CHAPTER 24

LIST OF PAGE EFFECTIVITY

CHAPTER SECTION SUBJECT	PAGE	DATE
24-EFFECTIVITY	1	May 12/78
24-CONTENTS	1	May 12/78
	2	May 12/78
24-00-00	1	May 12/78
24-30-00	101	May 12/78
	201	May 12/78
	202	May 12/78
	203	May 12/78
	204	May 12/78
24-31-00	101	May 12/78
	102	May 12/78
	103	May 12/78
	104	May 12/78
	201	May 12/78
	202	Nov 2/73
	203	Nov 2/73
	204	Nov 2/73
	205	Nov 2/73
	206	Nov 2/73
	207	Nov 2/73
	208	May 12/78
	209	May 12/78
24-32-00	201	May 12/78
24-50-00	201	Nov 2/73
	202	May 12/78
	202A	May 12/78
	203	Nov 2/73
	204	Nov 2/73
	205	Nov 2/73
	206	Nov 2/73

"END"

CHAPTER 24 - ELECTRICAL POWER

TABLE OF CONTENTS

CHAPTER 24 - ELECTRICAL POWER

TABLE OF CONTENTS (Cont'd)

"END"

GENERAL - DESCRIPTION AND OPERATION

AC GENERATION

Since the major portion of the airplane instrumentation functions on dc power, the ac power requirements are confined to only the fuel flow indicator, windshield heat, and some avionics. The inverter for the fuel flow indicator is a small unit designed to supply power only to this instrument. An inverter is installed for the operation of the left windshield heat and is activated by a switch on the pilot's subpanel marked L. WSHLD - OFF. This inverter is also used as a standby for the avionics inverter.

Avionics power is obtained by two switches mounted on the upper switch panel. One is marked MASTER - OFF and activates power to the avionics equipment. For that equipment requiring ac current, a three position switch marked MN INV - OFF - STBY INV must be placed in the MN INV position. Should a failure occur in the main inverter, the switch can be placed in the STBY INV position. This opens a relay to direct the current from the windshield heat inverter to the avionics provided the L. WSHLD switch is on. Because the STBY INV switch position is designed only to direct the current flow, no power can be supplied to the avionics with the L. WSHLD switch in the OFF position. Power for the operation of both systems cannot be supplied by this inverter at the same time.

AC VOLTAGE FREQUENCY INDICATOR

On airplanes that are equipped with the AC Voltage Frequency Indicator, the instrument is located in the pilot's instrument panel below and to the left of the standard turn and slip instrument. This instrument informs the flight crew when the ac voltage and frequency are not within the required limits for accurate operation of the ac power to the turn and slip, directional gyro, attitude and gyro horizon. Two terminal posts are located on the back of the instrument. The electrical wire leading from the main bus is connected to the left terminal post and the line supply is connected to the right terminal post.

DC GENERATION

GENERATORS

The Duke 60 Series electrical system includes two 125 ampere generators. The generators are isolated from the airplane bus by reverse current diodes and generator control relays, and are regulated individually by a carbon-pile type regulator. The circuit of each generator contains an overvoltage relay to protect the airplane system from excessive voltage. Paralleling relays are used to connect the equalization circuits of the voltage regulators and to sense generator output to the annunciators in the pilot's compartment.

BATTERY

The Duke 60 Series airplanes, P-4 through P-225, are equipped with either General Electric or Gulton nickel-cadmium batteries. P-226 through P-445 are equipped with General Electric air cooled nickel-cadmium batteries. For maintenance on these type batteries, refer to BATTERY MAINTENANCE PROGRAM (Airplanes prior to P-446), Chapter 24-31-00.

Airplanes P-446 and after are equipped with two 12 volt lead-acid batteries connected in series to provide 24 volts. To obtain optimum service from the twin battery, proper and regular maintenance of the batteries must be performed. For maintenance procedures on the lead-acid batteries, refer to BATTERY MAINTENANCE PROGRAM (P-446 and after), Chapter 24-31-00.

BATTERY CHARGE CURRENT DETECTOR SYSTEM

The battery charge current detector system installed on airplane serials P-243 through P-445 and those prior airplanes which have complied with Service Instructions No. 0587-356, provides an indication of the amount of battery charge current.

The system consists of a shunt in the negative lead of the battery, a current detector assembly located adjacent to the battery and a yellow caution light (BATTERY CHARGE) on the annunciator panel. The detector assembly receives power through a 5 ampere circuit breaker. The system senses the battery current through the shunt. Any time the battery charge current exceeds approximately 3 amperes for a period longer than approximately 6 seconds, the yellow light will be illuminated.

"END"

TROUBLESHOOTING
GENERATOR SYSTEM

TROUBLE		*PROBABLE CAUSE*		*REMARKS*
1. Zero or low charge indicated.	a.	Engine speed too low.	a.	Increase speed.
	b.	Loose connections.	b.	Check connections throughout system.
	c.	Open or shorted field circuit in generator; defective armature.	c.	Test resistance of field. Check field circuit connections. Replace generator if defective.
	d.	Brushes not contacting commutator.	d.	Clean brushes and holders with a clean lint-free, dry cloth. Replace weak springs.
	e.	Brushes worn out.	e.	Replace brushes if worn to a length of 1/2 inch or less.
	f.	Dirty commutator.	f.	With generator running, clean commutator with No. 0000 sandpaper. Use filtered air jet to remove grit.
	g.	Defective voltage regulator.	g.	Replace regulator.
	h.	Defective loadmeter.	h.	Replace loadmeter.
2. No generator output.	a.	Current limiter blown.	a.	Check for short circuit; replace.
	b.	Open circuit.	b.	Check continuity of circuit.
	c.	Defective generator control switches, generator control relay, or reverse current diode.	c.	Test switches, relay, or diode. Replace if defective.
	d.	Generator not turning.	d.	Check generator drive belts. Replace if necessary.
3. Low generator output.	a.	Generators not paralleled.	a.	Readjust minimum-load voltage. Then readjust paralleling rheostats.
4. Loadmeter reads off scale in wrong direction.	a.	Generator field magnetized in wrong direction.	a.	Flash field. (Do not flash field when generator is running.)
5. Loadmeter does not read.	a.	Loose connection or ground in airplane wiring.	a.	Check entire system.
	b.	Open fuse in loadmeter circuit.	b.	Check for short circuit; replace.

"END"

DC GENERATION - MAINTENANCE PRACTICES

GENERATOR REMOVAL

a. Remove the lower engine cowling.

b. Remove the generator wiring.

c. Remove the generator cooling air duct.

d. Remove the bolt from the adjusting bracket and loosen the attaching bolts of the mounting bracket until the generator can be rotated to permit removal of the drive belts from the generator.

e. Remove the attaching bolts and remove the generator from the airplane.

GENERATOR INSTALLATION

a. Secure the generator to the mounting brackets with the attaching bolts. Leave the bolts loose enough to allow the generator to rotate sufficiently to install the drive belts.

NOTE

To equalize belt service life, the belts must be replaced in pairs.

b. Install the bolt and washer in the adjusting bracket.

c. Position the generator in the mounting brackets so that a four pound pressure applied at the center of the belts will result in 1/4 inch deflection. Tighten the attaching bolts to a torque of 160 to 190 inch-pounds.

d. Safety as necessary.

e. Attach the generator cooling air duct.

f. Attach the electrical wiring and tighten securely.

GENERATOR BRUSH REPLACEMENT

During periodic maintenance inspections, the generator brushes should be inspected for cracks, chipped edges, loose or frayed wire. A lateral groove in the edge of the brush is an indication of the minimum wear length (approximately 1/2 inch). The brush should be replaced if it has been worn to the indicator or if it is obvious that the brush will reach the minimum length before the next inspection time.

New brushes must be properly seated on the commutator surface before the generator is subjected to heavy loads to prevent arcing which will cause burning and pitting of the commutator. New brushes should be sanded and run-in to properly seat them on the commutator surface. Refer to the applicable Vendor Publication (Chapter 20-00-00) for replacement and run-in procedures.

OVERVOLTAGE RELAYS

No attempt should be made to adjust the overvoltage relays. They are preset at the factory to trip at a voltage of 33.00 + 0.0 – 0.25 volts. When the relay is determined defective, it should be replaced with a new or exchange relay.

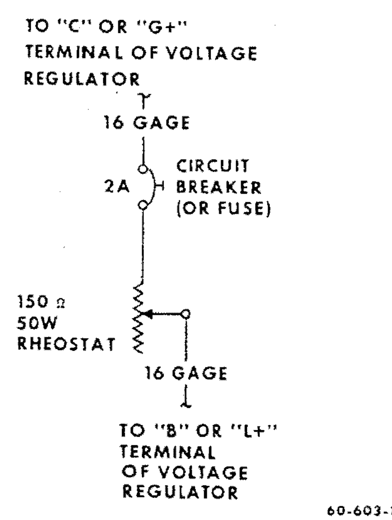
OVERVOLTAGE RELAY CHECK (Figure 201)

The overvoltage relays should be functionally checked for proper operation at 500 hour intervals or whenever an overvoltage relay, voltage regulator or generator is replaced. This test may best be accomplished in the airplane.

A variable resistance introduced in series with the voltage regulator input will allow the generator system to be driven into an overvoltage condition without disturbing the voltage regulator adjustment. The electrical components involved in this check are located in the electrical equipment compartment, immediately aft of the LH nacelle firewall. Test each overvoltage relay separately as outlined in the following procedure:

a. Attach a set of 16 gage test leads to a 2 ampere circuit breaker (or fuse) and a 150 ohm rheostat with a minimum rating of 50 watts.

b. Disconnect the wire, P117A18, from the voltage regulator base terminal which may be marked "B" or "L+". Then, disconnect the wire P116A18 from the terminal marked "C" or "G+".



Overvoltage Test Circuit
Figure 201

NOTE

Refer to the Wiring Diagram Manual, P/N 60-590001-29, for the applicable wiring code.

Attach the test lead from the wiper contact of the 150 ohm rheostat to the "B" or "L+" terminal of the RH voltage regulator.

c. Attach the test lead from the 2 ampere circuit breaker (or fuse) to the "C" or "G+" terminal of the RH voltage regulator. Do not remove the existing wire from the "C" or "G+" terminal.

d. Monitor the overvoltage relay trip voltage with a precision voltmeter that is known to be accurate within one percent over a range of 0 to 50 volts. Connect the voltmeter test leads to the voltage test jacks located on the right circuit breaker panel (P-436 and after). On airplanes prior to P-436, connect the positive lead of the circuit breaker bus behind the subpanel. Connect the negative lead of the voltmeter to the airplane structure.

e. Adjust the 150 ohm rheostat to its minimum resistance setting.

CAUTION

To prevent excessive overvoltage, check the resistance with an ohmmeter to ensure the rheostat is set for minimum resistance prior to initiating this test. Do not operate the system above 29 volts for more than two minutes during the test. If the battery is subjected to voltages in excess of 32 volts for more than two minutes, the battery must be removed from the airplane and completely serviced.

f. Start the engines and advance the throttles as required to obtain desired voltage output.

g. Turn off all switches and circuit breakers except the battery master switch and the generator protection circuit breakers.

CAUTION

Should the test equipment be improperly installed, the airplane electrical equipment may be damaged unless all switches and circuit breakers except those noted above are turned off.

h. After the airplane's loadmeters stabilize at a point below 10 percent of full scale, observe the precision voltmeter while slowly increasing the resistance setting of the 15(ohm rheostat. A sharp drop in voltage will indicate the operation of the voltage relay. This should occur when the precision voltmeter registers a reading of 32 to 34 volts. The GENERATOR OUT light on the annunciator panel shoul(illuminate at the same time the overvoltage relay trips. If the overvoltage relay does not operate within the prescribe(limits, it should be replaced with a new one, then recheckec for proper operation as in steps "f" through "h".

VOLTAGE REGULATOR ADJUSTMENT ANL GENERATOR PARALLELING

It is desirable that both generators share the electrical loa(equally. To obtain this condition, the voltage regulators an(the paralleling rheostats must be properly adjusted. The paralleling rheostats and voltage adjustment potentiometer: are located in the cabin (P-466 and after) for convenient an(precise adjustments. The adjustment procedure is outlined ir the following paragraphs.

PRELIMINARY POTENTIOMETER CHECK

A potentiometer located on each voltage regulator in the le nacelle, must be permanently adjusted to minimum resist ance (fully ccw). If the regulators have been changed or th setting altered for any reason, remove the access cover o top of the left nacelle, aft of the engine cowling, and ensur that these potentiometers are adjusted fully counterclock wise. No other adjustments or connections to component located within the nacelle compartment will be necessary fc voltage and paralleling settings.

PRELIMINARY ADUSTMENT OF PARALLELING RHEOSTATS.

a. On airplanes prior to P-466, open the electrica components compartment access cover on top of the le nacelle aft of the engine cowling. On P-466 and after, remov the access panel (placarded GENERATOR VOLTAGE ADJUSTMENT) located behind the copilot's seat on the righ side.

b. On airplanes prior to P-466, connect the negativ lead of a voltmeter to terminal "D" on the left voltage regulator base and the positive lead to the airplane structure (Terminal "D" carries a voltage that is negative with respe(to the airplane structure.) On P-466, connect the negativ lead of a voltmeter to the terminal point of wire P113B18 o the left paralleling rheostat and the positive lead to the termi nal point of wire P113C18N on the same rheostat. (Th negative test point carries a voltage that is negative wit respect to the airplane structure.)

c. Operate the LH engine with the generator chargin and carrying a moderate to heavy electrical load.

CAUTION

Monitor the bus voltage as soon as the generators are turned on. Voltages in excess of 32 volts for two minutes will damage the battery.

d. Monitor the voltmeter and turn the LH paralleling rheostat first clockwise then counterclockwise to determine which direction of rheostat rotation results in an increasing negative voltage.

e. Turn the LH paralleling rheostat to a maximum negative voltage then decrease the voltage by turning the rheostat back 1/8 turn.

f. Repeat steps "c", "d", and "e" for the RH system.

STABILIZATION OF GENERATOR SYSTEM

The generators and regulators must be stabilized for temperature changes before any final adjustments are attempted. Operate both engines at approximaely 1,000 rpm with both generators ON and a heavy electrical load turned on. Use the lights, blowers, radio equipment, etc. to obtain a 20% electrical load for each generator. Allow a minimum of 20 minutes to stabilize the system.

CAUTION

Do not operate the heated windshield or pitot heat for extended periods during ground operation. Excessive heat buildup may cause damage to these components.

VOLTAGE ADJUSTMENT (MINIMUM LOAD)

PRIOR TO P-466

On airplanes prior to P-466, the voltage regulators are adjusted to produce a voltage of 28.25 ± 0.25 volts measured at the battery relay with a minimum electrical load on the system as follows:

NOTE

If the airplane is to be operated continuously where temperatures are 32°F or below, the voltage should be adjusted to 28.50 ± 0.25 volts.

a. Connect the positive lead of a portable precision voltmeter to the battery relay. The meter must be capable of measuring 28.25 volts with an accuracy of 1%. Connect the negative lead of the voltmeter to a good ground.

b. Operate both engines at 1 300 to 1 500 rpm with both generators ON, and the electrical load reduced to a minimum.

c. Turn the RH generator OFF. Determine the bus voltage as maintained by the LH generator.

d. Turn RH generator ON and LH generator OFF. Determine the bus voltage as maintained by the RH generator.

e. Turn the LH generator ON, and idle the engines.

NOTE

Maintain temperature stabilization by operating the generators individually for only short periods.

f. Make the necessary voltage adjustments by turning the voltage adjusting potentiometer on the voltage regulator clockwise to increase the voltage and counterclockwise to decrease the voltage. Make the adjustments in small increments only. Allow ample time for the voltage to stabilize before making further adjustment.

g. Repeat steps "b" through "f" until the minimum load voltage is satisfactory.

CAUTION

Never adjust the core or carbon pile adjusting screw (slotted heads in the ends of the regulators). The regulating characteristics of the regulators will be altered as well as the voltage setting.

P-466 AND AFTER

On airplanes P-466 and after, the voltage regulators are adjusted to produce a voltage of 28.25 ± 0.25 volts measured at the main bus with a minimum electrical load on the system as follows:

NOTE

If the airplane is to be operated continuously where temperatures are 32°F or below, the voltage should be adjusted to 28.50 ± 0.25 volts.

a. Connect the positive lead of a portable precision voltmeter to the positive (red) test jack located on the right circuit breaker panel. Connect the negative lead to the negative (black) test jack. The meter must be capable of measuring 28.25 volts with an accuracy of ± 0.25 volts.

b. Operate both engines at 1300 to 1500 rpm with both generators ON, and the electrical load reduced to a minimum. Adjustment of both voltage potentiometers in steps "c" and "d" will provide an increase in voltage when the potentiometers are turned clockwise. Make the adjustment in small increments only. Allow ample time for the voltage to stabilize before making further adjustments.

c. Turn the right generator OFF and adjust the left voltage potentiometer to 28.25 ± 0.25 volts.

d. Turn the right generator ON and the left generator OFF and adjust the right voltage potentiometer to 28.25 ± 0.25 volts.

e. Repeat steps "c" and "d" until the minimum load voltage is satisfactory.

CURRENT ADJUSTMENT (MAXIMUM LOAD)

The paralleling rheostats are adjusted to produce equal outputs from the generators at heavy loads.

a. Check the accuracy of the loadmeters on the instrument panel by alternately switching from one generator to the other while a normal load is turned on. If equal readings are obtained as each generator supplies the current individually, the loadmeters are satisfactory. If excessive deviation in loadmeter readings exist, the loadmeters should be replaced.

b. Operate both engines at 1 300 to 1 500 rpm with both generators ON. Turn on all feasible electrical loads using lights, blowers, radio equipment, etc, except pitot heat and heated windshield.

c. Read the loadmeters. Each generator should take its share of the load within 10% of the loadmeter full scale reading.

d. Adjust the paralleling rheostats until the load is equally shared by increasing the output from the low generator and decreasing the output from the high generator.

NOTE

To maintain sensitivity, keep both rheostats as near the maximum voltage end of the rheostat as possible. There is a possibility of excessive sensitivity resulting in a "hunting" condition. Should such a condition be encountered, sensitivity may be reduced by turning both paralleling rheostats away from the high voltage end.

e. Check both minimum current voltage and ma imum current paralleling at cruise engine rpm (2,750 rpm

FINAL PARALLELING CHECKS

PRIOR TO P-466

a. Secure the access cover in place using sufficie fasteners to hold the cover securely in place during engi operation.

b. Stabilize the regulator and generator temperatur as outlined in STABILIZATION OF GENERATOR SYSTE

c. Check both minimum load voltage and maxim current paralleling at cruise engine rpm (2,750 rpm).

d. Remove the cover and make any necessary a justments. Replace the access cover and repeat the chec

e. After determining that the adjustments are sat factory, secure the access cover in place using all fastene

P-466 AND AFTER

a. Stabilize the regulator and generator temperatu as outlined in STABILIZATION OF GENERATOR SYSTE

b. Check both minimum load voltage and maxim current paralleling at cruise engine rpm (2750 rpm).

c. Make all necessary adjustments before replac the access panel.

"END"

TROUBLESHOOTING BATTERY SYSTEM

TROUBLE		*PROBABLE CAUSE*		*REMARKS*
1. No power indicated with battery master switch ON.	a.	Battery discharged or defective.	a.	Recharge or replace battery.
	b.	Open circuit between battery and master switch.	b.	Check continuity.
	c.	Master switch defective.	c.	Check switch for operation.
	d.	Defective relay.	d.	Check relay operation.
2. Power on with master switch in OFF position.	a.	Master switch defective.	a.	Check switch for operation.
	b.	Relay contacts stuck.	b.	Check and replace relay if necessary.

TROUBLESHOOTING NICKEL-CADMIUM BATTERY

1. Apparent loss of capacity.	a.	Cells unbalanced.	a.	Equalize cell voltage by performing full capacity discharge cycle.
	b.	Electrolyte level too low.	b.	Charge, adjust electrolyte level, and capacity test.
	c.	Charging rate too low in airplane.	c.	Check and adjust airplane charging system.
	d.	Too little usage or shallow discharges.	d.	See "a" above.
2. Complete failure to operate.	a.	Loose or broken lead.	a.	Repair or replace.
	b.	Loose or disengaged terminals in battery.	b.	Repair or replace any damaged hardware, and capacity test.
	c.	Battery not charged.	c.	Charge and capacity test.
	d.	Cell open internally.	d.	Replace defective cell and capacity test.
3. Excessive spewage (crystalline deposits on outside of cells).	a.	Excessive charge rate.	a.	Clean the battery, recondition, adjust the electrolyte level and capacity test. Adjust voltage regulator of airplane.
	b.	Electrolyte level too high.	b.	Clean cell.
	c.	Vent caps loose or broken.	c.	Clean cell, replace or tighten vent cap.
	d.	Cracked cell case.	d.	Replace cell, clean battery.

TROUBLESHOOTING
NICKEL - CADMIUM BATTERY (Cont'd)

TROUBLE	PROBABLE CAUSE	REMARKS
4. Cell cases distorted.	a. Excessive charge rate.	a. Clean the battery, recondition, adjust the electrolyte level and capacity test. Adjust voltage regulator of airplane.
	b. Cell with internal short.	b. Replace defective cell, recondition and capacity test.
	c. Plugged vent caps, minor explosion.	c. Disassemble, replace defective parts, clean the battery, recondition and capacity test.
5. Unequal voltages among cells.	a. Cells unbalanced.	a. Equalize cell voltages (perform a full capacity discharge cycle) and capacity test.
6. Foreign matter within cells.	a. Impure or acid-contaminated water.	a. Such cells will not normally respond to charging. They will show up as unbalanced cells and must be replaced.
7. Frequent addition of water.	a. Unbalanced cells.	a. Equalize cell voltages.
	b. Leaky or defective cells, damage to O-ring or vent cap.	b. Replace defective parts and inspect for electrolyte leakage. Clean, recondition and level electrolyte.
8. Burn marks on connectors.	a. Loose connectors.	a. Tighten connectors.
9. Overheating of inter-cell connectors.	a. Loose or dirty inter-cell connectors.	a. Disassembly, clean, reassemble and properly torque inter-cell connectors, and capacity test.
10. Foam or bubbling during charging.	a. Oil or grease contamination in the electrolyte.	a. Replace defective cells.
	b. Low concentration of electrolyte.	b. Recondition, replace cells that continue to foam.
11. Below normal output.	a. Battery switch left ON.	a. Recharge and capacity test.
	b. Voltage regulator set too low.	b. Recharge and capacity test. Reset voltage regulator.
	c. Internal connection links loose.	c. Torque, recharge and capacity test.
	d. External connector burned or pitted.	d. Clean or replace, recharge and capacity test.
	e. Cell case current leakage.	e. Disassemble, clean and recondition, replace any defective cells, and capacity test.

TROUBLESHOOTING
LEAD-ACID BATTERY

TROUBLE	PROBABLE CAUSE	REMARKS
1. Battery will not hold its charge.	a. Battery is worn out.	a. Replace battery.
2. Battery will not come up to full charge.	a. Charging rate set too low.	a. Adjust voltage regulator on airplane.
3. Battery consumes water rapidly.	a. Faulty battery.	a. Replace battery.
	b. Voltage regulator set too high.	b. Adjust voltage regulator on airplane.
4. Electrolyte runs out of vent plugs.	a. Electrolyte level too high.	a. Remove excess electrolyte down to specified level.
	b. Excessive charging rate.	b. Adjust voltage regulator on airplane.
	c. Vent caps loose or broken.	c. Replace or tighten vent caps.
5. Battery low.	a. Standing too long.	a. Remove battery and recharge.
	b. Equipment left on accidentally.	b. Remove battery and recharge.
	c. Short circuit or ground in wiring.	c. Check wiring and correct malfunction, then remove battery and recharge.
	d. Broken cell partition.	d. This is usually indicated by two or more adjacent cells running down continually, particularly, if left standing a few days. Replace battery.
6. Compound on top of battery melts.	a. Charging rate too high.	a. Adjust voltage regulator on airplane.
7. Cell connector melted in center.	a. Shorted or grounded cable causing direct full discharge of battery.	a. Check cables and repair malfunction. Replace battery.
8. Battery freezes.	a. Discharged.	a. Replace battery.
	b. Water added in cold weather without charging the battery sufficiently afterward to thoroughly mix the water with electrolyte before letting stand.	b. Replace battery.
	c. Too low specific gravity of the electrolyte caused by improper filling.	c. Replace battery.

TROUBLESHOOTING
LEAD-ACID BATTERY

TROUBLE	*PROBABLE CAUSE*	*REMARKS*
9. Cracked cell jars.	a. Hold down loose.	a. Replace battery.
	b. Frozen battery.	b. Replace battery.

"END"

DC GENERATION - MAINTENANCE PRACTICES

BATTERY MAINTENANCE PROGRAM (Airplanes prior to P-446)

A Systematic Battery Maintenance Program should be established and carefully followed.

CAUTION

Methods of servicing lead-acid batteries do not apply for the servicing of nickel-cadmium batteries.

a. The battery should be removed from the airplane for service.

b. A log of the services performed on each battery should be maintained.

c. The battery should be removed from the airplane and serviced after: 100 flight hours or 30 days, whichever occurs first. If the ambient temperatures are above 90°F or the time between engine starts averages less than 30 minutes, the duty cycle should be reduced.

d. The log of battery services performed should be evaluated to determine the need to service the battery at the above recommended intervals or to extend the intervals if justified. Accurate water consumption data is a valid barometer to use for adjustment of the servicing intervals.

Since the proper battery servicing requires two days, an additional battery (or batteries) will be required where airplane utilization warrants. For additional information on battery maintenance, refer to Gulton Instructions for Use and Care of Sintered Plate Vented Nickel-Cadmium Storage Batteries (P/N ABD-1100), or Marathon Battery Instruction Manual (P/N BA-89), or Operating and Service Manual for General Electric Nickel-Cadmium Vented-Cell Batteries (P/N GET-3593A), which ever the airplane is equipped with. Advisory Circular AC 00-33, printed by Department of Transporation, Federal Aviation Administration, is another good source of battery maintenance information.

MAINTENANCE LOG

Customers are advised to keep a complete and up-to-date maintenance log on each battery. This information will help determine the source of any battery problems and will assist in substantiating warranty claims. A sample format for a maintenance log is illustrated on the following page.

BATTERY REMOVAL

a. Remove the upper access door to the electrical equipment compartment, aft of LH nacelle firewall.

b. Cut the safety wire and remove the battery quick-disconnect.

c. On serials P-226 through P-445, equipped with General Electric air cooled batteries, disconnect the cooling ducts.

d. Disconnect the battery vent tubing.

e. Cut the safety wire, remove the two nuts from the battery hold-down bar and lift the battery out of the well.

PRE-INSTALLATION INSTRUCTIONS FOR NICKEL-CADMIUM BATTERIES

Unless otherwise indicated by a red warning tag, a nickel-cadmium battery is shipped in fully discharged state and contains the proper amount of electrolyte.

Observe the following precautions to ensure maximum performance and to protect the battery warranty.

a. Do not remove the shorting strap until prepared to charge the battery. Batteries from which the shorting strap has been removed (for even a short period of time) must be considered in an unknown state of charge condition and must be completely discharged prior to charging and installation.

b. Inspect batteries shipped from the factory for shipping plugs in the vent holes of each of the battery cells. The blunt aluminum screws that serve as shipping plugs must be removed prior to operation of the battery. The Bunson valves, included with the battery in a separate plastic bag, should then be screwed into the vent cap assembly in place of the screw plugs. The Bunson valves will release excessive pressure from gas accumulation to prevent cell rupture.

NOTE

On batteries not equipped with the screw-type plugs and Bunson valves, remove the shipping plugs and clean the filler cap vent plugs as noted under CLEANING AND INSPECTION. Retighten the cell vents with the vent plug wrench included with the battery.

c. Check for a torque of 6 foot-pounds on the terminal screws securing the cross links connecting the cells together.

d. Before charging, determine that all cells are properly installed by making a cumulative voltage check.

e. After determining the battery is in good physical condition and is properly assembled, it should be charged as outlined under BATTERY CHARGING and the electrolyte level adjusted.

BATTERY INSTALLATION

a. Place the battery in the well, install the battery hold-down bar and the two nuts. Safety wire the nuts.

MAINTENANCE LOG

Catalog No. ______________________ Serial No. ______________________

Date Installed ______________________ On ______________________

REMOVAL DATE AND REASON	GENERAL CONDITION	END OF CC CHARGE VOLTAGE RANGE		ELECTROLYTE LEVEL	ELECTRICAL LEAK CHECK	CAPACITY	REMARKS
M — Maintenance F — Failure (Indicate Type)	Case and Cover Hardware and Liners Cells and Vents	Lowest Reading Minimum 1.50	Highest Reading Maximum 1.70				Indicate: Average water added, hardware or cell replacements, burns or discolorations, etc.

b. Connect the battery vent tubing.

c. On serials P-226 and after, connect the cooling ducts.

d. Install the battery quick-disconnect and safety wire.

e. Reinstall the upper access door aft of the LH nacelle firewall.

BATTERY CHARGING

The two basic methods of charging nickel-cadmium batteries are the constant potential and constant current methods. Variations of the two basic methods may be incorporated in automatic equipment.

WARNING

Complete servicing of the battery is required if the battery is subjected to more than 32 volts for 2 minutes.

SPECIAL NOTES ON CHARGING

The following special comments are made with respect to charging nickel-cadmium batteries:

a. Charging is most efficient at battery temperatures between 40°F and 80°F.

b. Two or more batteries may be charged in parallel on a constant potential charging bus, provided the charging equipment has the proper current producing capability.

c. Do not charge batteries in parallel using the constant current method.

d. Do not charge individual cells unless the plastic case is supported on each side. A special frame may be built to fit the cell, or two boards or plates may be placed on each side of the cell and held together by a C-clamp. The sides of the cell must be kept flat during charging.

e. Perform necessary inspection, cleaning and repairs before charging.

f. Do not energize charging equipment until after the battery has been connected to the charging circuit.

g. When charging a battery in the shop, a thermometer should be placed so that the bulb is below and between the top of the cells. Do not place on charge any battery that has a temperature of 100°F or higher.

h. The foam sometimes seen in cells during charging does not indicate a defect. Foaming usually occurs after water is added and will disappear after a few cycles of operation.

The various charging procedures for the nickel-cadmium battery are outlined in the following paragraphs:

CONSTANT CURRENT CHARGING

CAUTION

Monitor the battery closely during charging (especially during the latter stages) to prevent an overcharge that will heat up and damage or destroy the battery.

AIRCRAFT BATTERY INSTALLATION CHECKLIST

- ○ *INSPECT FOR VISIBLE DAMAGE*
- ○ *REMOVE SHIPPING HARDWARE*
- ○ *ENSURE THAT ALL CONNECTORS ARE PROPERLY TIGHTENED (Do not level electrolyte on new battery prior to charging.)*
- ○ *CONNECT BATTERY CORRECTLY TO CHARGER*
- ○ *CHARGE BATTERY (Constant current recommended)*
- ○ *MEASURE END-OF-CHARGE VOLTAGE*
- ○ *REST BATTERY 2 TO 4 HOURS*
- ○ *CHECK ELECTROLYTE LEVEL*
- ○ *CLEAN AND CHECK AIRCRAFT'S BATTERY CONNECTOR*
- ○ *INSTALL BATTERY*
- ○ *CHECK AIRCRAFT'S BATTERY CHARGER SYSTEM*

PREVENTIVE MAINTENANCE CHECKLIST

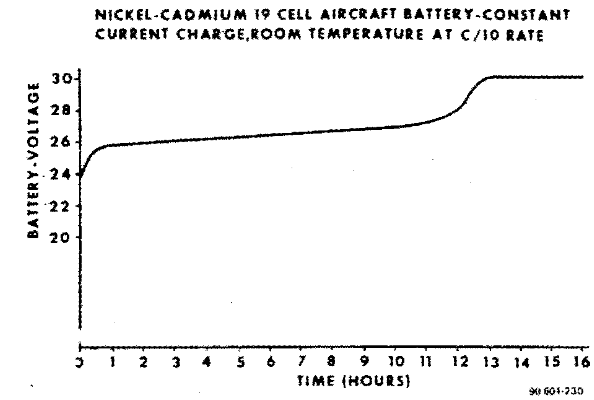
- ◯ *CLEAN BATTERY*
- ◯ *INSPECT FOR VISIBLE DAMAGE*
- ◯ *WASH VENT CAPS*
- ◯ *RECONDITION*
  - ◯ *DISCHARGE AND SHORT*
  - ◯ *CONSTANT CURRENT CHARGE*
  - ◯ *MEASURE END-OF-CHARGE VOLTAGE*
- ◯ *REST BATTERY 2 TO 4 HOURS*
- ◯ *LEVEL ELECTROLYTE*
- ◯ *MEASURE ELECTRICAL LEAKAGE*
- ◯ *DISCHARGE, MEASURING CAPACITY*

Although slower, the constant current method is the recommended way of charging the battery. Most shops are equipped with constant current chargers. In cases where the chargers are limited to 6 ampere capability, it will be necessary to start the charge of most batteries at a lower rate than recommended on the battery nameplate. If a reduced rate is used, a longer charging time is required. The constant current method is much more effective in correcting cell imbalance and temporary loss of capacity, and it permits easy computation of the charge capacity in ampere-hours. When using this method, one must usually monitor and maintain the constant current by manually adjusting the charger.

The following procedures for constant current charging are generally applicable to all aircraft nickel-cadmium storage batteries:

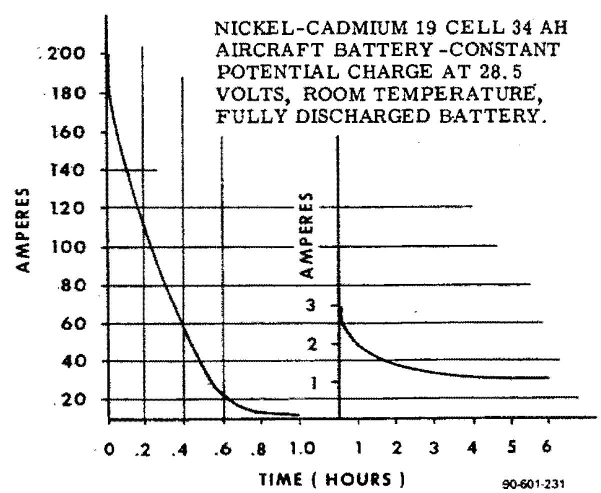
a. The time required to charge a nickel-cadmium storage battery varies with respect to the discharging current, capacity rating, and amount of charge already in the battery. If fully discharged, the battery should be charged to 140 percent of its nominal ampere-hour rating.

b. When using the constant current method of charging, the battery may be charged in two steps by using the START rate of current and the FINISH rate of current. (Lower starting rates may be used if required by such factors as equipment limitations.) These rates are usually given on the battery nameplate. The two step method is commonly used by the military. Single rates, slow or fast, are usually preferred by commercial service shops because of their simplicity. The single fast charging rate is 2.7



Constant Current Charge at C/10 Rate
Figure 201

amperes per hour for the 13.5 ampere-hour battery for seven hours. The slow charging rate is 1.4 amperes per hour for the 13.5 ampere-hour battery for 14 hours. See Figure 201 for slow (capacity/10), single rate, constant current charging voltage. A battery is charged at the START rate until the battery temperature takes a sharp rise or until the terminal voltage (while battery is charging) reaches 29.5 volts (for a 24-volt 19-cell battery). When the 29.5 volt point is reached or the temperature takes a sharp rise, the charging current is reduced to the FINISH rate and continued until one-third of the initial charge in ampere-hours is added. When the voltage rises to 29.5 volts, the charge received by the battery is approximately equal to that removed when it was previously discharged. The addition of ampere-hours at the FINISH rate equal to one-third of the ampere-hour input at the START rate will usually ensure that the battery is fully charged.



Constant Potential Charging
Figure 202

c. The time required for completing the charge at the FINISH rate may be computed by the following formula:

$$T_F = \frac{I_S \times T_S}{3 \times I_F}$$

T_F = Time, in hours, required for finishing charge.

I_S = Starting charge rate in amperes.

T_S = Time, in hours, of charge at the starting rate until 29.5 volts or temperature rise occurs.

I_F = Finish rate in amperes.

As an example, assume that a 20 ampere-hour battery is charged at a start rate of 8 amperes for 2 hours, at which time the voltage rises to 29.5 volts. The ampere-hour input at the start rate is then $I_S \times T_S$ = 16 ampere-hours. The ampere-hours of additional charge required are $(I_S \times T_S)/3 = T_F \times I_F = 16/3 = 5.3$. If a finish rate of 2 amperes is used, the finish rate charge time will be:

$$T_F = \frac{I_S \times T_S}{3 \times I_F} = \frac{16}{3 \times 2} = 2.7 \text{ hours}$$

d. While the battery is being charged, the charging current should be kept constant at the rate being used. If the battery charger is not a self-regulating type, this operation can be achieved by manually adjusting the charger on a periodic basis.

e. During the finish charge, the individual cell voltages should be measured with a precision voltmeter to determine if all cells are rising evenly. Should some cells indicate a voltage lower than the others by .05 volts or more, it is advisable to leave the battery on charge a while longer for additional equalization. Do not allow the battery to overheat.

CONSTANT POTENTIAL CHARGING

Nickel-cadmium batteries can be charged much faster by the constant potential method, but the charging time will depend on the current-delivery capability (300 ampere generators are good charging sources). A disadvantage of constant potential charging is that full capacity cannot normally be restored if a battery suffers from temporary loss of capacity. It should also be noted that such a loss of capacity is quite common in batteries after prolonged use in the aircraft.

a. Vented, 19-cell, 24-volt, nickel-cadmium batteries will normally be charged at 28.5 volts in the shop when charging with a constant potential voltage. Note that charging a 19-cell battery at 28.5 volts is equivalent to charging each cell at 1.50 volts. The initial charging current may be as high as 10 times the ampere-hour rating of the battery, depending on the amount of charge already in the battery. The high initial current will not damage the battery, but the charging equipment should have an inherent current-limiting capability or be provided with overload protection.

b. The time required to charge will depend primarily on the current-delivery capability of the charging unit. The lower the charging current, the longer the time required to charge. If the battery does not suffer from temporary loss of capacity, nearly full charge (approximately 90 percent of rated capacity) may be restored within 1 hour at 28.5 volts charging potential, provided the charging equipment is also capable of delivering current equal to 2 to 3 times the ampere-hour rating of the battery. (See Figure 202.)

CAUTION

When a battery is connected to a constant potential charging source, the initial high charging current will damage any 0-25 or 0-50 ampere-scale ammeter connected in series with the battery.

c. An ammeter with a range of zero to 25 or zero to 50 amperes should be connected in series with the battery and power source to monitor the charging current when the master generator panel meter indicates that the current has dropped sufficiently. Charging should continue until the ammeter indicates a current flow of 1 ampere or less, or until a maximum time of 4 hours has elapsed.

d. Should a battery be severely discharged, charging by the constant potential method may produce a slight imbalance in cell capacity. The imbalance can be detected by a periodic check of the cell terminal voltages with a precision voltmeter after the charging current levels off to a few amperes while the battery is charging. Should some cells differ from others by more than .05 volts, connect the battery to a constant current source and charge for 14 hours at a rate of 1.4 amperes on a 13.5 ampere-hour battery. If the cells still fail to equalize, perform an equalization charge.

BATTERY STAND-BY CHARGING

Since the self-discharge rate of a nickel-cadmium battery is approximately 1.2 percent per day at normal temperatures, standby charging is required to maintain a battery at its full rated capacity. For standby charging in the temperature range of 60°F to 90°F, use a current equal to .003 ampere per each ampere hour of rated capacity. Batteries on stand-by charge must be regularly checked to ensure adequate electrolyte level.

CAPACITY RECONDITIONING

The capacity of a nickel-cadmium battery does not decrease appreciably with age. However, there can be a temporary loss of capacity under certain duty cycles. A temporary loss of capacity is normally an indication of imbalance between cells. Imbalance can be caused by differences in temperature, charge efficiency, self-discharge rate, etc. The purpose of reconditioning is to restore a battery to its full capability and to prevent premature damage and failure. Effective reconditioning requires specific procedures for certain periods of time. No step in the procedure can be eliminated nor can any time period be shortened and still yield effective battery reconditioning.

FREQUENCY OF RECONDITIONING

Due to the variables involved in usage, it is impossible to establish a time interval for reconditioning that will cover all batteries. Until service experience dictates otherwise, a visual and electrolyte check of the battery should be made after the first 50 hours of flight. If the condition of the battery is normal and the level of electrolyte in the battery is satisfactory, schedule the initial reconditioning at 100 hours. Repeat the reconditioning procedure outlined below at 100-hour intervals until servicing experience justifies a change.

NOTE

The log of battery services performed should be evaluated to determine the need for servicing the battery at the above recommended intervals or extending the intervals. Accurate water consumption data is a valid barometer to use for adjustment of the servicing intervals.

RECONDITIONING PROCEDURE

a. Discharge the battery at a current equal to or less than the one-hour rate. Short out each cell as it drops below .5 volts. The cells may be shorted by clips or by wires having clips on each end. Allow the shorts to remain on the cells for a minimum of 16 hours, and preferably for 24 hours.

b. Remove the shorting clips and charge for 24 hours at 1.1 amperes for a 13.5 ampere-hour battery. After approximately 5 minutes of charge, measure the individual cell voltages. If any cell voltage is greater than 1.50 volts, add distilled water. The amount of water required is approximately 1 cc per rated ampere-hour capacity, for example, a 13.5 ampere-hour cell may require about 13.5 cc of water at this time.

c. After approximately 10 minutes of charge, remeasure the cell voltages. Replace any cell that measures below 1.20 volts or above 1.55 volts.

d. Continue charging for 20 hours. After 20 hours of charging, measure and record the individual cell voltages. If necessary, add distilled water to level the cell 1/8 to 1/4 inch above the baffle. Do not remove any electrolyte from the cells.

e. Measure and record the voltage at 24 charge hours and compare with the 20 hour reading. If the 24 hour voltage reading is below the 20 hour reading by more than .04 volts, replace the cell. Also replace any cell that measured below 1.50 volts at 24 charge hours. After removing the battery from charge, measure the electrolyte temperatures. If the electrolyte temperature of any cell is greater than 30°F above the ambient, replace that cell.

BATTERY ELECTROLYTE LEVEL ADJUSTMENT

Although the electrolyte level in the nickel-cadmium battery varies with the state of charge, it should be visible above the bottom of the baffle when the battery is fully charged. When the state of charge of the battery is low, the plates absorb some of the electrolyte, then release it as the battery is recharged. The electrolyte level on any battery must be adjusted after a full charge and a two to four hour rest on open circuit. Check the electrolyte level of the battery (fully charged) in the following manner:

CAUTION

Never use acid or tools contaminated with acid during this adjustment, for both bodily injury and equipment damage may result. If possible, use equipment reserved for nickel-cadmium batteries. If lead-acid battery equipment must be used, remove all possible acid contamination with a sodium bicarbonate solution and rinse. Even minute traces of acid can damage a nickel-cadmium battery.

a. Remove the battery from the aircraft.

b. With the battery removed from the aircraft, remove the filler cap vent plug on each cell, one cell at a time.

c. Insert a transparent tube (approximately 6 inches long and 1/4 inch in diameter) perpendicularily into the filler well until the open end rests lightly on the cell baffle, then place the index finger over the top open end and withdraw the tube.

CAUTION

Do not push down, for the light material of the baffle will give enough to result in a false indication of the electrolyte level.

d. The electrolyte level of a fully charged battery should be between 1/8 and 1/4 inch above the bottom of the baffle. If the level of liquid in the tube exceeds 1/4 inch, remove the excess with a syringe or squeeze bottle. If the level of the electrolyte is less than 1/8 inch above the bottom of the baffle, add distilled water with a syringe or squeeze bottle.

CAUTION

Tap water contains minerals, chlorines, softening agents, and other foreign materials which will contaminate a storage battery and shorten its life.

WARNING

The battery may be damaged if the proper procedure is not followed when adding distilled water to the cells.

e. Clean and reinstall the filler cap, vent cap, vent plugs and check the battery terminal links for tightness. Discolored links or melted nylon around cell terminals indicate loose link connections.

CAUTION

If water or electrolyte is spilled into the battery container, the resultant electrolyte corrosion may cause battery failure. The battery case must be cleaned as instructed in CLEANING AND INSPECTION.

ELECTRICAL LEAKAGE CHECK

The self (internal) discharge rate of a vented nickel-cadmium battery cell is in the order of C/1000 when fully charged. "C" in this formula represents capacity in ampere-hours. This is about 13.5 ma for 13.5 ampere-hour batteries. The only pertinent measure of external leakage is the rate of discharge caused by the leakage. The rate is significant only when it approaches the rate of internal leakage. Therefore, external leakage need be considered excessive only when an ammeter shorting the battery positive or negative terminal to the battery case indicates 13.5 ma or more on 13.5 ampere-hour batteries. Any current less than the preceding limits indicates a magnitude of leakage that has a negligible effect on battery performance.

Perform the following test to determine if external leakage is sufficient to necessitate cleaning the battery. Set the range selector of a multi-range ammeter to the 500 ma scale or higher (a low cost meter is recommended to preclude possible damage to an expensive precision meter). Connect the positive terminal of the ammeter to the positive battery terminal and the negative ammeter terminal to the battery case. Decrease the ammeter current range to obtain a readable value of current and record the value. Perform the same measurement at the negative battery terminal by connecting it to the negative terminal of the ammeter and connecting the positive terminal of the ammeter to the battery case. If the current reading at either terminal is more than 13.5 ma on 13.5 ampere-hour batteries, the battery should be cleaned. This test should be made again after the battery has been completely cleaned and charged. If the current measure is again more than 13.5 ma on 13.5 ampere-hour batteries, it may be assumed that one of the cells has a seal leak. That cell may be found by measuring connector-to-battery case voltages. The lowest voltages will occur at the connectors on each side of the defective cell. A cell found leaking in this manner should be replaced.

CAPACITY CHECK

a. Discharge the battery at a rate of 6.0 amperes on 13.5 ampere-hour batteries until an average voltage of one volt per cell is reached. Measure the time required for the battery to reach that discharged state. Any battery that discharges to one volt per cell in 84 minutes or less should be given another reconditioning (deep) cycle.

b. After the second reconditioning cycle, recheck the battery capacity by discharging at the rate used in step "a". Measure the individual cell voltages after 84 minutes of discharge. If any cell is below one volt, replace it.

CLEANING AND INSPECTION

a. Scrub each cell with a 5 percent solution of boric acid in water, but take great care to prevent the solution from entering the cell.

b. Wash each cell off under running water and dry with an air hose or clean absorbent towel.

c. Inspect each cell for defects such as cracks, holes, or burn spots. Replace defective cells with new or rebuilt cells.

d. Make sure that battery hardware is clean and in good mechanical condition. Wash the hardware, liners, case, cover, and other associated parts in a warm soapy solution to remove accumulated dirt and carbonate deposits. Use a stiff brush to remove heavy deposits. After washing, rinse the parts free of soap and spread them out to dry.

e. Remove corrosion preventive from connectors, screws, nuts, and washers with alcohol or by degreasing.

f. Wash vent caps thoroughly with hot water and no soap.

g. After the parts are dry, sort out damaged or heavily corroded pieces. Scrap any links having burns, bends, or defective nickel plating. If a link is tarnished at the terminal connection, it should be polished with a wire brush. It is recommended that new terminal screws and nuts be used to ensure proper electrical connection.

h. Check the battery receptacle for burns, cracks, and bent or pitted terminals. Defective receptacles can overheat, cause arcing, and decrease output voltage to result in premature battery failure.

i. Scrap bent or torn battery cases and covers that are beyond repair.

j. Replace or repair loose or damaged cover gaskets and cell holddown bars.

NOTE

Refer to the maintenance manual of the battery manufacturer for additional details on battery disassembly and assembly.

BATTERY MAINTENANCE PROGRAM (P-446 and after)

A systematic battery maintenance program should be established and carefully followed.

a. The batteries should be removed from the airplane for service.

b. A log of the services performed on each battery should be maintained.

c. The battery should be removed from the airplane and serviced after: 100 flight hours or 30 days, whichever occurs first. If the ambient temperatures are above 90°F or the time between engine starts averages less than 30 minutes, the duty cycle should be reduced.

d. The log of battery services performed should be evaluated to determine the need to service the batteries at the above recommended intervals or to extend the intervals if justified. Accurate water consumption data is a valid barometer to use for adjustment of the servicing intervals.

BATTERY REMOVAL

a. Remove the upper access door to the electrical equipment compartment aft of the left nacelle firewall.

b. Remove the nuts from the hold-down strap bolts.

c. Release the battery box lid latches and remove the box lid.

d. Remove the NEGATIVE battery cable from the batteries.

CAUTION

Always remove the ground cable terminal first and install it last to prevent accidental short circuits.

e. Remove the POSITIVE cable terminal from the batteries.

f. Remove the bus bar interconnect from the two batteries.

g. Remove the batteries from the airplane.

BATTERY INSTALLATION

a. Position the batteries in the battery box.

b. Coat the battery terminals and cable terminals with a light coating of petroleum jelly.

CAUTION

If the POSITIVE battery terminal is not marked +, POS or painted red and the NEGATIVE battery terminal is not marked −, NEG or painted black, use a voltmeter to determine the battery polarity before connecting the battery in the airplane. Reverse polarity will destroy the diodes and other electronic components in the electrical system.

c. Position the POSITIVE cable terminal on the battery and secure.

d. Position the NEGATIVE cable terminal on the battery and secure.

e. Install the bus bar interconnect on both batteries.

f. Remove any excess petroleum jelly from the terminals.

g. Position the battery box lid on the battery box and secure.

h. Install the nuts on the hold-down strap bolts.

i. Install the access door.

BATTERY CLEANING

For peak performance, the batteries must be kept clean and dry. If foreign materials are present in sufficient quantities, the resultant deposits may form conductive paths that permit a rapid discharge of the batteries. To prevent the collection of such deposits, use the following steps in cleaning the batteries after each 100 hours of service or every 30 days, whichever occurs first:

a. Remove the batteries as described in the section BATTERY REMOVAL.

b. Ensure that the battery cell filler caps are tight in place. Brush dirt off with a stiff bristle brush.

CAUTION

Never use a wire brush or brush with a metal construction for this purpose as short circuiting or other damage may result.

c. Scrub the batteries with a solution of ammonia or bicarbonate of soda (one part of soda to a gallon of water). This will neutralize any electrolyte sprayed or spilled out.

CAUTION

Entrance of ammonia or soda solution into a battery cell will neutralize the cell electrolyte. Never use solvents to clean the batteries, for these may damage the battery case.

d. Rinse the batteries with clear water, then sponge off the excess water. Allow the batteries to air-dry.
e. Wash the battery filler caps with clean hot water and no soap, then examine the vent holes in the battery filler caps to make sure they are clear.
f. Inspect the battery for cracks, holes or burn spots. Replace if necessary.
g. Make sure that all batteries hardware is clean and in good mechanical condition.

NOTE

If additional cleaning of the battery terminals and cable terminal is required, use a wire brush and brighten up the terminals to ensure a good electrical connection.

BATTERY BOX CLEANING

The battery box is vented overboard to dispose of electrolyte and hydrogen gas fumes discharged during normal charging operation. To ensure the disposal of these fumes, the vent hose connections at the battery box should be checked frequently for obstructions. The battery box should be washed out thoroughly and dried each time the battery is removed and cleaned.

BATTERY SERVICING

The batteries should be maintained in a fully charged state at all times and the electrolyte level checked at regular intervals. Clean fully charged batteries will provide peak performance. Never add anything but distilled water when adjusting the electrolyte level in the batteries. If electrolyte is added each time the level in the batteries are low, a high concentration of electrolyte may cause dissolution of the plates. Under high temperature conditions, this may be indicated by the presence of black particles in the electrolyte of the affected cells.

NOTE

Do not fill the batteries over one-half inch above the separators. Only lead-acid equipment should be used when servicing lead-acid type batteries.

RECHARGING BATTERIES USING AUXILIARY POWER

The following steps should be used in using auxiliary power to recharge the battery:

a. Place the battery master switch in the on position.
b. Place both alternator switches and all electrical and avionics equipment switches in the off positions.
c. Connect the auxiliary power unit to the external power receptacle.

CAUTION

Make certain that the battery switch is in the on position, all avionics and electrical switches are in the off positions and batteries are in the system before connecting an external power unit. This protects the electrical voltage regulators and associated electrical equipment from voltage transients (power fluctuations).

d. Set the output of the auxiliary power unit at 27.0 to 28.5 vdc.
e. Place the auxiliary power unit in the on position.

If the battery master relay will not close, the batteries must be removed from the airplane for recharging. Check the battery master relay control circuit for a malfunction.

"END"

DC GENERATION-MAINTENANCE PRACTICES

BATTERY CHARGE CURRENT DETECTOR SYSTEM FUNCTIONAL CHECK (Prior to P-446)

NOTE

Satisfactory load change as used herein, is defined as deflection of the loadmeter needle equal to or less than a .025 load change (approximately 3 amperes) for airplanes with a 13.5 ampere-hour battery. A load change of .025 or .050 is barely perceptible.

The system may be checked in the airplane with either engine running. After the engine is started, turn the applicable generator ON. After a time delay of approximately 6 seconds (provided the battery is sufficiently discharged and will accept a charge), the amber caution light (BATTERY CHARGE) located on the instrument panel should illuminate. The light should remain illuminated until the battery is recharged. Under normal circumstances, the battery should be recharged and the light should go out within 5 minutes. However, if the battery has had unusually low or high drain, the recharge time could be considerably shorter or longer. When the light does go out, turn the battery switch OFF while observing the affected loadmeter; the loadmeter should indicate a satisfactory load change.

Listed below are possible situations that could be experienced and corresponding action that is recommended:

a. Light does not illuminate - If the bulb is operational but the light does not come on within approximately 6 seconds after the operating generator is turned ON, it is possible that the battery is not sufficiently discharged to accept a charge. This can be determined by turning the battery OFF while observing the loadmeter needle deflection. A satisfactory load change indicates the battery is charged and the light should not be on. An unsatisfactory load change indicates the light should be on and that there is a malfunction in the detector system. Repair or replace the defective parts and repeat the functional check. If the battery was not discharged enough to accept a charge, turn the generator OFF and partially discharge the battery by operating electrical equipment. Repeat the functional check.

b. Light stays on - Check the following possibilities:

1. Battery is partially discharged and is charging. If the light stays on after charging for approximately 5 minutes, careful attention should be given the airplane loadmeter. With a constant load on the airplane electrical system, continue to charge the battery. The loadmeter should indicate a constantly decreasing charge current until the battery is charged. When the loadmeter appears to stabilize (see NOTE in condition 2 below), turn the battery OFF while observing the loadmeter for load change. If the load change is satisfactory and the light has gone out, the battery is charged and the system is operating properly.

2. Battery is charged and is being excessively overcharged. If the loadmeter stabilizes and indicates an unsatisfactory load change when the battery is turned OFF, the battery is overcharging excessively and the light should not have gone out. Check the battery and charging circuit for condition and proper operation.

NOTE

As the battery approaches full charge, the charge current may decrease slowly enough that the loadmeter would appear to stabilize before the charge current has decreased enough for the light to go out.

In the event of doubt as to the amount of charge current after the loadmeter appears to have stabilized, an ammeter can be integrated into the charging circuit. Install the ammeter and check the charge current as follows:

(a) An ammeter that will indicate approximately 10 amperes, lead lines that will reach from the battery relay to the pilot's compartment and an on-off switch for the ammeter leads will be required.

(b) Wire the on-off switch into one of the leads and connect the leads to the ammeter.

(c) Connect the negative side of the ammeter to the battery side of the battery relay and the positive side of the ammeter to the generator side of the battery relay.

(d) With the switch in the ammeter lead turned off, start either engine. Allow the battery to charge until the loadmeter appears to stabilize.

(e) Turn the switch in the ammeter lead on and turn the battery switch OFF, in that order to prevent a current surge and possible damage to the ammeter.

(f) Note the charge current as indicated on the ammeter. The charge current should decrease until the light goes out at approximately 3 or 7 amperes and may continue to decrease to a lower level.

Repair or replace any parts found to be defective and repeat the functional check.

3. Battery is charged and is not being excessively overcharged. If the light is on and the charge current has dropped to a satisfactory level, the detector assembly is malfunctioning and should be replaced.

(a) Light is erratic or does not operate in unison with suitable charge current values as previously outlined. Check the wiring and detector assembly for proper operation. Repair or replace defective parts and repeat the functional check.

"END"

EXTERNAL POWER - MAINTENANCE PRACTICES

The aircraft electrical system is protected against damage from reverse polarity by a relay and diodes in the external power circuit. The external power receptacle is located just outboard of the left engine nacelle. The receptacle is designed for a standard AN type plug. To supply power for ground checks and air conditioner operation, a ground power source capable of delivering a continuous load of 300 amperes at 24 to 30 volts is required. Use of an inadequate ground power unit can cause a voltage drop below the drop-out voltage of the starter relay, resulting in relay chatter and welded contacts. By the same token, a maximum continuous load in excess of 350 amperes will damage the external power relay and power cables of the aircraft.

Observe the following precautions when using an external power source:

a. Use only an auxiliary power source that is negatively grounded. If the polarity of the power source is unknown, determine the polarity with a voltmeter before connecting the unit to the aircraft.

b. Before connecting the external power unit, turn off all radio equipment and generator switches, but leave the battery on to protect transistorized equipment against transient voltage spikes.

CAUTION

When the battery switch is turned OFF for extended ground power operation, place an external battery in parallel with the output of the external power unit before operating any transistorized avionics equipment.

c. If the unit does not have a standard AN plug, check the polarity and connect the positive lead from the external power unit to the center post and the negative lead to the front post of the aircraft's external power receptacle. The small pin of the receptacle must be supplied with + 24 VDC to close the external power relay that provides protection against damage by reverse polarity.

"END"

ELECTRICAL LOAD DISTRIBUTION - MAINTENANCE PRACTICES

The dual bus feeder diodes should be inspected at 600 flight hour intervals as instructed under PERIODIC INSPECTION OF DUAL BUS FEEDER DIODES. Whenever the dual bus has been modified or extensive repairs have been made that could result in the dual bus loops being interconnected or open, it is necessary to perform a DUAL BUS CONFORMITY INSPECTION. This will ensure that the original design of the dual bus is maintained.

PERIODIC INSPECTION OF DUAL BUS FEEDER DIODES (Figure 202)

An open or shorted dual bus feeder diode cannot be detected during the normal operation of the aircraft electrical system. Should a malfunction occur which would cause a bus isolation limiter to open, such as a ground fault on a generator bus, an open dual bus feeder diode could not supply power to its respective dual bus loop. A shorted diode would not isolate its respective dual bus from a ground fault. The inspection procedure outlined here will ensure the dual bus capability. The inspection may be performed at a normal periodic inspection of the aircraft and either battery power or an auxiliary ground power unit connected to the external power receptacle may be used. A suggested inspection procedure follows:

a. Remove all power from the aircraft.

b. Open the four 50 ampere bus feeder circuit breakers labeled ELECTRICAL POWER on the right circuit breaker subpanel.

c. Turn the battery and/or auxiliary ground power unit ON.

d. Confirm the continuity of each dual bus feeder diode. This may be accomplished by closing a single ELECTRICAL POWER feeder diode circuit breaker and confirming the presence of voltage on the corresponding dual bus loop. The presence of voltage may be determined by the operation of circuits which receive power from the dual bus loop. Refer to the Power Distribution Schematic, Figure 202, or to the applicable wiring diagram for the appropriate aircraft serial in the Wiring Diagram Manual, 60-590001-29, to determine which circuits receive power from each dual bus loop. Repeat for each circuit breaker.

e. Confirm that each dual bus is not shorted. This may be accomplished by closing a single ELECTRICAL POWER feeder circuit breaker and determining that no voltage is present at the load side of each of the three remaining ELECTRICAL POWER feeder circuit breakers. Repeat for each circuit breaker.

Should any diode prove to be either shorted or open, this diode must be replaced and the inspection repeated. After completion of the inspection, reset all circuit breakers and tighten all connections securely. Ensure that all wires and terminals are not chafing against the aircraft structure. Check the system for normal operation.

DUAL BUS CONFORMITY INSPECTION (Figure 201)

A dual bus conformity inspection shoud be performed whenever the console or subpanel bus system has been modified or whenever repairs have been made that may result in the dual bus loops being interconnected or open. Either battery or auxiliary power may be used when conducting this inspection. Check for correct circuit connections by actual operation of the circuit as described by the appropriate power distribution circuit in the Wiring Diagram Manual, P/N 60-590001-29. The conformity inspection may be performed as follows:

a. Open the four 50 ampere bus feeder circuit breakers labeled ELECTRICAL POWER on the right circuit breaker subpanel.

b. Turn the battery ON. External power may be used.

c. Close the LH # 1 bus feeder circuit breaker, check each circuit and record the results.

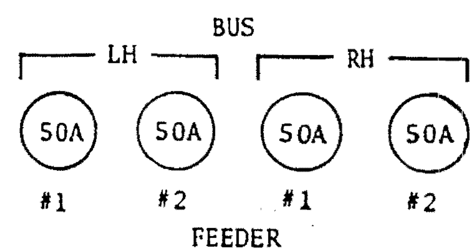
d. Open the LH # 1 bus feeder circuit breaker and close the LH # 2 bus feeder circuit breaker. Repeat the circuit checks and record the results.

e. Open the LH # 2 bus feeder circuit breaker and close the RH # 1 bus feeder circuit breaker. Repeat the circuit checks and record the results.

f. Open the RH # 1 bus feeder circuit breaker and close the RH # 2 bus feeder circuit breaker. Repeat the circuit checks and record the results.

g. If any of the results that have been recorded reveal a discrepancy, locate and repair to obtain the desired result.

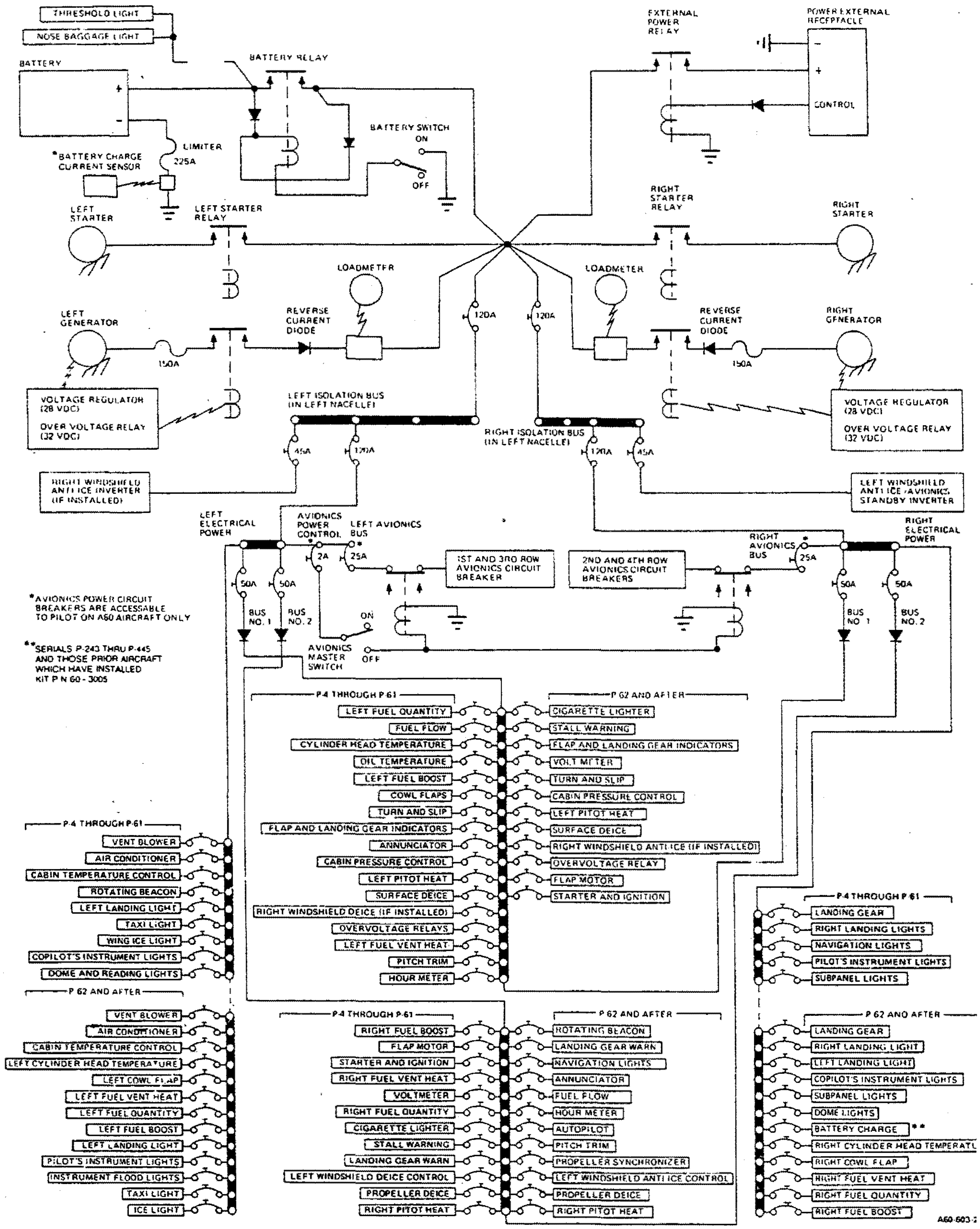
h. Close all circuit breakers and return the aircraft to normal.



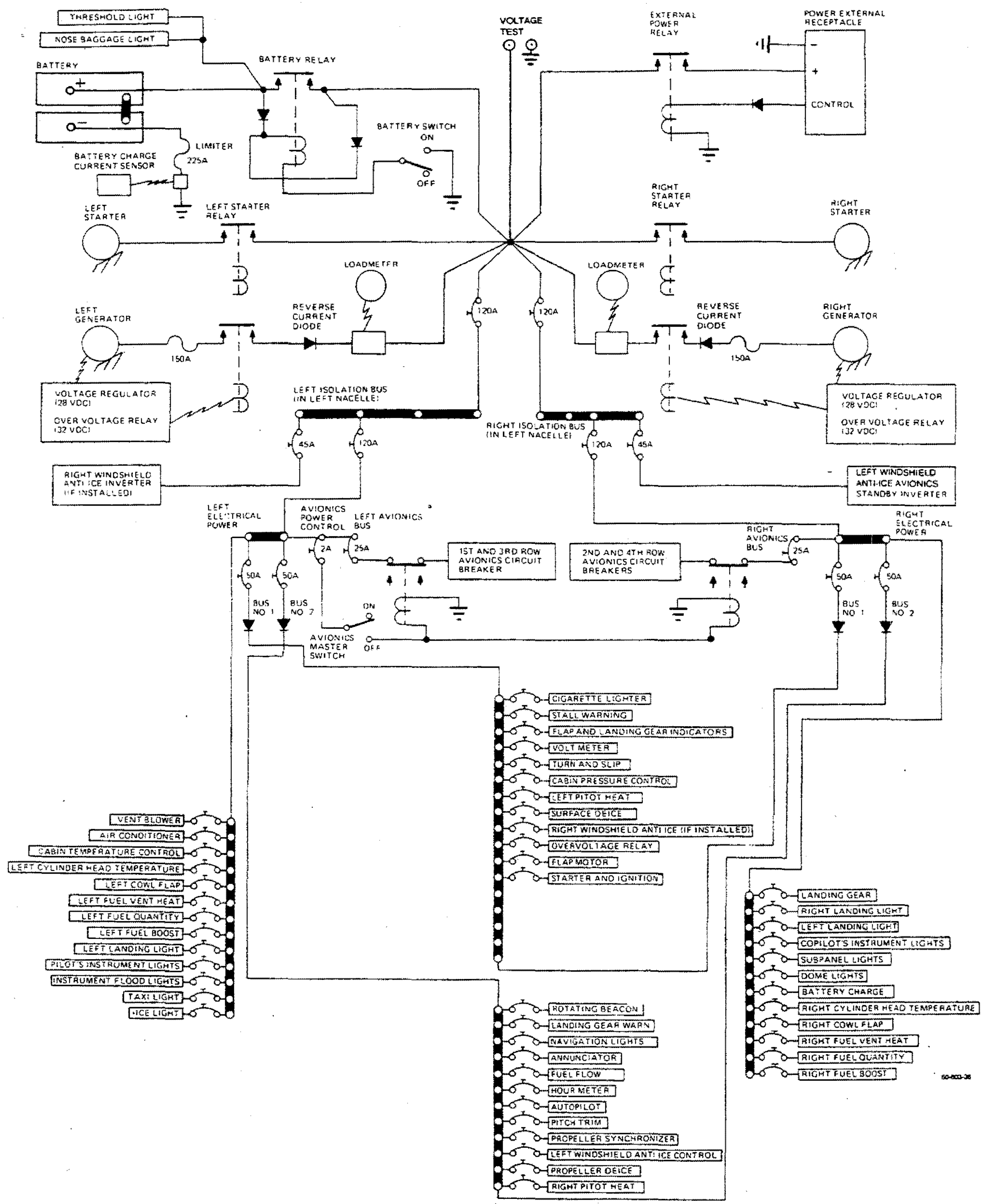
Dual Bus Conformity Inspection
Figure 201

ELECTRICAL UTILIZATION LOAD CHART

The following chart provides information pertaining to the capacity of the generator for supplying the electrical load on the aircraft while maintaining a full charge on the battery. To determine the total electrical load of the aircraft, add the continuous load for standard equipment to the load of the optional equipment installed in the aircraft (accessories and radio). Since the aircraft is equipped with two 28 volt, 125 ampere generators, the total load shall not exceed 80 percent of the total generating capacity. When an item of equipment functions at various times in different systems, the load per unit value listed in the chart represents the highest value required to operate that particular unit in the various systems in which it functions.



Power Distribution Schematic (P-4 thru P-445)
Figure 202



Power Distribution Schematic (P-446 and after)
Figure 203

CHART 201
ELECTRICAL UTILIZATION LOAD

	Number Per Aircraft	Load Per Unit In Amps.	Load Per Aircraft In Amps.
CONTINUOUS LOAD-STANDARD EQUIPMENT			
Battery Relay	1	0.60	0.60
Cabin Pressure Control System			
Ram Air Magnetic Door Catch	1	0.21	0.21
Isobaric Control Valve	1	0.90	0.90
Cabin Pressure Differential Control Valve	1	0.50	0.50
Cylinder Head and Oil Temperature System			
Cylinder Head Temperature Indicator	2	0.49	0.98
Oil Temperature Indicator	2	0.31	0.62
Flap Position System			
Flap Position Indicator	1	0.001	0.001
Flap Position Printed Circuit Board	1	0.059	0.059
Fuel System			
Fuel Flow Indicator Inverter	1	0.94	0.94
Fuel Quantity Indicator	2	0.05	0.10
Fuel Vent Heater	2	1.35	2.70
Heater System			
Vent Blower	1	17.00	17.00
* Vent Blower Relay	2	0.35	0.35
Combustion Air Blower	1	2.90	2.90
Manual or Automatic Select Relay	1	0.09	0.09
Heater Cycle Control Relay	1	0.09	0.09
Heater Fuel Pump	1	0.40	0.40
Remote Heater Solenoid Valve	1	0.33	0.33
Heater Assembly	1	1.30	1.30
Combustion Air Select Valve	1	0.63	0.63
Heater Safety Relay	1	0.09	0.09
Cabin Temperature Control Box	1	0.18	0.18
Cabin Air Sensing Element	1	0.25	0.25
Pitot Heater (LH)	1	3.30	3.30
Turn and Slip Indicator	1	0.15	0.15
Voltmeter	1	0.001	0.001
Lighting			
Dim Switches	8	0.05	0.40

*Only one used at a time.

CHART 201
ELECTRICAL UTILIZATION LOAD (Cont'd)

	Number Per Aircraft	Load Per Unit In Amps.	Load Per Aircraft In Amps.
CONTINUOUS LOAD-STANDARD EQUIPMENT			
Lighting (Cont'd)			
Edge Lights	163	0.04	6.52
Cabin Altitude Warning Light	2	0.04	0.08
Cabin Door Warning Light	2	0.04	0.08
Annunciator Lights Dim Relay	1	0.09	0.09
Inverter Out Light	2	0.04	0.08
* Landing Gear Position Lights			
Landing Gear Uplock Light	1	0.04	0.04
Landing Gear Down Lock Light	3	0.04	0.12
Compass Light	1	0.04	0.04
Engine Instrument Lights	10	0.04	0.40
Instrument Flood Lights (Red)	10	0.17	1.17
Instrument Flood Lights (White)	8	0.17	1.36
Outside Air Temperature (Post Light)	1	0.04	0.04
Pilot's Clock Light	1	0.04	0.04
Pilot's Instrument Lights (Post Light)	18	0.04	0.72
Pilot's Map Light	1	0.17	0.17
Reading Lights	6	0.30	1.80
Navigation Lights (Wing)	4	0.75	3.00
Navigation Light (Tail)	1	0.65	0.65
Rotating Beacon (Lower)	1	3.10	3.10
Rotating Beacon (Upper)	1	3.10	3.10
CONTINUOUS LOAD-OPTIONAL EQUIPMENT			
Air Conditioner			
Combustion Blower	1	2.90	2.90
Condenser Blower	1	15.00	15.00
Condenser Blower Relay	1	0.35	0.35
Cabin Temperature Control Box	1	0.17	0.17
Cabin Air Sensing Element	1	0.25	0.25
Heating or Cooling Temperature Control Relay	1	0.09	0.09
Hot Gas By-pass Solenoid Valve (P-4 through P-126, except P-123)	1	0.75	0.75
Solenoid Valve Timer	1	0.06	0.06
Magnetic Clutch	1	2.00	2.00
Nacelle Scoop Relay	1	0.35	0.35
Vent Blower	1	17.00	17.00
**Vent Blower Relay	2	0.35	0.35
Propeller Deice System	1	18.00	18.00
Pitot Heater (RH)	1	3.30	3.30
Cabin Air Inlet Deice Boot	1	2.50	2.50
Flight Hour Meter	1	0.02	0.02
Engine Hour Meter	1	0.02	0.02
Generator Control System			
Overvoltage Relay	2	0.03	0.03

*Maximum of three on at a time.
**Only one used at a time.

CHART 201
ELECTRICAL UTILIZATION LOAD (Cont'd)

	Number Per Aircraft	Load Per Unit In Amps.	Load Per Aircraft In Amps.
CONTINUOUS LOAD-OPTIONAL EQUIPMENT			
Generator Control System (Cont'd)			
Generator Out Light	4	0.04	0.16
Paralleling Relay	2	0.09	0.18
Generator Control Relay	2	0.60	1.20
LH Wing Ice Light	1	2.14	2.14
Oxygen Panel Post Light	1	0.04	0.04
Copilot's Instrument Post Lights	18	0.04	0.72
Copilot's Clock Light	1	0.04	0.04
Copilot's Map Light	1	0.17	0.17
LH Heated Windshield System			
Inverter	1	29.00	29.00
Windshield Temperature Control Box	1	0.03	0.03
Windshield Temperature Control Relay	1	0.35	0.35
RH Heated Windshield System			
Inverter	1	29.00	29.00
Windshield Temperature Control Box	1	0.03	0.03
Windshield Temperature Control Relay	1	0.35	0.35
INTERMITTENT LOAD-STANDARD EQUIPMENT			
Lights			
Landing Lights	2	8.90	17.80
Taxi Light	1	9.00	9.00
Threshold Light	1	0.17	0.17
Nose Baggage Compartment Light	1	0.30	0.30
Fuel Boost Out Lights	4	0.04	0.16
Cowl Flap Motor	2	1.20	2.40
*Cigarette Lighter	5	7.50	7.50
Fuel Boost Pumps	2	14.00	28.00
Landing Gear Warning Horn	1	1.50	1.50
Landing Gear Warning Flasher	1	0.40	0.40
Landing Gear Dynamic Brake Relay	1	0.40	0.40

*Only one used at a time.

CHART 201
ELECTRICAL UTILIZATION LOAD (Cont'd)

	Number Per Aircraft	Load Per Unit In Amps.	Load Per Aircraft In Amps.
INTERMITTENT LOAD-STANDARD EQUIPMENT			
Landing Gear Motor	1	20.00	20.00
Wing Flap Motor	1	13.00	13.00
*Starter Relay	2	0.06	0.06
**Starter	2	275.00	275.00
Starting Vibrator	1	2.00	2.00
Stall Warning Horn	1	1.50	1.50
INTERMITTENT LOAD-OPTIONAL EQUIPMENT			
Electric Trim System (Elevator)			
Trim Motor	1	0.85	0.85
Trim Clutch	1	0.50	0.50
Magic Hand Switch	1	2.50	2.50
Surface Deice System			
Deice Relay	1	0.09	0.09
Time Delay Relay	1	0.17	0.17
Deice Valve	2	0.59	1.18
Control Valve	1	1.75	1.75
Nacelle Scoop Actuator	1	1.20	1.20

*Only one used at a time.

**Maximum stall load, only one used at a time.

"END"