At Apollo mission loads, each battery is capable of providing 45 AH and will provide this amount after each complete recharge cycle. However, 40 AH is used in mission planning for inflight capability, and 45 AH for postlanding capability of a fully charged battery.

Open circuit voltage is 37.2 volts. Sustained battery loads are extremely light (2 to 3 watts); therefore, a battery bus voltage of approximately 34 V dc will be indicated on the spacecraft voltmeter, except when the main bus tie switches have been activated to tie the battery outputs to the main dc buses. Normally, only batteries A and B will be connected to the main dc buses. Battery C is isolated during prelaunch by opening the MAIN A-BAT C and MAIN B-BAT C circuit breakers (RHEB-275). Battery C will therefore provide a backup for main dc bus power in case of failure of battery A or B or during the time battery A or B is being recharged. The two-battery configuration provides more efficient use of fuel cell power during peak power loads and decreases overall battery recharge time. The MAIN A- and MAIN B-BAT C circuit breakers are closed prior to CSM separation or as required during recharge of battery A or B.

Battery C, through circuit breakers BAT C to BAT BUS A and BAT C to BAT BUS B (RHEB-250), provides backup power to the respective battery bus in the event of failure of entry battery A or B. These circuit breakers are normally open until a failure of battery A or B occurs. This circuit can also be used to recharge battery A or B in the event of a failure in the normal charging circuit.

The two pyrotechnic batteries supply power to initiate ordnance devices in the SC. The pyrotechnic batteries are isolated from the rest of the EPS to prevent the high-power surges in the pyrotechnic system from affecting the EPS, and to insure source power when required. These batteries are not to be recharged in flight. Entry and postlanding battery A, B, or C can be used as a redundant source of power for initiating pyro circuits in the respective A or B pyro system, if either pyro battery fails. This can be performed by proper manipulation of the circuit breakers on RHEB-250. Caution must be exercised to isolate the failed pyro battery by opening the PYRO A (B) SEQ A (B) circuit breaker, prior to closing the yellow colored BAT BUS A (B) to PYRO BUS TIE circuit breaker.

Performance characteristics of each SC battery are as follows:

Battery	Rated capacity per battery	Open circuit voltage (max.)	Nominal voltage	Minimum voltage	Ambient battery temperature
Entry and Postlanding, A, B, and C (3)	40 amp-hrs (25 ampere rate)	37.8 V dc max. (37.2 V dc in flight)	29 V dc (35 amps load)	27 V dc (35 amps load)	50° to 110° F
Pyro A and B (2)	0.75 amp-hrs (75 amps for 36 seconds)	37.8 V dc max. (37.2 V dc in flight)	23 V dc (75 amps load)	20 V dc (75 amps load) (32 V dc open circuit)	60° to 110° F

NOTE: Pyro battery load voltage is not measurable in the SC due to the extremely short time they power pyro loads.

Fuel cell power plants.- Each of the three Bacon-type fuel cell power plants is individually coupled to a heat rejection (radiator) system, the hydrogen and oxygen cryogenic storage systems, a water storage system, and a power distribution system. A typical power plant schematic is shown in figure A2.6-5.

The power plants generate dc power on demand through an exothermic chemical reaction. The by-product water is fed to a potable water storage tank in the CM where it is used for astronaut consumption and for cooling purposes in the ECS. The amount of water produced is equivalent to the power produced which is relative to the reactant consumed. (See table A2.6-II.)

TABLE A2.6-II.- REACTANT CONSUMPTION AND WATER PRODUCTION

Load (amps)	O_2 lb/hr	H_2 lb/hr	H_2O lb/hr	cc/hr
0.5	0.0102	0.001285	0.01149	5.21
1	0.0204	0.002570	0.02297	10.42
2	0.0408	0.005140	0.04594	20.84
3	0.0612	0.007710	0.06891	31.26
4	0.0816	0.010280	0.09188	41.68
5	0.1020	0.012850	0.11485	52.10
6	0.1224	0.015420	0.13782	62.52
7	0.1428	0.017990	0.16079	72.94
8	0.1632	0.020560	0.18376	83.36
9	0.1836	0.023130	0.20673	93.78
10	0.2040	0.025700	0.2297	104.20
15	0.3060	0.038550	0.34455	156.30
20	0.4080	0.051400	0.45940	208.40
25	0.5100	0.064250	0.57425	260.50
30	0.6120	0.077100	0.68910	312.60
35	0.7140	0.089950	0.80395	364.70
40	0.8160	0.10280	0.91880	416.80
45	0.9180	0.11565	1.03365	468.90
50	1.0200	0.12850	1.1485	521.00
55	1.1220	0.14135	1.26335	573.10
60	1.2240	0.15420	1.3782	625.20
65	1.3260	0.16705	1.49305	677.30
70	1.4280	0.17990	1.6079	729.40
75	1.5300	0.19275	1.72275	781.50
80	1.6320	0.20560	1.83760	833.60
85	1.7340	0.21845	1.95245	885.70
90	1.8360	0.23130	2.06730	937.90
95	1.9380	0.24415	2.18215	989.00
100	2.0400	0.25700	2.2970	1042.00

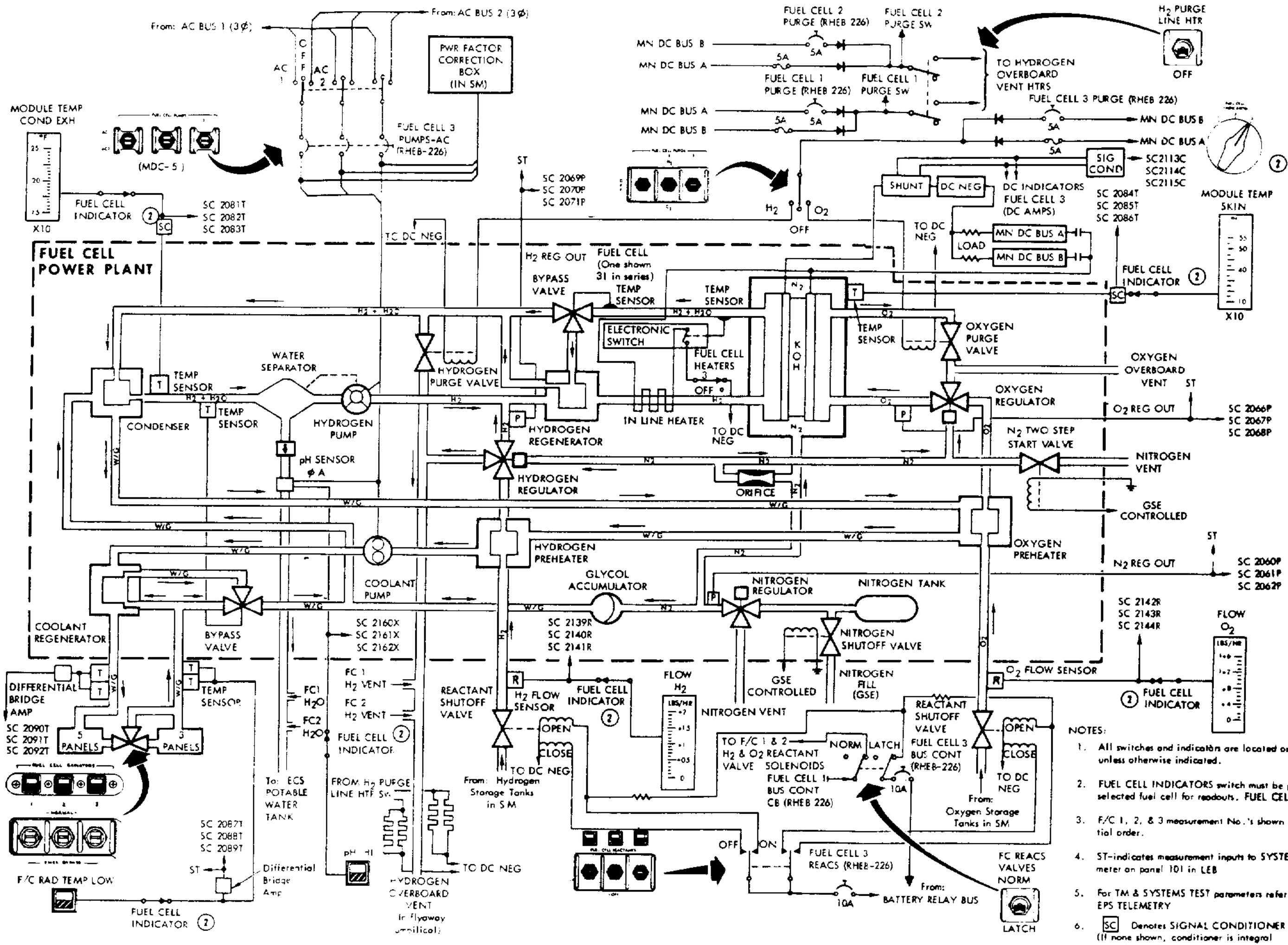
FORMULAS:

$O_2 = 2.04 \times 10^{-2}$ I

$H_2 = 2.57 \times 10^{-3}$ I

$H_2O = 10.42$ cc/amp/hr

$H_2O = 2.297 \times 10^{-2}$ lb/amp/hr



NOTES:

1. All switches and indicators are located on MDC-3 unless otherwise indicated.
2. FUEL CELL INDICATORS switch must be placed to selected fuel cell for readouts. FUEL CELL 3 shown
3. F/C 1, 2, & 3 measurement No.'s shown in sequential order.
4. ST-indicates measurement inputs to SYSTEM TEST meter on panel 101 in LEB
5. For TM & SYSTEMS TEST parameters refer to EPS TELEMETRY
6. SC Denotes SIGNAL CONDITIONER (If none shown, conditioner is integral part of sensor)

Figure A2.6-5.- Fuel cell schematic.

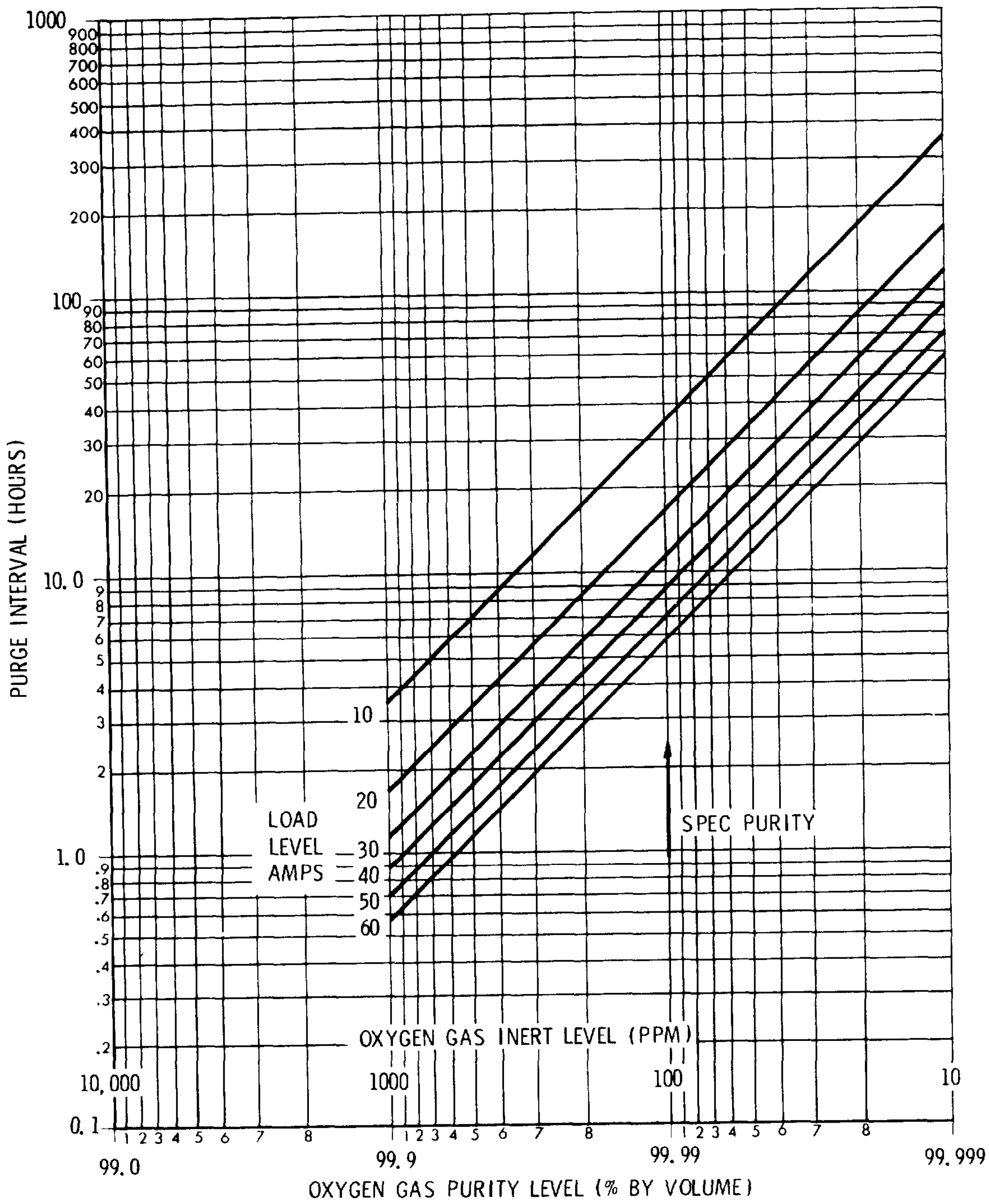


Figure A2.6-7.- O_2 gas purity effect on purge interval.

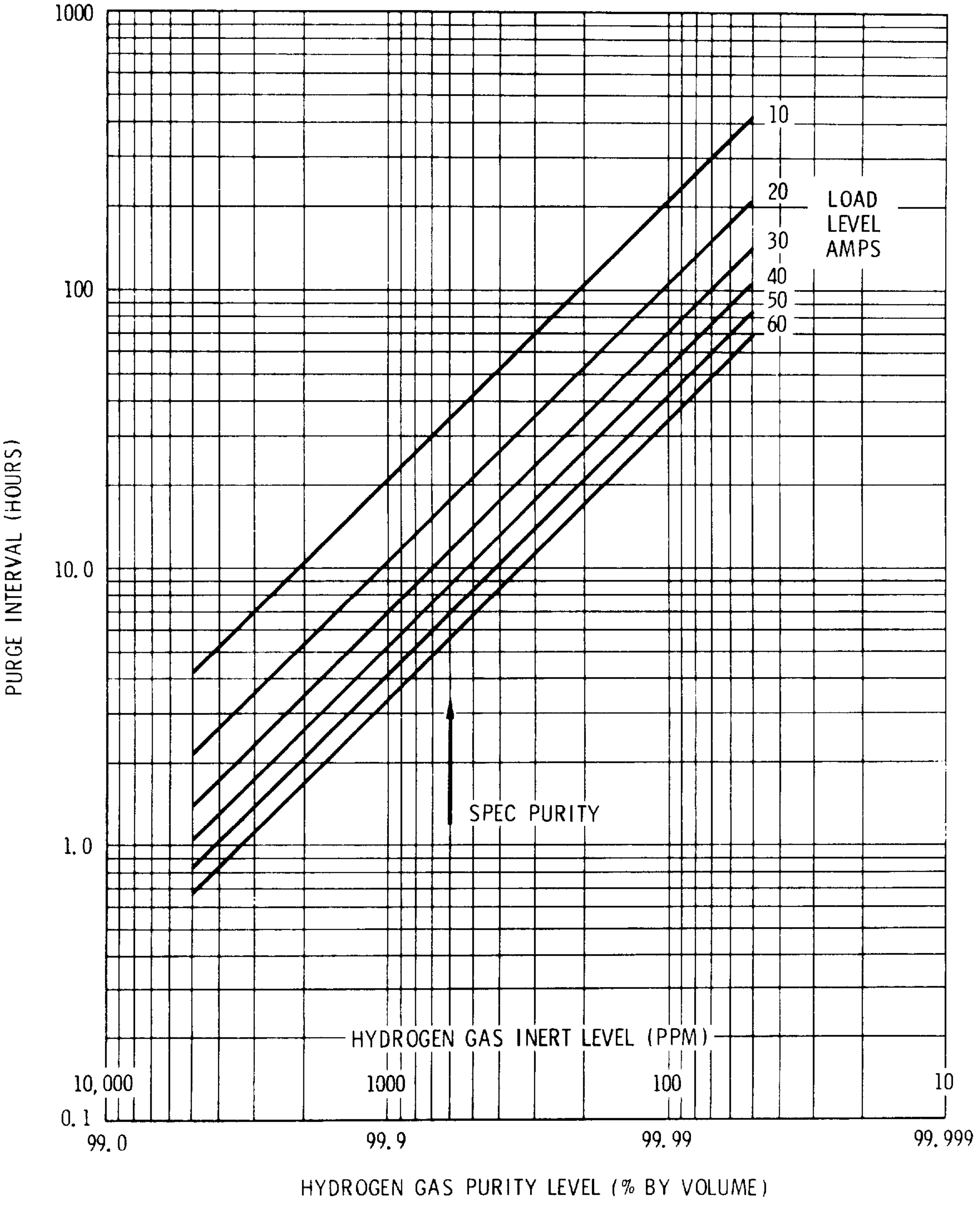


Figure A2.6-8.- H_2 gas purity effect on purge interval.

voltage, resulting from a decreased load, is followed by a gradual decrease in fuel cell skin temperature which causes a decrease in terminal voltage.

The range in which the terminal voltage is permitted to vary is determined by the high and low voltage input design limits of the components being powered. For most components the limits are 30 volts dc and 25 volts dc. To remain within these design limits, the dc bus voltage must be maintained between 31.0 and 26.2 volts dc. To compensate for cyclic loads, it is recommended sustained bus voltage be maintained between 26.5 and 30.0 V dc. Bus voltage is maintained within prescribed limits by the application of entry and postlanding batteries during load increases (power up). Load increase or decrease falls well within the limits of power supply capability and, under normal conditions, should not require other than normal checklist procedures.

Power up.- Powering up spacecraft systems is performed in one continuous sequence providing the main bus voltage does not decrease below 26.5 volts. If bus voltage decreases to this level, the power up sequence can be interrupted for the time required for fuel cell temperatures to increase with the resultant voltage increase or the batteries can be connected to the main buses thus reducing the fuel cell load. In most cases, powering up can be performed in one continuous sequence; however, when starting from an extremely low spacecraft load, it is probable that a power up interruption or earlier battery coupling may be required. The greatest load increase occurs while powering up for a delta V maneuver.

Power down.- Powering down spacecraft systems is performed in one continuous sequence providing the main bus voltage does not increase above 31.0 volts. Powering down from relatively high spacecraft load levels, that is, following a delta V, the sequence may have to be interrupted for the time required for fuel cell temperature, and as a result, bus voltage to decrease. To expedite power down, one fuel cell can be disconnected from the buses increasing the loads on the remaining fuel cells and decreasing bus voltage, thus allowing continuation of the power down sequence.

Fuel cell disconnect.- If the requirement arises to maintain a power plant on open circuit, temperature decay would occur at an average rate of approximately 6 deg/hr, with the automatic in-line heater circuit activating at a skin temperature of 385° F and maintaining power plant temperature at 385° F. In-line heater activation can be confirmed by a 4.5- to 6-amp indication as observed on the dc amps meter (MDC-3) with the dc indicator switch positioned to the open circuited fuel cell position. Reactant valves remain open. Fuel cell pumps can be turned off until the in-line heater circuit activates, at which time they must be on.

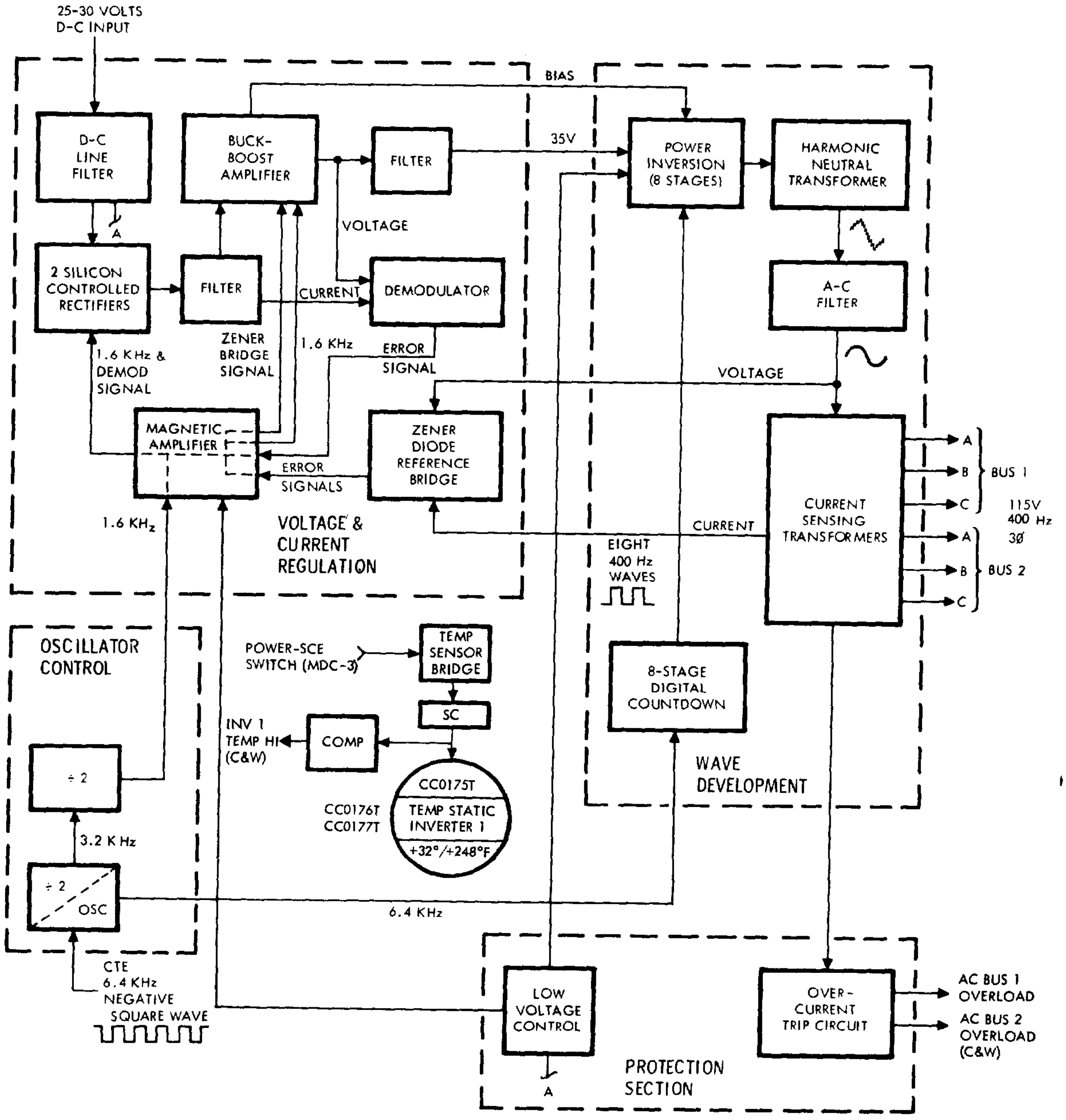
Closing of reactant valves during a power plant disconnect is dependent on the failure experienced. If power plant failure is such as to allow future use, that is, shutdown due to partially degraded output, it is recommended the reactant valves remain open to provide a positive reactant pressure. The valves should be closed after power-plant skin temperature decays below 300° F. The reactant valves are closed during initial shutdown, if the failure is a reactant leak, an abnormally high regulator output pressure, or complete power-plant failure.

Prior to disconnecting a fuel cell, if a single inverter is being used, each of the remaining power plants is connected to both main dc buses to enhance load sharing since bus loads are unbalanced. If two inverters are being used, main dc bus loads are relatively equal; therefore, each of the remaining power plants is connected to a separate main dc bus for bus isolation. If one power plant had been placed on open circuit for an extended period of time, prior to powering up to a configuration requiring three power plants, reconnecting is accomplished prior to the time of heavy load demands. This permits proper conditioning of the power plant which has been on open circuit. The time required for proper conditioning is a function of skin temperature increase and the load applied to the power plant.

Inverters.- Each inverter (fig. A2.6-9) is composed of an oscillator, an eight-stage digital countdown section, a dc line filter, two silicon controlled rectifiers, a magnetic amplifier, a buck-boost amplifier, a demodulator, two dc filters, an eight-stage power inversion section, a harmonic neutralization transformer, an ac output filter, current sensing transformers, a Zener diode reference bridge, a low-voltage control, and an overcurrent trip circuit. The inverter normally uses a 6.4-kHz square wave synchronizing signal from the central timing equipment (CTE) which maintains inverter output at 400 Hz. If this external signal is completely lost, the free running oscillator within the inverter will provide pulses that will maintain inverter output within ±7 Hz. The internal oscillator is normally synchronized by the external pulse. The subsequent paragraphs describe the function of the various stages of the inverter.

The 6.4-kHz square wave provided by the CTE is applied through the internal oscillator to the eight-stage digital countdown section. The oscillator has two divider circuits which provide a 1600-Hz signal to the magnetic amplifier.

The eight-stage digital countdown section, triggered by the 6.4-kHz signal, produces eight 400-Hz square waves, each mutually displaced one pulse-time from the preceding and following wave. One pulse-time is 156 microseconds and represents 22.5 electrical degrees. The eight square waves are applied to the eight-stage power inversion section.



NOTE: Unless otherwise specified:
1. Inverter 1 is shown.
2. A denotes input voltage.

Figure A2.6-9.- Inverter block diagram.

The eight-stage power inversion section, fed a controlled voltage from the buck-boost amplifier, amplifies the eight 400-Hz square waves produced by the eight-stage digital countdown section. The amplified square waves, still mutually displaced 22.5 electrical degrees, are next applied to the harmonic neutralization transformer.

The harmonic neutralization section consists of 31 transformer windings on one core. This section accepts the 400-Hz square-wave output of the eight-stage power inversion section and transforms it into a 3-phase 400-Hz 115-volt signal. The manner in which these transformers are wound on a single core produces flux cancellation which eliminates all harmonics up to and including the fifteenth of the fundamental frequency. The 22.5° displacement of the square waves provides a means of electrically rotating the square wave excited primary windings around the 3-phase, wye-connected secondary windings, thus producing the 3-phase 400-Hz sine wave output. This 115-volt signal is then applied to the ac output filter.

The ac output filter eliminates the remaining higher harmonics. Since the lower harmonics were eliminated by the harmonic neutral transformer, the size and weight of this output filter was reduced. Circuitry in this filter also produces a rectified signal which is applied to the Zener diode reference bridge for voltage regulation. The amplitude of this signal is a function of the amplitude of ac output voltage. After filtering, the 3-phase 115-volt ac 400-Hz sine wave is applied to the ac buses through individual phase current-sensing transformers.

The current-sensing transformers produce a rectified signal, the amplitude of which is a direct function of inverter output current magnitude. This dc signal is applied to the Zener diode reference bridge to regulate inverter current output: it is also paralleled to an overcurrent sensing circuit.

The Zener diode reference bridge receives a rectified dc signal, representing voltage output, from the circuitry in the ac output filter. A variance in voltage output unbalances the bridge, providing an error signal of proper polarity and magnitude to the buck-boost amplifier via the magnetic amplifier. The buck-boost amplifier, through its bias voltage output, compensates for voltage variations. When inverter current output reaches 200 to 250 percent of rated current, the rectified signal applied to the bridge from the current sensing transformers is of sufficient magnitude to provide an error signal, causing the buck-boost amplifier to operate in the same manner as during an overvoltage condition. The bias output of the buck-boost amplifier, controlled by the error signal, will be varied to correct for any variation in inverter voltage or a beyond-tolerance increase in current output. When inverter current output exceeds 250 percent of rated current, the overcurrent sensing circuit is activated.

The overcurrent sensing circuit monitors a rectified dc signal representing current output. When total inverter current output exceeds 250 percent of rated current, this circuit will illuminate an overload lamp in 15±5 seconds. If current output of any single phase exceeds 300 percent of rated current, this circuit will illuminate the overload lamp in 5±1 seconds. The AC BUS 1 OVERLOAD and AC BUS 2 OVERLOAD lamps are in the caution/warning matrix on MDC-2.

The dc power to the inverter is supplied from the main dc buses through the dc line filter. The filter reduces the high-frequency ripple in the input, and the 25 to 30 volts dc is applied to two silicon-controlled rectifiers.

The silicon-controlled rectifiers are alternately set by the 1600-Hz signal from the magnetic amplifier to produce a dc square wave with an on-time of greater than 90° from each rectifier. This is filtered and supplied to the buck-boost amplifier where it is transformer-coupled with the amplified 1600-Hz output of the magnetic amplifier, to develop a filtered 35 volts dc which is used for amplification in the power inversion stages.

The buck-boost amplifier also provides a variable bias voltage to the eight-stage power inversion section. The amplitude of this bias voltage is controlled by the amplitude and polarity of the feedback signal from the Zener diode reference bridge which is referenced to output voltage and current. This bias signal is varied by the error signal to regulate inverter voltage and maintain current output within tolerance.

The demodulator circuit compensates for any low-frequency ripple (10 to 1000 Hz) in the dc input to the inverter. The high-frequency ripple is attenuated by the input filters. The demodulator senses the 35-volt dc output of the buck-boost amplifier and the current input to the buck-boost amplifier. An input dc voltage drop or increase will be reflected in a drop or increase in the 35-volt dc output of the buck-boost amplifier, as well as a drop or increase in current input to the buck-boost amplifier. A sensed decrease in the buck-boost amplifier voltage output is compensated for by a demodulator output, coupled through the magnetic amplifier to the silicon-controlled rectifiers. The demodulator output causes the SCR's to conduct for a longer time, thus increasing their filtered dc output. A sensed increase in buck-boost amplifier voltage output, caused by an increase in dc input to the inverter, is compensated for by a demodulator output coupled through the magnetic amplifier to the silicon-controlled rectifiers, causing them to conduct for shorter periods, thus producing a lower filtered dc output to the buck-boost amplifier. In this manner, the 35-volt dc input to the power inversion section is maintained at a relatively constant level irrespective of the fluctuations in dc input voltage to the inverter.

The low-voltage control circuit samples the input voltage to the inverter and can terminate inverter operation. Since the buck-boost amplifier provides a boost action during a decrease in input voltage to the inverter, in an attempt to maintain a constant 35 volts dc to the power inversion section and a regulated 115-volt inverter output, the high boost required during a low-voltage input would tend to overheat the solid state buck-boost amplifier. As a precautionary measure, the low-voltage control will terminate inverter operation by disconnecting operating voltage to the magnetic amplifier and the first power inversion stage when input voltage decreases to between 16 and 19 volts dc.

A temperature sensor with a range of +32° to +248° F is installed in each inverter and provides an input to the C&WS which will illuminate a light at an inverter overtemperature of 190° F. Inverter temperature is telemetered to MSFN.

Battery charger.- A constant voltage, solid-state battery charger (fig. A2.6-10), located in the CM lower equipment bay, is incorporated into the EPS. The BATTERY CHARGER selector switch (MDC-3) controls power input to the charger, as well as connecting the charger output to the selected battery (fig. A2.6-14). When the BATTERY CHARGER selector switch is positioned to entry battery A, B, or C, a relay (K1) is activated completing circuits from ac and dc power sources to the battery charger. Battery charger output is also connected to the selected battery to be charged through contacts of the MAIN BUS TIE motor switch. Positioning the MAIN BUS TIE switch (A/C or B/C) to OFF for battery A or B, and both switches to OFF for battery C will disconnect main bus loads from the respective batteries and also complete the circuit from the charger to the battery.

The battery charger is provided 25 to 30 volts from both main dc buses and 115 volts 400-Hz 3-phase from either of the ac buses. All three phases of ac are used to boost the 25- to 30-volt dc input and produce 40 volts dc for charging. In addition, phase A of the ac is used to supply power for the charger circuitry. The logic network in the charger, which consists of a two-stage differential amplifier (comparator), Schmitt trigger, current sensing resistor, and a voltage amplifier, sets up the initial condition for operation. The first stage of the comparator is in the on mode, with the second stage off, thus setting the Schmitt trigger first stage to on with the second stage off. Maximum base drive is provided to the current amplifier which turns the switching transistor to the on mode. With the switching transistor on, current flows from the transformer rectifier through the switching transistor, current sensing resistor, and switch choke to the battery being charged. Current lags voltage due to switching choke action. As current flow increases, the voltage drop across the sensing resistor increases, and at a specific level sets the first stage of the comparator to off and the second stage

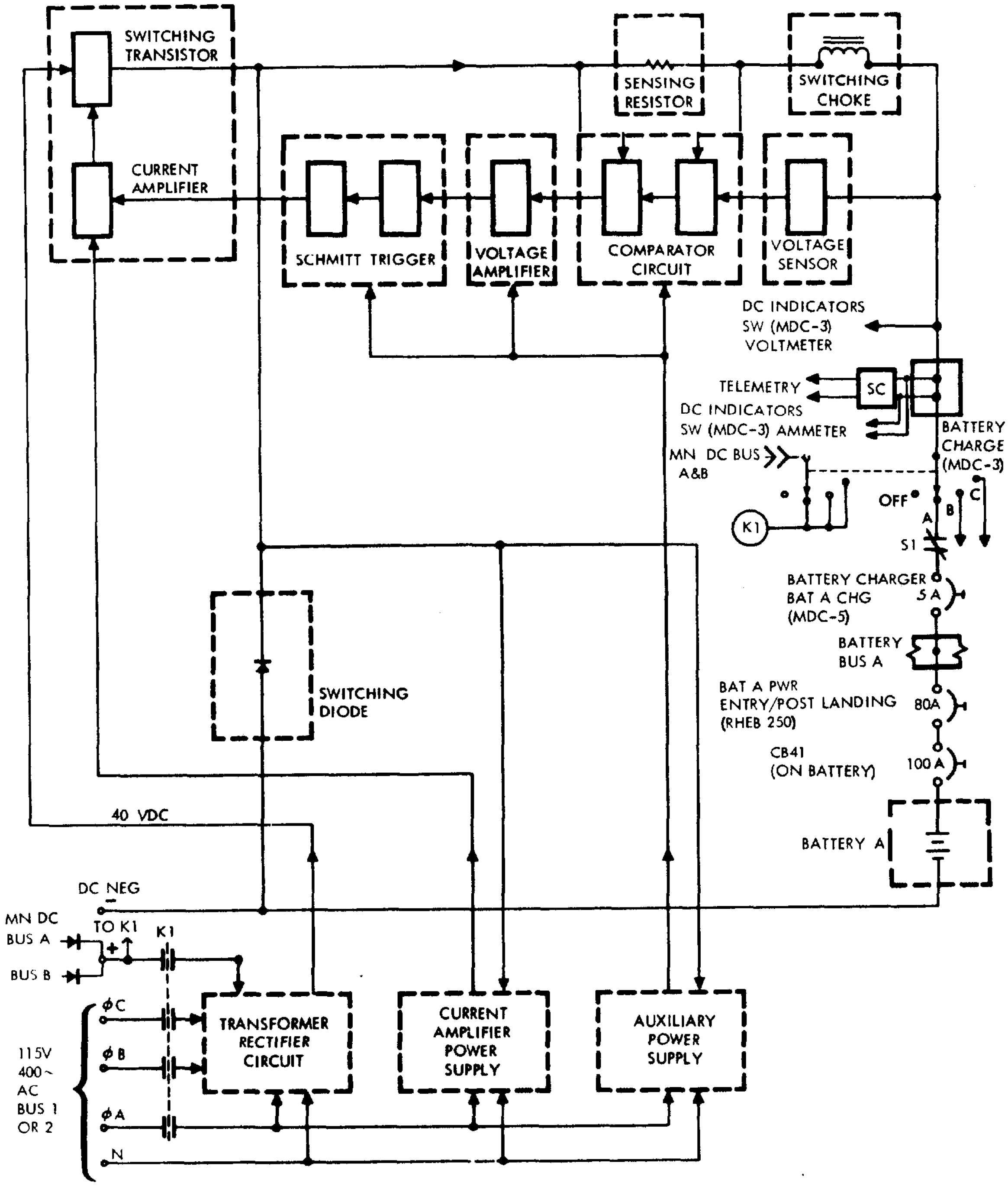


Figure A2.6-10.- Battery charger block diagram.

to on. The voltage amplifier is set off to reverse the Schmitt trigger to first stage off and second stage on. This sets the current amplifier off, which in turn sets the switching transistor off. The switching transistor in the off mode terminates power from the source, causing the field in the choke to continue collapsing, discharging into the battery, then through the switching diode and the current sensing resistor to the opposite side of the choke. As the EMF in the choke decreases, current through the sensing resistor decreases, reducing the voltage drop across the resistor. At some point, the decrease in voltage drop across the sensing resistor reverses the comparator circuit, setting up the initial condition and completing one cycle of operation. The output load current, due to the choke action, remains relatively constant except for the small variation through the sensing resistor. This variation is required to set and reset the switching transistor and Schmitt trigger through the action of the comparator.

Battery charger output is regulated by the sensing resistor until battery voltage reaches approximately 37 volts. At this point, the biased voltage sensor circuit is unbiased, and in conjunction with the sensing resistor, provides a signal for cycling the battery charger. As battery voltage increases, the internal impedance of the battery increases, decreasing current flow from the charger. At 39.8 volts, the battery is fully charged and current flow becomes negligible. Recharging the batteries until battery amp hour input equates amp hours previously discharged from the battery assures sufficient battery capacity for mission completion. The MSFN will monitor this function. If there is no contact with the MSFN, battery charging is terminated when the voltmeter indicates 39.5 V dc with the DC INDICATORS switch set to the BAT CHARGER position.

Charger voltage is monitored on the DC VOLTS METER (MDC-3). Current output is monitored on the inner scale of the DC AMPS meter (MDC-3) by placing the DC INDICATORS switch (MDC-3) to the BAT CHARGER position. Battery charger current output is telemetered to the MSFN.

When charging battery A or B, the respective BAT RLY BUS-BAT A or B circuit breaker (MDC-5) is opened to expedite recharge. During this period, only one battery will be powering the battery relay bus. Relay bus voltage can be monitored by selecting positions 4 and B on the Systems Test Meter (LEB-101) and from the couches by the Fuel Cell-Main Bus B-1 and Fuel Cell - Main Bus A-3 talk-back indicators (MDC-3) which will be barber-poled. If power is lost to the relay bus, these indicators will revert to the gray condition, indicating loss of power to the relay bus and requiring remedial action.

Recharge of a battery immediately after it is exposed to any appreciable loads requires less time than recharge of a battery commencing 30 minutes or more after it is disconnected from these loads. Therefore, it is advantageous to connect batteries to the charger as soon as possible after they are disconnected from the main buses since this decreases overall recharge time.

Power distribution.- The dc and ac power distribution to components of the EPS is provided by two redundant buses in each system. A single-point ground on the spacecraft structure is used to eliminate ground loop effects. Sensing and control circuits are provided for monitoring and protection of each system.

Distribution of dc power (fig. A2.6-11) is accomplished with a two-wire system and a series of interconnected buses, switches, circuit breakers, and isolation diodes. The dc negative buses are connected to the vehicle ground point (VGP). The buses consist of the following:

a. Two main dc buses (A and B), powered by the three fuel cells and/or entry and postlanding batteries A, B, and C.

b. Two battery buses (A and B), each powered by its respective entry and postlanding battery A and B. Battery C can power either or both buses if batteries A and/or B fail.

c. Flight and postlanding bus, powered through both main dc buses and diodes, or directly by the three entry and postlanding batteries A, B, and C, through dual diodes.

d. Flight bus, powered through both main dc buses and isolation diodes.

e. Nonessential bus, powered through either dc main bus A or B.

f. Battery relay bus, powered by entry and postlanding batteries through the individual battery buses and isolation diodes.

g. Pyro buses, isolated from the main electrical power system when powered by the pyro batteries. A capbility is provided to connect either entry battery to the A or B pyro system in case of loss of a pyro battery.

h. SM jettison controllers, completely isolated from the main electrical power system until activated during CSM separation, after which they are powered by the fuel cells.

Power from the fuel cell power plants can be connected to the main dc buses through six motor switches (part of overload/reverse current circuits in the SM) which are controlled by switches in the CM located on MDC-3. Fuel cell power can be selected to either or both of the main dc buses. Six talk-back indicators show gray when fuel cell output is connected and striped when disconnected. When an overload condition occurs, the overload-reverse current circuits in the SM automatically disconnect the fuel cell power plants from the overloaded bus and provide visual displays (talk-back indicator and caution and warning lamp illumination)(FC BUS DISCONNECT) for isolation of the trouble. A reverse current condition will disconnect the malfunctioning power plant from the dc system. The dc undervoltage sensing circuits (fig. A2.6-12) are provided to indicate bus low-voltage conditions. If voltage drops below 26.25 volts dc, the applicable dc undervoltage light on the caution and warning panel (MDC-2) will illuminate. Since each bus is capable of handling all EPS loads, an undervoltage condition should not occur except in an isolated instance; if too many electrical units are placed on the bus simultaneously or if a malfunction exists in the EPS. A voltmeter (MDC-3) is provided to monitor voltage of each main dc bus, the battery charger, and each of the five batteries. An ammeter is provided (MDC-3) to monitor current output of fuel cells 1, 2, 3, batteries A, B, C, and the battery charger.

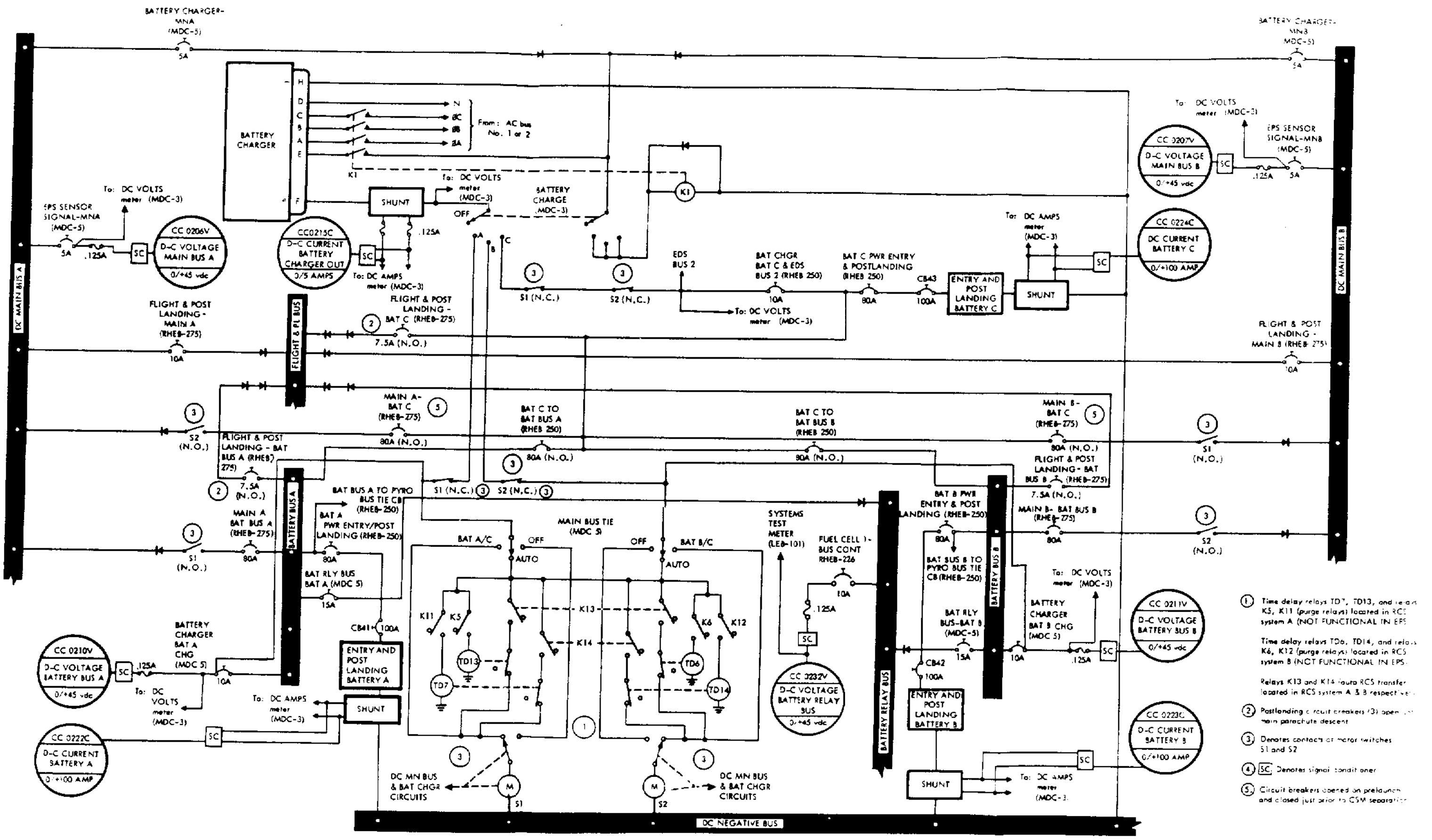
During high power demand or emergencies, supplemental power to the main dc buses can be supplied from batteries A and B via the battery buses and directly from battery C (fig. A2.6-13). During entry, spacecraft power is provided by the three entry and postlanding batteries which are connected to the main dc buses prior to CSM separation; placing the MAIN BUS TIE switches (MDC-5) to BAT A/C and BAT B/C provides this function after closing the MAIN A-BAT C and MAIN B-BAT C circuit breakers (RHEB-275). The switches are manually placed to OFF after completion of RCS purge and closing the FLIGHT AND POST LDG-BAT BUS A, BAT BUS B, and BAT C circuit breakers (RHEB-275) during main chute descent. The AUTO position provides an automatic connection of the entry batteries to the main dc buses at CSM separation. The auto function is used only on the launch pad after the spacecraft is configured for a LES pad abort.

A nonessential bus, as shown on fig. A2.6-11, permits isolating nonessential equipment during a shortage of power (two fuel cell power plants out). The flight bus distributes power to inflight telecommunications equipment. The flight and postlanding bus distributes power to some of the inflight telecommunications equipment, float bag No. 3 controls, the ECS postlanding vent and blower control, and postlanding communications and lighting equipment. In flight, the postlanding bus receives power from the fuel cells and/or entry and postlanding batteries through the main dc buses. After completion of RCS purge during main chute descent, the entry batteries supply power to the postlanding bus directly through individual circuit breakers. These circuit breakers (FLIGHT & POST LANDING-BAT BUS A, BAT BUS B, and BAT C - RHEB-275) are normally open in flight and closed during main chute descent just prior to positioning the MAIN BUS TIE switches to OFF.

Motor switch contacts which close when the MAIN BUS TIE switches are placed to ON, complete the circuit between the entry and postlanding batteries and the main dc buses, and open the connection from the battery charger to the batteries. The battery relay bus provides dc power to the ac sensing units, the fuel cell and inverter control circuits, fuel cell reactant and radiator valves, and the fuel cell—main BUS A and B talk—back indicators on MDC-3. The pyrotechnic batteries supply power to ordnance devices for separation of the LES, S-IVB, forward heat shield, SM from CM, and for deployment and release of the drogue and main parachutes during a pad abort, high-altitude abort, or normal mission progression. The three fuel cell power plants supply power to the SM jettison controllers for the SM separation maneuver.

Distribution of ac power (fig. A2.6-14) is accomplished with a four-wire system via two redundant buses, ac bus 1 and ac bus 2. The ac neutral bus is connected to the vehicle ground point. The ac power is provided by one or two of the solid-state 115/200-volt 400-Hz 3-phase inverters. The dc power is routed to the inverters through the main dc buses. Inverter No. 1 is powered through dc main bus A, inverter No. 2 through dc main bus B, and inverter No. 3 through either dc main bus A or B by switch selection. Each of these circuits has a separate circuit breaker and a power control motor switch. Switches for applying power to the motor switches are located on MDC-3. All three inverters are identical and are provided with overtemperature circuitry. A light indicator, in the caution/warning group on MDC-2, illuminates at 190° to indicate an overtemperature situation. Inverter output is routed through a series of control motor switches to the ac buses. Six switches (MDC-3) control motor switches which operate contacts to connect or disconnect the inverters from the ac buses. Inverter priority is 1 over 2, 2 over 3, and 3 over 1 on any one ac bus. This indicates that inverter 2 cannot be connected to the bus until the inverter 1 switch is positioned to OFF. Also, when inverter 3 switch is positioned to ON, it will disconnect inverter 1 from the bus before the inverter 3 connection will be performed. The motor switch circuits are designed to prevent connecting two inverters to the same ac bus at the same time. The ac loads receive power from either ac bus through bus selector switches. In some instances, a single phase is used for operation of equipment and in others all three. Over-undervoltage and overload sensing circuits (fig. A2.6-12) are provided for each bus. An automatic inverter disconnect is effected during an overvoltage. The ac bus voltage fail and overload lights in the caution/warning group (MDC-2) provide a visual indication of voltage or overload malfunctions. Monitoring voltage of each phase on each bus is accomplished by selection with the AC INDICATORS switch (MDC-3). Readings are displayed on the AC VOLTS meter (MDC-3). Phase A voltage of each bus is telemetered to MSFN stations.

Several precautions should be taken during any inverter switching. The first precaution is to completely disconnect the inverter being taken out of the circuit whether due to inverter transfer or malfunction. The second precaution is to insure that no more than one switch on AC BUS 1 or AC BUS 2 (MDC-3) is in the up position at the same time. These



① Time delay relays TD7, TD13, and rela
K5, K11 (purge relays) located in RCS
system A (NOT FUNCTIONAL IN EPS

Time delay relays TD6, TD14, and rela
K6, K12 (purge relays) located in RCS
system B (NOT FUNCTIONAL IN EPS

Relays K13 and K14 (auto RCS transfer
located in RCS system A & B respective

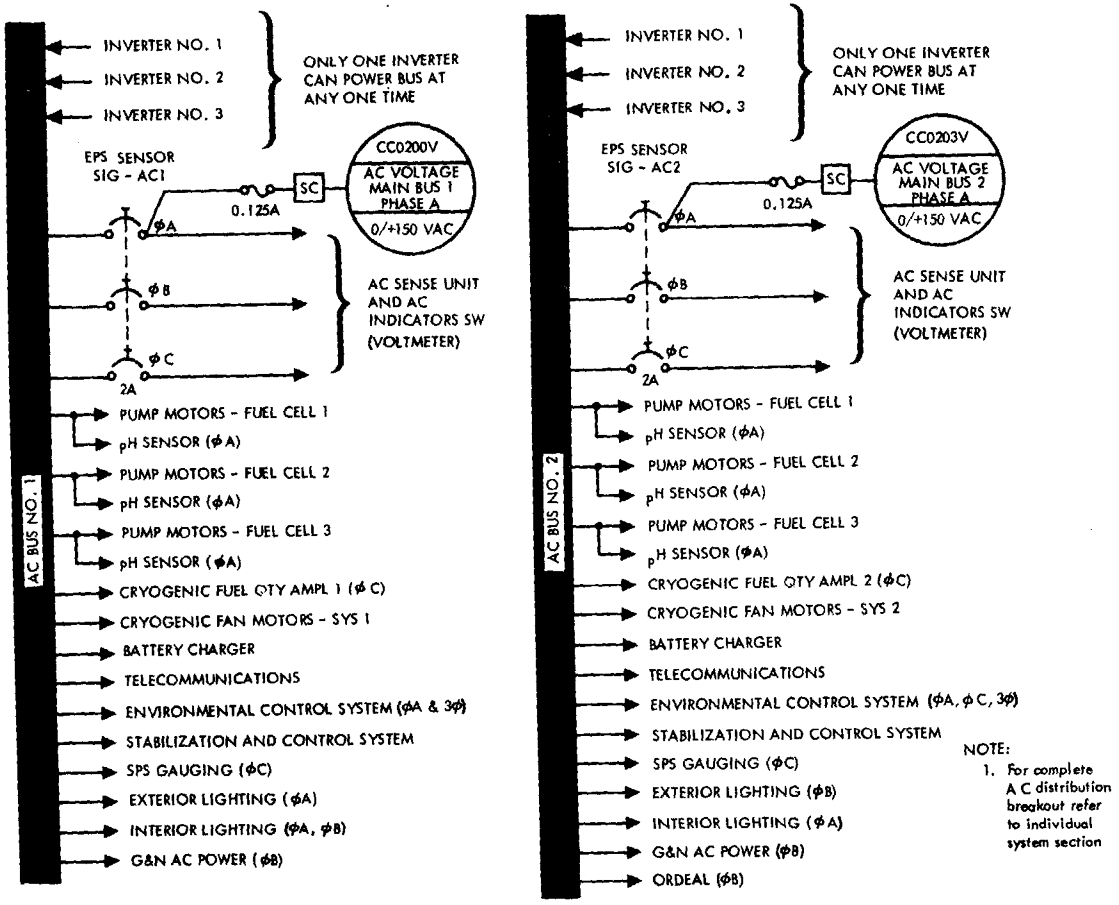
② Postlanding circuit breakers (3) open
main parachute descent

③ Denotes contacts of motor switches
S1 and S2

④ SC Denotes signal conditioner

⑤ Circuit breakers opened on prelaunch
and closed just prior to CSM separati

Figure A2.6-13.- Battery charger and CM dc bus control circuits.



NOTE:
1. For complete A C distribution breakout refer to individual system section

Figure A2.6-14.- Alternating current power distribution.

precautions are necessary to assure positive power transfer since power to any one inverter control motor switch is routed in series through the switch of another inverter. A third precaution must be exercised to preclude a motor switch lockout when dc power to inverter 3 is being transferred from dc main bus A to dc main bus B, or vice versa. The AC INVERTER 3 switch (MDC-3) should be held in the OFF position for 1 second when performing a power transfer operation from one main dc bus to the other.

Performance and Design Data

Alternating current and direct current data.- The ac and dc performance and design data for the EPS is as follows:

Alternating current

Phases	3
Displacement	120 ± 2°
Steady-state voltage	115.5 (+1, -1.5) V ac (average 3 phases)
Transient voltage	115 (+35, -65) V ac
Recovery	To 115 ± 10 V within 15 ms, steady state within 50 ms
Unbalance	2 V ac (worst phase from average)
Frequency limites	
Normal (synchronized to central timing equipment)	400 ± 3 Hz
Emergency (loss of central timing equipment)	400 ± 7 Hz
Wave characteristics (sine wave)	
Maximum distortion	5 percent
Highest harmonic	4 percent
Crest factor	1.414 ± 10 percent
Rating	1250 V ac

Direct current

Steady-state voltage limits	
Normal	29 ± 2.0 V dc
Minimum CM bus	26.2 V dc
Min Precautionary CM bus	26.5 V dc (allows for cyclic loads)
Maximum CM bus	31.0 V dc
Max Precautionary CM bus	30.0 V dc (allows for cyclic loads)
During postlanding and preflight checkout periods	27 to 30 V dc
Ripple voltage	1 V peak to peak

Operational Limitations and Restrictions

Fuel cell power plants.- Fuel cell power plants are designed to function under atmospheric and high-vacuum conditions. Each must be able to maintain itself at sustaining temperatures and minimum electrical loads at both environment extremes. To function properly, fuel cells must operate under the following limitations and restrictions:

External nonoperating temperature	-20° to +140° F.
Operating temperature inside SM	+30° to 145° F.
External nonoperating pressure	Atmospheric
Normal voltage	27 to 31 V dc
Minimum operating voltage at terminals	
Emergency operation	20.5 V dc at 2295 watts (gross power level)
Normal operation	27 V dc

Maximum operating voltage at terminals	31.5 V dc
Fuel cell disconnect overload	75 amperes no trip, 112 amperes disconnect after 25 to 300 seconds
Maximum reverse current	1 second minimum before disconnect
Minimum sustaining power/ fuel cell power plant (with in-line heater OFF)	420 watts
In-line heater power (sustain F/C skin temp above 385° F min)	160 watts (5 to 6 amps)
Maximum gross power under emergency conditions	2295 watts at 20.5 V dc min.
Nitrogen pressure	50.2 to 57.5 psia (53 psia, nominal)
Reactant pressure	
Oxygen	58.4 to 68.45 psia (62.5 psia, nominal)
Hydrogen	57.3 to 67.0 psia (61.5 psia, nominal)
Reactant consumption/fuel cell power plant	
Hydrogen	PPH = Amps x (2.57×10^{-3})
Oxygen	PPH = Amps x (2.04×10^{-2})
Minimum skin temperature for self-sustaining operation	+385° F
Minimum skin temperature for recovery in flight	+360° F
Maximum skin temperature	+500° F
Approximate external environment temperature range outside SC (for radiation)	-260° to +400° F

Fuel cell power plant normal operating temperature range	+385° to +450° F
Condenser exhaust normal operating temperature	+150° to +175° F
Purging nominal frequency	Dependent on mission load profile and reactant purity after tank fill
O_2 purge duration	2 minutes
H_2 purge duration	80 seconds
Additional flow rate while purging	
Oxygen	Up to 0.6 lb/hr
Hydrogen	Up to 0.75 lb/hr (nominal 0.67 lb/hr)

Cryogenic storage subsystem.- The cryogenic storage subsystem must be able to meet the following requirements for proper operation of the fuel cell power plants and the ECS:

Minimum usable quantity	
Oxygen	320 lbs each tank (min)
Hydrogen	28 lbs each tank (min)
Temperature at time of fill	
Oxygen	-297° F. (approx.)
Hydrogen	-423° F. (approx.)
Operating pressure range	
Oxygen	
Normal	865 to 935 psia
Minimum	150 psia
Hydrogen	
Normal	225 to 260 psia
Minimum	100 psia
Temperature probe range	
Oxygen	-325° to +80° F
Hydrogen	-425° to -200° F
Maximum allowable difference in quantity balance between tanks	

Oxygen tanks No. 1 and 2	2 to 4 percent
Hydrogen tanks No. 1 and 2	3 percent

Pressure relief valve operation	
Crack pressure	
Oxygen	983 psig min.
Hydrogen	273 psig min.
Reseat pressure	
Oxygen	965 psig min.
Hydrogen	268 psig min.
Full flow, maximum relief	
Oxygen	1010 psig max.
Hydrogen	285 psig max.

Additional data.- Additional data about limitations and restrictions may be found in the CSM/LM Spacecraft Operational Data Book SNA-8-D-027, Vol I, (CSM SD68-447).

Systems Test Meter

The SYSTEMS TEST meter and the alphabetical and numerical switches, located on panel 101 in the CM LEB, provide a means of monitoring various measurements within the SC, and verifying certain parameters displayed only by event indicators. The following can be measured using the SYSTEMS TEST meter, the respective switch positions, and the range of each sensor. Normal operating parameters of measurable items are covered in the telemetry listing.

Conversion of the previously listed measurements to the SYSTEMS TEST meter indications are listed in Table A2.6-IV. The XPNDR measurements are direct readouts and do not require conversion.

TABLE A2.6-III.- SYSTEMS TEST DATA

Systems test indication (telemetry identity and code no.)	Switch positions		Sensor range
	Numerical select	Alphabetical select	
N_2 pressure, psia			0 to 75 psia
F/C 1 SC 2060P	1	A	
F/C 2 SC 2061P	1	B	
F/C 3 SC 2062P	1	C	
O_2 pressure, psia			0 to 75 psia
F/C 1 SC 2066P	1	D	
F/C 2 SC 2067P	2	A	
F/C 3 SC 2068P	2	B	
H_2 pressure, psia			0 to 75 psia
F/C 1 SC 2069P	2	C	
F/C 2 SC 2070P	2	D	
F/C 3 SC 2071P	3	A	
EPS radiator outlet temperature			-50° to +300° F
F/C 1 SC 2087T	3	B	
F/C 2 SC 2088T	3	C	
F/C 3 SC 2089T	3	D	
Battery manifold pressure, psia	4	A	0 to 20 psia
Batt relay bus CC0232V	4	B	0 to +45 V dc
LM power	4	D	0 to +10 amps
SPS oxidizer line temperature SP 0049T	5	A	0 to +200° F
CM-RCS oxidizer valve temperature			-50° to +50° F
-P engine, sys A CR 2100T	6	B	
+Y engine, sys B CR 2116T	5	D	
-P engine, sys B CR 2110T	5	C	
CW engine, sys B CR 2119T	6	D	
CCW engine, sys A CR 2114T	6	A	
-Y engine, sys A CR 2103T	6	C	
Pwr output	XPNDR	A	≥1.0 V dc (nominal)
AGC signal	XPNDR	B	Test ≥1.0 V dc Operate 0.0 to 4.5 V dc
Phase lockup	XPNDR	C	Locked ≥4.0 V dc Unlocked ≤0.8 V dc

NOTE: Position 7 on the numerical selector switch is an off position.

Command Module Interior Lighting

The command module interior lighting system (fig. A2.6-15) furnishes illumination for activities in the couch, lower equipment bay and tunnel areas, and back-lighted panel lighting to read nomenclature, indicators, and switch positions. Tunnel lighting is provided on SC which will be concerned with LM activity.

Floodlighting for illumination of work areas is provided by use of fluorescent lamps. Integral panel and numerics lighting is provided by electroluminescent materials. Tunnel lights are incandescent. Pen flashlights are provided for illuminating work areas which cannot be illuminated by the normal spacecraft systems, such as under the couches.

Electroluminescence (EL) is the phenomena whereby light is emitted from a crystalline phosphor (Z_NS) placed as a thin layer between two closely spaced electrodes of an electrical capacitor. One of the electrodes is a transparent material. The light output varies with voltage and frequency and occurs as light pulses, which are in-phase with the input frequency. Advantageous characteristics of EL for spacecraft use are an "after-glow" of less than 1 second, low power consumption, and negligible heat dissipation.

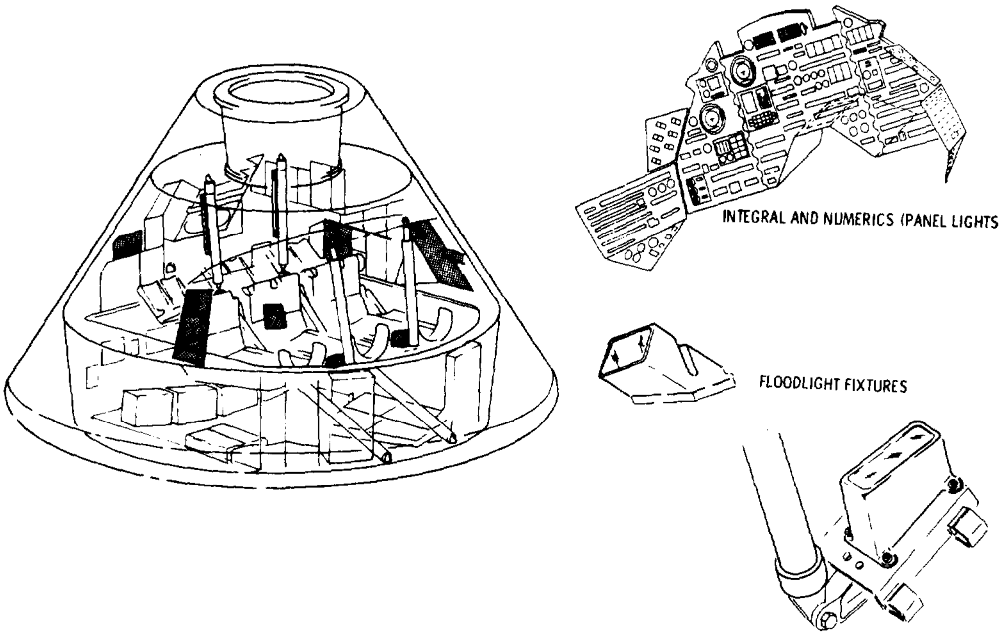


Figure A2.6-15.- CM interior lighting.

TABLE A2.6-IV.- SYSTEMS TEST METER INDICATIONS

Systems test meter display	N_2, O_2, H_2 pressure (PSIA)	EPS radiator outlet temperature (° F.)	CM-RCS oxidizer valve temperature (° F.)	LM power (amps)	SPS temperature (° F.)	Battery manifold pressure (PSIA)	Battery relay bus (V dc)
0.0	0	-50	-50	0	0	0.00	0
0.2	3	-36	-46	0.4	8	0.80	1.8
0.4	6	-22	-42	0.8	16	1.60	3.6
0.6	9	-8	-38	1.2	24	2.40	5.4
0.8	12	+6	-34	1.6	32	3.20	7.2
1.0	15	+20	-30	2.0	40	4.00	9.0
1.2	18	+34	-26	2.4	48	4.80	10.8
1.4	21	+48	-22	2.8	56	5.60	12.6
1.6	24	+62	-18	3.2	64	6.40	14.4
1.8	27	+76	-14	3.6	72	7.20	16.2
2.0	30	+90	-10	4.0	80	8.00	18.0
2.2	33	+104	-6	4.4	88	8.80	19.8
2.4	36	+118	-4	4.8	96	9.60	21.6
2.6	39	+132	0	5.2	104	10.40	23.4
2.8	42	+146	+4	5.6	112	11.20	25.2
3.0	45	+160	+10	6.0	120	12.00	27.0
3.2	48	+174	+14	6.4	128	12.80	28.8
3.4	51	+188	+18	6.8	136	13.60	30.6
3.6	54	+202	+22	7.2	144	14.40	32.4
3.8	57	+216	+26	7.6	152	15.20	34.2
4.0	60	+230	+30	8.0	160	16.00	36.0
4.2	63	+244	+34	8.4	168	16.80	37.8
4.4	66	+258	+38	8.8	176	17.60	39.6
4.6	69	+272	+42	9.2	184	18.40	41.4
4.8	72	+286	+46	9.6	192	19.20	43.2
5.0	75	+300	+50	10.0	200	20.00	45.0

Floodlight system.- The interior floodlight system consists of six floodlight fixture assemblies and three control panels (fig. A2.6-16). Each fixture assembly contains two fluorescent lamps (one primary and one secondary) and converters. The lamps are powered by 28 V dc from main dc buses A and B (fig. A2.6-17). This assures a power source for lights in all areas in the event either bus fails. The converter in each floodlight fixture converts 28 V dc to a high-voltage pulsating dc for operation of the fluorescent lamps.

Floodlights are used to illuminate three specific areas: the left main display console, the right main display console, and the lower equipment bay. Switches on MDC-8 provide control of lighting of the left main display console area. Switches on MDC-5 provide control of lighting of the right main display console area. Switches for control of lighting of the lower equipment bay area are located on LEB-100. Protection for the floodlight circuits is provided by the LIGHTING - MN A and MN B circuit breakers on RHEB-226.

Each control panel has a dimming (DIM-1-2) toggle switch control, a rheostat (FLOOD-OFF-BRT) control, and an on/off (FIXED-OFF) toggle switch control. The DIM-1 position provides variable intensity control of the primary flood lamps through the FLOOD-OFF-BRT rheostat, and on-off control of the secondary lamps through the FIXED-OFF switch. The DIM-2 position provides variable intensity control of the secondary lamps through the FLOOD-OFF-BRT rheostat, and on-off control of the primary lamps through the FIXED-OFF switch. When operating the primary lamps under variable intensity control (DIM-1 position), turn on of the lamps is acquired after the FLOOD-OFF-BRT rheostat is moved past the midpoint. In transferring variable intensity control to the secondary lamps, the FLOOD-OFF-BRT rheostat should first be rotated to the OFF position before placing the DIM switch to the DIM-2 position. The rheostat is then moved to the full bright setting and should remain in this position unless dimming is desired. Dimming of the secondary flood lamps should not be used unless dimming control of the primary floodlights is not available. Dimming of the secondary lamps results in approximately a 90-percent reduction in lamp life. The range of intensity variation is greater for the primary than the secondary floodlights.

The commander's control panel (MDC-8) has a POST LANDING-OFF-FIXED switch which connects the flight and postlanding bus to his floodlights (fig. A2.6-17). The POST LANDING position provides single intensity lighting to the commander's primary or secondary lamps as selected by the DIM-1 or DIM-2 position, respectively. It is for use during the latter stages of descent after main dc bus power is disconnected, and during postlanding.

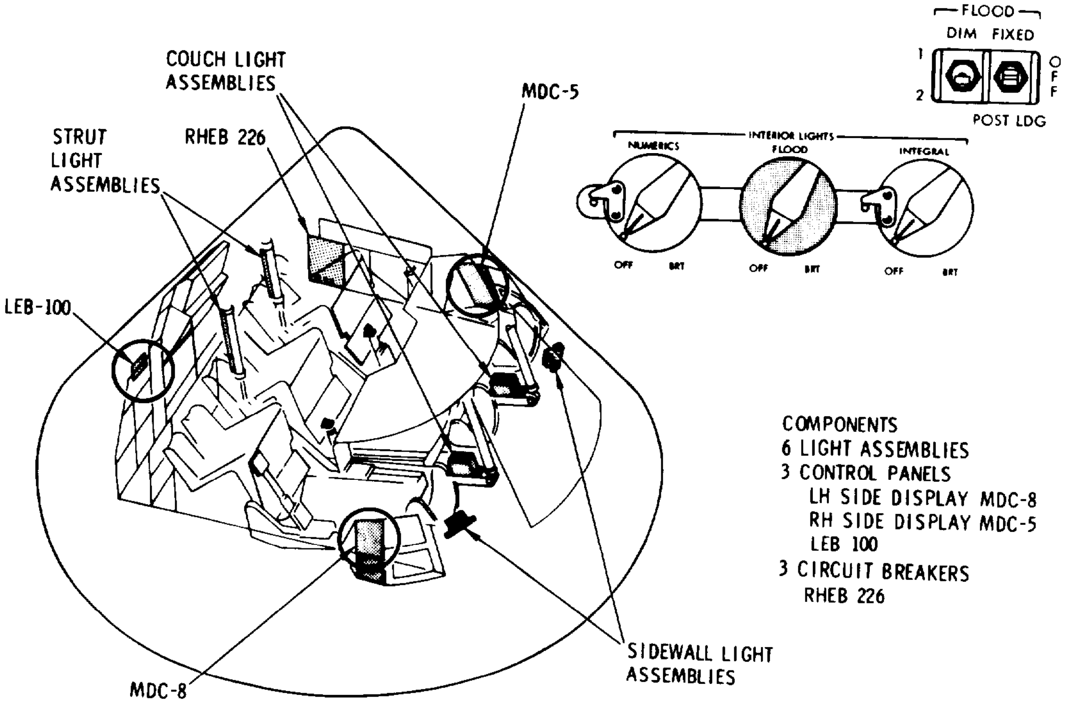


Figure A2.6-16.- CM floodlight configuration.

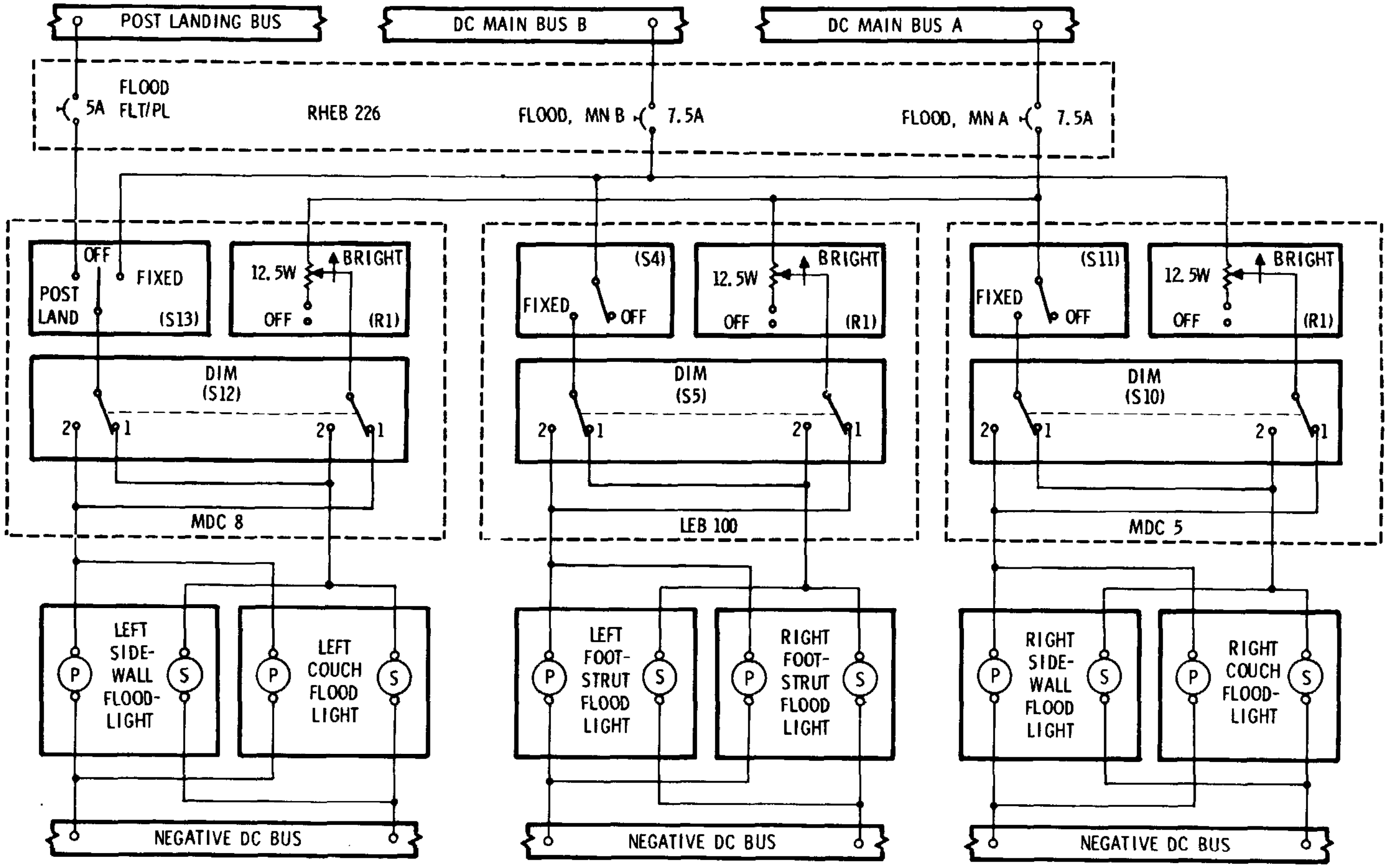


Figure A2.6-17.- CM floodlight system schematic.

Integral lighting system.- The integral lighting system controls the EL lamps behind the nomenclature and instrument dial faces on all MDC panels, and on specific panels in the lower equipment bay, left hand equipment bay, and right hand equipment bay (figs. A2.6-18 and A2.6-19). The controls (fig. A2.6-18) are rotary switches controlling variable transformers powered through the appropriate ac bus. Each rotary control switch has a mechanical stop which prevents the switch being positioned to OFF. Disabling of a circuit because of malfunctions is performed by opening the appropriate circuit breaker on RHEB-226. The INTEGRAL switch on MDC-8 controls the lighting of panels viewed by the commander, MDC-1, 7, 8, 9, 15, and the left half of 2. The INTEGRAL switch on MDC-5 controls the lighting of panels viewed by the LM pilot, MDC-3, 4, 5 and 6, 16, RHEB-229 and 275, and the right half of MDC-2. The INTEGRAL switch on LEB-100 controls the lighting of MDC-10, LEB-100, 101, 122 and the DSKY lights on 140, RHEB-225, 226 and LHEB 306. Intensity of the lighting can be individually controlled in each of the three areas.

Numerics lighting system.- Numerics lighting control is provided over all electroluminescent digital readouts. The NUMERICS rotary switch on MDC-8 controls the off/intensity of numerals on the DSKY and Mission Timer on MDC-2, and the range and delta V indicators of the Entry Monitor System of MDC-1. The switch on LEB-100 controls the off/intensity of the numerals on the LEB-140 DSKY and the Mission Timer on LHEB-306. Protection for the integral and numerics circuits is provided by the LIGHTING-NUMERICS/INTEGRAL-LEB AC 2, L MDC AC 1, and R MDC AC 1 circuit breakers on RHEB-226. These circuit breakers are used to disable a circuit in case of a malfunction. The L MDC AC 1 circuit breakers also feed the EMS roll attitude and scroll incandescent lamps.

Tunnel lighting.- The six light fixtures in the CM tunnel provide illumination for tunnel activity during docking and undocking. Each of the fixtures, containing two incandescent lamps, is provided 28 V dc through a TUNNEL LIGHTS-OFF switch on MDC-2 (fig. A2.6-20). Main dc bus A distributes power to one lamp in each fixture, and main dc bus B to the other lamp. Protection is provided by the LIGHTING/COAS/TUNNEL/RNDZ/SPOT MN A and MN B circuit breakers on RHEB-226.

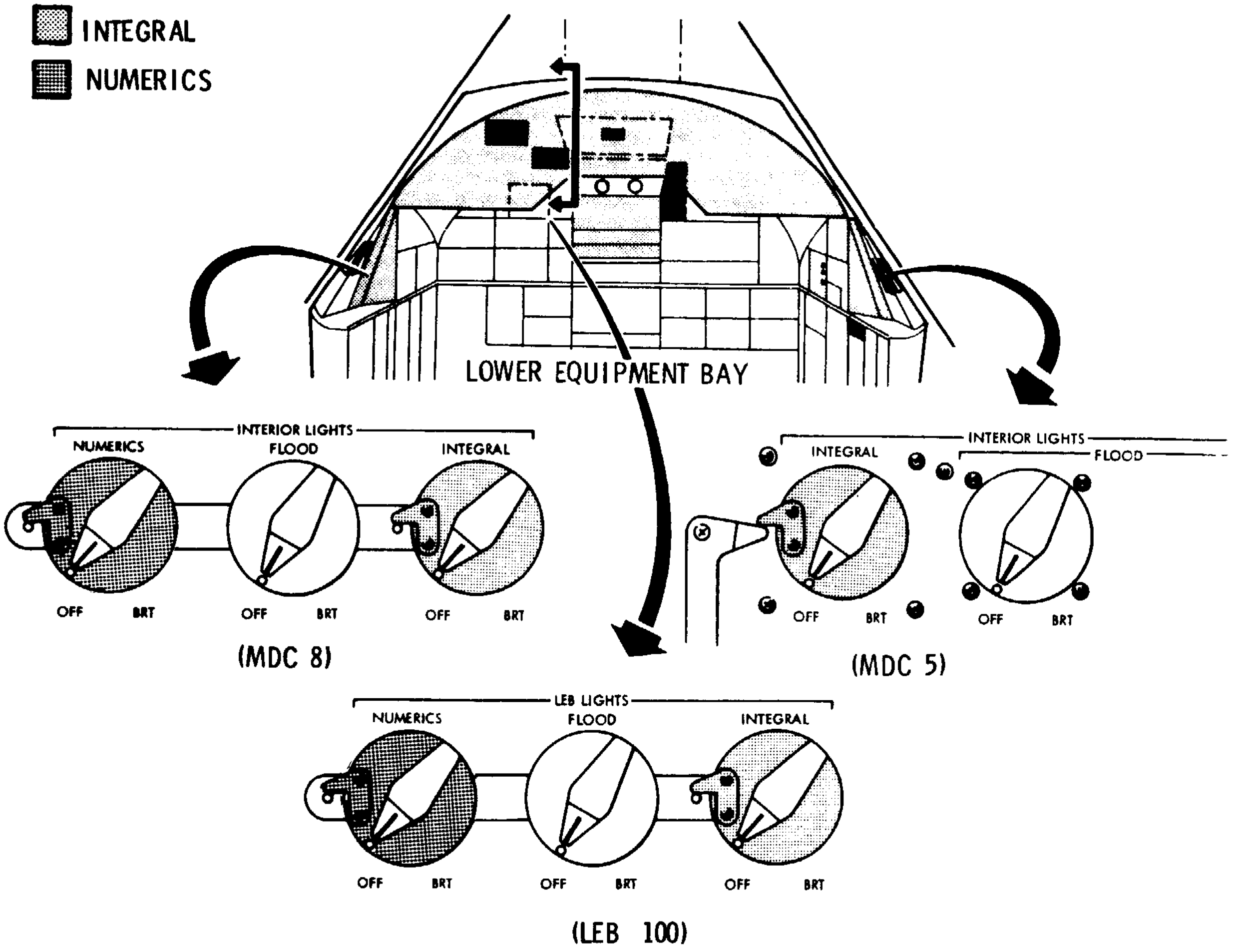


Figure A2.6-18.- CM integral/numerics illumination system.

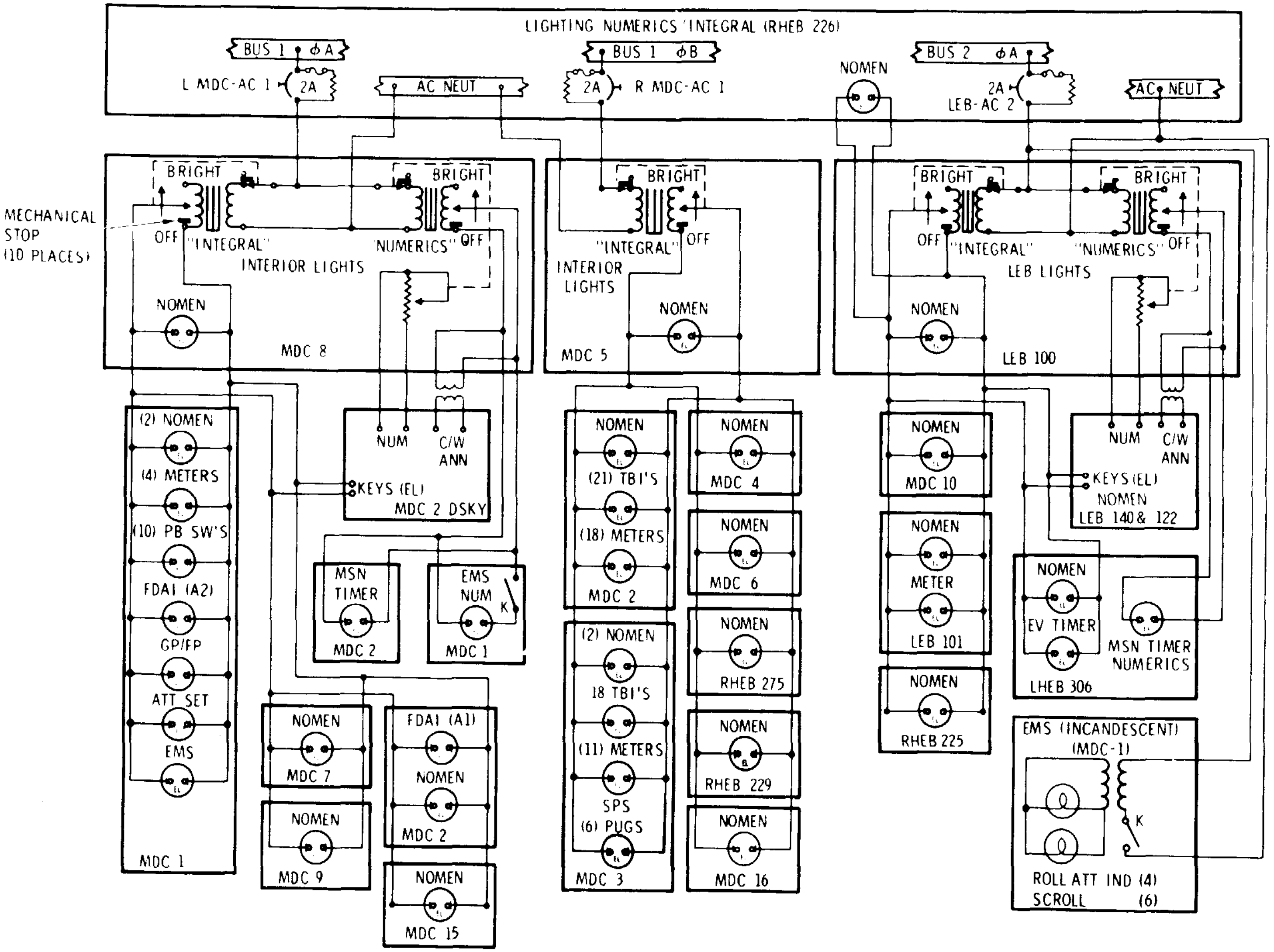


Figure A2.6-19.- Integral and numerics panel lighting schematic.

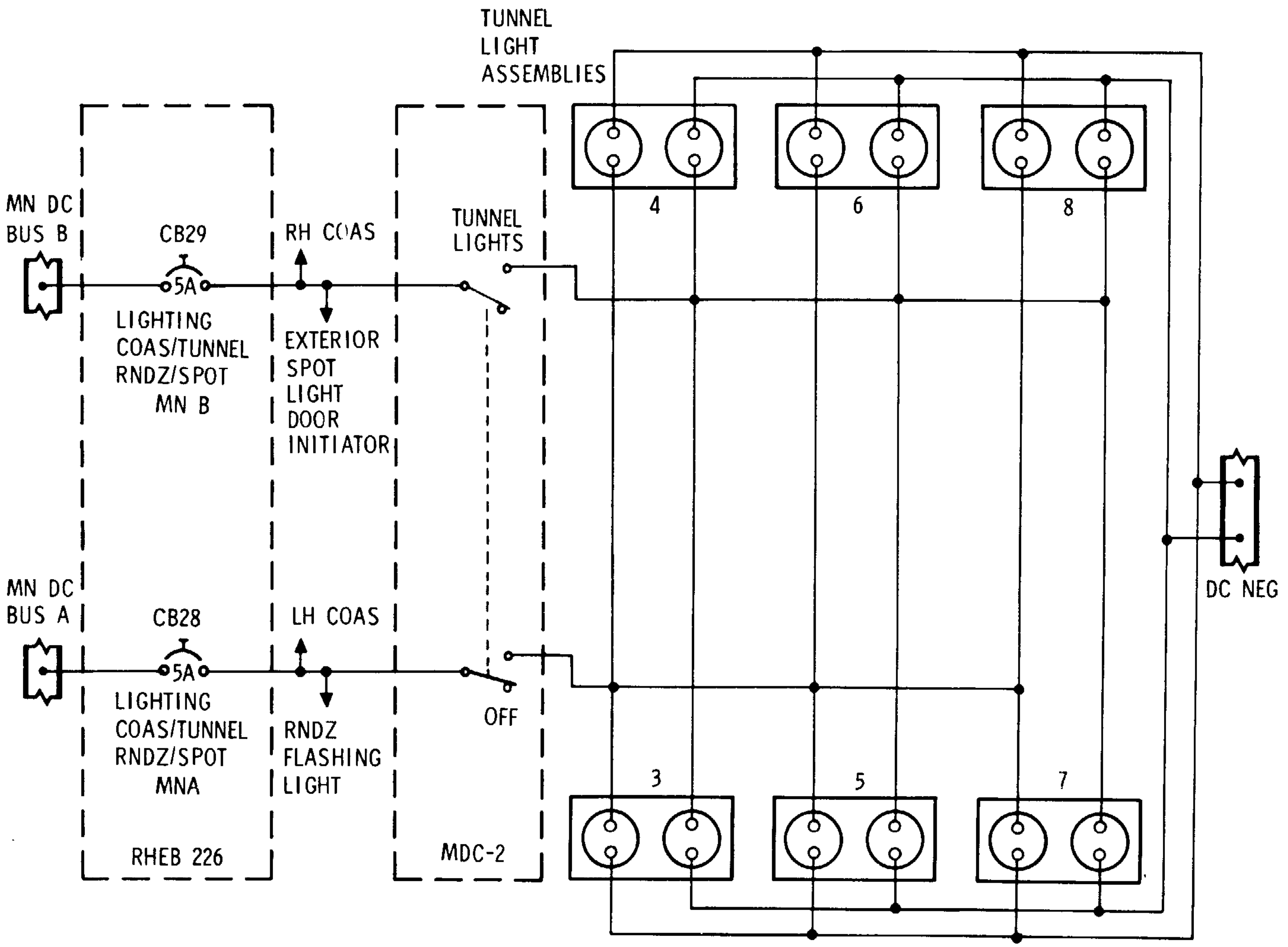


Figure A2.6-20.- Tunnel lighting schematic.

PART A2.7

ENVIRONMENTAL CONTROL SYSTEM

Introduction

The environment control system (ECS) is designed to provide the flight crew with a conditioned environment that is both life-supporting, and as comfortable as possible. The ECS is aided in the accomplishment of this task through an interface with the electrical power system, which supplies oxygen and potable water. The ECS also interfaces with the electronic equipment of the several Apollo systems, for which the ECS provides thermal control, with the lunar module (LM) for pressurizing the LM, and with the waste management system to the extent that the water and the urine dump lines can be interconnected.

The ECS is operated continuously throughout all Apollo mission phases. During this operating period the system provides the following three major functions for the crew:

a. Spacecraft atmosphere control

b. Water management

c. Thermal control.

Control of the spacecraft atmosphere consists of regulating the pressure and temperature of the cabin and suit gases; maintaining the desired humidity by removing excess water from the suit and cabin gases; controlling the level of contamination of the gases by removing CO_2, odors, and particulate matter; and ventilating the cabin after landing. There are provisions for pressurizing the lunar module during docking and subsequent CSM/LM operations.

Water management consists of collecting, sterilizing, and storing the potable water produced in the fuel cells, and delivering chilled and heated water to the crew for metabolic consumption, and disposing of the excess potable water by either transferring it to the waste water system or by dumping it overboard. Provisions are also made for the collection and storage of waste water (extracted in the process of controlling humidity), delivering it to the glycol evaporators for supplemental cooling, and dumping the excess waste water overboard.

Thermal control consists of removing the excess heat generated by the crew and the spacecraft equipment, transporting it to the cab heat exchanger (if required), and rejecting the unwanted heat to space, either by radiation from the space radiators, or in the form of steam by boiling water in the glycol evaporators.

Five subsystems operating in conjunction with each other provide the required functions:

a. Oxygen subsystem

b. Pressure suit circuit (PSC)

c. Water subsystem

d. Water-glycol subsystem

e. Postlanding ventilation (PLV) subsystem.

The oxygen subsystem controls the flow of oxygen within the command module (CM); stores a reserve supply of oxygen for use during entry and emergencies; regulates the pressure of oxygen supplied to the subsystem and PSC components; controls cabin pressure in normal and emergency (high flow-rate) modes; controls pressure in the water tanks and glycol reservoir; and provides for PSC purge via the DIRECT O_2 valve.

The pressure suit circuit provides the crew with a continuously conditioned atmosphere. It automatically controls suit gas circulation, pressure, and temperature; and removes debris, excess moisture, odors, and carbon dioxide from both the suit and cabin gases.

The water subsystem (potable section) collects and stores potable water; delivers hot and cold water to the crew for metabolic purposes; and augments the waste water supply for evaporative cooling. The waste water section collects and stores water extracted from the suit heat exchanger, and distributes it to the water inflow control valves of the evaporators, for evaporative cooling.

The water-glycol subsystem provides cooling for the PSC, the potable water chiller, and the spacecraft equipment; and heating or cooling for the cabin atmosphere.

The postlanding ventilation subsystem provides a means for circulating ambient air through the command module cabin after landing.

Functional Description

The environmental control system operates continuously throughout all mission phases. Control begins during preparation for launch and continues through recovery. The following paragraphs describe the operating modes and the operational characteristic of the ECS from the time of crew insertion to recovery.

Spacecraft atmosphere control.- During prelaunch operations the SUIT CIRCUIT RETURN VALVE is closed; and the DIRECT O_2 valve is opened slightly (approximately 0.2 pound per hour flowrate) to provide an oxygen purge of the PSC. Just before prime crew insertion the O_2 flowrate is increased to 0.6 pound per hour. This flow is in excess of that required for metabolic consumption and suit leakage. This excess flow causes the PSC to be pressurized slightly above the CM cabin. The slight overpressure maintains the purity of the PSC gas system by preventing the cabin gases from entering the PSC.

Any changes made in the pressure or composition of the cabin gas during the prelaunch period is controlled by the ground support equipment through the purge port in the CM side hatch.

As soon as the crew connects into the PSC, the suit gas becomes contaminated by CO_2, odors, moisture, and is heated. The gases are circulated by the suit compressor through the CO_2 and odor absorber assembly where a portion of the CO_2 and odors are removed; then through the heat exchanger, where they are cooled and the excess moisture is removed. Any debris that might get into the PSC is trapped by the debris trap or on felt pads on the upstream side of each LiOH cartridge.

During the ascent, the cabin remains at sea level pressure until the ambient pressure decreases a nominal 6 psi. At that point the CABIN PRESSURE RELIEF valve vents the excess gas overboard, maintaining cabin pressure at 6 psi above ambient. As the cabin pressure decreases, a relief valve in the O_2 DEMAND REGULATOR vents suit gases into the cabin to maintain the suit pressure slightly above cabin pressure.

Sometime after attaining orbit it will be necessary to close the DIRECT O_2 valve to conserve oxygen. (Refer to Volume 2, Apollo Operations Handbook for the procedure.) After the DIRECT O_2 valve is closed, makeup oxygen for the PSC is supplied by the DEMAND REGULATOR when the SUIT CIRCUIT RETURN VALVE is closed or from the cabin via the cabin pressure regulator when the SUIT CIRCUIT RETURN VALVE is open.

Before changing from a suited to a shirtsleeve environment it is necessary to open the SUIT CIRCUIT RETURN VALVE, for the following reasons. When a suit is vented (by removing helmet, gloves, etc.) some of the PSC gases flow into the cabin, which results in contaminating the cabin gas, and in lowering suit pressure relative to cabin pressure. Opening the SUIT CIRCUIT RETURN VALVE allows cabin gas to circulate through the PSC for scrubbing, and tends to equalize the pressure differential between the PSC and cabin. If the valve is not opened, the resultant pressure differential will cause the suit DEMAND REG to dump oxygen into the PSC at a flowrate that will turn on the O_2 FLOW HI warning light. Opening the SUIT CIRCUIT RETURN VALVE will correct this situation.

During normal space operations, the cabin pressure is maintained at a nominal 5 psia by the cabin pressure regulator, at flowrates up to 1.4 pounds of oxygen per hour. In the event a high leak rate develops, the EMERGENCY CABIN PRESSURE regulator will supply oxygen at high flow rates to maintain the cabin pressure above 3.5 psia for more than 5 minutes, providing the leak is effectively no larger than a 1/2-inch hole.

When performing depressurized operations the suit circuit pressure is maintained above 3.5 psia by the O_2 DEMAND REGULATOR; the cabin pressure regulator shuts off automatically to prevent wasting oxygen.

Prior to entry SUIT CIRCUIT RETURN VALVE is closed, isolating the suit circuit from the cabin; the O_2 DEMAND REGULATOR then controls suit pressure. Cabin pressure is maintained during the descent by the cabin pressure regulator until the ambient pressure rises to a maximum of 0.9 psi above cabin pressure. At that point the cabin relief valve will open, allowing ambient air to flow into the cabin. As the cabin pressure increases, the O_2 DEMAND REGULATOR admits oxygen into the suit circuit to maintain the suit pressure slightly below the cabin, as measured at the suit compressor inlet manifold.

After spacecraft landing, the cabin is ventilated with ambient air by postlanding ventilation fan and valves. When the CM is floating upright in the water, the POST LANDING VENT switch is placed in the HIGH (day) or LOW (night) position. Either of these positions will supply power to open both vent valves and start the fan. In the HIGH position, the fan will circulate 150 cubic feet per minute (cfm); LOW, 100 cfm. An attitude sensing device automatically closes both valves and removes power from the fan motor when the CM X axis rotates more than 60 degrees from vertical. Once the device is triggered, it will remain locked up until the CM is upright, and the POST LANDING VENT switch is placed in the OFF position. This action resets the control circuit for normal system operation. The PLVC switch on panel 376 provides an override