. Tighten with screw driver.

2. Install electrical connector.

3. Place rubber gasket on Fan Housing Adapter.

4. Line up four (4) holes of Fan Silencer with holes in Fan Housing Adapter.

5. Install four (4) Allen head bolts using a 3/16" Allen wrench.

6. Slip Fan Housing Inlet into flexible hose duct. It may be necessary to heat the flexible hose duct with air to facilitate installation.

7. Install three (3) band clamps. Clamp on Fan Housing Adapter can be installed loosely before Step 4. Slip rubber gasket under two clamps on Fan Silencer. Do not tighten.

5.3.1.5 Continued

8. Line up inlet coolant tube fittings and connect using two 7/8" Open End wrenches.

9. Position three (3) band clamps and tighten using a screwdriver.

10. Connect one (1) electrical connector on top of the Fan Housing Adapter.

5.3.2 Item 26 - Silencer, Fan

5.3.2.1 Location - Front Access--See Figure 8, Find No. 2

5.3.2.2 Tools Required

3/16" Allen wrench or
Screwdriver
7/8" Open End wrench (2)

5.3.2.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off. Fan and Fan Housing Adapter should be removed with Silencer.

5.3.2.4 Maintenance Steps - Removal

1. Remove one (1) electrical connector on top of the Fan Housing Adapter.

2. Disconnect the inlet coolant tube fittings using two 7/8" Open End Wrenches.

3. Loosen clamp (1) on Fan Housing Adapter Housing using a screwdriver.

4. Remove clamps (2) on Fan Silencer using a screwdriver.

5. Slip flexible hose duct off Fan Housing inlet duct.

6. Lift out assembly.

7. Remove four (4) bolts holding Silencer to Fan Housing Adapter using a 3/16" Allen wrench.

5.3.2.5 Maintenance Step - Installation

1. Place rubber gasket on Fan Housing Adapter.
2. Line up four (4) holes of Fan Silencer with holes in Fan Housing Adapter.
3. Install four (4) Allen head bolts using a 3/16" Allen wrench.
4. Slip Fan Housing Inlet into flexible hose duct. It may be necessary to heat the flexible hose duct with warm air to facilitate installation.
5. Install three (3) band clamps. Clamp on Fan Housing Adapter can be installed loosely before Step 4. Slip rubber gasket under two (2) clamps on Fan Silencer. Do not tighten.
6. Line up inlet coolant tube fittings and connect using two 7/8" Open End wrenches.
7. Position three (3) band clamps and tighten using a screwdriver.
8. Connect one (1) electrical connector on top of the Fan Housing Adapter.

5.3.3 Item 61 - Accumulator Assembly, H_2O

5.3.3.1 Location - Left Side--See Figure 12, Find No. 4 and Top

5.3.3.2 Tools Required

3/8" Socket wrench
9/16" Open End wrench
7/8" Open End wrench

5.3.3.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.
2. Water lines should be drained and be essentially free of water before maintenance steps are initiated.

5.3.3.4 Maintenance Steps - Removal

1. Remove the one (1) electrical connector from the quantity indicator at the bottom of the accumulator.

5.3.3.4 Continued

2. Disconnect the water inlet line tube fitting by using a 9/16" Open End wrench and a 7/8" Open End wrench.

3. Remove four (4) lock nuts on bracket with 3/8" socket while holding captive bolts from rotating with a 3/8" Open End wrench.

5.3.3.5 Maintenance Steps - Installation

1. Position accumulator against mounting bracket to line up captive bolts with holes in bracket.

2. Install lock nut on bolts and tighten nut using 3/8" socket while holding bolt head with a 3/8" Open End wrench.

3. Aline the water inlet tube fitting with inlet tubing. It may be necessary to loosen tube fitting with 9/16" Open End wrench at opposite end of tube to facilitate assembly. Tighten both fitting ends using 9/16" Open End wrench.

4. Connect one (1) electrical connector to quantity indicator at the bottom of the accumulator.

5.3.4 Item 51 - Condenser, Sabatier

5.3.4.1 Location - Back Side--See Figure 9, Find No. 5

5.3.4.2 Tools Required

#2 Phillips Screwdriver
Screwdriver
9/16" Open End wrench (2)
11/16" Open End wrench (2)

5.3.4.3 Steps Required Before Maintenance

1. Maintain coolant flow until the condenser has cooled off sufficiently to allow maintenance to be performed.

2. Be sure all power to the subsystem is completely turned off.

3. Open all valves manually.

4. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.4.4 Maintenance Steps - Removal

1. Remove three (3) screws with a screwdriver while holding the nuts from turning by using a 3/8" Socket wrench.
2. Loosen the cooling air outlet duct clamp using a screwdriver.
3. Disconnect water outlet line tube fitting using two (one for support) 9/16" Open End wrenches.
4. Disconnect gas inlet and outlet lines tube fittings by using two (one for support) 11/16" Open End wrenches.
5. Slip flexible hose duct off condenser air inlet line.

5.3.4.5 Maintenance Steps - Installation

1. Slip clamp over flexible hose duct and then place hose duct on condenser air inlet line. It may be necessary to heat the flexible hose duct with warm air to facilitate installation. Position hose clamp and tighten with screwdriver.
2. Connect gas inlet and outlet line tube fittings using two (one for support) 9/16" Open End wrenches.
3. Position condenser mounting port over mounting holes and insert screw with washer under head. Fasten nut and tighten with screwdriver while holding nut with 3/8" Socket wrench.
4. Connect water outlet line tube fitting using two (one for support) 9/16" Open End wrenches.

5.3.5 Item 31 - Reactor Sabatier

5.3.5.1 Location - Back (Primary Access) Right Side and Top Access-- See Figure 9, Find No. 6

5.3.5.2 Tools Required

Screwdriver or
3/8" Socket wrench
15/16" Open End wrench (2)
7/8" Open End wrench (2)

5.3.5.3 Steps Required Before Maintenance

1. Be sure all power to the subsystem is completely turned off.
2. Wait until the reactor has cooled off sufficiently to allow safe maintenance to be performed.
3. Open all valves manually.
4. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.5.4 Maintenance Steps - Removal

1. Disconnect two (2) heater electrical connector (Item 83-1 and 83-2) and two (2) temperature sensors electrical connector (Item 82-1 and 85-1) from internal panel.
2. Disconnect process inlet tube fitting using an 11/16" Open End wrench. This operation should be done from the top of the package.
3. Disconnect the reactor cooling air outlet lines tube fittings (2) using two (one for support) 7/8" Open End wrenches.
4. Loosen three (3) mounting screws that hold the condenser in place. (Reference Step 1 of condenser removal maintenance.)
5. Disconnect water outlet line tube fitting using two (one for support) 9/16" Open End wrenches. (Reference Step 3 of condenser removal maintenance.)
6. Disconnect reactor gas outlet tube fitting near reactor and condenser outlet line tube fittings by using two (one for support) 11/16" Open End wrenches.
7. Remove screws that hold the reactor mounting brackets (Find No's. 26 and 27 in Back View, Figure 9) with a screwdriver while holding nut with a 3/8" Socket wrench.
8. Slip reactor assembly out through frame support members as shown in Figure 13. Use care so as not to damage reactor core thermocouple wires.

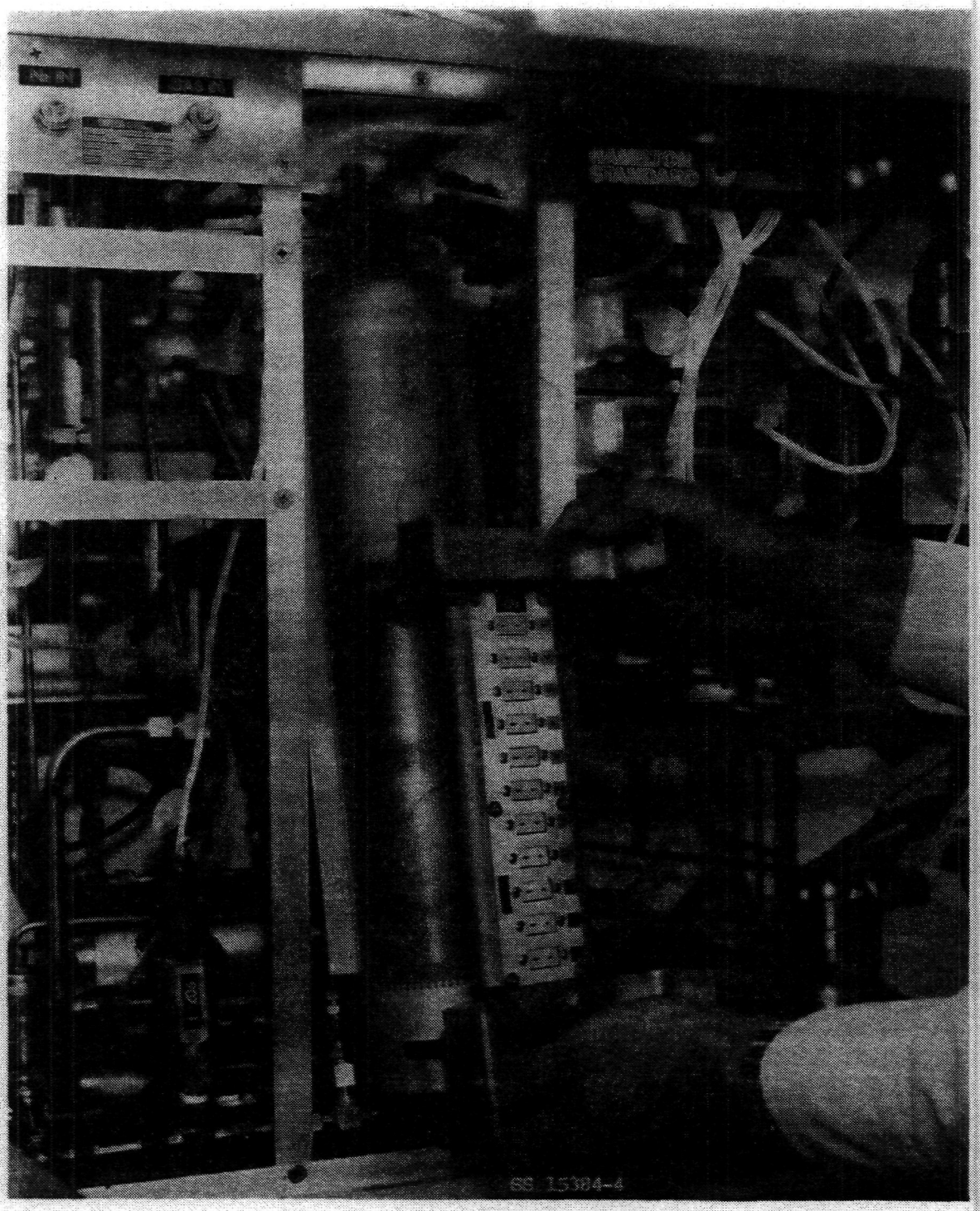


FIGURE 13
REACTOR INSTALLATION

5.3.5.5 Maintenance Steps - Installation

1. Insert reactor assembly through frame support members as shown in Figure 13. Use care so as not to damage reactor core thermocouple wires.

2. Position reactor brackets with hole in support frame structure and insert four mounting screws. Tighten each screw with screwdriver while holding nut with 3/8" Socket wrench.

3. Connect reactor gas outlet tube fitting and condenser outlet line tube fitting by using two (one for support) 11/16" Open End wrenches.

4. Position condenser mounting feet over mounting holes and insert screws with washer under head. Fasten nut and tighten with screwdriver while holding nut with 3/8" Socket wrench.

5. Connect water outlet line tube fitting using two (one for support) 9/16" Open End wrenches.

6. Connect the reactor cooling air outlet line tube fittings (2) using two (one for support) 7/8" Open End wrench.

7. Connect process inlet tube fitting using a 11/16" Open End wrench. Check all inlet tube fitting around Charcoal Canister (Item 7) for tightness.

8. Connect two heater electrical connectors (Item 83-1 and 83-2) and two electrical connectors (Item 82-1 and 85-1) to mating connectors.

5.3.6 Item 31 - Canister, Charcoal

5.3.6.1 Location - Right Side and Top Access--Figure 11, Find No. 7

5.3.6.2 Tools Required

9/16" Open End wrench
11/16" Open End wrench (2)

5.3.6.3 Steps Required Before Maintenance

None

5.3.6.4 Maintenance Steps - Removal

1. Disconnect inlet tube fittings using a 9/16" and 11/16" Open End wrench.

2. Disconnect outlet tube fittings using two (one to support) 11/16" Open End wrenches.

5.3.6.5 Maintenance Steps - Installation

1. Connect the outlet tube fittings and tighten nuts using two (one for support) 11/16" Open End wrench.

2. Connect the inlet tube fitting and tighten nuts using a 9/16" and a 11/16" Open End wrench.

5.3.7 Item 545 - Pump

5.3.7.1 Location - Left Rear and Back Access--Figure 9, Find No. 8

5.3.7.2 Tools Required

Phillips screwdriver
9/16" Open End wrench
3/18" Socket wrench

5.3.7.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.

2. Coolant water lines should be drained and essentially free of water before maintenance steps are initiated.

5.3.7.4 Maintenance Steps - Removal

1. Remove the one (1) electrical connector from the pump.

2. Disconnect the pump inlet and outlet tube fittings using a 9/16" Open End wrench.

3. Remove four screws (left side) with a Phillips #2 screwdriver. It may be necessary to hold the nuts with a 3/8" Socket wrench.

5.3.7.5 Maintenance Steps - Installation

1. Position pump assembly against frame support bracket, install four (4) screws and lock nuts. Tighten screws with Phillips #2 screwdriver while holding nuts with 3/8" Socket wrench.

5.3.7.5 Continued

2. Connect the outlet and the inlet tube fittings using a 9/16" Open End wrench.

3. Connect one (1) electrical connector to the pump.

5.3.8 Item 306 - Valve, Electrical Shut-Off

5.3.8.1 Location - Front Access--Figure 8, Find No. 9

5.3.8.2 Tools Required

3/16" Allen wrench or
3/8" Socket wrench
3/8" Open End wrench
1.0" Open End wrench

5.3.8.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.

2. Open all valves manually.

3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.8.4 Maintenance Steps - Removal (Common for all five valves)

1. Disconnect electrical connector.

2. Disconnect inlet and outlet tube fittings using a 9/16" Open End wrench while supporting fitting adapter with a 1.0" Open End wrench.

3. Loosen two (2) captive screws using either a 3/16" Allen wrench or a 3/8" Socket wrench. Hold lock nut with a 3/8" Open End wrench. Care should be taken to hold the component when the last screw is being disengaged.

5.3.8.5 Maintenance Steps - Installation (Common for all five valves)

1. Place valve on panel approximately 1/4" from tube fittings and slide downward into position.

2. Tighten two (2) captive screws using either a 3/16" Allen wrench or a 3/8" Socket wrench while holding nut in place with a 3/8" Open End wrench.

5.3.8.5 Continued

3. Connect the inlet and outlet tube fittings and tighten nuts using a 13/16" Open End wrench while supporting fitting adapter with a 1.0" Open End wrench.

4. Connect electrical connector (1).

5.3.9 Item 310 Regulator, Back Pressure

5.3.9.1 Location - Item 310-1 Right Side and Bottom Access-- Figure 11, Find No. 10
Item 310-2 Left Side and Bottom Access-- Figure 12, Find No. 10

5.3.9.2 Tools Required

Screwdriver - Flat Head or
9/16" Open End wrench
11/16" Open End wrench

5.3.9.3 Steps Required Before Maintenance

1. Open all valves manually.

2. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.9.4 Maintenance Steps - Removal

1. Disconnect inlet and outlet tube fittings using a 9/16" Open End wrench for Item 310-2 and a 9/16" and 11/16" Open End wrench for Item 310-1.

2. Loosen one (1) screw using a screwdriver. Note: Regulator mounting bracket can be removed to facilitate removal.

5.3.9.4 Maintenance Steps - Installation

1. Place valve on mounting bracket and fasten with screw on bottom of valve.

2. Connect the inlet and outlet tube fittings and tighten nuts using a 13/16" and a 11/16" wrench as appropriate.

5.3.10 Item 507 - Valve, Manual Shut-off (-1, -2, -3, -4)

5.3.10.1 Location - Front Access--See Figure 8, Find No. 11

5.3.10.2 Tools Required

3/16" Allen wrench
9/16" Open End wrench
1.0" Open End wrench

5.3.10.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.
2. Open all valves manually.
3. Disconnect "N_2" and "GAS IN" inlet lines.
4. For Items 507-3 and 507-4, coolant water lines should be drained and be essentially free of water before maintenance steps are initiated.

5.3.10.4 Maintenance Steps - Removal

1. Disconnect inlet and outlet tube fittings using a 9/16" and a 1.0" (for support) Open End wrench.
2. Loosen two (2) screws using a 3/16" Allen wrench.

5.3.10.5 Maintenance Steps - Installation

1. Place valve on mounting panel and insert two screws.
2. Tighten two (2) captive screws using a 3/16" Allen wrench.
3. Connect the inlet and outlet tube fittings and tighten nuts using a 9/16" and a 1.0" (for support) Open End wrench.

5.3.11 Item 178 - Sensor, Combustible Gas (-1, -2, -3, -4)

5.3.11.1 Location

Item 178-1 - Right Side Access, Figure 11, Find No. 12
Item 178-2 - Right Side and Front Access, Figure 11, Find No. 12
Item 178-3 - Left Side and Top Access, Figure 12, Find No. 12
Item 178-4 - Top Access, Figure 10, Find No. 12

5.3.11.2 Tools Required

3/16" Allen wrench or
3/8" Socket wrench
3/8" Open End wrench

5.3.11.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.

2. Calibrate replacement sensor and signal conditioner as a matched pair per SVSK TR 84456.

5.3.11.4 Maintenance Steps - Removal

1. Disconnect electrical connector from panel.

2. Loosen two (2) captive screws using either a 3/16" Allen wrench or a 3/8" Socket wrench. On Item 178-2, -3, and -4 hold lock nut with 3/8" Open End wrench. Care should be taken to hold the component when the last screw is being disengaged.

3. Remove lead restraints.

4. Remove sensor by lifting out of mounting bracket.

5.3.11.5 Maintenance Steps - Installation

1. Place sensor into mounting bracket and tighten two (2) active screws using either a 3/16" Allen wrench or a 3/8" Socket wrench. Hold lockout on Item -2, -3, and -4, with a 3/8" Open End wrench.

2. Connect electrical sensor to panel.

3. Position and tie down wire leads, as appropriate.

5.3.12 Item 178 - Sensor, Monitor Assembly (-1, -2, -3, -4)

5.3.12.1 Location - Back Access--Figure 9, Find No. 13

5.3.12.2 Tools Required

3/16" Allen wrench or
3/8" Socket wrench

5.3.12.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.

2. Calibrate replacement sensor and monitor assembly as a matched pair per SVSK TR 84456.

5.3.12.4 Maintenance Steps - Removal

1. Disconnect two (2) electrical connector.

2. Loosen two (2) captive screws using either a 3/16" Allen wrench or a 3/8" Socket wrench.

3. Removal signal conditioner by grasping handle and sliding out of tray. (See Figure 14)

5.3.12.5 Maintenance Steps - Installation

1. Grasp handle and place signal conditioner into slide tray.

2. Install two (2) captive screws using either a 3/15" Allen wrench or a 3/8" Socket wrench. (Do not over-tighten screws.)

3. Install two (2) electrical connectors.

5.3.13 Item 41 - Valve, Check

5.3.13.1 Location - Top Access--Figure 10, Find No. 14

5.3.13.2 Tools Required

9/16" Open End wrench
7/8" Open End wrench

5.3.13.3 Steps Required Before Maintenance

1. Water lines should be drained and be essentially free of water before maintenance steps are initiated.

5.3.13.4 Maintenance Steps - Removal

1. Disconnect water inlet and outlet tube fittings using a 9/16" Open End wrench. Support valve with a 7/8" Open End wrench.

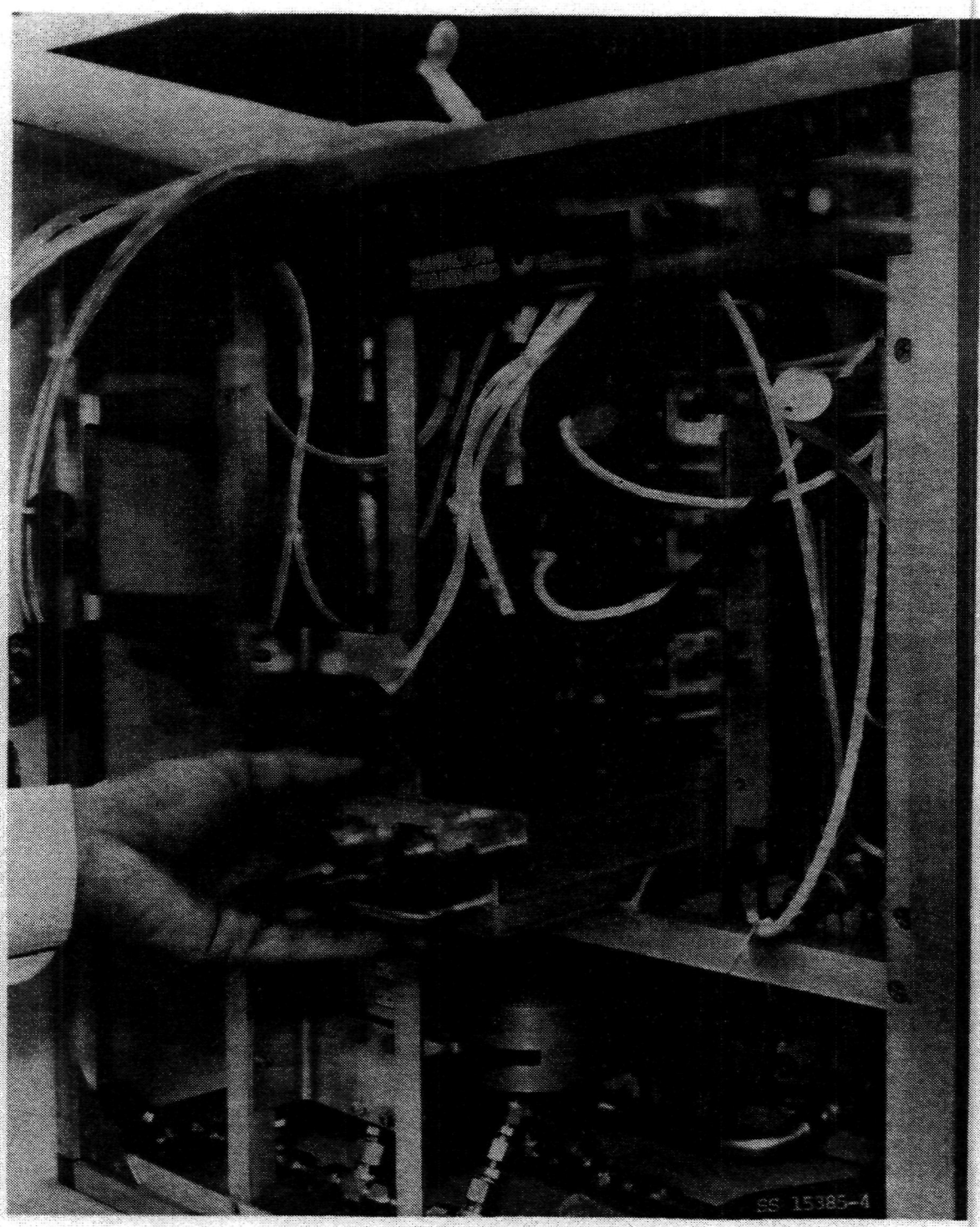


FIGURE 14
GAS MONITOR INSTALLATION

5.3.13.5 Maintenance Steps - Installation

1. Connect water inlet and outlet tube fittings using a 9/16" Open End wrench. Support valve with a 7/8" Open End wrench.

5.3.14 Item 42 - Valve, Check

5.3.14.1 Location - Left Side Access--Figure 12, Find No. 15

5.3.14.2 Tools Required

9/16" Open End wrench
7/8" Open End wrench

5.3.14.3 Steps Required Before Maintenance

1. Water lines should be drained and essentially free of water before maintenance steps are initiated.

5.3.14.4 Maintenance Steps - Removal

1. Disconnect water inlet and outlet tube fittings using a 9/16" Open End wrench. Support valve with a 7/8" Open End wrench.

5.3.14.5 Maintenance Steps - Installation

1. Connect water inlet and outlet tube fitting using a 9/16" Open End wrench. Support valve with 7/8" Open End wrench.

5.3.15 Item 81-1 Sensor, Temperature

5.3.15.1 Location - Right and Rear Access--Figure 11, Find No. 17

5.3.15.2 Tools Required

9/16" Open End wrench

5.3.15.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.

2. Open all subsystem valves manually.

3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.15.4 Maintenance Steps - Removal

1. Disconnect electrical connector from panel.
2. Disconnect sensor from tube fitting by using a 9/16" Open End wrench.

5.3.15.5 Maintenance Steps - Installation

1. Place temperature sensor into fitting and tighten with a 9/16" Open End wrench.
2. Connect electrical connector to panel.

5.3.16 Item 81-2 - Sensor, Temperature

5.3.16.1 Location - Right and Rear Access--Figure 11, Find No. 18

5.3.16.2 Tools Required

9/16" Open End wrench

5.3.16.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.
2. Open all valves manually.
3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.16.4 Maintenance Steps - Removal

1. Disconnect electrical connector from signal conditioner.
2. Disconnect sensor from tube fittings by using a 9/16" Open End wrench.

5.3.16.5 Maintenance Steps - Installation

1. Place temperature sensor into fitting and tighten with 9/16" Open End wrench.
2. Connect electrical connector to panel.

5.3.17 Item 902-1 - Transducer, Pressure-gage

5.3.17.1 Location - Rear Access--Figure 9, Find No. 19

5.3.17.2 Tools Required

9/16" Open End wrench

5.3.17.3 Steps Required Before Maintenance

1. Be sure main power to subsystem is completely off.
2. Open all subsystem valves manually.
3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.17.4 Maintenance Steps - Removal

1. Remove electrical connector.
2. Remove pressure transducer using a 9/16" Open End wrench.

5.3.17.5 Maintenance Steps - Installation

1. Install pressure transducer using a 9/16" Open End wrench.
2. Install electrical connector.

5.3.18 Item 902-2 - Transducer, Pressure-gage

5.3.18.1 Location - Rear Access--Figure 9, Find No. 20

5.3.18.2 Tools Required

9/16" Open End wrench

5.3.18.3 Steps Required Before Maintenance

1. Be sure main power to subsystem is completely off.
2. Open all subsystem valves manually.
3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.18.4 Maintenance Steps - Removal

1. Remove electrical connector.
2. Remove pressure transducer using a 9/16" Open End wrench.

5.3.18.5 Maintenance Steps - Installation

1. Install pressure transducer using a 9/16" Open End wrench.
2. Install electrical connector.

5.3.19 Item 907 - Detector, Liquid Water

5.3.19.1 Location - Back Access, Figure 9, Find No. 21

5.3.19.2 Tools Required

1.0" Open End wrench

5.3.19.3 Steps Required Before Maintenance

1. Be sure main power to the system is completely off.

5.3.19.4 Maintenance Steps - Removal

1. Disconnect electrical connector.
2. Remove sensor using 1.0" Open End wrench.

5.3.19.5 Maintenance Steps - Installation

1. Insert sensor into mounting boss and tighten with 1.0" Open End wrench.
2. Install electrical connector.

5.3.20 Item 82 & 85 - Sensor, Temperature

5.3.20.1 Location - These items are part of the Sabatier reactor (Item 91) assembly and are considered a test bed bench maintainable component.

Item 82, Figure 10, Find No. 28
Item 85, Figure 9, Find No. 30

5.3.21 Item 83 - Heater Sabatier (-1 & -2)

5.3.21.1 Location - This Item is part of the Sabatier reactor (Item 51) assembly. (Figure 10, Find No. 29.)

5.3.21.2 Tools Required

1/8" Allen wrench

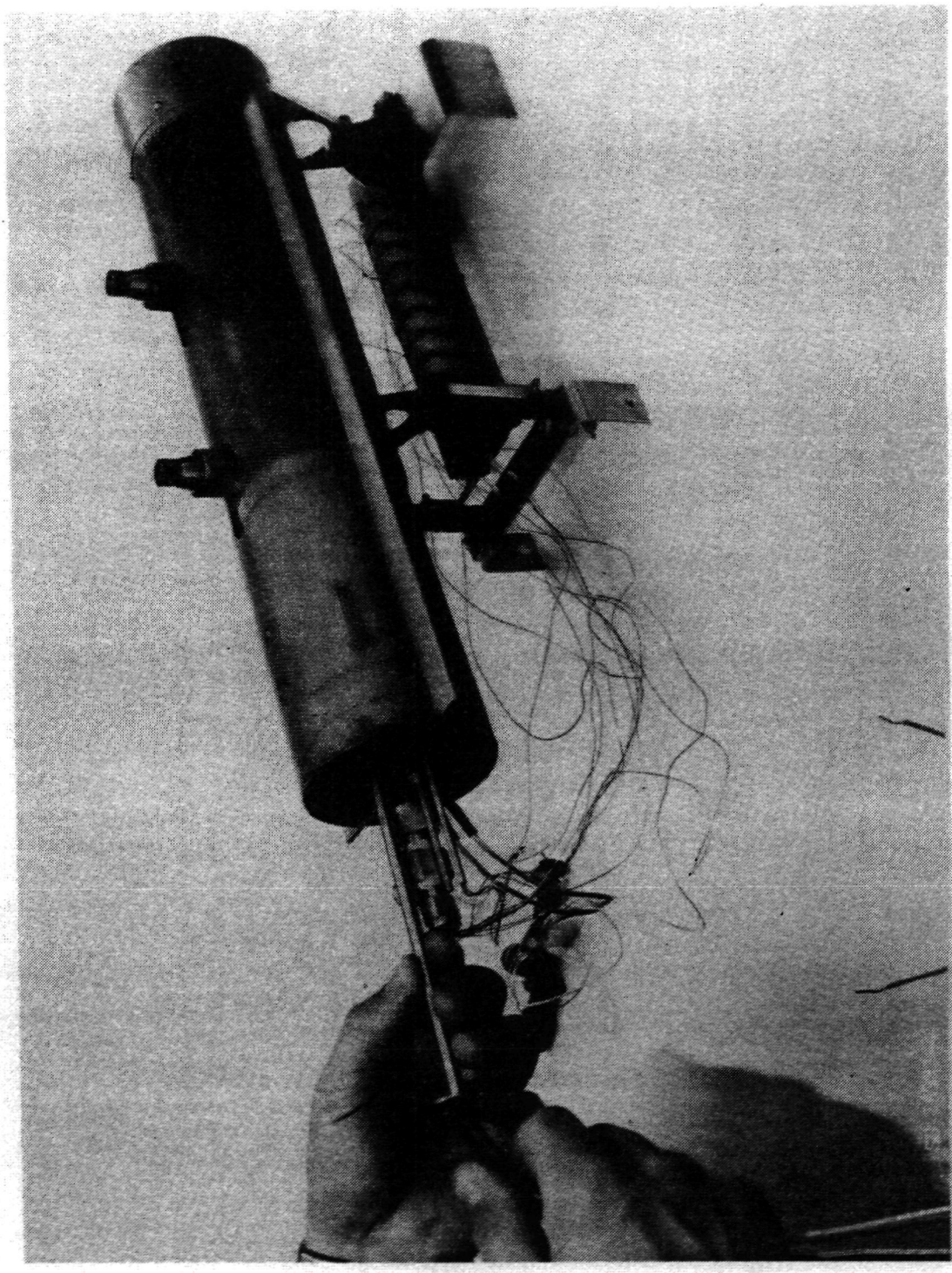


FIGURE 15
HEATER INSTALLATION

5.3.21.3 Steps Required Before Maintenance

1. Remove Sabatier reactor as described in Paragraph 5.3.5 of this manual.

5.3.21.4 Maintenance Step - Removal

1. Remove two (2) screws with 1/8" Allen wrench. Remove heater from reactor. Use care so as not to damage thermocouple wire leads. (Figure 15)

5.3.21.5 Maintenance Step - Installation

1. Insert heater into reactor, insert two (2) screws and tighten with 1/8" Allen wrench. (Figure 15)

5.3.22 Item 701 Orifice, Control Cooling Air Primary (.070" Dia)
Item 702 Orifice, Control Cooling Air Secondary (.120" Dia)

5.3.22.1 Location

701 - Top and Right Access--Figure 10, Find No. 35
702 - Right Side Access--Figure 11, Find No. 36

5.3.22.2 Tools Required

7/8" Open End wrench (2)

5.3.22.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off and subsystem is cooled down.

5.3.22.4 Maintenance Steps - Removal

1. Disconnect inlet and outlet tube fittings using a 7/8" Open End wrench.

5.3.22.5 Maintenance Steps - Installation

1. Install orifice in reactor coolant outlet line.

2. Connect the inlet and outlet tube fittings and tighten nuts using a 7/8" Open End wrench.

5.3.23 Item 703 - Orifice Control, Nitrogen Purge (.035" Dia)

5.3.23.1 Location - Front and Right Access--Figure 9, Find No. 37

5.3.23.2 Tools Required

9/16" Open End wrench (2)

5.3.23.3 Steps Required Before Maintenance

1. Be sure main power to the subsystem is completely off.
2. Open all valves manually.
3. Disconnect "N_2" and "GAS IN" inlet lines.

5.3.23.4 Maintenance Steps - Removal

1. Disconnect tube fittings (3) using a 9/16" Open End wrench. Support with second 9/16" Open End wrench.

5.3.23.5 Maintenance Steps - Installation

1. Position orifice "T" so that orifice restricts flow from nitrogen inlet supply line.
2. Connect the three (3) tube fittings and tighten nuts using a 9/16" Open End wrench. Support fitting with a 9/16" Open End wrench.

5.3.24 Item 704 Orifice Control, Water Control (.024" Dia)
Item 705 Orifice Control, Water Bypass (.040" Dia)

5.3.24.1 Location

704 - Front Access--Figure 8, Find No. 38
705 - Top Access--Figure 10, Find No. 39

5.3.24.2 Tools Required

9/16" Open End wrench

5.3.24.3 Steps Required Before Maintenance

1. Water lines should be drained and be essentially free of water before maintenance steps are initiated.

5.3.24.4 Maintenance Steps - Removal

1. Disconnect inlet and outlet tube fittings using 9/16" Open End wrenches.

5.3.24.5 Maintenance Steps - Installation

1. Connect the inlet and outlet tube fittings and tighten nuts using 9/16" Open End wrenches.