EPA-600/9-76-020
August 1976

EPA VAN OPERATIONAL MANUAL

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into five series. These five broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The five series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment, and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

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EPA VAN
OPERATIONAL
MANUAL

by

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Contract No. 68-02-1482
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Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, DC 20460

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SECTION I

INTRODUCTION

The EPA-Van is a research unit designed and constructed by Engelhard Industries for the U. S. Environmental Protection Agency (EPA). It is a part of EPA's research program to control air pollution through the demonstration of an energy supply system for the home which contains environmentally clean and energy conserving components. The EPA-Van is designed to be mobile for experimental testing in various parts of the United States.

SECTION II

GENERAL SYSTEM DESCRIPTION

The EPA-Van, a research unit designed and constructed by Engelhard Industries for the U. S. Environmental Protection Agency (EPA), is part of EPA's research program to control air pollution. The pollution control technique is an energy supply system for the home which contains environmentally clean and energy-conserving components. The EPA-Van is designed to be mobile for experimental testing in various parts of the United States.

The EPA-Van's energy supply system includes fuel cells, a solar energy collector, a heat pump, and catalytic appliances. This essentially non-polluting equipment is integrated so as to optimize the energy-conserving features which characterize each of its components. The integrated system provides all the energy needed by the EPA-Van for space heating, cooling and ventilating; cooking; lighting; food refrigeration; water heating; and for appliances.

EPA-Van Design

The design of the EPA-Van began in 1973. Engineers at EPA's Industrial Environmental Research Laboratory, Research Triangle Park, N.C. decided to combine three approaches for reducing air pollution and conserving energy: (1) better home construction, and (2) solar energy (both of which reduce fuel consumption and thereby reduce pollution) and (3) low-polluting devices such as fuel cells and catalytic applicances.

Better Home Construction

Better home construction includes heavily insulated walls, floors, and ceiling; storm doors and double-pane windows; and accurately-controlled ventilation (uncontrolled infiltration of cold air and exfiltration of heated room air is a large waster of energy). The walls consist of several bonded layers: a polystyrene core (5 cm) is sandwiched between two sets of wall studs (3.75 cm each); the studs are covered by an outer skin of aluminum and an inner sheet of wood paneling; and urethane foam fills the cavities between the studs.

Solar Energy

Solar energy is used in a manner unique to the EPA-Van: the solar energy system is integrated with an electrically driven heat pump.

Solar Energy System (Fig. 1)

The solar energy system includes a collector mounted on the roof and a thermal storage tank located under the kitchen floor. (In an actual home, the tank could be installed in a basement or utility room or buried nearby.) The collector itself is a commercially available standard design: a solution of ethylene glycol and water is heated as it circulates (at 10 liters/min) in tubes mounted on a black panel and under a glass cover. The heated solution is either used immediately for space heating, or its heat is transferred to the storage tank (1,400 liters of water) for later use.

Heat Pump (Fig. 1)

The heat pump extracts heat from the solar energy system through a glycol-solution/Freon® heat exchanger. Solar-heated glycol solution from the storage tanks is used to vaporize Freon® in the heat pump. Thus, solar energy becomes the heat source for the heat pump. (In conventional units, the heat source is usually the air outside the home.) The rest of the heat pump is conventional; the vaporized Freon® is compressed and used to heat air (via Freon® condensation) which is delivered to the living areas. (The heat pump is also used for cooling the EPA-Van in the summer; it operates just like a conventional air conditioner, extracting heat from the inside air and delivering it to the outside air. No solar energy is used.)

The addition of a heat pump to a solar energy system offers several advantages. First, unlike other solar heating systems, the EPA-Van's system can extract energy from the thermal storage tanks even when the temperature of the stored water is below room temperature (down to 50°F or lower). This characteristic increases the effective energy storage capacity of the tanks and permits longer periods of operation without sunlight. Second, because the tank temperature can be lower, the EPA-Van's solar collector will operate at lower temperatures (on the average) than those in other solar heating systems. This is an advantage because a solar collector is more efficient at low temperatures--it retains more of the incident energy. Consequently, the EPA-Van can be heated with a smaller solar collector, but at the expense of electrical energy to drive the heat pump.

Low-Polluting Devices (Fig. 1)

Fuel Cells: The EPA-Van needs electricity to power the glycol-solution pumps for the solar energy system, the Freon^{R} compressor, the air blower for the heat pump, and the lighting, food refrigeration, and electrical appliances. Normally, electricity would be purchased from a local power company; but the EPA-Van uses a different approach, one which will result in less pollution and more efficient use of our energy resources.

A fuel cell produces electricity by electrochemically combining oxygen from the air with hydrogen. The by-products of this process are heat and water. The EPA-Van utilizes two Engelhard Model 750 fuel cells connected in parallel. Each fuel cell produces 800 watts nominal at 28 volts. Storage batteries are electrically floated in parallel with the fuel cells to provide supplementary power during start-up and periods of peak power demand.

The fuel cells employ a cell design developed by Engelhard that utilizes a single air stream to perform the three functions of removing heat, removing moisture, and providing oxygen for the fuel cell reaction. The basic cell contains two platinum-catalyzed electrodes separated by a polymer matrix containing the phosphoric acid electrolyte.

The hydrogen fuel for the fuel cells is produced in the EPA-Van from anhydrous ammonia which is catalytically dissociated into a fuel gas consisting of 75 percent H_2 and 25 percent N_2. Traces of undissociated ammonia are scrubbed from the fuel gas (via silica gel treated with sulfuric acid) before it enters the fuel cells. The ammonia dissociator is heated by a burner that consumes the bleed gas from the fuel cell.

The EPA-Van's fuel-cell system offers many advantages in the form of low maintenance, simple operation and being virtually pollution free. The use of the immobilized electrolyte and air cooling permits a system which is simple (no bulk liquids) and reliable (only one moving part, the air blower). More importantly, fuel cells appear to be nearly pollution-free---they produce only electricity, water, and hot air. (The effluents from the hydrogen generator's burner and scrubber are potential sources of pollution, though believed to be minor. These effluents will be analyzed thoroughly during the testing program) In addition, the hot air ($\sim 200^{\circ}F$) is not always discarded but is used in winter for space heating. Thus, the heat from the fuel cells supplements that provided by the solar/heat pump system. During severely cold and cloudy periods, when the energy demand for heating could exhaust the capacity of the fuel cells and the solar/heat pump system, an auxiliary heater is used to supplement the solar energy system.

Catalytic Appliances (Fig. 1)

The auxiliary heater and the cooking range, are further examples of the EPA-Van's special design. These two appliances burn a gaseous fuel catalytically. The operation of the cooking range is described below.

The range looks like a modern smooth-top unit, but underneath is a catalytic burner. Inside the burner, hydrogen fuel (from the ammonia dissociator) and air are passed over a platinum-catalyzed surface. There the hydrogen burns readily without a flame, thereby releasing heat and producing water vapor. The heat is transmitted by radiation from the catalyst surface to the underside of the range top. The top, made of ceramic/glass material called CER-VIT^{R}, conducts the heat to the cooking utensil. The combustion gases do not enter the kitchen, as they do with most gas ranges, but are vented to the outside.

The catalytic burner does not need a pilot light for ignition. Ignition occurs spontaneously at room temperature as soon as the hydrogen reaches the catalyst. Thus the elimination of pilot lights could significantly reduce energy consumption and its associated pollution.

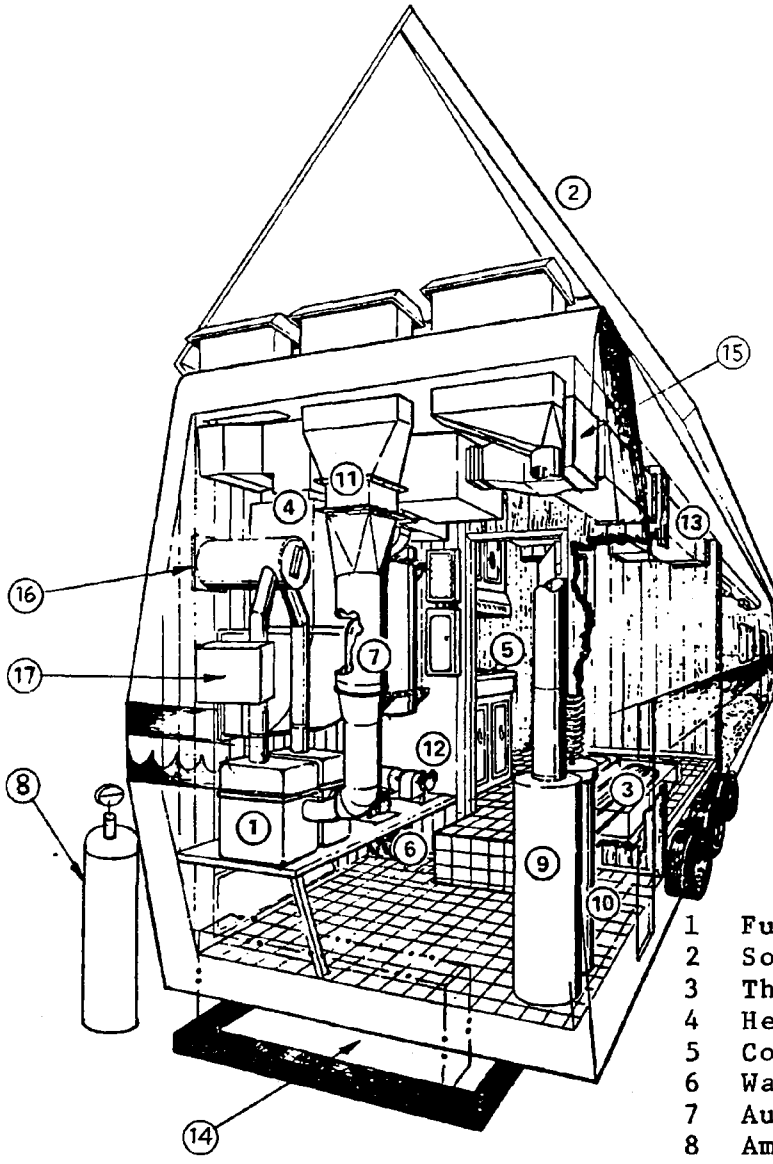
Flameless, catalytic combustion offers other environmental benefits as well. Whereas normal gas ranges reach combustion temperatures of 3,000^{o}F or more, the catalytic range operates at only 1,600^{o}F. This means that the formation of nitric oxide, which occurs at temperatures above 2,800^{o}F, is virtually eliminated. The catalytic combustion of hydrogen appears to be nearly pollution-free; water is the combustion product. Even if unburned hydrogen were to appear in the exhaust gases, no environmental damage would result, since hydrogen is not considered to be a pollutant. However, hydrogen's safety hazard's do require very careful consideration.

The other catalytic appliance, the auxiliary heater, uses the same type of catalytic burner as the range, although the burner shape and operating temperature is somewhat different.

Water Heater

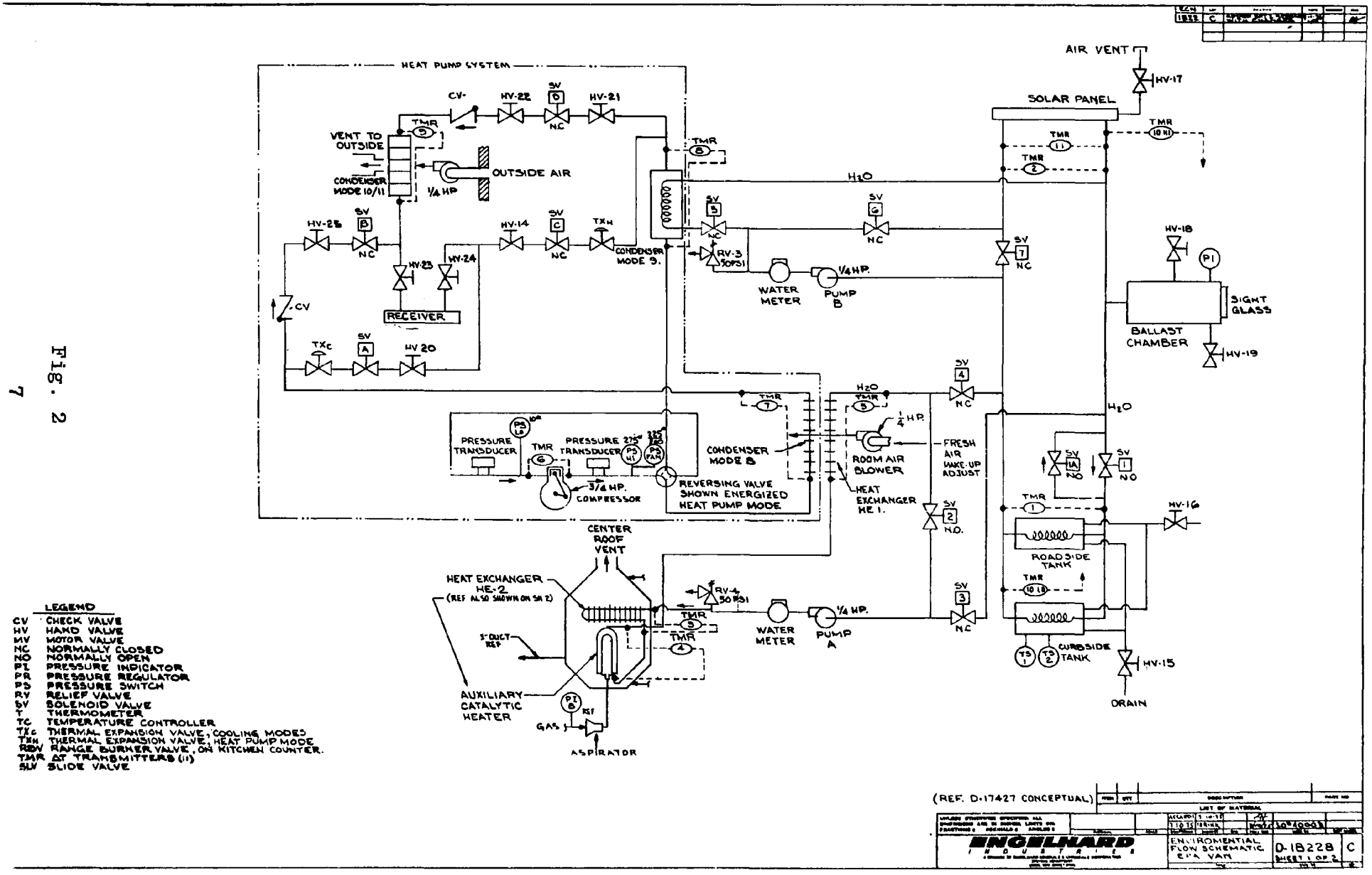
Initially designed and successfully tested in the laboratory with a catalytic heating unit, the water heater was converted to flame heating using the 75 percent H_2, 25 percent N_2 as fuel. The standard gas controls for the burner was successfully integrated into the EPA-Van control system.

The flame temperature was found to be 2100^{o}F, well below the formation temperature of nitric oxides.



1 Fuel cells
2 Solar collector
3 Thermal storage tank
4 Heat pump
5 Cooking range
6 Water heater
7 Auxiliary heater
8 Ammonia tanks
9 Ammonia dissociator
10 Scrubber
11 Fuel/cell/heat recovery unit
12 Pumps for glycol circuits
13 HVAC duct to living areas
14 Battery box
15 Solar panel/erector control
16 Cover/fuel cell air inlet
17 Fuel cell/control panel

SYSTEM COMPONENT LOCATION
FIGURE 1



LEGEND

CV	CHECK VALVE
HV	HAND VALVE
MV	MOTOR VALVE
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
PI	PRESSURE INDICATOR
PR	PRESSURE REGULATOR
PS	PRESSURE SWITCH
RV	RELIEF VALVE
SV	SOLENOID VALVE
T	THERMOMETER
TC	TEMPERATURE CONTROLLER
TXC	THERMAL EXPANSION VALVE, COOLING MODES
TXH	THERMAL EXPANSION VALVE, HEAT PUMP MODE
RBV	RANGE BURNER VALVE, ON KITCHEN COUNTER.
TMR	AT TRANSMITTERS (11)
SLV	SLIDE VALVE

(REF. D-17427 CONCEPTUAL)

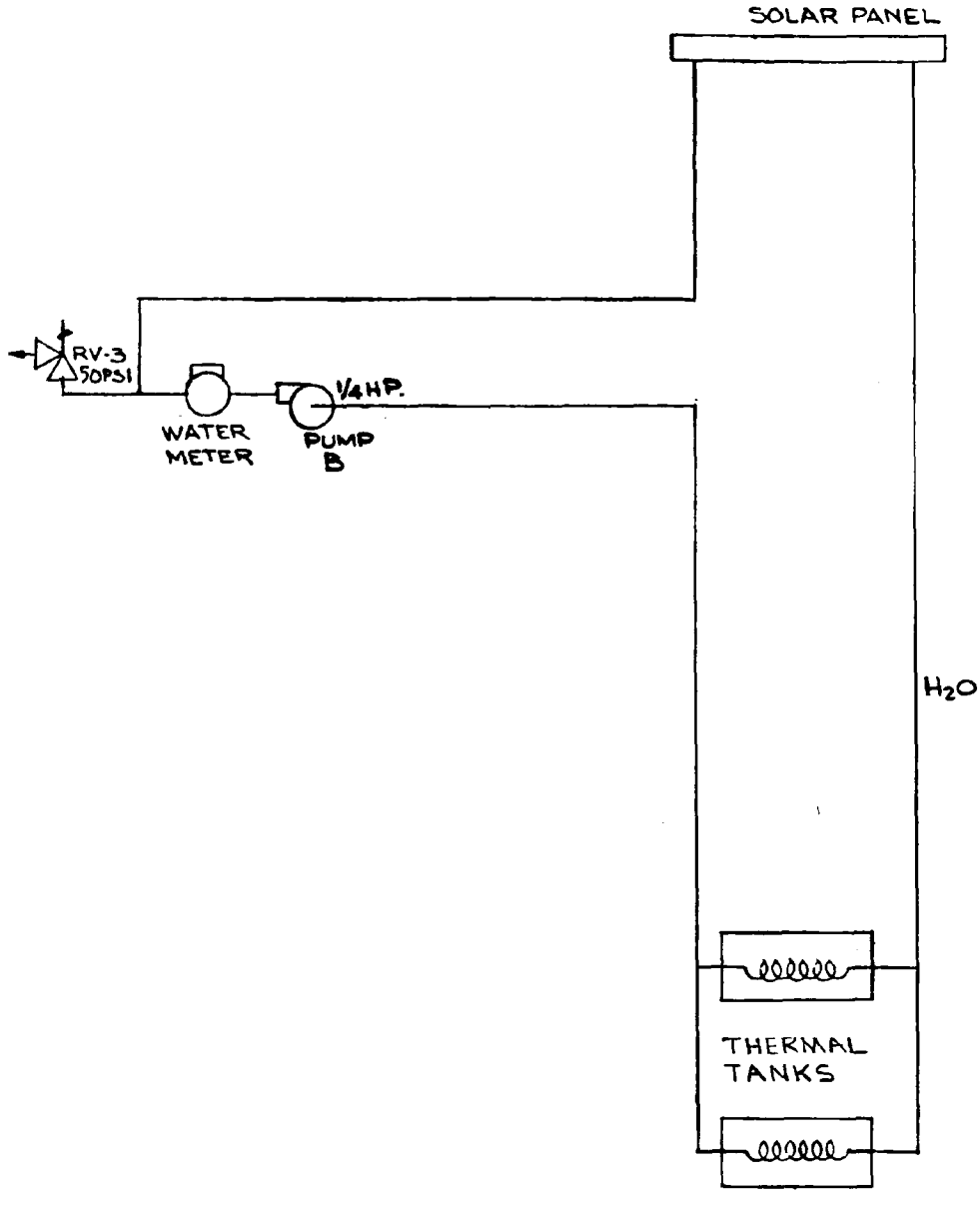
ENGELHARD INDUSTRIES

ENVIRONMENTAL FLOW SCHEMATIC EPA VAN

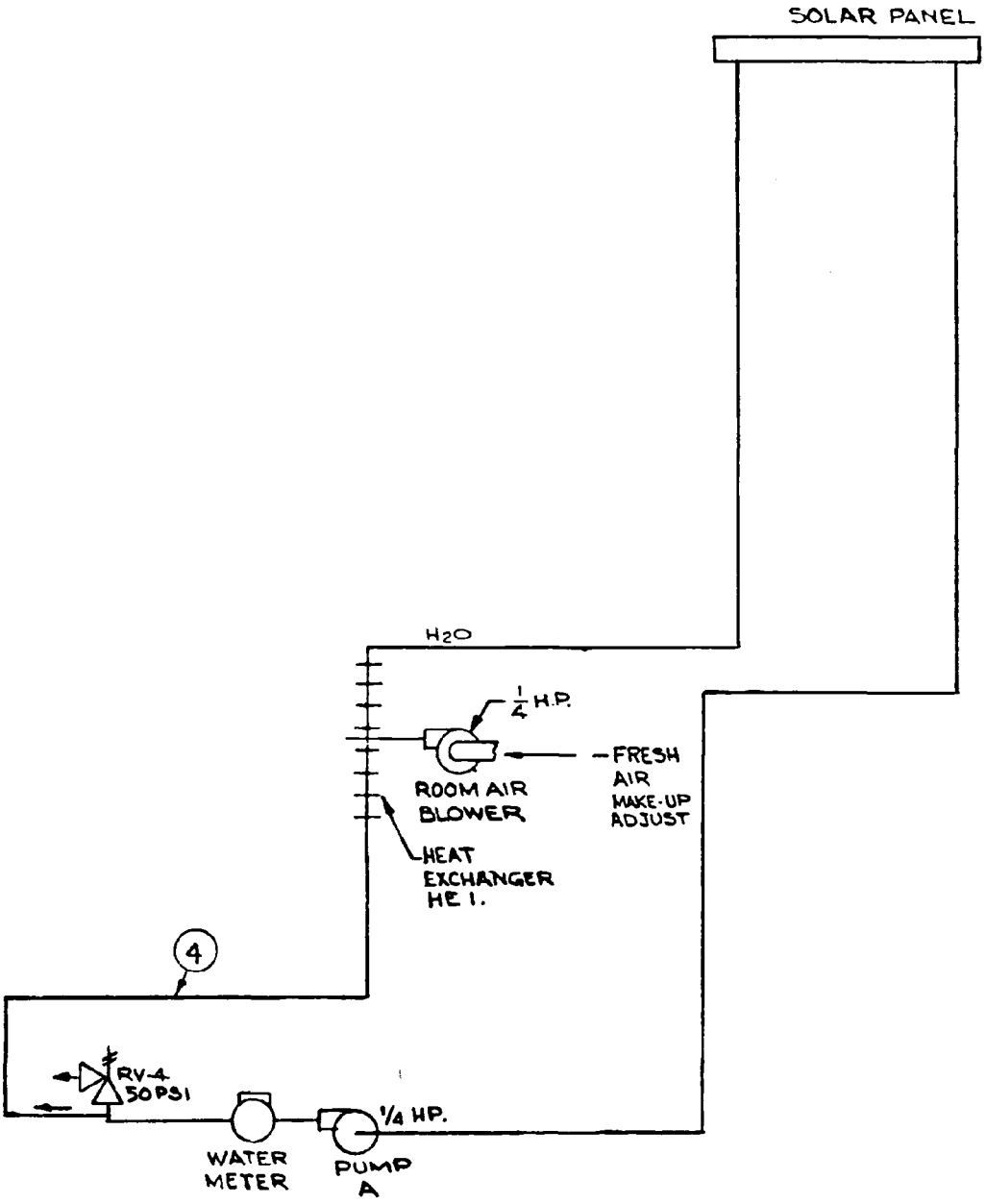
D-18228 C

SHEET 1 OF 2

Fig. 2

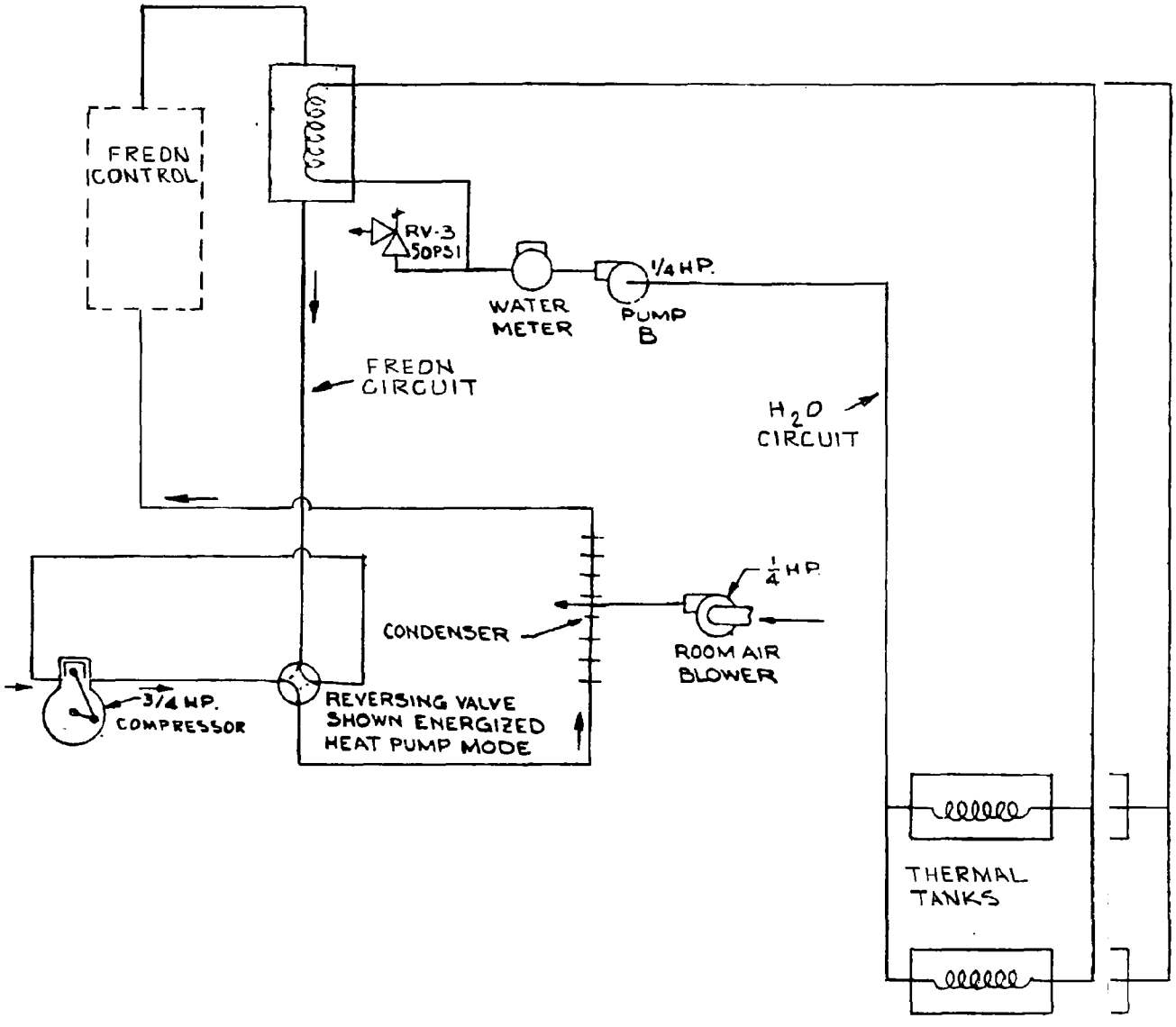


"1st" Circuit
Solar Heat Storage
Fig. 2A



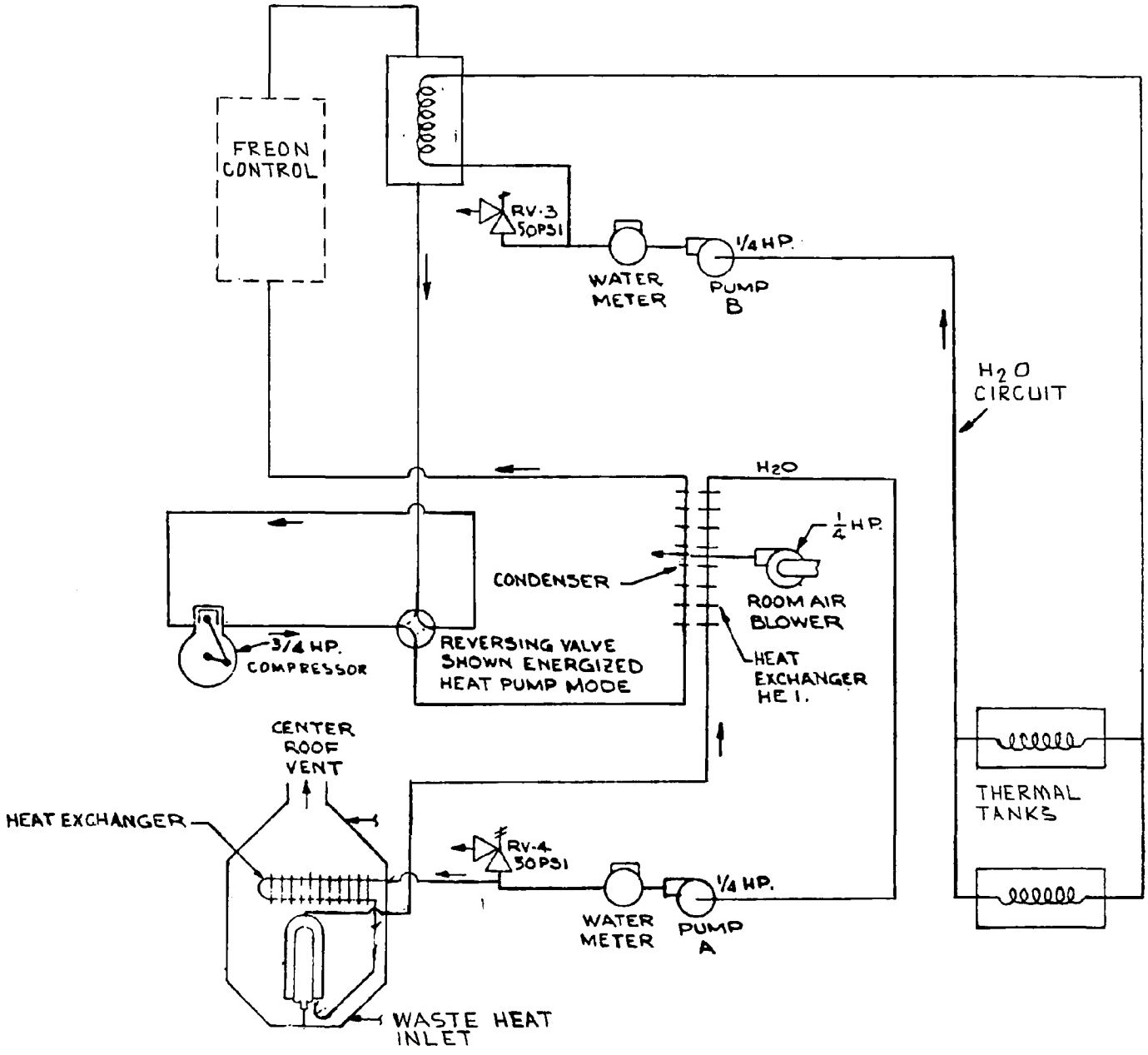
"2nd" Circuit
Direct Heating from
Solar Panel

Fig. 2B



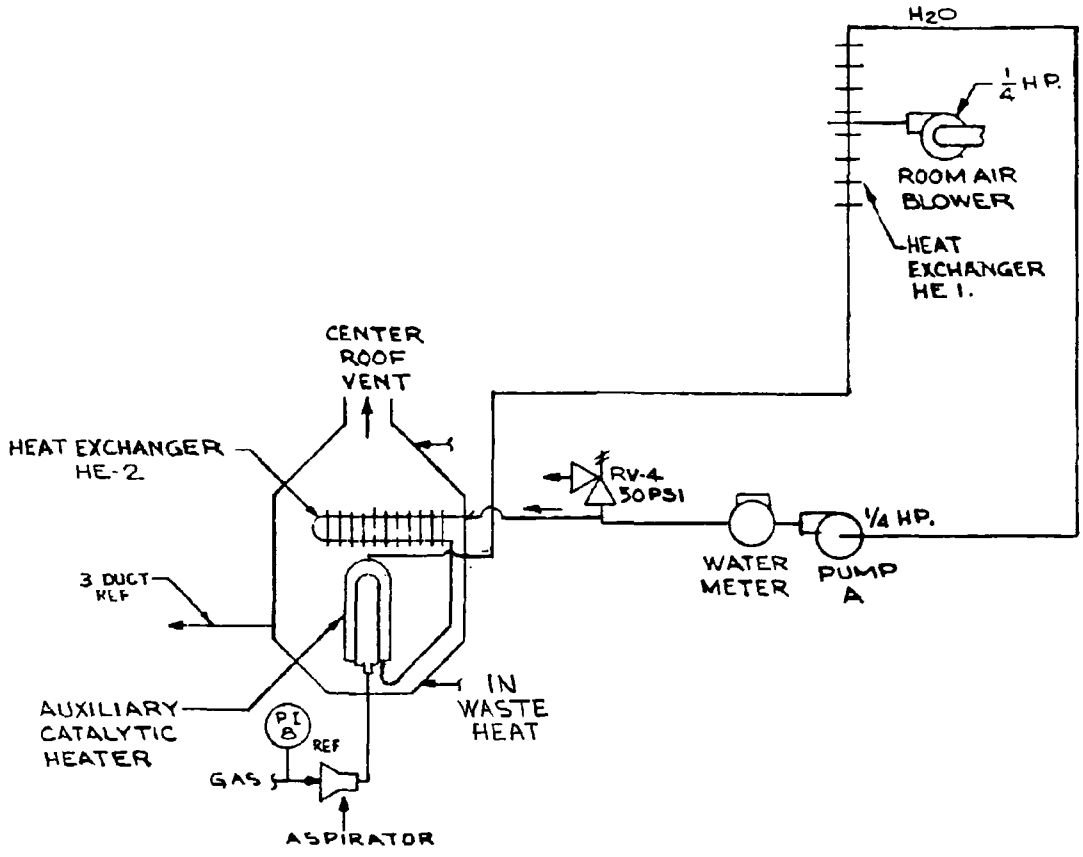
"3rd" Circuit
"Indirect" Heating
Heat Pump in Heating Mode

Fig. 2C-1



"3rd" Circuit, Indirect Heating: Heat Pump With Waste Heat

Fig. 2C-2



"4th" Circuit
Direct Heating with Auxiliary
Catalytic Heater

Fig. 2D

The Integration of Components

As previously described, the EPA-Van is composed of a solar collector and storage tank, a heat pump, two fuel cells, a water heater, and two catalytic appliances. These components do not function independently, however, but are integrated into one system, which satisfies all domestic needs. The system provides for space heating, cooling, and ventilating; cooking; water heating; and electricity for lighting, food refrigeration, and all other needs.

The methods by which the EPA-Van components are linked together and controlled are discussed in the following sections.

Four Glycol-Solution Circuits (Fig. 2,2A,2B,2C-1,2C-2,2D)

Four glycol-solution circuits serve as the key linkages between the EPA-Van components. Each circuit is a closed loop which transfers energy between two components. The first circuit transfers solar energy from the solar collector to the thermal storage tank. The second circuit transfers solar energy from the collector to a glycol-air heat exchanger for "direct" space heating. (Return air from the living areas is heated in this exchanger and then recirculated.) The third circuit transfers energy from the storage tanks to the heat pump for "indirect" heating. The fourth circuit transfers energy from the auxiliary heater to the glycol/air exchanger for "direct" space heating. Pumps and control valves allow two circuits, the first and fourth, to be operated simultaneously.

Eight HVAC Functions (Fig. 3)

The four glycol circuits allow for great flexibility in operating the EPA-Van's system for heating, ventilating, and air conditioning (the HVAC system). Eight separate HVAC functions are possible, as summarized below:

Operation	Code	Function
Heating	1	Fuel-Cell Waste Heat
	3	Auxiliary Heater
	4	Stored Heat from Thermal Storage Tank
	5	Heat Pump
	7	Direct Solar Heat
Cooling	6w	Heat Pump Rejecting Heat to Thermal Storage Tank
	6a	Heat Pump Rejecting Heat to Outside Air
Neutral	2	Solar Energy Storage

ECN	LET.	CHANGE	DATE	CHECKER	ENG.
1670	A	ADDED VALVES HEAT PUMP	5 NOV 75	WS	
1822	B	NOTE WAS M.O.5 LOCKED OUT WHEN K.R. IS ON, SYSTEM GOES TO M.O.4	3-24-76	W	

LEGEND:

- O VALVE OPEN
- X VALVE CLOSED
- + MOTOR OPERATING
- H HEATING
- C COOLING
- A AIR
- W WATER

	MODES OF OPERATION	SOLENOIDS 1	2	3	4	5	6	7	CB	PUMPS A	B	FANS RH	AC	C_{HP}	SWITCH M/C	A/W	LOCKOUT WH	KR	VALVES HEAT PUMP A&D	B&C	REV.
1	WASTE HEAT	O	O	X	X	X	X	X	X	+		+			H	W					
2	SOLAR HEAT STORAGE	O	O	X	X	X	O	X	X		+	+			H	W					
3	WH + SHST	O	O	X	X	X	O	X	X	+	+	+			H	W					
4	WH + CAT. BURNER	O	O	X	X	X	X	X	O	+		+			H	W	X	*			
5	WH + CB + SHST	O	O	X	X	X	O	X	O	+	+	+			H	W	X	*			
6	WH + TANK HEAT	O	X	O	O	X	X	X	X	+		+			H	W					
7	WH + SOLAR HEAT	X	X	O	O	X	X	O	X	+		+			H	W					
8	WH + HEAT PUMP/H	O	O	X	X	O	X	X	X	+	+	+		+	H	W	X		X	O	O
9	HP/COOL (WATER)	O	O	X	X	O	X	X	X		+	+		+	C	W	X		O	X	X
10	HP/COOL (AIR)	O	O	X	X	X	X	X	X			+	+	+	C	A	X		O	X	X
11	HP/C (AIR) + SHST	O	O	X	X	X	O	X	X		+	+	+	+	C	A	X		O	X	X

	TANK TEMP. →	SOLAR PANEL DIFFERENTIAL <3°F < 50	50-100	>100	>3°F < 50	50-100	>100	ABS. >100°F	
ROOM TEMP.	>78	10	9	10	11	9	11		COOLING
	70-78				2	2	2		NEUTRAL
	69-70	1	1	1	3	3	3		HEAT
	< 69	4	8	6	5	8	6	7	

Fig. 3
14

NOTE:

* MODES 4 & 5 CATALYTIC BURNER LOCKED OUT WHEN KITCHEN RANGE IS ON. SOLENOIDS 1 AND 2 ARE N.O. OTHERS N.C.

ITEM	QTY.	DESCRIPTION	PART NO.
		LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS ARE IN INCHES, LIMITS ON: FRACTIONS ± DECIMALS ± ANGLES ±

MATERIAL	SCALE	DRAFTSMAN	CHECKER	ENG	PROJ. ENG.	USED ON	NEXT ASSEM.
—	—	4-8-75 J.Z.	4-8-75 W3	4-8-75 B.V.	4-8-75	40003	

ENGELHARD INDUSTRIES
A DIVISION OF ENGELHARD MINERALS & CHEMICALS CORPORATION
SYSTEMS DEPARTMENT
EAST NEWARK, NEW JERSEY 07029

TITLE	DWG. NO.	REV.
EPA VAN MODES & ENVIRON. CONT. SYSTEM	B-18090	B

HVAC Controller (Fig. 3)

The HVAC control system, automatically selects the proper HVAC functions. Like the thermostat in a conventional home, the controller senses room temperature and thereby determines the HVAC requirements of the EPA-Van. It also selects the most fuel conservative function (or combination of functions) to satisfy the HVAC requirements.

Four temperature inputs allow the HVAC control system to select the proper function(s): room temperature, storage tank temperature, solar collector outlet temperature, and solar collector inlet/outlet differential temperature (dynamic). Using these inputs, and the logic matrix, the controller calls for heating, cooling, or neutral functions.

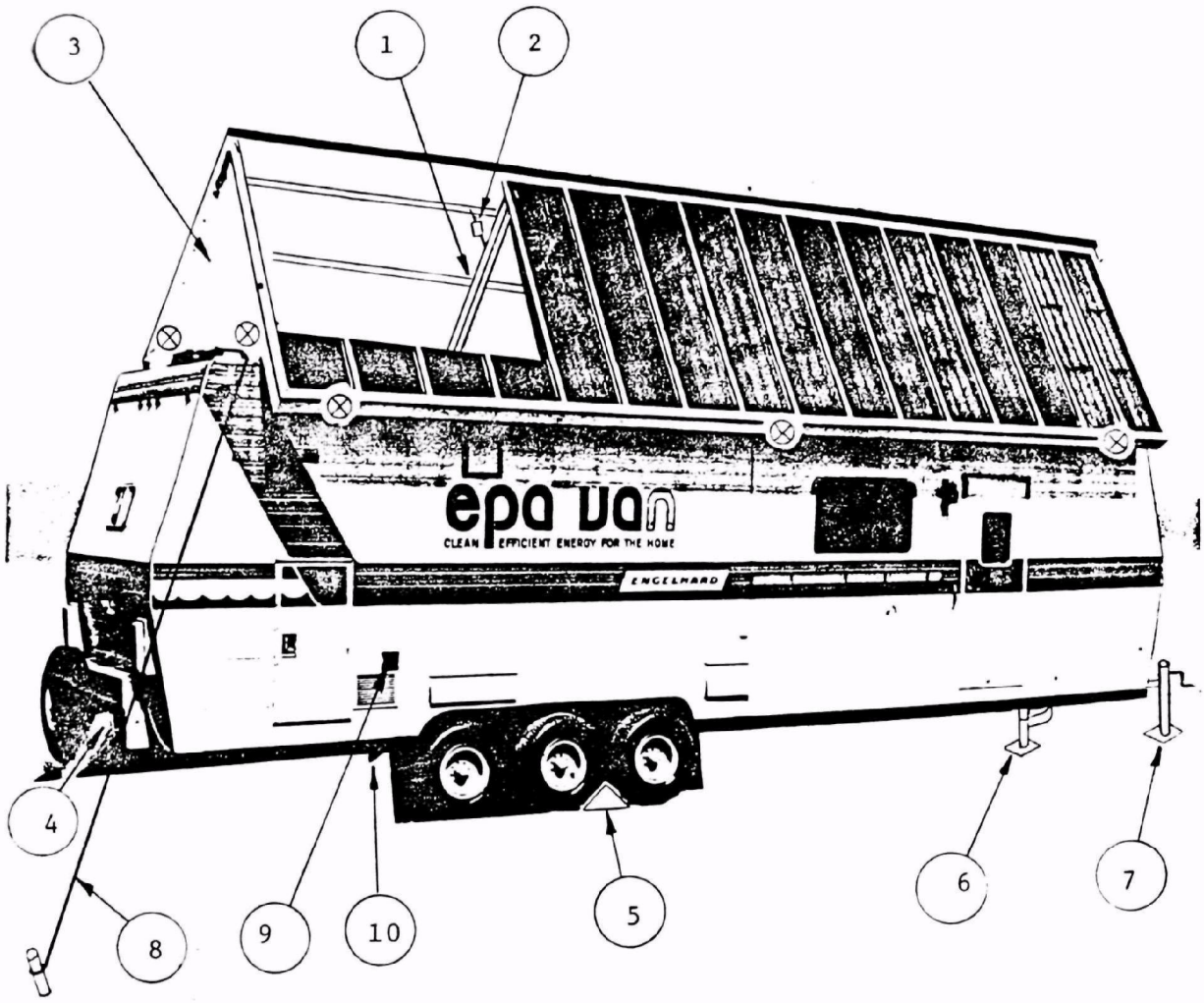
Heating: When the room temperature falls below 70°F, the HVAC control system calls for heating. The fuel-cell waste heat, which is always the most fuel-conservative function, is used first. If this waste heat is inadequate to maintain the room above 69°F, it is supplemented by one of the other four heating functions, depending upon solar conditions and the storage tank temperature.

If the sunlight is intense (i.e., the glycol-solution exits the solar collector above 100°F), direct solar heating is used. If there is no sun, but the storage tank is hot (+ 100°F), stored heat is used. If the tank is warm (50-100°F), the heat pump function is used. If the tank is cold (+50°F) and there is insufficient sunlight, the auxiliary heater is called for.

Cooling: When the room temperature rises above 78°F, the HVAC control system calls upon the heat pump for cooling. The heat pump rejects its heat either to the outside air or to the thermal storage tank, depending upon the tank temperature.

Neutral: At room temperatures between 70 and 78°F, neither heating nor cooling is required. But if there is adequate sunlight, solar energy is stored in the thermal storage tank for later use. To be adequate, the amount of solar energy collected must exceed the "pumping energy" consumed in transferring the solar energy into and out of storage. Engelhard has calculated that an inlet/outlet differential temperature of 3°F is adequate.

Solar energy is also stored concurrently with certain heating and cooling functions. This concurrent capability is particularly valuable during certain periods in the fall and spring; the solar energy which is stored during the warm days, when the heat pump is cooling the home, is used to heat the home during the cool nights. Moreover, since the heat pump rejects its heat to the thermal storage tanks during the day, this rejected heat is also available for heating at night.



Item 1	Roof Support	(Total 6)
2	Tie-Down Hook	(Total 6)
3	Awning	(Total 2)
4	Battery Box	(Total 1)
5	Chucks	(Total 2)
6	Hydraulic Jacks	(Total 4)
7	Mechanical Jacks	(Total 4)
8	Hurricane Tie-Down	(Total 4)
9	Filling Connection Thermal Tanks	(Total 1)
10	Drain Valve Thermal Tanks	(Total 1)

⊗ Location of shipping tie-down straps.

EXTERIOR COMPONENT LOCATIONS

FIG. 4

SECTION III

TRANSPORTATION INSTRUCTIONS

For basic trailer information and maintenance refer to trailer manual.

A. Check List Prior to Transportation (Fig. 4)

1. Remove all roof supports, clevices, and awnings pack properly into compartments provided on the roof of the trailer.

2. Retract solar panel all the way in and fasten solar panel cover to bottom frame securely using the appropriate straps.

3. Install three (3) shipping retainers on front and three (3) on back of solar panel.

4. Close all ammonia valves tightly and remove ammonia tanks from trailer.

5. Place the batteries (4 banks) in living room compartment under front table.

6. Empty H_2O tanks by opening appropriate valves located underneath the trailer.

7. Secure all loose accessories and hardware.

B. Recommendations for Towing

1. Trailer dimensions:

Length: 41 ft. 3 inches
Width : 8 ft. 0 inches
Height: 13 ft. 4 inches

2. Trailer Shipping Weight:

Gross Vehicle Weight: 21,500 lbs.
Hitch Weight: 2,440 lbs.

3. Towing Vehicle:

Minimum weight:	24,000 lbs.
Ball Diameter :	2-5/16 inches

4. Safety Chain Arrangement:

A heavy safety chain must be used between the frame of the towing vehicle and the hitch frame on the trailer.

5. Coupler Safety Lock:

Use the coupler safety lock to prevent accidental release of the spring loaded latch.

6. Escort Vehicles:

It is recommended to use both a front and a rear vehicle during transport of the trailer. Both vehicles should carry flags or lights for warning.

7. Maximum Speed:

The towing speed should never exceed 40 miles per hour. Adjust the speed to road, wind, and traffic conditions.

8. Wind Speed:

Do not tow the trailer when the wind velocity exceeds 20 miles per hour.

9. Tunnels:

Tunnels should be avoided at all cost. Use detours around the tunnel to avoid being jammed against the roof of the tunnel.

10. Parking During Transport:

If short term parking is required make sure to park on a level area, where the trailer is protected against wind gusts. Place the 2 chucks provided between the wheels. If overnight parking is needed use both the 4 hydraulic and the 4 mechanical jacks in addition to the chucks to secure the trailer.

C. Set-Up of Trailer at Location (Fig. 4)

1. Orientation of the trailer should be such that the solar panel has a due South exposure.

2. Leveling Jacks: The trailer should be leveled using the 4 hydraulic jacks and the tongue jack.

   Shoring lumber and/or timber may be needed to extend the use of the hydraulic jacks working length.

3. Stabilizing: Use the four mechanical corner jacks for stabilizing the trailer after the leveling has been completed.

4. Hurricane Tie-Downs: Connect the 4 steel cables between the eye-rings in the solar panel base frame and 4 solid anchors, secure firmly.

5. Return the batteries to the box on the rear bumper, and make the connections in proper sequence, as marked within the box.

NOTE: MAKE CONNECTIONS BOTH FOR 24 VOLTS AND 12 VOLTS SERVICE. OBSERVE POLARITY AND MAKE SURE THE WIRES ARE FASTENED SECURELY.

6. Shoreline: 110V, 60 Hz, 1 Ph., 30 amperes. Connect the shoreline to an outside power source, with a fusible disconnect switch.

   The shoreline provides the following power:
   1) For start-up 110V A.C. required and 2) all 24V-DC power normally provided by the fuel cells.

7A. Erection of Solar Panel: (Figs. 1 and 4)

   NOTICE: FILL THE 2 TANKS WITH WATER (350 GAL.) BEFORE ATTEMPTING ANY SOLAR PANEL OPERATION.

   THE RECIRCULATING SYSTEM IS ALREADY PRECHARGED WITH WATER/GLYCOL MIXTURE.

   a) The erection operation takes 2 men to perform. Remove the 3 shipping tie-down straps from the curbside and the 3 clamps on each end, and loosen the 2 hand lines.

   b) Inspect the top front and back for obstructions.

c) Have 1 man take hold of the handlines, to prevent wind gusts from catching the top cover. Use only enough force on the line to keep control of the panel.

d) Power the erector control panel. Shoreline rectified or battery power can be used individually.

e) Pressing and retaining pressure on the "UP" pushbutton will erect the panel.

WARNING: THE OPERATOR SHOULD BE ALERT FOR ANY UNUSUAL BEHAVIOUR OR NOISES DURING THE ERECTION. HE MUST INVESTIGATE AND CORRECT ANY PROBLEMS, OR THE SOLAR PANEL MAY BE DESTROYED.

f) Press the "UP" button until no further upward motion is detected. A limit switch is provided to cut-off motor power once optimum solar panel position is attained (60^{o} from horizontal).

NOTICE: IF IT IS REQUIRED TO ERECT OR RETRACT THE SOLAR PANELS DURING SEVERE WIND CONDITIONS, MAN BOTH END CABLES AS WELL AS THE HANDLINE.

g) Push circuit breaker to the "OFF" position.

h) Go up to Van roof and install the roof support between the roof frame and the solar panel.

i) Secure tie-down hooks to cover frame and tighten securely. Large blue arrows show these locations.

j) Install the triangular awning cover on each end of the roof.

NOTICE: BY OBERVING THE MAIN DC AMMETER, IT WILL BE FOUND THAT THE CURRENT DRAWN BY THE ERECTOR MOTOR RUNS AT 11 TO 12 AMPS, EXCEPT FOR A SHORT PERIOD OF UP TO 52 AMPS. THE 52 AMP LOAD CORRESPONDS TO THE INITIAL PANEL LIFT OFF FROM THE CAM FOLLOWERS.

7B. Retraction of Solar Panel:

NOTICE: THE SAME PRECAUTIONS FOR ERECTION MUST BE OBSERVED DURING THE RETRACTION OF THE SOLAR PANEL.

1. Remove triangular awnings for both ends of the roof.

2. Remove the tie-down hooks and the six support rods and place them in the provided compartment on the roof.

3. Push circuit breaker to the "ON" position.

4. Press "DOWN" button until the solar collector is in the down position, the motor power will cut off automatically, as a separate limit switch is provided for the downward motion.

5. Secure roof cover to bottom frame with tie-down straps.

6. Push circuit breaker to the "OFF" position.

8. Ammonia Supply:

The ammonia supply to the system can be in the form of a large supply tank or in the form of 150 lb. cylinders.

WARNING

UNDER NO CIRCUMSTANCES MUST THE CYLINDERS BE STORED WITHIN THE EPA-VAN.

IN CASE OF A FIRE IT WILL BE IMPOSSIBLE TO SAFELY REMOVE THE CYLINDERS FROM THE UTILITY ROOM. THE CYLINDERS WILL DEVELOP DANGEROUSLY HIGH PRESSURES WHEN EXPOSED TO TEMPERATURES ABOVE 120°F.

The proper orientation of the EPA-Van and the location of the ammonia door allow for keeping the cylinders in the shade during daylight hours.

The cylinders must be securely chained to prevent accidental upsets.

The cylinders can remain upright during operation.

Ammonia Quality:

NOTE: ONLY HIGH PURITY GRADE AMMONIA SHOULD BE USED, I.E. METALLURGICAL GRADE TO PROVIDE LONG CATALYST LIFE IN THE AMMONIA CRACKER.

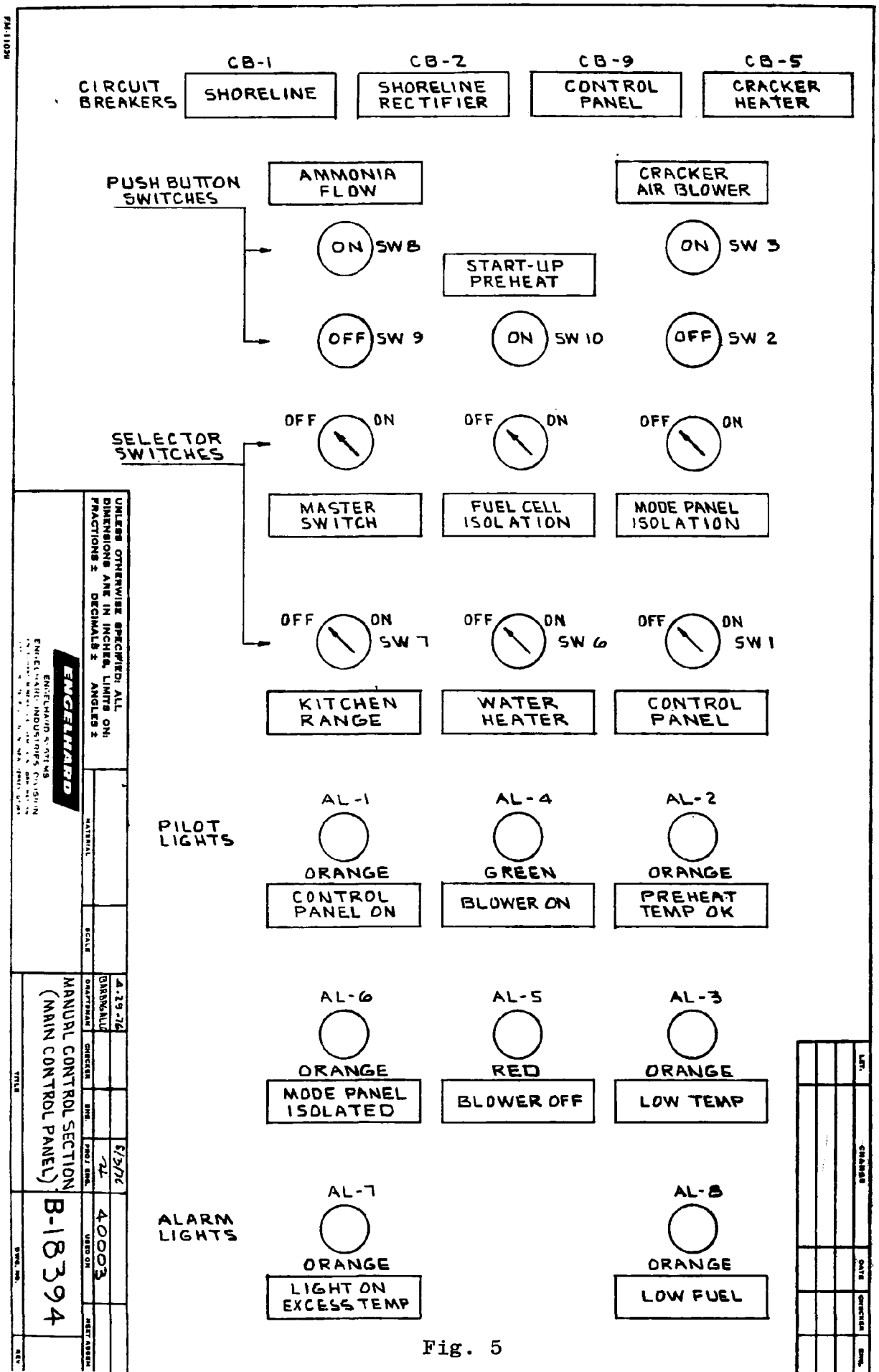
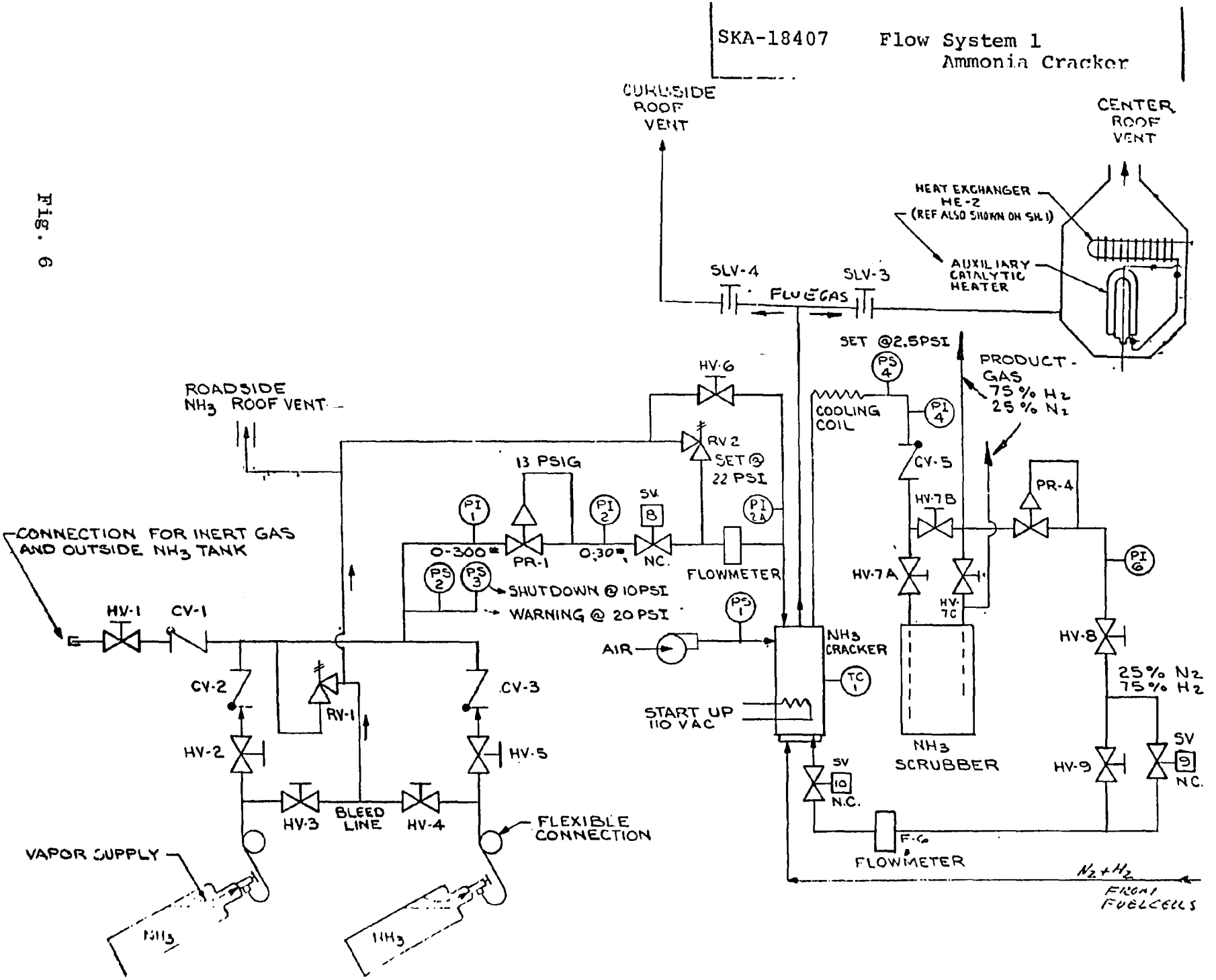

CIRCUIT BREAKERS
CB-1
SHORELINE
CB-2
SHORELINE RECTIFIER
CB-9
CONTROL PANEL
CB-5
CRACKER HEATER
PUSH BUTTON SWITCHES
AMMONIA FLOW
ON SW 8
OFF SW 9
START-UP PREHEAT
ON SW 10
CRACKER AIR BLOWER
ON SW 3
OFF SW 2
SELECTOR SWITCHES
OFF ON
MASTER SWITCH
FUEL CELL ISOLATION
MODE PANEL ISOLATION
OFF ON SW 7
KITCHEN RANGE
OFF ON SW 6
WATER HEATER
OFF ON SW 1
CONTROL PANEL
PILOT LIGHTS
AL-1
ORANGE
CONTROL PANEL ON
AL-4
GREEN
BLOWER ON
AL-2
ORANGE
PREHEAT TEMP OK
AL-6
ORANGE
MODE PANEL ISOLATED
AL-5
RED
BLOWER OFF
AL-3
ORANGE
LOW TEMP
ALARM LIGHTS
AL-7
ORANGE
LIGHT ON EXCESS TEMP
AL-8
ORANGE
LOW FUEL
ENGELHARD
MANUAL CONTROL SECTION (MAIN CONTROL PANEL)
B-18394
40003

Fig. 5

Fig. 6


SKA-18407 Flow System 1
Ammonia Cracker
CURBSIDE ROOF VENT
CENTER ROOF VENT
HEAT EXCHANGER HE-2
(REF ALSO SHOWN ON SH. 1)
AUXILIARY CATALYTIC HEATER
SLV-4
SLV-3
FLUE GAS
SET @2.5PSI
PS 4
PRODUCT GAS
75% H2
25% N2
HV-6
ROADSIDE NH3 ROOF VENT
COOLING COIL
PI 4
CV-5
RV 2
SET @ 22 PSI
13 PSIG
PI 1
PI 2
SV 8
PI 2A
HV-7B
PR-4
CONNECTION FOR INERT GAS AND OUTSIDE NH3 TANK
0-300#
PR-1
0-30#
NC.
FLOWMETER
PS 2
PS 3
SHUTDOWN @ 10PSI
WARNING @ 20 PSI
HV-7A
HV-7C
PI 6
HV-1
CV-1
PS 1
AIR
NH3 CRACKER
HV-8
CV-2
CV-3
RV-1
TC 1
START UP 110 VAC
25% N2
75% H2
HV-2
HV-5
SV 10 N.C.
NH3 SCRUBBER
HV-9
SV 9 N.C.
HV-3
BLEED LINE
HV-4
FLEXIBLE CONNECTION
F-6
FLOWMETER
VAPOR SUPPLY
N2 + H2
FRONT FUELCELLS
NH3
NH3

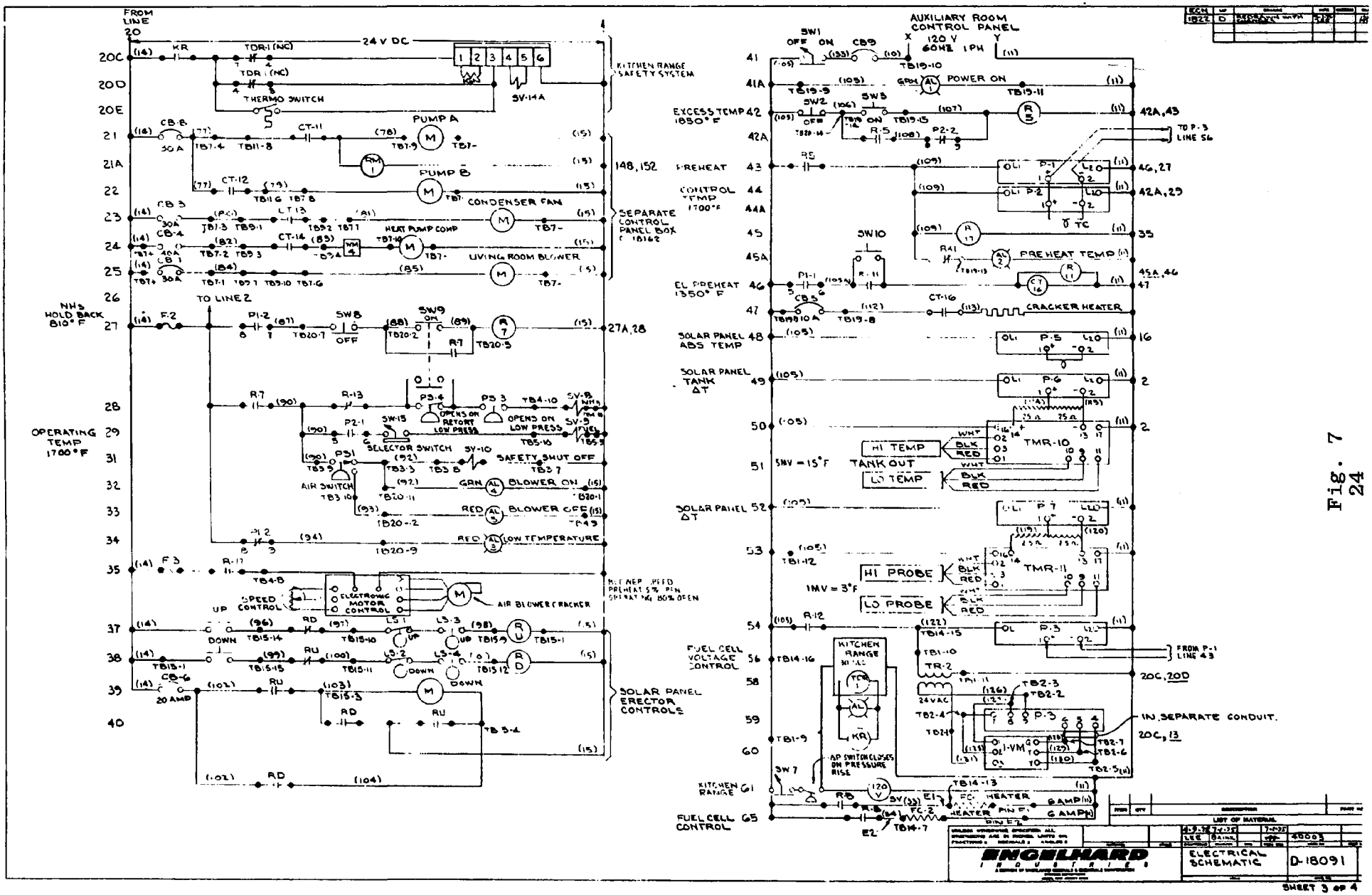

FROM LINE 20
24 V DC
KR
TDR-1 (NC)
TDR-1 (NC)
THERMO SWITCH
SV-14A
KITCHEN RANGE SAFETY SYSTEM
PUMP A
CB-B
30A
CT-11
TB7-4
TB11-8
TB7-9
TB7-
PUMP B
CT-12
TB11-9
TB7-8
148, 152
CB-3
30A
CB-4
30A
CB-1
30A
CT-13
CT-14
HEAT PUMP COMP
CONDENSER FAN
LIVING ROOM BLOWER
SEPARATE CONTROL PANEL BOX C 18162
NH3 HOLD BACK 810° F
TO LINE 2
F-2
PI-2
SW8
OFF
SW9
ON
TB20-2
TB20-7
TB20-5
27A, 28
OPERATING TEMP 1700° F
R7
R-13
PS-4
OPENS ON RETORT LOW PRESS
PS-3
OPENS ON LOW PRESS
SV-8
SV-9
P2-1
SW-15
SELECTOR SWITCH
SV-10
PS1
AIR SWITCH
SAFETY SHUT OFF
TB3-7
BLOWER ON
BLOWER OFF
LOW TEMPERATURE
TB20-9
F-3
R-17
TB4-8
SPEED CONTROL
ELECTRONIC MOTOR CONTROL
AIR BLOWER CRACKER
KITCHEN RANGE PREHEAT 5% PIN SPRAY VALVE 80% OPEN
UP
DOWN
RD
RU
LS-1
LS-2
LS-3
LS-4
TB15-14
TB15-10
TB15-15
TB15-11
TB15-9
TB15-12
TB15-1
CB-6
20 AMP
TB15-5
TB 5-4
SOLAR PANEL ERECTOR CONTROLS
AUXILIARY ROOM CONTROL PANEL
SW1
OFF ON
CB9
X
120 V
60HZ 1PH
Y
TB19-10
TB19-9
POWER ON
TB19-11
SW2
SW3
EXCESS TEMP 1850° F
TB19-14
TB19-13
R-5
P2-2
42A, 43
TO P-5 LINE 56
PREHEAT
CONTROL TEMP 1700° F
42A, 29
TC
SW10
PREHEAT TEMP
35
EL PREHEAT 1350° F
PI-1
CT-16
45A, 46
47
CB-5
10A
CRACKER HEATER
SOLAR PANEL ABS TEMP
16
SOLAR PANEL TANK ΔT
2
HI TEMP TANK OUT
LO TEMP
TMR-10
SHV = 15° F
SOLAR PANEL ΔT
HI PROBE
LO PROBE
TMR-11
1MV = 3° F
FUEL CELL VOLTAGE CONTROL
KITCHEN RANGE
TR-2
24 VAC
20C, 20D
FROM P-1 LINE 43
IN SEPARATE CONDUIT.
20C, 13
AP SWITCH CLOSES ON PRESSURE RISE
SW 7
KITCHEN RANGE
FUEL CELL CONTROL
HEATER
SHEET 3 OF 4

Fig. 7
24

SECTION IV

START-UP INSTRUCTIONS

1. Start-Up Ammonia Cracker (Fig. 6)

A) Close all hand valves shown on Fig. 6. Except HV-8 and HV-9. These two valves are preset for gas burner control.

B) Hook-up and secure yokes on NH_3 cylinder. Use a new rubber washer for each NH_3 cylinder. Check for leaks.

C) Electric Preheat: (Fig. 5 and 7)

-1. Provide external power to the shoreline.

-2. Close CB-1 circuit breaker "SHORELINE".

-3. Close CB-9 circuit breaker "CONTROL PANEL".

-4. Close CB-2 circuit breaker "SHORELINE RECTIFIED".

-5. Switch SW-1 "CONTROL PANEL" to "ON" position. "CONTROL PANEL" light will be lit. P-4 "SOLAR PANEL ABSOLUTE TEMP", P-6 "SOLAR PANEL TANK DELTA T", and P-7 "SOLAR PANEL DELTA T, instruments will be powered.

-6. Press SW-3 "CRACKER" green pushbutton in. Indicator lights on P-1 "CRACKER TEMP" and P-2 "CRACKER TEMP PROTECTOR" instruments will show power "ON".

Initially, "LOW TEMP" (RED) light will light, and the blower will start. Make sure the cracker blower control is set at "LOW" position.

-7. Check settings on P-1 and P-2.

P-1: (Yellow setpoint) should be set at 810°F.

(Red setpoint) should be set at 1350°F.

P-2: (Red setpoint) should be set at 1700°F.

(Yellow setpoint) should be set at 1850°F.

-8. Press SW-10 "START-UP" black pushbutton in. Press cracker heater breaker "ON". This will initiate electric preheat of the cracker.

-9. Switch SW-15 "BURNER CONTROL" to HI/LO position.

D) Preheat: Using Partially Cracked Ammonia:

When the temperature on P-1 reads 800°F sufficient H_2 can be generated to start using the Gas Burner in the generator.

1. Open one NH_3 cylinder valves using appropriate wrenches.

2. Open HV-2, or HV-5 depending on which cylinder is to be used.

(Use one NH_3 cylinder at any given time, the other cylinder is used for changeover.)

NOTE: HV-1 IS OPENED FOR OUTSIDE TANK CONNECTION. WHEN OUTSIDE TANK CONNECTION IS USED, CLOSE HV-2 AND HV-5. APPROPRIATE CHECK VALVES (CV) WHICH INSURE AGAINST LIQUID AMMONIA BACKFLOW ARE PROVIDED FORWARD OF HV-1, HV-2, AND HV-5; HOWEVER CLOSING OF UNUSED INLET VALVES ARE RECOMMENDED.

3. Open valve HV-7B fully to allow flow to the burner section of the ammonia cracker.

4. Turn blower speed control to "80%" setting.

5. Press "AMMONIA FLOW" on button and hold depressed until Pl-4 reads 3 psig.

6. Flow should now be indicated on the F-6 flowmeter at the "8" mark. If not, adjust HV-8 to obtain this reading.

7. Switch "BURNER CONTROL" SW-15, Fig. 7 to "LO" position to check the flow in "LOW FIRING". F-6 should read about 1/2 to 1 mark on the flowmeter. Return "BURNER CONTROL" to "HI/LO".

8. The heating of the generator is now done both by the electrical heater and the gas-fired burner. The temperature rise will now proceed at a more accelerated rate.

When P-1 red setpoint (1350°F) is attained; "PREHEAT TEMP OK" (green) light should go on. This means that cracker heating is being accomplished solely by generated hydrogen and that electrical preheating has turned off automatically.

The heating will now continue until the P-2 setpoint of 1700°F is satisfied. At 1700°F the control will turn the gas flow for the burner to "LOW" as registered on flowmeter F-6 approximately at "1/2". Once the temperature on P-2 is 1700°F the generator is ready to deliver a product gas suitable for use in the fuel cells, water heater, auxiliary catalytic heater, and in the kitchen range.

Do not admit the product gas unless the proper procedure for starting each individual component has been followed.

NOTICE: THE FUEL GAS TO THE FUEL CELLS MUST ALWAYS PASS THRU THE SCRUBBER TO REMOVE THE RESIDUAL AMMONIA. THE FUEL GAS TO THE WATER HEATER, THE AUXILIARY CATALYTIC HEATER, AND THE KITCHEN RANGE, DOES NOT PASS THRU THE SCRUBBER IN ORDER TO EXTEND THE LIFE OF THE SCRUBBER MATERIAL.

THE SMALL AMOUNT OF FREE AMMONIA IN THE UNSCRUBBED PRODUCT GAS WILL COMPLETELY DISSOCIATE IN THE WATER HEATER, CATALYTIC AUXILIARY HEATER, AND THE KITCHEN RANGE.

Start-Up Fuel Cells: (Figs. 1,5,8,9)

1. Start preheat when gas firing begins on the cracker.

2. Press the green "HEATER" button on the fuel cell control panel, located on the rear wall in the utility room.

   After about 30 minutes the green light "FUEL ON" will light.

3. Allow a minimum of 45 minutes of preheat time prior to admitting product gas to the fuel cells.

4. Press "HEATER OFF" button after 1 hour of preheat time.

CAUTION: Do not operate preheat for more than 1 hour.

Placing the Fuel Cells in Power Operation:

1. a) Remove the fuel cell air-intake cover on the road side wall.

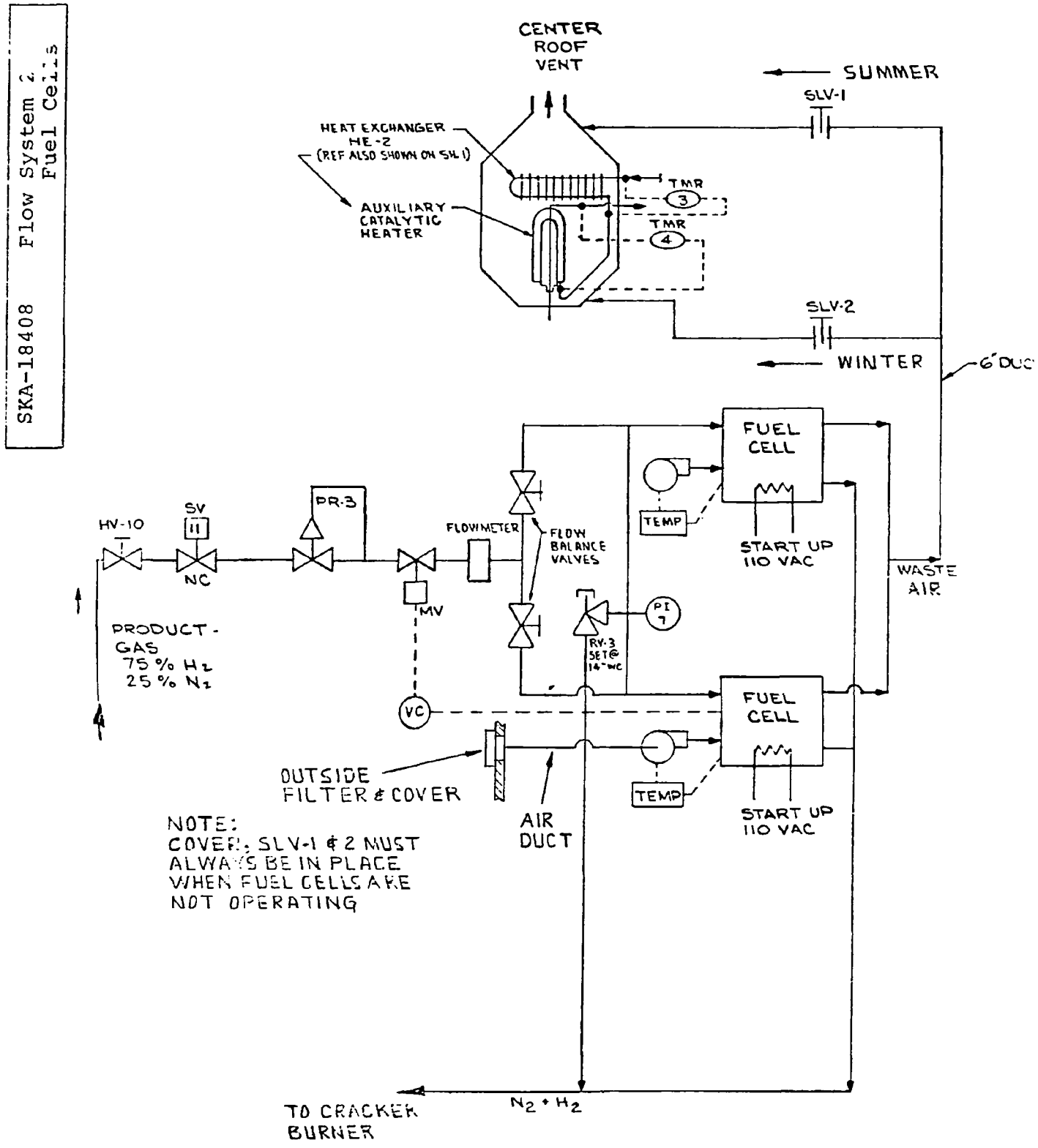
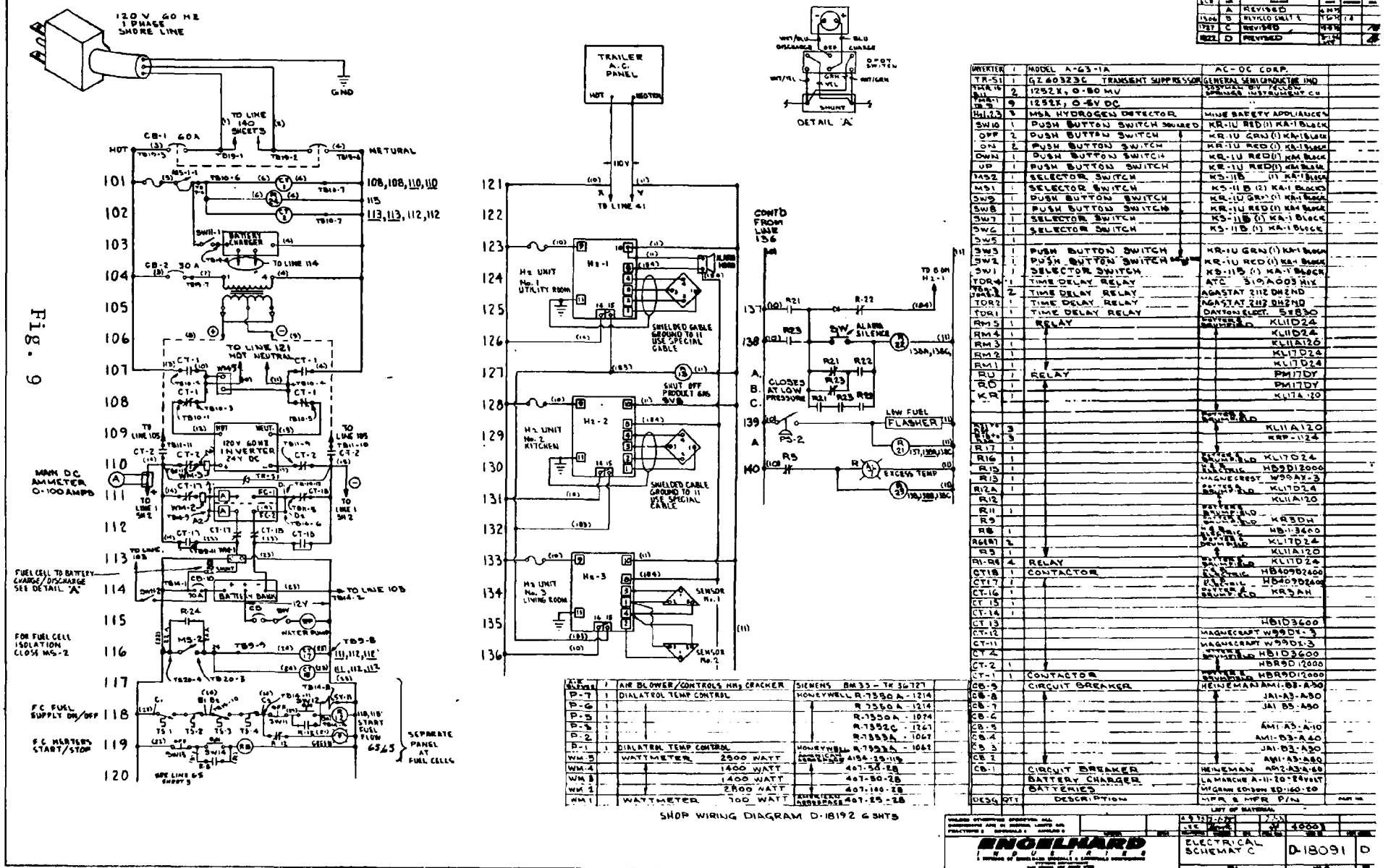

SKA-18408 Flow System 2. Fuel Cells
CENTER ROOF VENT
SUMMER
SLV-1
HEAT EXCHANGER HE-2 (REF ALSO SHOWN ON SH 1)
AUXILIARY CATALYTIC HEATER
TMR 3
TMR 4
SLV-2
WINTER
6" DUCT
FUEL CELL
TEMP
START UP 110 VAC
WASTE AIR
HV-10
SV 11
NC
PR-3
FLOWMETER
FLOW BALANCE VALVES
MV
PI 7
RV-3 SET @ 14" WC
PRODUCT-GAS 75% H2 25% N2
VC
FUEL CELL
TEMP
START UP 110 VAC
OUTSIDE FILTER & COVER
AIR DUCT
NOTE: COVERS SLV-1 & 2 MUST ALWAYS BE IN PLACE WHEN FUEL CELLS ARE NOT OPERATING
TO CRACKER BURNER
N2 + H2

FIG. 8

Fig. 9



SYMBOL				
P-7	1	AIR BLOWER/CONTROLS NH_3 CRACKER	SIEMENS	BM35 - TK 34727
P-6	1	DIALATROL TEMP CONTROL	HONEYWELL	R-7350 A - 1214
P-5	1			R 7350 A - 1214
P-4	1			R-7350 A - 1074
P-3	1			R-7352 C - 1241
P-2	1			R-7353 A - 1062
P-1	1	DIALATROL TEMP CONTROL	HONEYWELL	R-7353 A - 1062
WM-5		WATTMETER 2500 WATT	AMERICAN LAVA CORP	4154-23-115
WM-4		1400 WATT		407-58-28
WM-3		1400 WATT		407-80-28
WM-2		2800 WATT		407-160-28
WM-1		WATTMETER 700 WATT	REFERENCE ABOVE PAGE	407-25-28

SHOP WIRING DIAGRAM D-18192 6 SHTS

DESIG	QTY	DESCRIPTION	MFR & MFR P/N
INVERTER	1	MODEL A-63-1A	AC-DC CORP.
TR-S1	1	GZ 60323C TRANSIENT SUPPRESSOR	GENERAL SEMICONDUCTOR IND
THR 16	2	1252X, 0-80 MV	ASSEMBLED BY ROCKY MOUNTAIN INSTRUMENT CO
THR-1	9	1252X, 0-5V DC	"
16,23	3	MSA HYDROGEN DETECTOR	MINE SAFETY APPLIANCES
SW10	1	PUSH BUTTON SWITCH SHUNTED	KR-1U RED (1) KA-1 BLACK
OFF	2	PUSH BUTTON SWITCH	KR-1U GRN (1) KA-1 BLACK
ON	2	PUSH BUTTON SWITCH	KR-1U RED (1) KA-1 BLACK
DWN	1	PUSH BUTTON SWITCH	KR-1U RED (1) KA-1 BLACK
UP	1	PUSH BUTTON SWITCH	KR-1U RED (1) KA-1 BLACK
1452	1	SELECTOR SWITCH	KS-11B (1) KA-1 BLOCK
MS1	1	SELECTOR SWITCH	KS-11B (2) KA-1 BLOCKS
SW9	1	PUSH BUTTON SWITCH	KR-1U GRN (1) KA-1 BLOCK
SW8	1	PUSH BUTTON SWITCH	KR-1U RED (1) KA-1 BLOCK
SW7	1	SELECTOR SWITCH	KS-11B (1) KA-1 BLOCK
SW6	1	SELECTOR SWITCH	KS-11B (1) KA-1 BLOCK
SW5	1		
SW3	1	PUSH BUTTON SWITCH	KR-1U GRN (1) KA-1 BLOCK
SW2	1	PUSH BUTTON SWITCH	KR-1U RED (1) KA-1 BLOCK
SW1	1	SELECTOR SWITCH	KS-11B (1) KA-1 BLOCK
TDR-4	1	TIME DELAY RELAY	ATC 319A003 HIX
TDR-3	2	TIME DELAY RELAY	AGASTAT 2112 DH2ND
TDR2	1	TIME DELAY RELAY	AGASTAT 2112 DH2ND
TDR1	1	TIME DELAY RELAY	DAYTON ELECT. 5X830
RM5	1	RELAY	POTTER & BRUMFIELD KLIID24
RM4	1		KLIID24
RM3	1		KLIIA120
RM2	1		KL17D24
RM1	1		KL17D24
RU	1	RELAY	PM17DY
RD	1		PM17DY
KR	1		KL17A-120
			POTTER & BRUMFIELD
RM6	3		KLIIA120
RM5	3		KRP-11124
RL17	1		
R16	1		POTTER & BRUMFIELD KL17D24
R15	1		ELECTRIC HB9D12000
R13	1		MAGNECRAFT W99AX-3
R12A	1		POTTER & BRUMFIELD KLIID24
R12			KLIIA120
R11	1		POTTER & BRUMFIELD
R9			MAGNECRAFT KR3DN
R8	1		ELECTRIC HB-1-3600
RG181	2		POTTER & BRUMFIELD KLIID24
R5	1		KLIIA120
R1-R4	4	RELAY	POTTER & BRUMFIELD KLIID24
CT18	1	CONTACTOR	ELECTRIC HB40902400
CT17	1		ELECTRIC HB40902400
CT16	1		POTTER & BRUMFIELD KR3AH
CT15	1		
CT14	1		
CT13			HB1D3600
CT12			MAGNECRAFT W99DX-3
CT11			MAGNECRAFT W99DX-3
CT4			POTTER & BRUMFIELD HB1D3600
CT-2	1		HBR9D12000
CT-1	1	CONTACTOR	POTTER & BRUMFIELD HBR9D12000
CB-9	1	CIRCUIT BREAKER	HEINEMAN AMI-B3-A50
CB-8			JAI-A3-A50
CB-7			JAI B3-A50
CB-6			
CB-5			AMI-A3-A10
CB-4			AMI-B3-A40
CB 3			JAI-B3-A30
CB 2			AMI-A3-A60
CB-1		CIRCUIT BREAKER	HEINEMAN AM2-A3-A-60
		BATTERY CHARGER	LA MARCHE A-11-20-24 VOLT
		BATTERIES	MCGRAW EDISON ED-160-20

LIST OF MATERIAL

REVISIONS			
LTR		REVISED	
A		REVISED	
B		REVISED SHEET 5	
C		REVISED	
D		REVISED	

ENGELHARD INDUSTRIES

ELECTRICAL SCHEMATIC

D-18091 D

SHEET 1 OF 4

b) Using SLV-1 and SLV-2 direct the waste heat flow for winter use below HE-2 or above HE-2 for summer use.

c) Shutdown the use of shoreline by placing "SHORELINE", CB-1, circuit breaker in "OFF" position.

2. Close MS-2 "FUEL CELL ISOLATION".

3. Shut off all lights and motors in the Van.

4. Close the battery circuit breaker CB-10, located on the side of the battery charger.

5. Set P-3, "FUEL CELL CONTROL" to 1700°F.

6. Set P-2, "CRACKER CONTROL" to 1500°F.

7. Restart ammonia cracker by pressing:

a) SW-3 cracker "ON".

b) SW-8 ammonia flow "ON".

NOTE: HOLD SW-8 IN UNTIL P1-4 READ 3 PSIG.

8. Open HV-10 fully and press "FUEL ON" button on the fuel cell control panel (rear wall).

NOTE: THE FUEL CELLS ARE NOW OPERATING "OPEN CIRCUITED" WITH A MINIMUM FUEL FLOW GOING THROUGH THE CELLS. MAINTAIN THIS CONDITION FOR 4 MINUTES TO STABILIZE THE FUEL CELL TEMPERATURE.

CHECK THE TEMPERATURE ON THE CRACKER CONTROL INSTRUMENT TO MAKE SURE THAT EXCESS TEMPERATURE CONDITION IS NOT REACHED.

AT THIS POINT THE EPA-VAN IS POWERED USING THE BATTERIES ONLY TO SUPPLY BOTH THE 24 VOLTS DC AND THE 115 VOLTS AC VIA THE INVERTER.

9. Place MS-2 "FUEL CELL ISOLATION" in "OFF" position. This places the fuel cells in parallel with the batteries. Observe the main D-C voltmeter, 24 volt should be maintained.

10. Gradually increase the electrical load on the system as follows:

a) kitchen lights : 93 watts

b) Living room lights : 186 watts

c) Room air blower : 186 watts

d) Pump A : 186 watts

e) Pump B : 186 watts

f) Heat pump motor : 186 watts

After each new load is added, observe the main D.C. voltmeter. The voltmeter reading should not fall below 24 volts, or the system will shutdown due to low voltage droput of the D-C relays. As the fuel cells recover, the DC-voltage will stabilize and the next load can be added.

Once the two fuel cell ammeters indicate outputs of 24 to 28 amps and the main voltmeter maintains a steady 24 volts reading, the entire trailer system can be placed in automatic mode operation.

3. Environmental Heating/Cooling (Fig. 2, 10)

A. Set the room thermostat in living room at 68°F for the heating setpoint.

B. Set the room thermostat for cooling at 78°F.

C. Set tank temperature switch No. 1 for 50°F.

D. Set tank temperature switch No. 2 for 100°F.

NOTE: BOTH TS NO. 1 AND TS NO. 2 ARE LOCATED IN THE LOWER LEFT-HAND SIDE OF THE PROJECTOR COUNTER CABINET, ONCE THE SETTINGS ARE CORRECT NO FURTHER ATTENTION WILL BE NEEDED.

E. Close the circuit breakers on the motor control panel:

1) Room air blower CB-7

2) Pumps A & B CB-8

3) Heat Pump Compressor CB-4

4) Condenser Fan CB-3

F. Adjust the makeup air louver to provide the required makeup air.

G. Waste heat control is done by using SLV-1 and SLV-2 for the fuel cells. SLV-3 and SLV-4 controls the

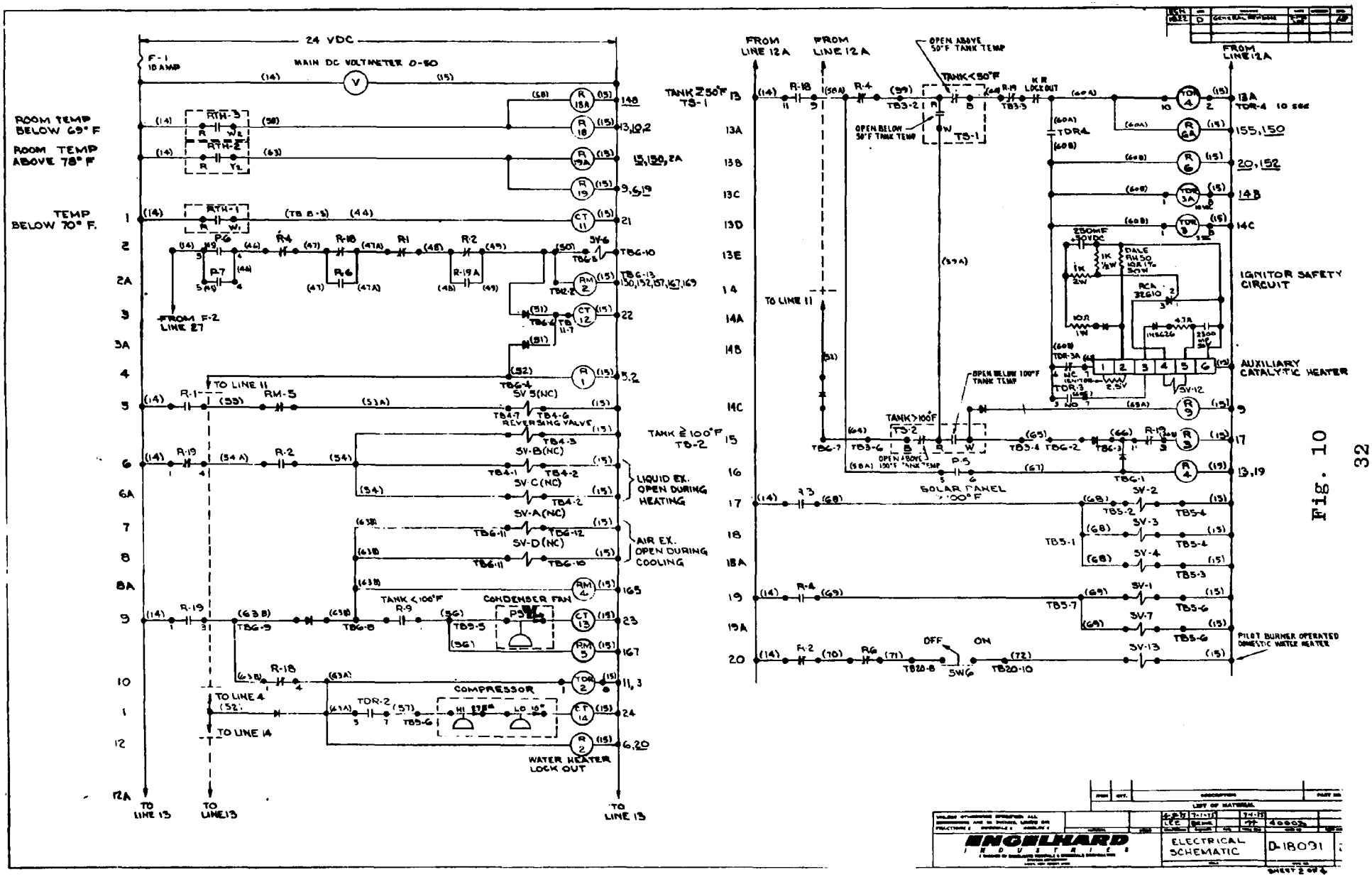

24 VDC
MAIN DC VOLTMETER 0-50
ROOM TEMP BELOW 69° F
ROOM TEMP ABOVE 78° F
TEMP BELOW 70° F.
TANK ≥ 150°F TS-1
TANK ≥ 100°F TS-2
FROM LINE 12A
OPEN ABOVE 150° F TANK TEMP
OPEN BELOW 150° F TANK TEMP
TANK < 150°F
TANK > 100°F
OPEN BELOW 100°F TANK TEMP
IGNITOR SAFETY CIRCUIT
AUXILIARY CATALYTIC HEATER
SOLAR PANEL > 100° F
PILOT BURNER OPERATED DOMESTIC WATER HEATER
LIQUID EX. OPEN DURING HEATING
AIR EX. OPEN DURING COOLING
REVERSING VALVE
CONDENSER FAN
COMPRESSOR
WATER HEATER LOCK OUT
FROM F-2 LINE 27
TO LINE 11
TO LINE 4
TO LINE 14
TO LINE 13
TO LINE 13
TO LINE 13
OFF
ON
ELECTRICAL SCHEMATIC
D-18031

Fig. 10

waste heat flow from the ammonia cracker. The use of waste heat is depending on summer or winter operation. In periods where no heating of the Van is required the waste heat from both the fuel cells and the ammonia cracker should be vented to the outside without passing across heat exchanger HE-2.

Auxiliary Catalytic Heater (Fig. 2, 12)

1. Open HV-11. The heater will automatically cut in and out to satisfy the environmental heating control demand.

4. Water Heater (Note: Flame Type Combustion) (Fig. 13)

A) Fill the water system as described in the trailer manual, See appendix.

B) The water heater burner system is lighted as per the instructions attached to the cover plate.

C) The gas supply to the burner system is activated as follows:

   1. Close "WATER HEATER" switch on the main control panel (SW-6).

   2. Open the hand valves HV-12 and HV-13.

   3. Check that the pressure on P1-9 does indicate 0.5 psig for actual operation.

   4. Follow the burner lighting instructions (B).

NOTICE: ONCE THE PILOT HAS BEEN LIGHTED IT REMAINS "ON" AS LONG AS THE PRODUCT GAS IS AVAILABLE. THE MAIN BURNER WILL ONLY OPERATE DURING MODES 1, 2, 3, 6, AND 7 WHEN THE THERMOSTAT CALLS FOR OPERATION.

5. Kitchen Range (Fig. 13)

A) Remove the transport cover plate from the air-grill on the road side.

B) Install the storm cover using the cover plate from "A" as the outer cover.

C) The gas supply to the range is opened by:

   1. Open HV-12 and HV-14.

   2. Close SW-7 "KITCHEN RANGE" on main panel.

SKA-18409 Flow System 3
Aux Heater

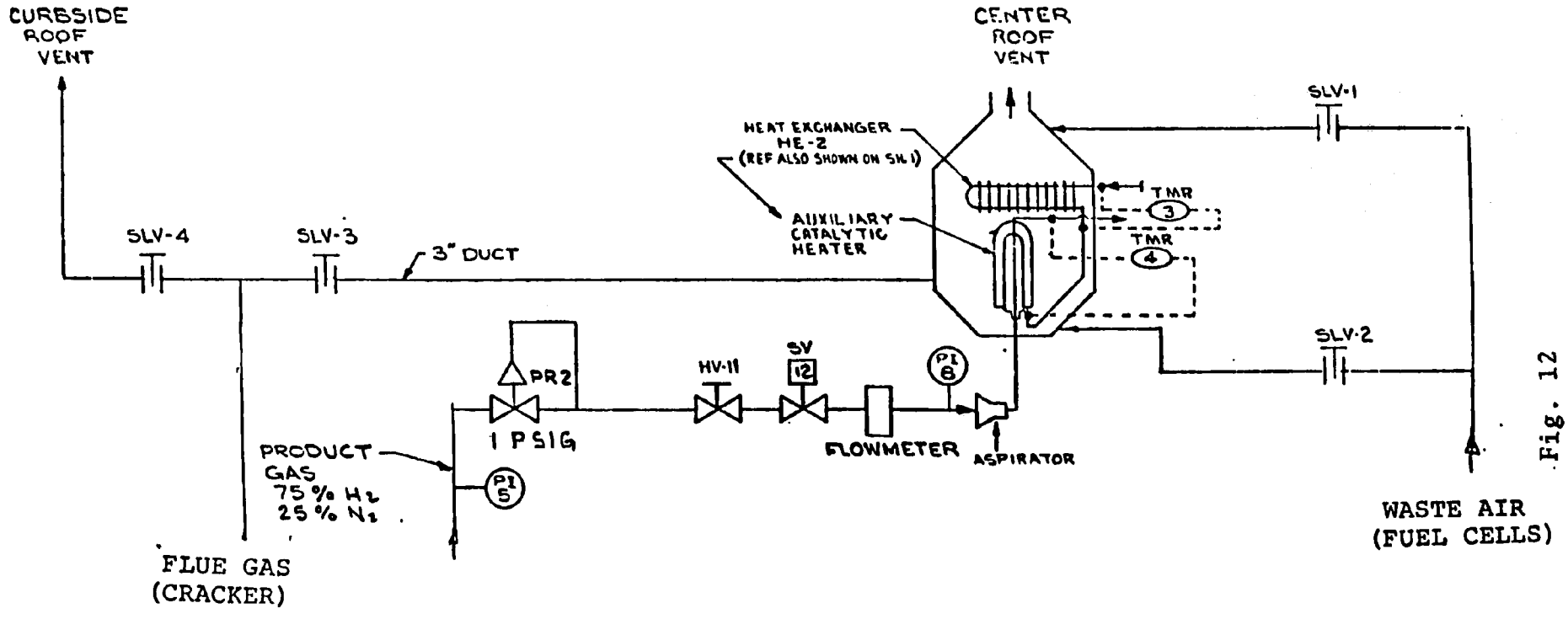


Fig. 12

SKA-18410 Flow System 4
Water Heater &
Kitchen Range

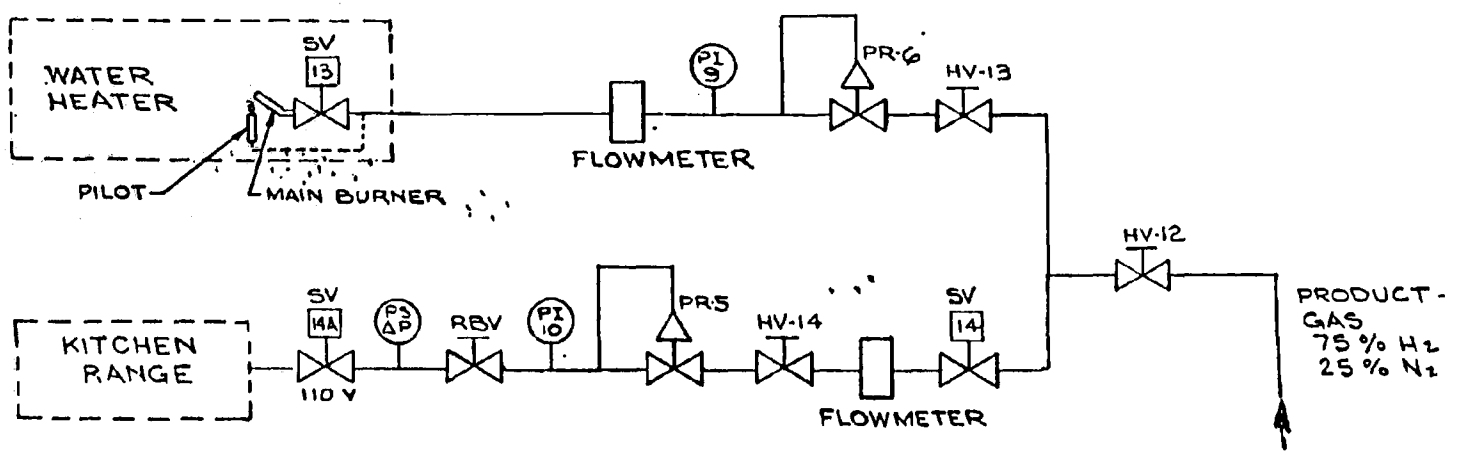


Fig. 31

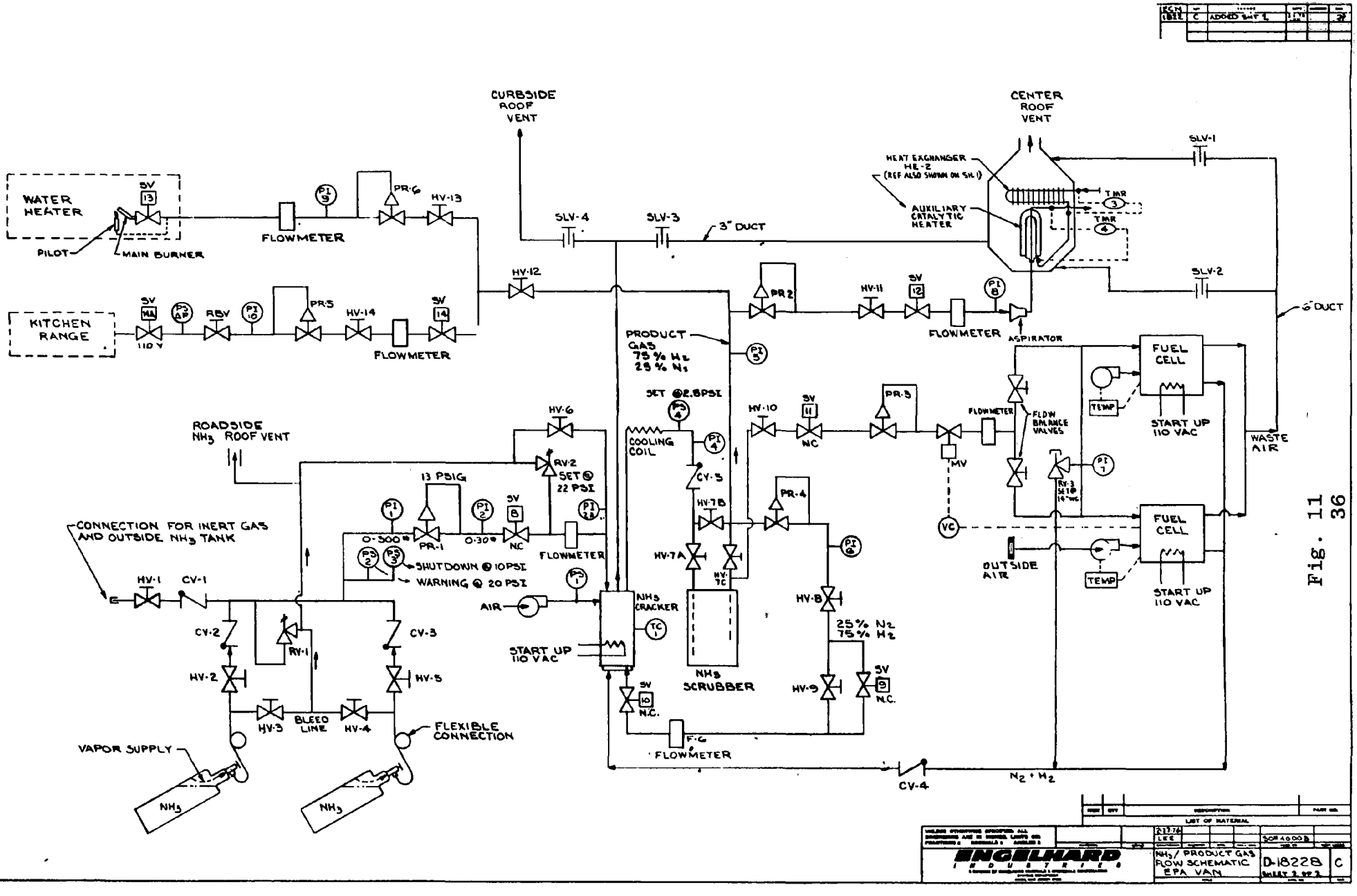


Fig. 11

36

ECN 1811	C	ADDED SHT 2		

		LIST OF MATERIAL		
		2-17-76 LEE		SOP 4.0.0 B
ENGELHARD INDUSTRIES		NH_3/ PRODUCT GAS FLOW SCHEMATIC EPA VAN	D-18228 SHEET 2 OF 2	C

3. The pressure gage "P1-10" should read 0.5 psig.

4. Open "RBV" valve fully. This valve is located on the front side of the kitchen counter just below the range.

   The range plate will start heating up in 10 to 15 seconds.

6.0 System Shutdown Procedure

The normal shutdown sequence of the system is as follows:

1. All motor circuit breakers in motor control panel.
2. Product gas supply to appliances.
3. Fuel cell operation shutdown.
4. Transfer to shoreline operation.
5. Ammonia cracker shutdown.
6. Charging of batteries.

6.1 Motor Control Panel (Fig. 7)

Place the following circuit breakers in "OFF".

1. Heat pump compressor.
2. Condenser fan.
3. Pump.
4. Living room blower.

6.2 Product Gas Supply (Fig. 5, 11, 12, 13)

Switch and valve shutdown sequence:

	Number		Number
Appliance	Hand Valve		Selector Switch
Water Heater	HV-12	HV-13	SW-6
Kitchen Range	HV-12	HV-13	SW-7
Aux Catalytic Heater		HV-11	None

6.3 Fuel Cell Operation Shutdown (Fig. 5, 1, 8)

a) Open "FUEL CELL ISOLATION" switch. "MS-2".

b) Press "FUEL OFF" button.

c) Close HV-10 manual valve.

NOTICE: THE SYSTEM IS NOW OPERATING ON THE BATTERY BANK ONLY, THUS THIS CONDITION SHOULD BE OF AS SHORT DURATION AS POSSIBLE IN ORDER TO AVOID DRAINING THE BATTERY BANK.

6.4 Transfer to Shoreline Operation (Fig. 5, 7, 9)

a) Open battery circuit breaker (located on the side of the battery charger).

b) Close "SHORELINE" circuit breaker "CB-1".

c) Close "SHORELINE RECTIFIER".

d) Restart "CRACKER BLOWER" by pressing "ON" button.

e) Raise blower speed to maximum.

6.5 Ammonia Cracker Fuel Supply

a) Press "AMMONIA FLOW" off button.

b) Close hand valves HV-1, HV-2, HV-5.

c) Close ammonia cylinder valve.

d) Close hand valve HV-7A, 7B, 7C.

e) Leave "CRACKER AIR BLOWER" running for cooling of the cracker. When P-1 indicates a temperature of 400°F, it is safe to shut the power off to the ammonia cracker by pressing SW-2, the "CRACKER AIR BLOWER" off button.

Return the blower speed setting to "LOW".

6.6 Start Battery Charge (Fig. 9)

a) Close the switch SW-11 located next to the battery circuit breaker on the side of the battery charger.

b) Set the timer to the full timing. The charging rate will register on the ammeter on front of the battery charger.

SECTION V

SAFETY PRECAUTIONS

1. Before the system is made operational, make sure the hydrogen detectors located in living room, kitchen, utility room are on. The instrument console is located on the top shelf in the kitchen above the mode panel.

2. Make sure the NH_3 supply is adequate, have extra supply available and hooked up for easy changeover and replacement.

3. Ammonia odor is easily detectable by the human nose and if ammonia leakage is detected, trace and pinpoint leak by using a sulfur candle, and eliminate the leak(s).

4. When trailer/home is parked and operational, make sure that trailer is anchored and fastened down on all four corners using the guy wires provided.

5. When strong winds above 50 MPH are expected, the solar panel has to be retracted and the solar panel cover tied down securely. (See III 7B F 16 4 & 7)

6. Alarm System - An alarm condition exists and an audio alarm (horn) will sound whenever any of the following conditions prevail.

   a) Hydrogen present in the room air (i.e., at 1% H_2 in air).

      1. Red light on the left instrument means hydrogen in the <u>utility room</u>.

      2. Red light on the center instrument means hydrogen in the <u>kitchen</u>.

      3. Red light on the right instrument means hydrogen in the <u>living room</u>.

   Existence of this alarm condition shuts off NH_3

feed to the cracker. Audio alarm can be silenced by pressing the alarm SILENCE BUTTON on the instrument console. (Fig. 9)

However, corrective measures must be taken to eliminate the hydrogen leak before pressing the reset button.

b) Low Fuel Condition as evidenced by flashing light by the NH_3 supply timer on the mode panel. When this condition occurs, silence the horn by pressing the horn silence button on top of the mode panel.

NOTE: THIS ALARM CONDITION IS PRESET AT 20 PSI ON THE NH_3 SUPPLY SYSTEM.

THE SYSTEM WILL SHUTDOWN WHEN THE FUEL PRESSURE DROPS TO 10 PSI. AT 10 PSI, SYSTEM OPERATION IS AUTOMATICALLY TERMINATED. PROVIDE A NEW CYLINDER BEFORE THIS HAPPENS.

c) Excess temperature or thermocouple break as evidenced by RED light on control panel. When this condition exists, NH_3 supply shuts down automatically.

If a full upscale indication is consistent on P-1/P-2 an open circuit must be corrected, or a broken thermocouple be replaced in the ammonia cracker control system.

SECTION VI

TROUBLESHOOTING GUIDE

Ammonia Cracker (Fig. 5, 6, 7)

1) Excess temperature condition - refer to Section IV No. D-7 (page 26).

2) Temperature dropping towards lower setpoint on Temperature Protector, P-2 dialatrol.

   a) Check SW-10, make sure switch position is on "HI/LO".

   b) Check fuel supply gages, PI-2, Pl-1.
   Pl-1 should be minimum of 20 psi.
   Pl-2 should be set at 13 psig.

   c) If alarm condition has just occurred, press (green) NH_3 supply pushbutton in to reset switch. (Fig. 5)

3) Fresh Ammonia Supply - low pressure in system.

   a) Refer to Fig. 6, RV-1 or RV-2 (Relief Valves) may be opened. Valve O-rings may have opened. Valve O-rings may have to be replaced.

   b) Check NH_3 supply for closed valves.

4) Alarm Conditions - Refer to Section VI, 1, 2, 3.

Kitchen Range Section

1) Chattering of switch, amber light blinking on and off check pressure gauge Pl-10 under countertop, set at .5 psig.

2) Pilot light stays on, no heat being generated - this indicates that initial combustion condition was achieved, but time delay relay contact dropped out before the thermoswitch was satisfied. The 24V solenoid coil is closed so there is no danger of

hydrogen leak but gas is trapped in the line thereby keeping the pressure switch contact closed and the pilot light on. This situation may occur when room temperature in the trailer is allowed to drop to 40°F during winter. Close the valve RBV Fig. 13, wait 30 seconds and reopen the valve.

PERFORMANCE TESTING W.O. 40003 // EPA VAN

DATE:_____ WEATHER CONDITION Sun Rain Wind Temp/Hum.

Time	Indicating Mode	Temperatures °F						Air Duct Registers								Pumps				
				Solar Panel		Tanks		Kitchen		Living Room			NH_3 Cracker			A		B		REMARKS
		Outside	Living Room	ABS	ΔT Mv/°F	ABS	ΔT Mv/°F	Return Air	1	2	3	4	Temp	Inlet Press	Outlet Press	Pres	Total Gal	Pres	Total Gal	

Fig. 23

43

SKB-18342 11/21
J. ACCARDI 11-25-75

OPERATING DATA

DATE _____

W/O 40003 EPA VAN NH_3 - CRACKER SYSTEM

LOCATION _____

	AMMONIA CRACKER					PRODUCT GAS												
	CONTROL TEMP	NH_3 SUPPLY				BURNER/ SCRUBBER				FUEL CELLS		AUX. HEATER		WATER HEATER		RANGE		TOTAL FLOW PRODUCT
TIME	°F	PI-1 PSIG	PI-2 PSIG	PI-2A PSIG	F-1 V.D.C.	PI-4 PSIG	PI-5 PSIG	PI-6 PSIG	NH_3 PPM	PI-7 PSIG	F-2 V.D.C.	PI-8 PSI	F-3 V/CFH	PI-9 PSI	F-4 V/CFH	PI-10 PSI	F-5 V/CFH	

Fig. 24

B-18351

SECTION VII

MAINTENANCE INSTRUCTIONS

1. Calibrate H_2 Detectors as recommended in the equipment manual. Calibrate weekly until experience warrants longer periods. DO NOT EXCEED 6 MONTHS BETWEEN CALIBRATIONS.

2. Check for free ammonia in the product gas. Use the two test ports located on the top of the ammonia scrubber.

   The test port originating in the outlet elbow takes the sample halfway down the scrubber material.

   The test port in the outlet tube provides a sample of the final scrubbed gas.

   The halfway sample should be used to guide and judge the operation time still available before new scrubber material will be needed. Contact Engelhard Industries for proper material replacement.

   There should be no free ammonia in the gas going to the fuel cells.

3. Data Logging

   Figures 23 and 24.

   The use of these data sheets provides an easy way of understanding the system operation and component location.

   The data sheets also provides a ready means of pin-pointing potential problems.

   Any unusual pressure drops will reveal the location of problem.

4. Refrigeration Service

   Have a competent refrigeration serviceman check periodically the system for proper operational

pressures. (Fig. 2)

5. Fuel Cells

The air inlet cover and SLV's No. 1 and No. 2 must always be closed during down time to prevent moisture from entering the fuel cells when they are cold.

Remove and clean the air filter regularly.

6. Recommended Test Equipment

1) Volt-Ohm Milliammeter
Simpson Model 260

2) Temperature Measuring Instrument
Thermoelectric "Minimite"
Range: 0-2000°F Type K & Type J

3) Free Ammonia Tester
Bendix/Gastel Model 400
Test Tubes for: 2-30 ppm
50-500 ppm
1-18%

4) Calibration Gas for H_2 Detector
0.8% H_2 in air.

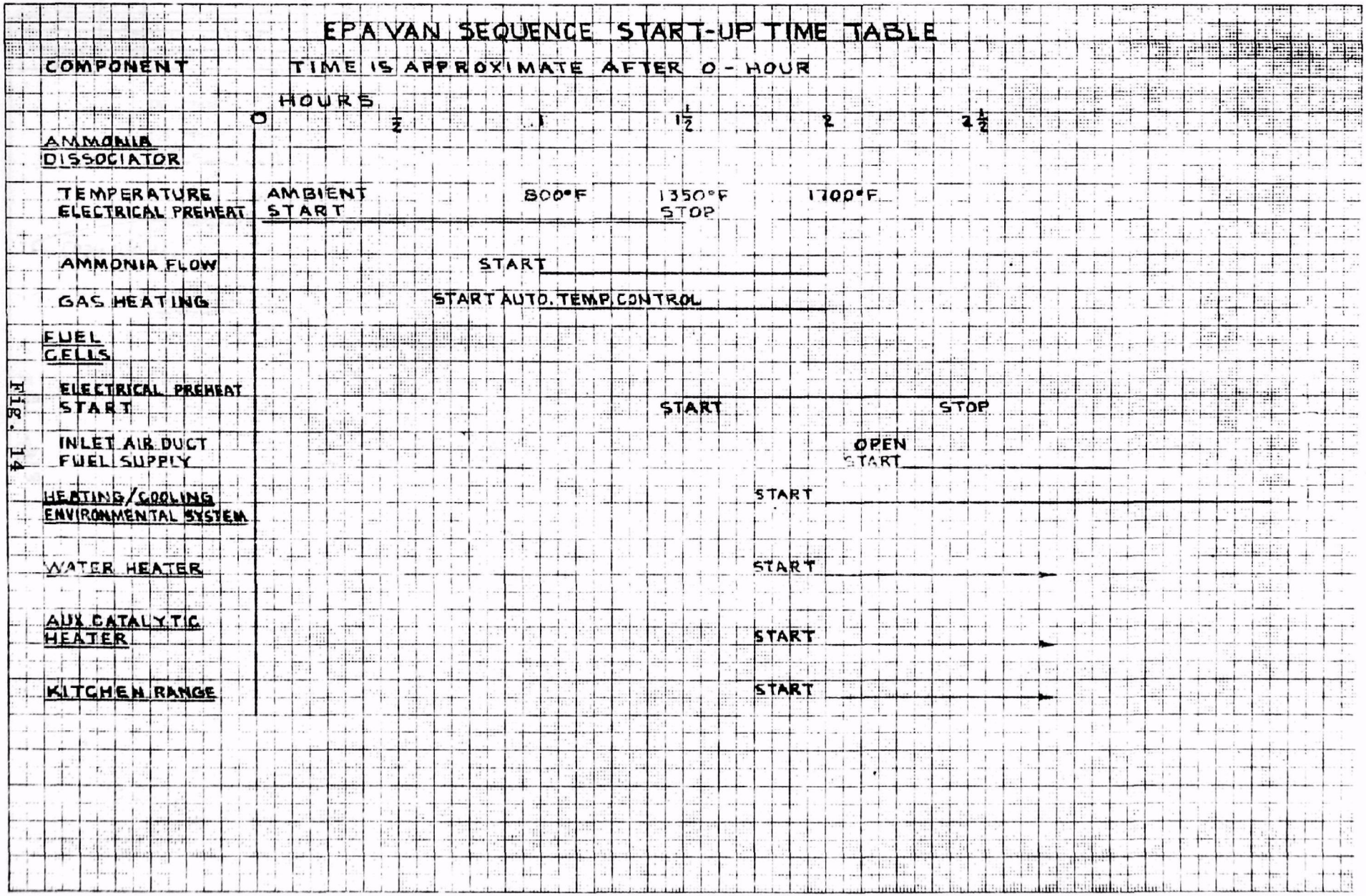


FIG. 14

B-18393

LET.	CHANGE	DATE	CHECKER	ENG

	CONTROL INSTRUMENT No.	TYPE	RANGE	SET POINT	SENSING/CONTROLLED COMPONENT	FUNCTION
POWER SYSTEM	P-1	DIALATROL	0-2000° F	1350° F 800° F	NH_3 CRACKER	EL - PREHEAT HOLD BACK OF AMMONIA — POWER SYSTEM
	P-2	DIALATROL	0-2000°F	1750° F 1850° F	NH_3 CRACKER	OPERATING TEMPERATURE EXCESS TEMPERATURE — GAS BURNER
	P-3	DIALATROL	0-2000°F	1700° F	NH_3 CRACKER/FUEL CELLS	GAS FLOW TO FUEL CELLS [EXCESS H_2 GOES TO GAS BURNER] NOTICE FOR FUEL CELL OPERATION RESET P-2 TO 1500°F
MODE SYSTEM CONTROL	P-5	DIALATROL	0-400°F	100° F	SOLAR PANEL ABSOLUTE TEMP. AIR/WATER	START SOLAR HEATING OF TRAILER [MODE 7] — MODE SELECTION
	P-6	DIALATROL	0-50 MV [0-150°F]	5 MV 15° F	SOLAR PANEL/TANK Δ T	STARTS SOLAR HEAT STORAGE MODES 2,3,5,11
	P-7	DIALATROL	0-50 MV [0-150°F]	1 MV 3° F	SOLAR PANEL Δ T	TERMINATE SOLAR HEAT STORAGE AT ΔT BELOW 3° F
	TS-1	THERMAL SWITCH	0-200°F	50° F	TANK TEMP.	CONTROLS AUX CATALYTIC BURNER BELOW 50°F [MODE 5] ABOVE 50°F MODE SELECTION TRANSFERS TO TS-2
	TS-2	THERMAL SWITCH	0-200°F	100°F	TANK TEMP.	CONTROLS MODES 6,8,9,10,11
	RTH-1	LIVING ROOM THERMOSTAT	44-86°F	HEATING 68°F	ENVIRONMENTAL HEATING/COOLING	ENVIRONMENTAL CONTROL HEATING MODES 1,3,4,5,6,7,8
	RTH-2			COOLING 78°F		COOLING MODES 9,10,11

Fig. 15

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS ARE IN INCHES, LIMITS ON: FRACTIONS ± DECIMALS ± ANGLES ±

MATERIAL | SCALE | DRAFTSMAN | CHECKER | ENG | PROJ. ENG | ISSUED ON

ENGELHARD

EPA VAN 40003

CONTROL INSTRUMENTS FUNCTIONS & SETPOINTS

TITLE

B-18379

DWG NO

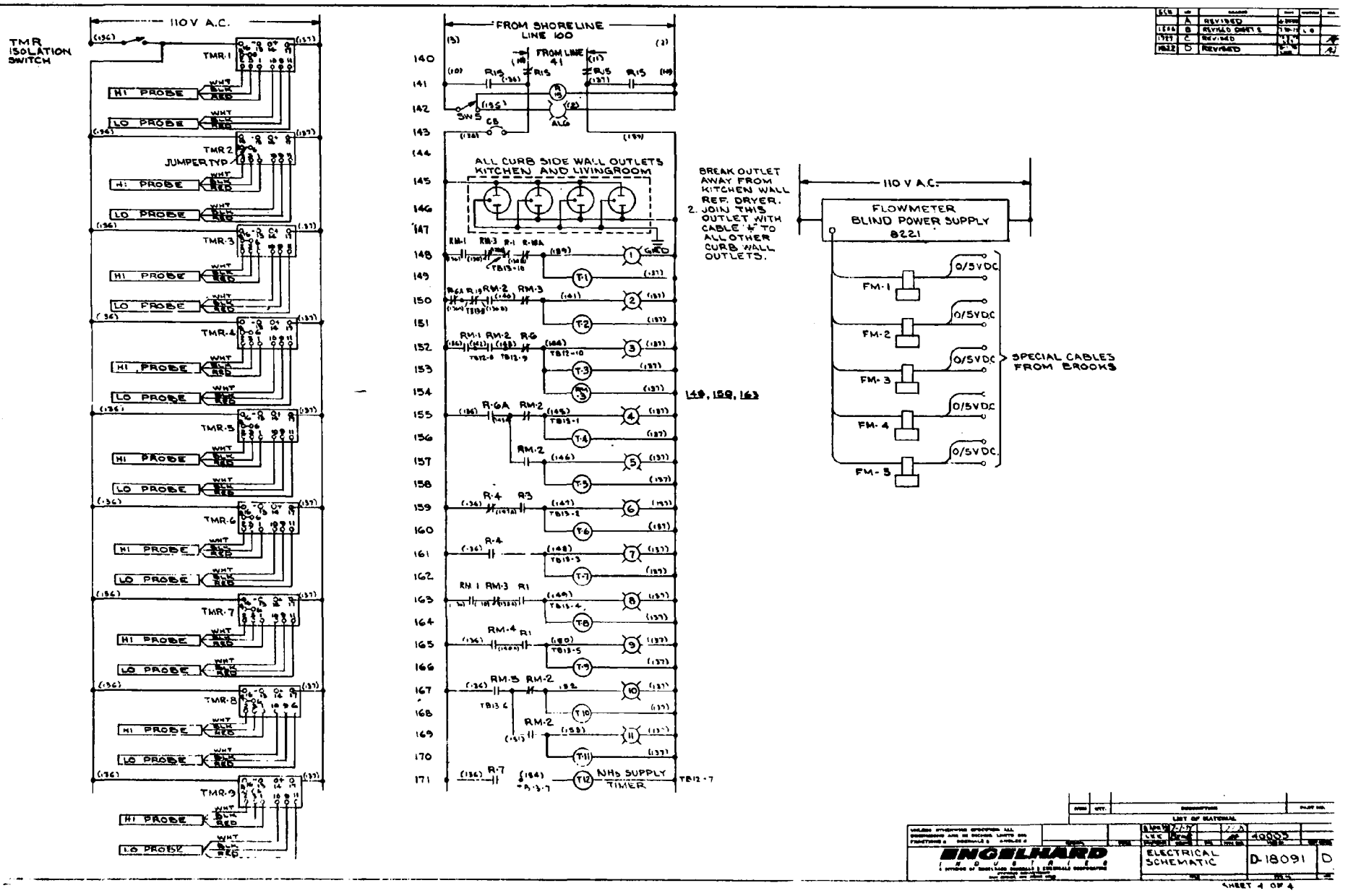

110V A.C.
TMR ISOLATION SWITCH
TMR-1
HI PROBE
LO PROBE
TMR-2
JUMPER TYP
TMR-3
TMR-4
TMR-5
TMR-6
TMR-7
TMR-8
TMR-9
WHT
BLK
RED
FROM SHORELINE LINE 100
FROM LINE 41
SW 5
CB
ALG
ALL CURB SIDE WALL OUTLETS KITCHEN AND LIVINGROOM
GRD
T-1
T-2
T-3
T-4
T-5
T-6
T-7
T-8
T-9
T-10
T-11
T-12
NH3 SUPPLY TIMER
TB12-7
BREAK OUTLET AWAY FROM KITCHEN WALL REF. DRYER.
2. JOIN THIS OUTLET WITH CABLE 4 TO ALL OTHER CURB WALL OUTLETS.
149, 150, 163
110 V A.C.
FLOWMETER BLIND POWER SUPPLY 8221
FM-1
FM-2
FM-3
FM-4
FM-5
0/5VDC
SPECIAL CABLES FROM BROOKS
ENGELHARD
ELECTRICAL SCHEMATIC
D-18091
D
SHEET 4 OF 4

Fig. 16

ECN	LET.	CHANGE	DATE	CHECKER	ENG.
1822	B	Revised and added Flowrates	3/1/76		

AC TERMINALS	DESCRIPTION	DC TERMINALS	DESCRIPTION	FLOWRATE/0-5 VDC
1	Mode 1	27 & 28	NH_3 Flowmeter	0-60 SL/M
2	Mode 2	29 & 30	Kitchen Flowmeter, H_2	0-50 "
3	Mode 3	31 & 32	Water Heater Flowmeter H_2	0-20 "
4	Mode 4	33 & 34	Fuel Cell Flowmeter H_2	0-100 "
5	Mode 5	35 & 36	Catalytic Burner Flowmeter H_2	0-50 "
6	Mode 6	37 & 38 } NOT USED		
7	Mode 7	39 & 40 }		
8	Mode 8	45 & 46	WM-1 (Fuel Cell to Battery)	0-700 Watts
9	Mode 9	47 & 48	WM-2 (Fuel Cell Output)	0-2800 " } /0-250 mV
10	Mode 10	49 & 50	WM-3 (Input to Inverter)	0-1400 "
11	Mode 11	51 & 52	WM-4 (Input to Compressor)	0-1400 "
12	Neutral	53 & 54	WM-5 (A.C. Power Usage)	0-2500 "/0-5 volt
19	Vacant	55 & 56	TMR-1 (Tank H_2O In Out T)	} 0-180°F/0-5 volt
20	Alarm Hot	57 & 58	TMR-2 (Solar Panel H_2O)	
21	Alarm Neutral	59 & 60	TMR-3 (Input Heat Exchanger)	- HE-2
22	Vacant			
23	Hot 110 volts	61 & 62	TMR-4 Auxilliary Catalytic Heater	} 0-125°F/0-5 volts - HE-1
24	Neutral 110 volts	63 & 64	TMR-5 Output, Heat Exchangers	
25	Speaker +	65 & 66	TMR-6 Freon, Compressor	
26	Speaker -	67 & 68	TMR-7 Freon, Condenser	
		69 & 70	TMR-8 Freon to H_2O, Heat Exchanger	
		71 & 72	TMR-9 Freon to Air, Heat Exchanger	

TERMINALS NOT POWERED

13,14,15	NO, C, N.C. Pump A (H_2O Flowmeter)
16,17,18	NO, C, N. C. Pump B (H_2O Flowmeter)
41 & 42	Compressor Pressure (inlet)
43 & 44	Compressor Pressure (Outlet)

Fig. 17

ITEM	QTY.	DESCRIPTION	PART NO.
		LIST OF MATERIAL	

UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS ARE IN INCHES, LIMITS ON: FRACTIONS ± DECIMALS ± ANGLES ±

MATERIAL	SCALE	DRAFTSMAN	CHECKER	ENG.	PROJ ENG	USED ON	NEXT ASSEM
					3-1-75	40003	

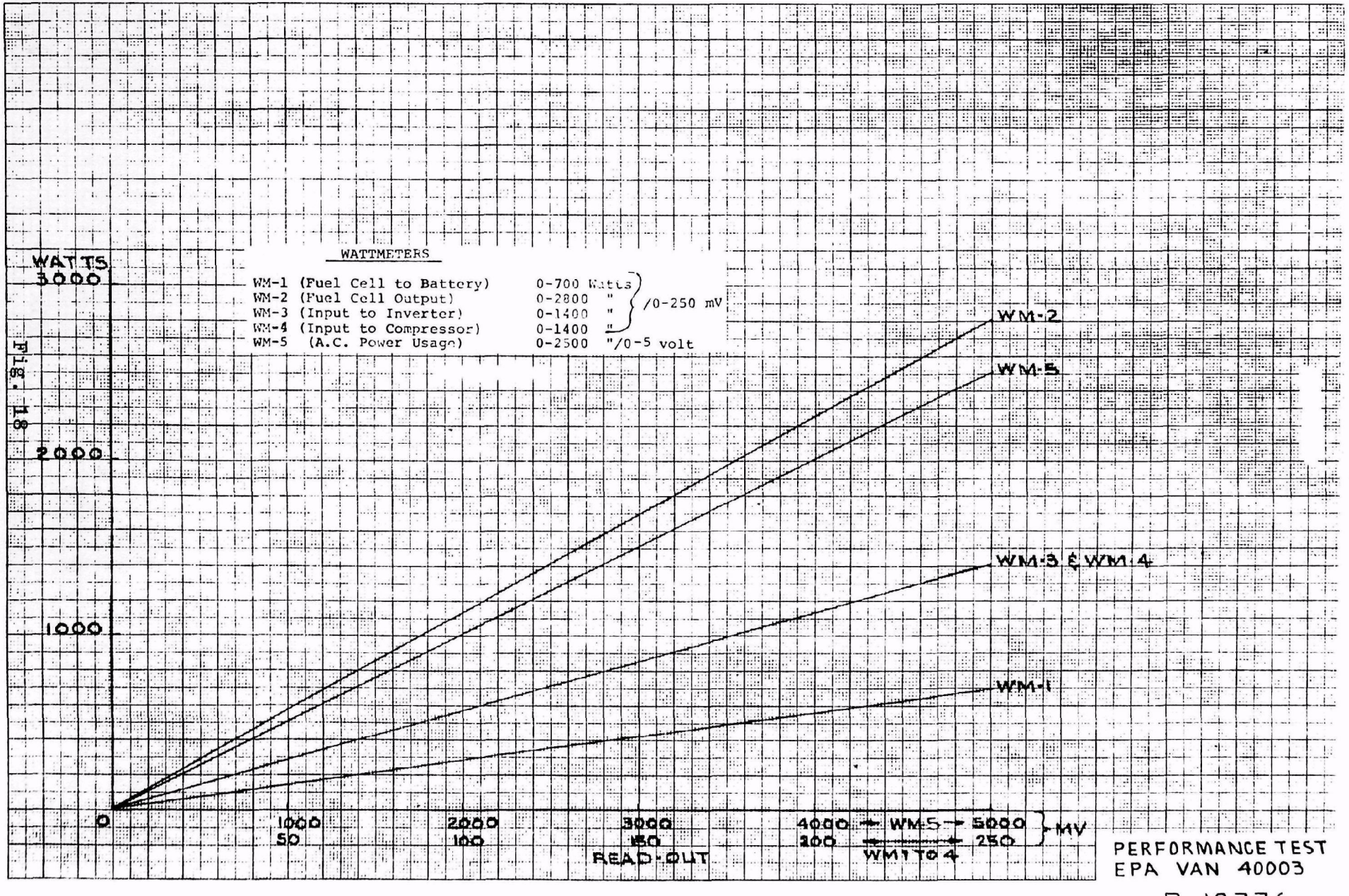
ENGELHARD INDUSTRIES
A DIVISION OF ENGELHARD MINERALS & CHEMICALS CORPORATION
SYSTEMS DEPARTMENT
EAST NEWARK, NEW JERSEY 07029

TERMINAL CONNECTIONS PERFORMANCE TEST FOR EPAVAN

TITLE

B-18296 - B

DWG NO REV


WATTMETERS
WM-1 (Fuel Cell to Battery) 0-700 Watts
WM-2 (Fuel Cell Output) 0-2800 "
WM-3 (Input to Inverter) 0-1400 "
WM-4 (Input to Compressor) 0-1400 "
WM-5 (A.C. Power Usage) 0-2500 "/0-5 volt
/0-250 mV
WATTS
3000
2000
1000
0
WM-2
WM-5
WM-3 & WM-4
WM-1
1000
50
2000
100
3000
150
READ-OUT
4000 → WM-5 → 5000
200 ← WM 1 TO 4 → 250
MV
PERFORMANCE TEST
EPA VAN 40003
B-18376

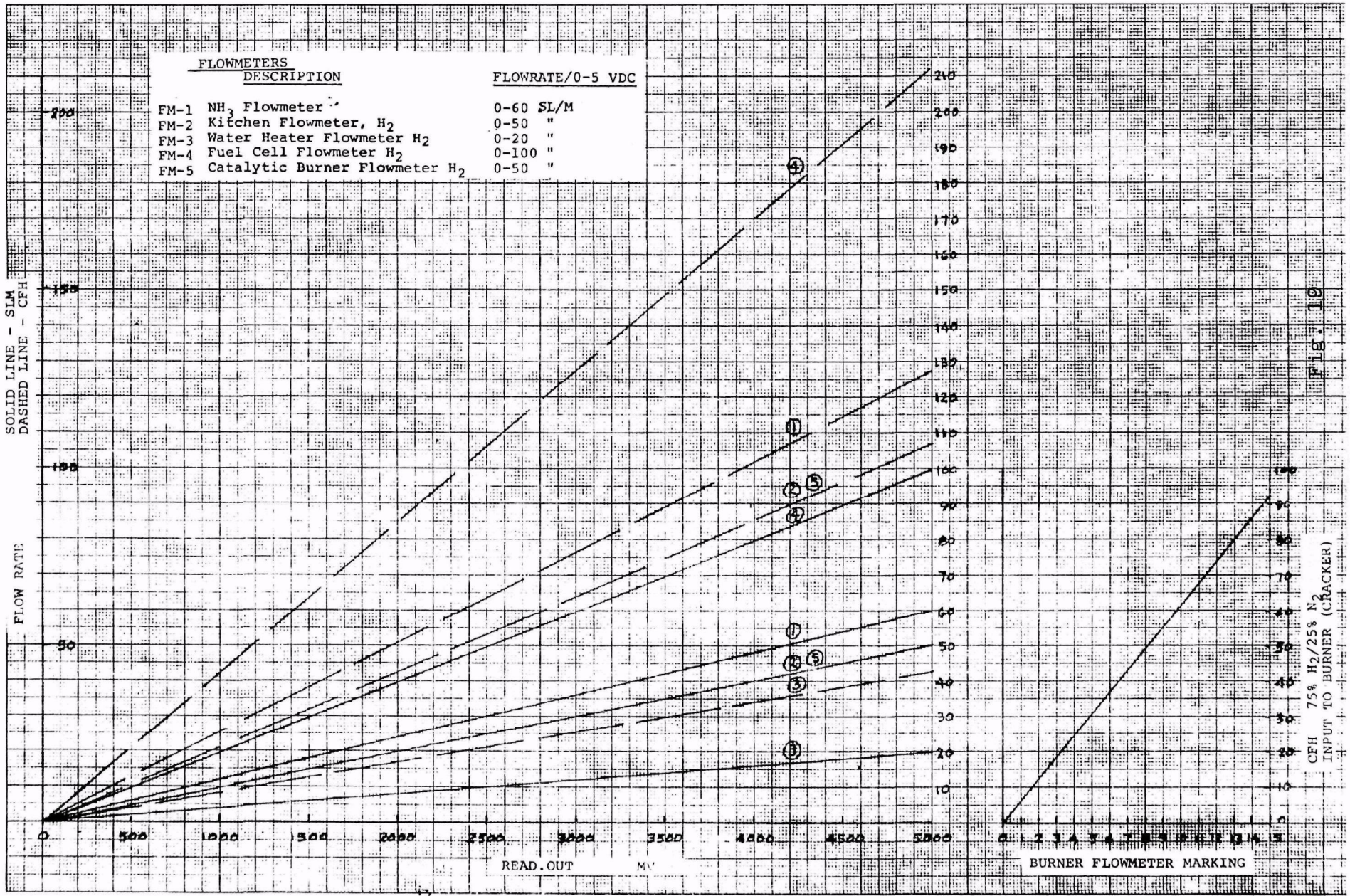


Fig. 19

PERFORMANCE TEST
EPA VAN 40003

B-18377

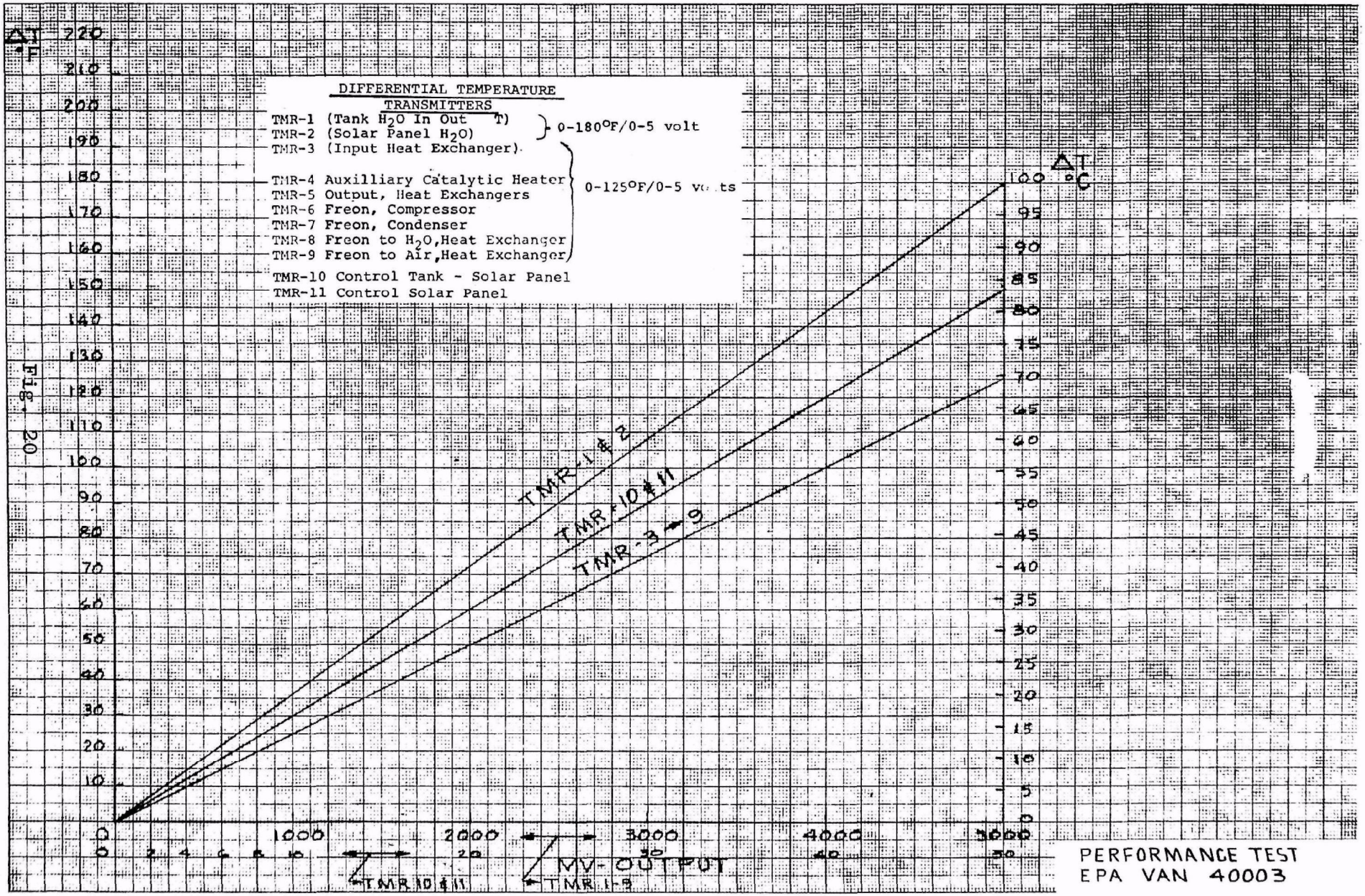


Fig. 20

PERFORMANCE TEST
EPA VAN 40003

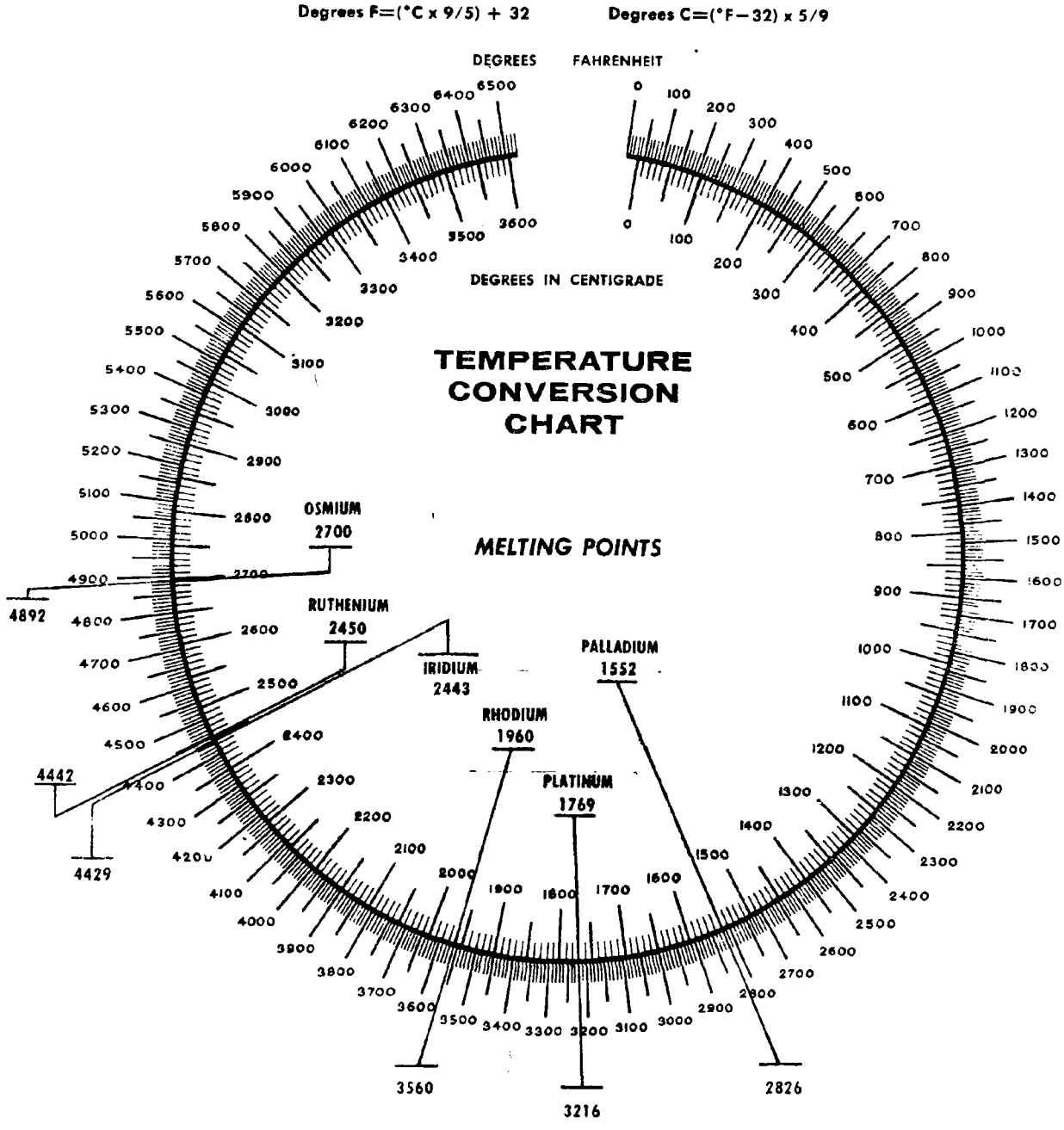
B-18378

METRIC CONVERSION TABLE

	To Convert	to	Multiply by
Length:	Feet	Meters	0.3048
	Inches	Meters	2.54×10^{-2}
	Miles	Kilometers	1.6093
Volume:	Gallons	Liters	3.785
	Cubic Ft.	Liters	28.32
Mass:	Pounds	Kilograms	0.45359
Pressure:	Pounds/in^2	Kilo Pascal	6.8948
Velocity:	Miles/hr	Km/hr	1.6093
Flowrate:	Cubic Ft/hr	Liters/Min.	0.472
Temperature:	Celsius-^oC		$^oC = 5/9\ (^oF-32)$
	Kelvin ^oK		$^oK = {}^oC + 273.15$
	Fahrenheit ^oF		$^oF = 9/5\ (^oC) + 32$

Figure 21

MELTING POINTS
OF THE PLATINUM GROUP METALS



ENGELHARD

ENGELHARD INDUSTRIES DIVISION

Fig. 22

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO. EPA-600/9-76-020	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE EPA VAN OPERATIONAL MANUAL		5. REPORT DATE August 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Niels E. Scholer		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Engelhard Minerals and Chemical Corp. 2655 Route 22 Union, New Jersey 07083		10. PROGRAM ELEMENT NO. 1AB013; ROAP (see 15, below) 11. CONTRACT/GRANT NO. 68-02-1482
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Operating manual; 10/74-6/76 14. SPONSORING AGENCY CODE EPA-ORD

15. SUPPLEMENTARY NOTES Project officer for this report is W. B. Steen, Mail Drop 61, Ext 2825. Work under six tasks of three ROAPs supports this manual: 21ADE-034; 21BBZ-009; and 21BJV-30, -35, -36, and -37.

16. ABSTRACT

The manual generally describes the EPA Van, and discusses both its energy control system and Van operation. The manual includes instructions for the Van's transportation, setup, safety, troubleshooting, and maintenance. The Van is a mobile research unit, designed for testing in various parts of the United States. Its unique energy supply system includes fuel cells, a solar energy collector, a heat pump, and catalytic appliances. An energy control system optimizes the energy consumed by the integrated system.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution	Tests	Air Pollution Control	13B
Energy Conversion	Fuel Cells	Stationary Sources	
Heat Sources	Solar Energy	EPA Van	10B
Laboratories	Solar Energy Concentrators	Energy Consumption	14B
Mobile Equipment		Catalytic Appliances	15E
Energy Storage	Heat Pumps	Operating Instructions	10C 13A

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Unlimited	Unclassified	56
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

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