SECTION XI

ELECTRICAL SYSTEM

Paragraph		Aerofiche Grid No.

Paragraph		Aerofiche Grid No.

Reissued: 2/18/81

TABLE XI-I. INDEX - ELECTRICAL SYSTEM SCHEMATICS

System	Figure	Aerofiche Grid No.
Accessory and Autopilot, PA-23-250 (six place), Serial Nos. 27-3457 to 27-7554172 incl.	11-99	4I12
Accessory and Autopilot, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-147	4L11
Alternator System (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.	11-106	4I19
Alternator System (Prestolite), PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-4793 incl.	11-107	4I21
Alternator Paralleling System (Prestolite), PA-23-250 (six place), Serial Nos. 27-4794 to 27-5005 incl.	11-109	4J1
Alternator Paralleling System (Prestolite), PA-23-250 (six place), Serial Nos. 27-5006 to 27-7554172 incl.	11-108	4I23
Alternator Paralleling System (Prestolite), PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-149	4L13
External Power Supply, PA-23-250 and PA-23-250 (six place)	11-100	4I13
External Power Supply, PA-23-250 and PA-23-235	11-101	4I13
External Power Supply, PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl	11-102	4I14
External Power Supply, PA-23-250 (six place), Serial Nos. 27-3837, 37-3944 to 27-7554172 incl.	11-103	4I14
Fuel Pumps (14 & 28-volt), PA-23-250; PA-23-235; and PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-68	4H10
Fuel Pumps, PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.	11-69	4H11
Fuel Pumps, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.	11-70	4H12
Fuel Pumps, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)	11-134	4K23
Fuel Pumps, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)	11-135	4K24
Generator System (Delco-Remy) (14 & 28-volt), PA-23-250 and PA-23-235	11-104	4I15
Generator System (Delco Remy) (14 & 28-volt), PA-23-250 (six palce), Serial Nos. 27-2000 to 27-2504 incl.	11-105	4I17
Heated Windshield, PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.	11-98	4I12
Heated Windshield, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-141	4L5
Heater, Map Lights and Cigar Lighter (14 & 28-volt), PA-23-250 and PA-23-235	11-71	4H13

TABLE XI-I. INDEX - ELECTRICAL SYSTEM SCHEMATICS (cont)

System	Figure	Aerofiche Grid No.
Landing Gear and Flap System (14 & 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-125	4K11
Landing Gear and Flap System, PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.	11-126	4K13
Landing Gear and Flap System, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.	11-127	4K15
Landing Gear and Flap System, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)	11-152	4L21
Landing Gear and Flap System, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)	11-153	4L23
Navigation and Instrument Lights, PA-23-250, Serial Nos. 27-1 to 27-258 incl.; 27-365 to 27-401 incl. and 27-403 to 27-504 incl. and PA-23-235	11-80	4H21
Navigation and Instrument Lights (28-volt), PA-23-250, Serial Nos. 27-259 to 27-364 incl.	11-81	4H22
Navigation and Instrument Lights (28-volt), PA-23-250, Serial Nos. 27-402	11-82	4H23
Pitot Heat (14 & 28-volt), PA-23-250 and PA-23-235	11-78	4H20
Pitot Heat (14 & 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-7554172 incl.	11-79	4H20
Pitot Heat, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-140	4L4
Position Lights (14 & 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-83	4H24
Position Lights, PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.	11-84	4I1
Position Lights, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)	11-142	4L6
Position Lights, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)	11-143	4L7
Post Lights, PA-23-250 (six place), Serial Nos. 27-2505 to 27-2704 incl.	11-85	4I2
Post Lights, PA-23-250 (six place), Serial Nos. 27-2705 to 27-3836 incl. and 27-3838 to 27-3943 incl.	11-86	4I3
Post Lights, PA-23-250 (six place), Serial Nos. 27-4794 to 27-7554172 incl.	11-87	4I4
Post Lights, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-4793 incl.	11-88	4I5
Post Lights, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-144	4L8

TABLE XI-I. INDEX - ELECTRICAL SYSTEM SCHEMATICS (cont)

System	Figure	Aerofiche Grid No.
Rotating Beacon (14 & 28-volt), PA-23-250 and PA-23-235	11-89	4I6
Rotating Beacon (14 & 28-volt), PA-23-250 (six place)	11-90	4I6
Stall Warning (14 & 28-volt), PA-23-250; PA-23-235; and PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-93	4I8
Stall Warning, PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.	11-94	4I9
Stall Warning, PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.	11-95	4I10
Stall Warning, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up	11-146	4L10
Starter System (Delco-Remy, 14 & 28-volt), PA-23-250; PA-23-235; and PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-110	4J3
Starter System (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3831 inc.	11-111	4J5
Starter System (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.	11-112	4J7
Starter System (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl. with AiResearch Turbocharger Starter System Schematic	11-113	4J9
Starter System (Prestolite), PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.	11-114	4J11
Starter System (Prestolite), PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)	11-115	4J13
Starter System (Prestolite), PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)	11-116	4J15
Strobe Light (Red Anti Collision) (14 & 28-volt), PA-23-250 and PA-23-235	11-91	4I7
Strobe Light (Red Anti-Collision) (14 & 28-volt), PA-23-250 (six place)	11-92	4I7
Strobe Light (Red Anti Collision)	11-128	4K17
Strobe Light (Red Anti Collision)	11-129	4K18
Strobe Light (White Anit Collision)	11-130	4K19
Strobe Light (White Anti Collision)	11-131	4K20
Strobe Light (White Anti Collision) PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)	11-132	4K21
Strobe Light (White Anti Collision) PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)	11-133	4K22
Turn & Bank (14 & 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.	11-96	4I11
Turn and Bank, PA-23-250 (six place), Serial Nos. 27-2505 and up	11-97	4I11

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SECTION XI

ELECTRICAL SYSTEM

11-1. INTRODUCTION. This section contains instructions for correcting difficulties which may arise in the operation of the electrical system. It includes a general description and function of each part of the system along with test and adjustments of the various components, a circuit load chart and electrical system schematics. For AutoPilot or Radio Service Information, refer to Section XII of this manual.

11-2. DESCRIPTION. Electrical power is supplied by a 14- or 28-volt, direct current, single wire, negative ground electrical system. One or two 12-volt batteries are incorporated in the system to furnish power for starting, and as a reserve power source, in case of generator or alternator failure.

On PA-23-250; PA-23-235; and PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl. airplanes, the system consists of two engine driven, 50-ampere generators when the 14-volt system is installed and two 25-ampere generators when the 28-volt system is utilized; however, a kit is available to convert the 28-volt, 25-ampere system to a 50-ampere system. Two generator regulator assemblies, composed of a voltage regulator, current regulator, and a reverse current cutout, are installed in the generator circuits to protect the system and its components.

On PA-23-250 (six place), Serial Nos. 27-2505 and up airplanes, the electrical system consists of two engine-driven 70-ampere alternators. They are paralleled by the use of one voltage regulator to control field voltage of both units. Also incorporated in the system is an over-voltage relay. Its function is to open and remove field voltage to the unregulated alternators in the event of a failure of the voltage regulator. An auxiliary voltage regulator and over-voltage relay are also furnished.

An external power receptacle can be provided as optional equipment in the nose of the airplane, for the use of external power during cold weather operation. Electrical switches and rheostats are located on the left side of the cockpit under the instrument panel. The circuit breakers are mounted, in a panel, just to the left of the control quadrant. The airplane is equipped with standard navigation lights, one landing light located in the nose, and a taxi light mounted on the nose gear assembly.

11-3. TROUBLESHOOTING. Troubles peculiar to the electrical system are listed in Table XI-I in the back of this section, along with their probable causes and suggested remedies. An electrical schematic index may be found just prior to Section XI.

WARNING

All checks and adjustments of the generator or alternator and/or its components should be made with the engines stopped. Therefore, to complete some checks or adjustments, it will be necessary to remove these units from the airplane and be placed on a test stand.

11-4. GENERATOR SYSTEM (Delco-Remy).

11-5. DESCRIPTION OF GENERATOR SYSTEM. The generator is of the two brush, shunt type and is controlled by a regulator operating on the principal of inserting resistance into the generator field circuit to cause a reduction of generator voltage and current output. With each generator is the regulator assembly, composed of a voltage regulator and current regulator, to prevent overloading of the battery and electrical circuits. Also with the regulator is a reverse current cutout to prevent the generator from being motorized by the battery when the generator output drops below the battery voltage. A paralleling relay is used to connect the two generators. The generator is located on the front lower right side of the engine and utilizes a belt drive from the engine crankshaft. The generator voltage regulator is located on the engine firewall. The best assurance of obtaining maximum service from the generator with minimum trouble is to follow a regular inspection and maintenance procedure.

11-6. DESCRIPTION OF GENERATOR PARALLELING SYSTEM. Dual generators are installed with standard three unit regulators which incorporate a "paralleling winding" on the voltage regulator unit. These paralleling windings function in such a manner that each generator tends to take an equal portion of the electrical load.

The cut-out relay, current regulator and voltage regulator unit of the regulators function in the same manner as standard regulators. The paralleling coil, located on the voltage regulator unit of each regulator, is connected into the cir-

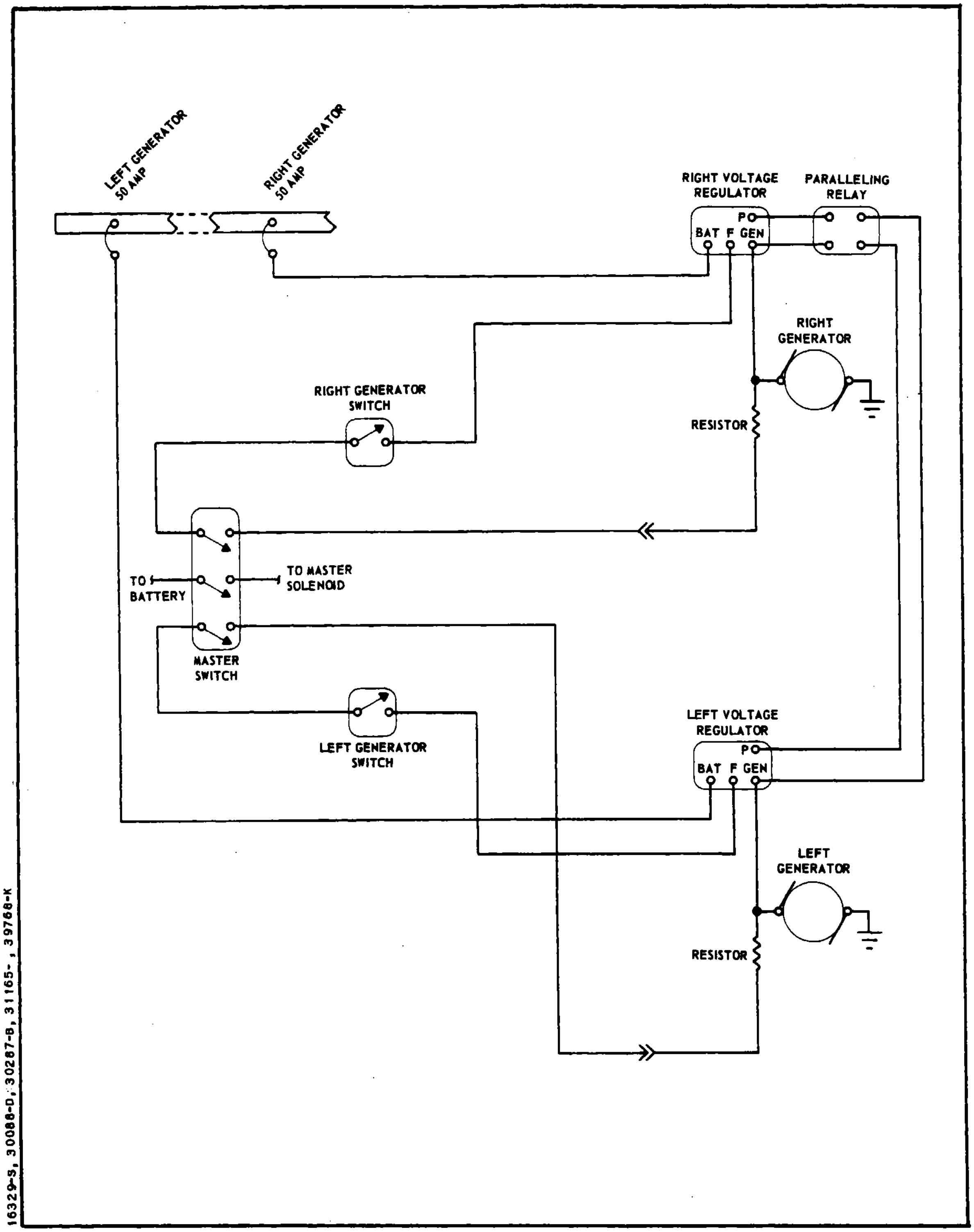

Figure 11-1. Generator Wiring System Schematic

cuit so that it either aids or opposes the voltage regulator shunt winding, depending on the direction of current flow through the coil.

When the operating voltage of one regulator tends to be at a different voltage than that of the other regulator, current will flow through the paralleling coils from the regulator with the higher setting. The paralleling coils are connected so that this current flow lowers the voltage of the regulator with the highest setting. The amount of current which flows through the paralleling coils is the amount required to cause the regulators to operate at the same voltage.

The two-unit paralleling relay acts as a switch to either join or separate the ends of the paralleling coils of the two regulators. Each set of contacts in the external two-unit paralleling relay (Refer to Figure 11-4.) close when the voltage of each respective generator reaches the value for which the relay is adjusted. These contacts close the circuit joining the ends of the paralleling windings on the voltage regulator units. If one generator should fail, the contacts of the paralleling relay unit of that charging system open, breaking the circuit between the paralleling windings. If the other generator and regulator are not defective, they will operate as a normal single generator charging system.

11-7. CHECKING GENERATOR SYSTEM. In analyzing complaints of generator-regulator operation, any of several basic conditions may be found.

a. Fully Charged Battery and Low Charging Rate: This indicates normal generator-regulator operation. Regulator setting may be checked as outlined in paragraph 11-24.

b. Fully Charged Battery and a High Charging Rate: This indicates that the voltage regulator is not reducing the generator output as it should. A high charging rate to a fully charged battery will damage the battery and the accompanying high voltage is very injurious to all electrical units.

This operating condition may result from:

1. Improper voltage regulator setting.
2. Defective voltage regulator unit.
3. Grounded generator field circuit (in either generator, regulator or wiring).
4. Poor ground connection at regulator.
5. High temperature which reduces the resistance of the battery to charge so that it will accept a high charging rate even though the voltage regulator setting is normal.

If the trouble is not due to high temperature, determine the cause of trouble by disconnecting the lead from the regulator "F" terminal with the generator operating at medium speed. If the output remains high, the generator field is grounded either in the generator or in the wiring harness. If the output drops off, the regulator is at fault, and it should be checked for a high voltage setting or grounds.

c. Low Battery and High Charging Rate: This is normal generator-regulator action. Regulator settings may be checked as outlined in paragraph 11-24.

d. Low Battery and Low or No Charging Rate: This condition could be due to:

1. Loose connections, frayed or damaged wires.
2. Defective battery.
3. High circuit resistance.
4. Low regulator setting.
5. Oxidized regulator contact points.
6. Defects within the generator.

If the condition is not caused by loose connections, frayed or damaged wires, proceed as follows to locate cause of trouble.

To determine whether the generator or regulator is at fault, momentarily ground the "F" terminal of the regulator and increase generator speed. If the output does not increase, the generator is probably at fault and it should be checked as outlined in paragraph 11-9. If the generator output increases, the trouble is due to:

1. A low voltage (or current) regulator setting.
2. Oxidized regulator contact points which insert excessive resistance into the generator field circuit so that output remains low.
3. Generator field circuit open within the regulator at the connections or in the regulator wiring.

e. Burned Resistances, Windings or Contacts: These result from open circuit operation or high resistance in the charging circuit. Where burned resistances, windings or contacts are found, always check wiring before installing a new regulator. Otherwise the new regulator may also fail in the same way.

f. Burned Relay Contact Points: This is due to reversed generator polarity. Generator polarity must be corrected as explained in paragraph 11-22 after any checks of the regulator or generator or after disconnecting and reconnecting leads.

11-8. ADJUSTMENTS, TESTS AND MAINTENANCE OF GENERATOR SYSTEM.

The best assurance of obtaining maximum service from generators with minimum trouble is to follow a regular inspection and maintenance procedure. Periodic lubrication where required, inspection of the brushes and commutator and checking of the brush spring tension are essentials in the inspection procedure. In addition, disassembly and thorough overhauling of the generator at periodic intervals are desirable as a safeguard against failures from accummulations of dust and grease and normal wear of parts. This is particularly desirable on installations where maintenance of operating schedules is of special importance. In addition to the generator itself, the external circuits between the generator, regulator and battery must be kept in good condition since defective wiring or loose or corroded connections will prevent normal generator and regulator action. At times it may be found necessary to adjust the voltage regulator or if dual generators are installed, the voltage regulators and paralleling relay. More detailed instructions may be found in the paragraph to follow.

11-9. TEST AND MAINTENANCE OF GENERATOR (Delco-Remy).

11-10. INSPECTION OF GENERATOR.

a. At periodic intervals the generator should be inspected to determine its condition. The frequence with which this should be done will be determined by the type of service in which it is used. High speed operation, excessive dust or dirt, high temperatures and operating the generator at or near full output most of the time are all factors which increase bearing, commutator, and brush wear. Generally speaking, the units should be inspected at approximately 100-hour intervals. The inspection procedure follows:

b. First inspect the terminals, external connections and wiring, mounting, pulley and belt. Then remove the cover band so that the commutator, brushes and internal connections can be inspected. If the commutator is dirty it may be cleaned with a strip of No. 00 sandpaper. Never use emery cloth to clean the commutator.

c. The sandpaper may be used by holding it against the commutator with a wood stick while the generator is rotated, moving it back and forth across the commutator. Gum and dirt will be sanded off in a few seconds. All dust should be blown from the generator after the commutator has been cleaned. A brush seating stone can also be used to clean the commutator.

d. If the commutator is rough, out of round, or has high mica, the generator must be removed and disassembled so that the armature can be turned down in a lathe and the mica undercut.

e. If the brushes are worn down to less than half their original length, they should be replaced. Compare the old brush with a new one to determine how much it is worn. New brushes should be seated to make sure that they are in good contact with the commutator. A convenient tool for seating brushes is a brush seating or bedding stone. This is a soft abrasive material which, when held against a revolving commutator, disintegrates so that particles are carried under the brushes and wear their contacting faces to the contour of the commutator in a few seconds. All dust should be blown from the generator after the brushes are seated.

f. The brush spring tension must be correct since excessive tension will cause rapid brush and commutator wear, while low tension causes arcing and burning of the brushes and commutator. Brush spring tension can be checked with a spring gauge hooked on the brush arm or brush attaching screw. Correction can be made by bending the brush spring as required. If the brush spring shows evidence of

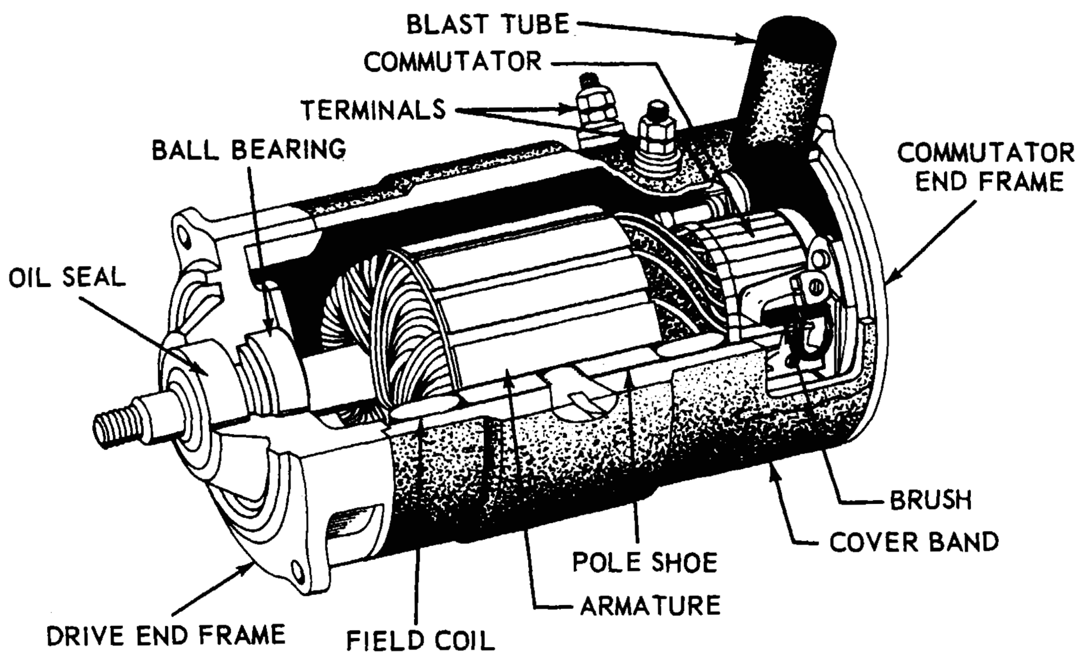

Figure 11-2. Sectional View of Generator

overheating (blued or burned), do not attempt to readjust it, but install a new spring. Overheating will cause a spring to lose its temper.

g. The belt should be checked to make sure that it is in good condition and has correct tension. Low belt tension will permit belt slippage with a resulting rapid belt wear and low or erratic generator output. Excessive belt tension will cause rapid belt and bearing wear. Check the tension of a new belt 25 hours after installation. Proper adjustment is given in paragraph 11-102.

11-11. SHUNT GENERATOR OUTPUT. The maximum output of shunt generators is determined by the current setting of the current regulator with which the shunt generator is used. Checking of this setting is discussed in the applicable regulator bulletin.

11-12. CHECKING DEFECTIVE GENERATORS. If the generator-regulator system does not perform according to specifications (generator does not produce rated output or produces excessive output), and the trouble has been isolated in the generator itself by following the procedure outlined in paragraph 11-6, the generator may be checked further as follows to determine the location of trouble in the generator.

11-13. NO OUTPUT.

a. If the generator will not produce any output, remove the cover band and check the commutator, brushes and internal connections. Sticking brushes, a dirty or gummy commutator (Refer to paragraph 11-21.) or poor connections may prevent the generator from producing any output. Thrown solder on the cover band indicates that the generator has been overloaded (allowed to produce excessive output) so it has overheated and melted the solder at the commutator riser bars. Solder thrown out often leads to an open circuit and burned commutator bars. If the brushes are satisfactorily seated and are making good contact with the commutator, and the cause of trouble is not apparent, use a set of test points and a test lamp as follows to locate the trouble (leads must be disconnected from generator terminals).

b. Raise the grounded brush from the commutator and insulate with a piece of cardboard. Check for grounds with test points from the generator main brush to the generator frame. If the lamp lights, it indicates that the generator is internally grounded. Location of the ground can be found by raising and insulating all brushes from the commutator and checking the brush holders, armature, commutator and field separately. Repair or replace defective parts as required. (Refer to paragraph 11-19.)

NOTE

If a grounded field is found, check the regulator contact points, since a grounded field may have permitted an excessive field current which will have burned the regulator contact points. Burned regulator points should be cleaned or replaced as required.

c. If the generator is not grounded, check the field for an open circuit with a test lamp. The lamp should light when one test point is placed on the field terminal or grounded field lead and the other is placed on the brush holder to which the field is connected. If it does not light, the circuit is open. If the open is due to a broken lead or bad connection, it can be repaired, but if the open is inside one of the field coils, it must be replaced.

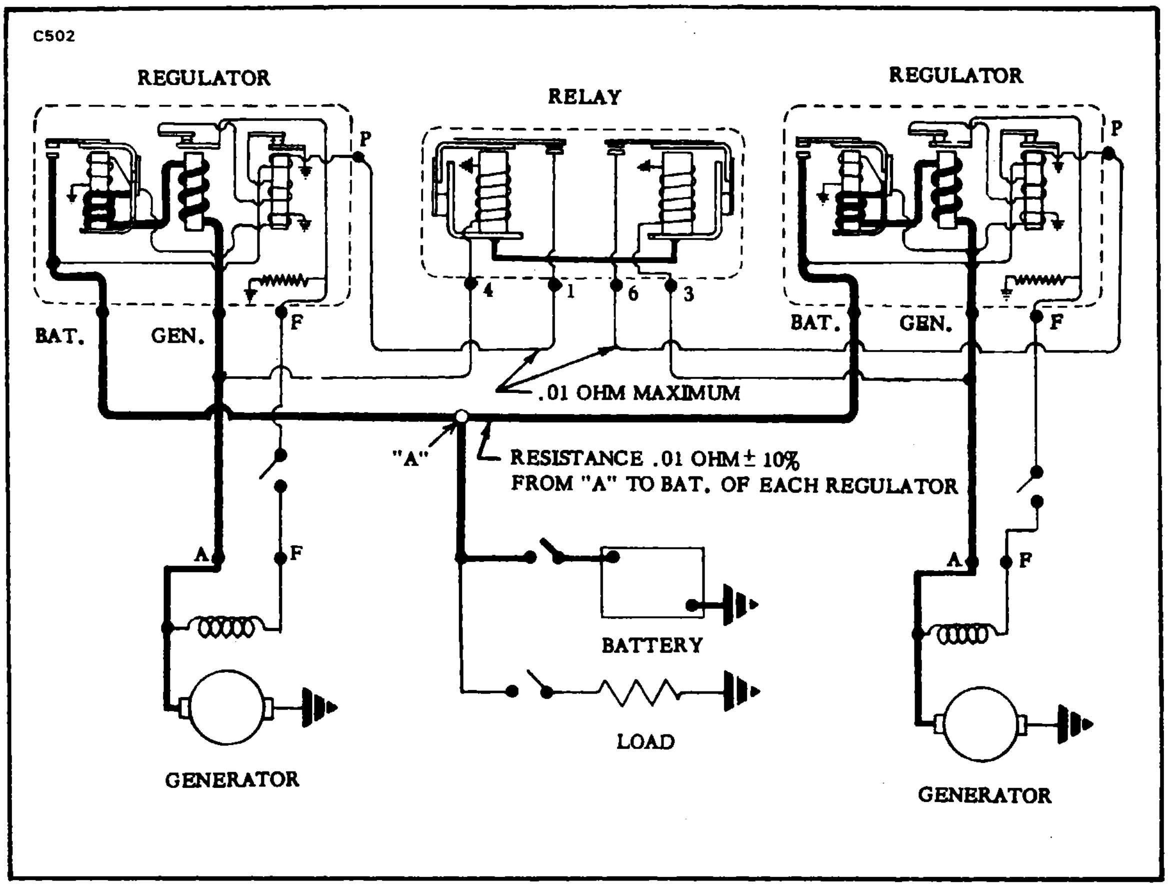

Figure 11-3. Wiring Circuit

d. If the field is not open, check for a short circuit in the field by connecting a battery of the specified voltage and an ammeter in series with the field circuit. Proceed with care, since a shorted field may draw excessive current which might damage the ammeter. If the field is not within specification, new field coils will be required. (Refer to paragraph 11-19.)

NOTE

If a shorted field is found, check the regulator contact points, since a shorted field may have permitted excessive field current which would have caused the regulator contact points to burn. Clean or replace points as required.

e. If the trouble has not yet been located, check the armature for open and short circuits. Open circuits in the armature are usually obvious, since the open circuited commutator bars will arc every time they pass under the generator brushes so that they will soon become burned. If the bars are not too badly burned and the open circuit can be repaired, the armature can usually be saved. In addition to repairing the armature, generator output must be brought down to specifications to prevent overloading by readjustment of the regulator.

f. Short circuits in the armature are located by use of a growler. The armature is placed in the growler and slowly rotated (while a thin strip of steel such as a hacksaw blade is held above the armature core). The steel strip will vibrate above the area of the armature core in which short circuited armature coils are located. If the short circuit is obvious, it can often be repaired so that the armature can be saved.

11-14. UNSTEADY OR LOW OUTPUT. If the generator produces a low or unsteady output, the following factors should be considered:

a. A loose drive belt will slip and cause a low or unsteady output.

b. Brushes which stick in their holders, or low brush spring tension will prevent good contact between the brushes and commutator so that output will be low and unsteady. This will also cause arcing and burning of the brushes and commutator.

c. If the commutator is dirty, out of round, or has high mica, generator output is apt to be low and unsteady. The remedy here is to turn the commutator down in a lathe and undercut the mica. Burned commutator bars may indicate an open circuit condition in the armature as already stated above. (Refer to paragraph 11-13.)

11-15. EXCESSIVE OUTPUT.

a. When a generator produces excessive output on an application, the procedure for determining whether the trouble is in the generator, regulator, or elsewhere is outlined in paragraph 11-7. If the generator output remains high, even with the "F" terminal lead disconnected, then the trouble is in the generator itself, and it must be further analyzed to locate the source of trouble.

b. In the system which has the generator field circuit grounded externally, accidental internal grounding of the field circuit would prevent normal regulation so that excessive output might be produced by the generator. On this type of unit, an internally grounded field which would cause excessive output may be located by use of test points connected between the "F" terminal and the generator frame. Leads should be disconnected from the "F" terminal and the brush to which the field lead is connected inside the generator should be raised from the commutator before this test is made. If the lamp lights, the field is internally grounded. If the field has become grounded because the insulation on a field lead has worn away, repair can be made by reinsulating the lead. It is also possible to make repair where the ground has occurred at the pole shoes by removing the field coils and reinsulating and reinstalling them. A ground at the "F" terminal stud can be repaired by installing new insulating washers or bushings.

NOTE

If battery temperature is excessive, battery overcharge is apt to occur, even though regulator settings are normal. Under this condition, it is permissible to reduce the voltage regulator setting as explained in the applicable bulletin pertaining to the regulator used on the application.

11-16. NOISY GENERATOR. Noise emanating from a generator may be caused by a loose mounting, drive pulley, or gear; worn or dirty bearings; or improperly seated brushes. Dirty bearings may sometimes be saved by cleaning and relubrication, but worn bearings should be replaced. Brushes can be seated as explained in paragraph 11-10. If the brush holder is bent, it may be difficult to reseat the brush so that it will function properly without excessive noise. Such a brush holder will require replacement.

11-17. DISASSEMBLY, REPAIR AND REASSEMBLY. Normally, disassembly should proceed only so far as is necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens, shorts, or grounds before being removed from the field frame. They should be removed only if they require repair or replacement.

11-18. FIELD COIL REMOVAL. Field coils can be removed from the field frame most easily by use of a pole shoe screw driver. It is also advisable to use a pole shoe spreader, since this prevents distortion of the field frame. The pole shoe screw driver permits easy loosening and removal of the pole shoe screws so that the pole shoes and field coils can be taken out of the field frame. The pole shoe screw driver and spreader should be used on reassembly of the field frame. Careful reassembly is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place.

11-19. INSPECTION AND REPAIR OF PARTS. The armature or field should not be cleaned in any degreasing tank or by use of degreasing compounds, since this might damage insulation so that a short or ground would subsequently develop. Sealed ball bearings do not require cleaning or relubrication. Other generator parts should be cleaned and carefully inspected for wear and other damage. Any defective parts should be repaired or replaced. On reassembly all soldered electrical connections should be made with rosin flux. Acid flux must never be used on electrical connections.

11-20. FIELD COIL SERVICE.

a. The field coils should be checked for grounds, opens or shorts as already explained in paragraph 11-13.

b. Grounded field coils may sometimes be repaired by removing them so they can be reinsulated. Care must be used to avoid excessive bulkiness when applying new insulation, since this might cause the pole shoe to cut through and cause another ground when the coils are reinstalled.

c. Usually if a field coil is open or shorted internally it will require replacement, since it is difficult to repair such a defect.

d. To remove or replace field coils in the field frame, the use of a pole shoe spreader and screw driver is recommended.

11-21. ARMATURE SERVICE.

a. The armature should be checked for opens, shorts and grounds as explained in following paragraphs. If the armature commutator is worn, dirty, out of round, or has high mica, the armature should be put in a lathe so the commutator can be turned down and the mica undercut. The mica should be undercut .031 of an inch and the slots cleaned out carefully to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any slight burrs that might be left as a result of the undercutting procedure.

b. Open circuited armatures can often be saved when the open is obvious and repairable. The most likely place an open will occur is at the commutator riser bars. This usually results from overloading of the generator which causes overheating and melting of the solder. Repair can be effected by resoldering the leads in the riser bars (using rosin flux) and turning down the commutator in a lathe to remove the burned spot and then undercutting the mica as explained in the previous paragraph. In some heavy-duty armatures, the leads are welded into the riser bars and these cannot be repaired by resoldering.

c. Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler, with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short is located. Copper or brush dust in the slots between the commutator bars sometimes causes shorts between bars which can be eliminated by cleaning out the slots. Shorts at cross-overs of the coils at the core end can often be eliminated by bending wires slightly and reinsulating the exposed bare wire.

d. Grounds in the armature are detected by use of a test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure, which is often brought on by overloading and consequent overheating of the generator. Repairs can sometimes be made if grounds are at core ends (where coils come out of slots) by placing insulating strips between core and coil which has grounded.

11-22. POLARIZING GENERATOR. After a generator has been repaired and reinstalled or at any time after a generator has been tested, it must be repolarized to make sure that it has the correct polarity with respect to the battery it is to charge. Failure to repolarize the generator may result in burned relay contact points, a run-down battery and possibly serious damage to the generator itself. The procedure to follow in correcting generator polarity depends upon the generator-regulator wiring circuits; that is, whether the generator field is internally grounded or is grounded through the regulator.

11-23. GENERATOR SERVICE TEST SPECIFICATIONS. Delco-Remy Specifications for 14- and 28-volt generators installed on PA-23 series airplanes are as follows:

Generator	1101915	1101905	1105055
Delco-Remy, Ref. Service Bulletin	1G-150	1G-150	1G-150
Brush Spring Tension	24 oz.	24 oz.	28 oz.
Field Current (80° F) Amps Volts	 1.62-1.72 12	 0.75-0.85 24	 1.45-1.55 24
Cold Output Amps Volts Approx. R.P.M.	 50 14.0 3960	 25 26.0 3550	 50 28.5 3730

COLD OUTPUT: Cold output data applies to generators at 80 degrees F, and with brushes well seated. Variations in temperature and brush seating as well as the condition of the generator may cause deviations of 100 RPM or more from rated speed.
HOT OUTPUT: Hot output is maximum output as controlled by current regulator.

11-24. REGULATOR (Delco-Remy).

11-25. DESCRIPTION OF REGULATOR. The regulator shown in Figure 11-4 consists of a cutout relay, a voltage regulator and a current regulator unit. The cutout relay closes the generator to battery circuit when the generator voltage is sufficient to charge the battery, and it opens the circuit when the generator slows down or stops. The voltage regulator unit is a voltage-limiting device that prevents the system voltage from exceeding a specified maximum and thus protects the battery and other voltage-sensitive equipment. The current regulator unit is a current-limiting device that limits the generator output so as not to exceed its rated maximum.

11-26. CUTOUT RELAY.

a. The cutout relay (Refer to Figure 11-4.) has two windings, a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire (shown in dashed lines). The shunt winding is connected across the generator so that generator voltage is impressed upon it at all times. The series winding is connected in series with the charging circuit so that all generator output passes through it. The relay core and windings are assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is centered just above the stationary contact points. When the generator is not operating, the armature contact points are held away from the stationary points by the tension of a flat spring riveted on the side of the armature.

b. When the generator voltage builds up a value great enough to charge the battery, the magnetism induced by the relay windings is sufficient to pull the armature toward the core so that the contact points close. This completes the circuit between the generator and battery. The current which flows from the generator to the battery passes through the series winding in a direction to add to the magnetism holding the armature down and the contact points closed.

c. When the generator slows down or stops, current begins to flow from the battery to the generator.

d. This reverse flow of current through the series winding causes a reversal of the series winding magnetic field. The magnetic field of the shunt winding does not reverse. Therefore, instead of helping each other, the two windings now oppose so that the resultant magnetic field becomes insufficient to hold the armature down. The flat spring pulls the armature away from the core so that the points separate; this opens the circuit between the generator and battery.

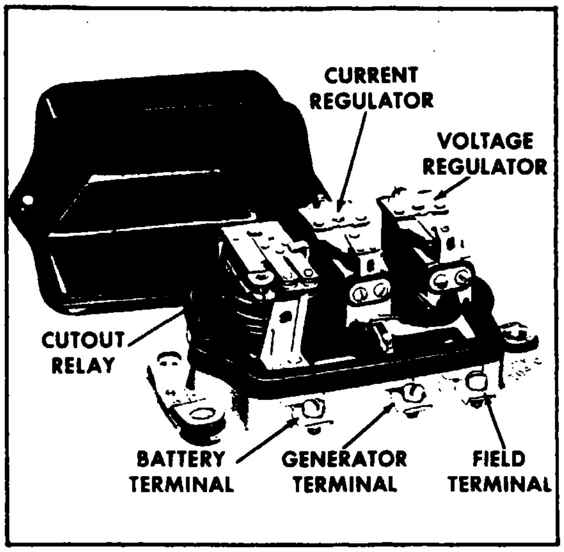

Figure 11-4. Current/Voltage Regulator

11-27. VOLTAGE REGULATOR.

a. The voltage regulator (Refer to Figure 11-4.) has two windings assembled on a single core, a shunt winding consisting of many turns of fine wire (shown in dashed lines) which is shunted across the generator, and a series winding of a few turns of relatively heavy wire which is connected in series with the generator field circuit when the regulator contact points are closed.

b. The windings and core are assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is just above the end of the core. The armature contains a contact point which is just beneath a stationary contact point. When the voltage regulator is not operating, the tension of a spiral spring holds the armature away from the core so that the points are in contact and the generator field circuit is completed to ground through them.

c. When the generator voltage reaches the value for which the voltage regulator is adjusted, the magnetic field produced by the two windings (shunt and series) overcomes the armature spring tension and pulls the armature down so that the contact points separate. This inserts resistance into the generator field circuit so that the generator field current and voltage are reduced. Reduction of the generator voltage reduces the magnetic field of the regulator shunt winding. Also, opening the regulator points opens the regulator series winding circuit so that its magnetic field collapses completely. The consequence is that the magnetic field is reduced sufficiently to allow the spiral spring to pull the armature away from the core so that the contact points again close. This directly grounds the generator so that generator voltage and output increase. The above cycle of action again takes place and the cycle continues at a rate of 50 to 200 times a second, regulating the voltage to a predetermined value. With the voltage thus limited, the generator supplies varying amounts of current to meet the varying states of battery charge and electrical load.

11-28. CURRENT REGULATOR.

a. The current regulator (Refer to Figure 11-4.) has a series winding of a few turns of heavy wire which carries all generator output. The winding core is assembled into a frame. A flat steel armature is attached to the frame by a flexible hinge so that it is just above the core. The armature has a contact point which is just below a stationary contact point. When the current regulator is not operating, the tension of a spiral spring holds the armature away from the core so that the points are in contact. In this position the generator field circuit is completed to ground through the current regulator contact points in series with the voltage regulator contact points.

b. When the load demands are heavy, as for example, when electrical devices are turned on and the battery is in a discharged condition, the voltage may not increase to a value sufficient to cause the voltage regulator to operate. Consequently, generator output will continue to increase until the generator reaches rated maximum current. This is the current value for which the current regulator is set. Therefore, when the generator reaches rated output, this output, flowing through the current regulator winding, creates sufficient magnetism to pull the current regulator armature down and open the contact points. With the points open, resistance is inserted into the generator field circuit so that the generator output is reduced.

c. As soon as the generator output starts to fall off, the magnetic field of the current regulator winding is reduced, the spiral spring tension pulls the armature up, the contact points close and directly connect the generator field to ground. Output increases and the above cycle is repeated. The cycle continues to take place while the current regulator is in operation 50 to 200 times a second, preventing the generator from exceeding its rated maximum. When the electrical load is reduced (electrical devices turned off or battery comes up to charge), then the voltage increases so that the voltage regulator begins to operate and tapers the generator output down. This prevents the current regulator from operating. Either the voltage regulator or the current regulator operates at any one time - the two do not operate at the same time.

11-29. RESISTANCES. The current and voltage regulator circuits use a common resistor which is inserted in the field circuit when either the current or voltage regulator operates. A second resistor[1] is connected between the regulator field terminal and the cutout relay frame, which places it in parallel with the generator field coils. The sudden reduction in field current occurring when the current or voltage regulator contact points open, is accompanied by a surge of induced voltage in the field coils as the strength of the magnetic field changes. These surges are partially dissipated by the two resistors, thus preventing excessive arcing at the contact points.

(1)(The second resistor is not present on all regulators. Many aircraft regulators have this resistor omitted.)

11-30. TEMPERATURE COMPENSATION. Voltage regulators are compensated for temperature by means of a bimetal thermostatic hinge on the armature. This causes the regulator to regulate at a higher voltage when cold which partly compensates for the fact that a higher voltage is required to charge a cold battery. Many current regulators also have a bimetal thermostatic hinge on the armature. This permits a somewhat higher generator output when the unit is cold, but causes the output to drop off as temperature increases.

11-31. REGULATOR POLARITY. Some regulators are designed for use with negative grounded systems, while other regulators are designed for use with positive grounded systems. Using the wrong polarity regulator on an installation will cause the regulator contact points to pit badly and give short life. As a safeguard against installation of the wrong polarity regulator, all regulators of this type have the model number and the polarity clearly stamped on the end of the regulator base. (Refer to paragraph 11-33, step f.)

11-32. REGULATOR MAINTENANCE.

NOTE

The regulator maintenance instructions to follow apply to Regulators, P/N 1119246 and 1118976. For maintenance instructions for Regulator, P/N 1119656, refer to Delco-Remy Service Bulletin 1R-119A. Specifications for all regulators are found in paragraph 11-44.

11-33. MAINTENANCE INSTRUCTIONS.

a. Mechanical checks and adjustments (air gaps, point opening) must be made with battery disconnected and regulator preferably off the aircraft.

CAUTION

The cutout relay contact points must never be closed by hand with the battery connected to the regulator. This would cause a high current to flow through the units which would seriously damage them.

b. Electrical checks and adjustments may be made either on or off the airplane. The regulator must always be operated with the type generator for which it is designed.

c. The regulator must be mounted in the operating position when electrical settings are checked and adjusted and it must be at operating temperature.

d. Specified generator speeds for testing and adjusting.

1. Voltage Regulator
   (a) Operating speed
2. Current Regulator
   (a) All generators must be operated at a speed sufficient to produce current in excess of specified setting.
   (b) Voltage of the generator must be kept high enough to insure sufficient current output, but below the operating voltage of the voltage regulator unit.

e. After any tests or adjustments the generator on the airplane must be polarized after leads are connected, but before the engine is started, as follows:

After reconnecting leads, momentarily connect a jumper lead between the GEN and BAT terminals of the regulator. This allows a momentary surge of current to flow through the generator which correctly polarizes it. Failure to do this may result in severe damage to the equipment since reversed polarity causes vibration, arcing and burning of the relay contact points.

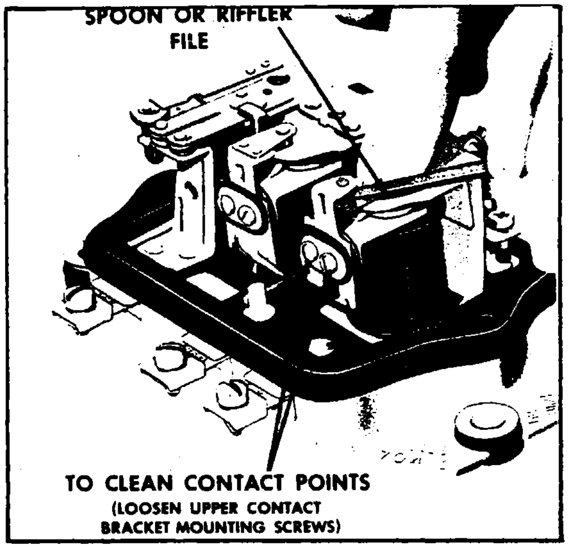

Figure 11-5. Use of Riffler File to Clean Contact Points

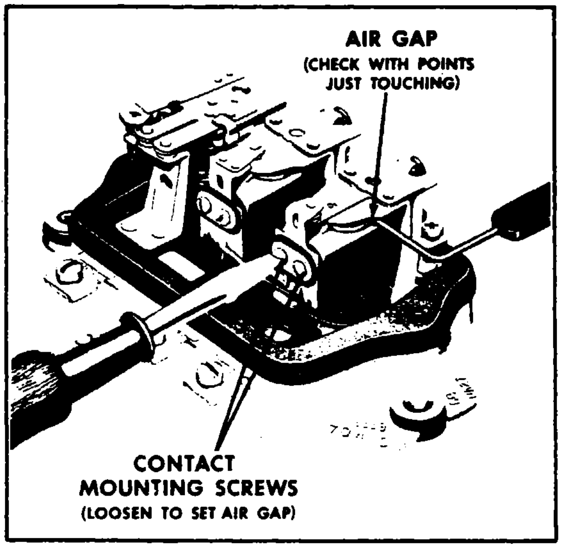

Figure 11-6. Voltage Regulator Air Gap

11-34. CLEANING CONTACT POINTS. The contact points of a regulator will not operate indefinitely without some attention. It has been found that a great majority of all regulator trouble can be eliminated by a simple cleaning of the contact points, plus some possible readjustment. The flat points should be cleaned with a spoon or riffler file. On negative grounded regulators which have the flat contact point on the regulator armatures, loosen the contact bracket mounting screws so that the bracket can be tilted to one side. A flat file cannot be used successfully to clean the flat contact points since it will not touch the center of the flat point where point wear is most apt to occur. Never use emery cloth or sandpaper to clean the contact points. Remove all the oxides from the contact points but note that it is not necessary to remove any cavity that may have developed.

11-35. REGULATOR CHECKS AND ADJUSTMENTS.

11-36. VOLTAGE REGULATOR. Two checks and adjustments are required on the voltage regulator; air gap and voltage setting.

a. Air Gap: To check air gap, push armature down until the contact points are just touching and then measure air gap. (Refer to Figure 11-6.) Adjust by loosening the contact mounting screws and raising or lowering contact bracket as required. Be sure the points are lined up and tighten screws after adjustment.

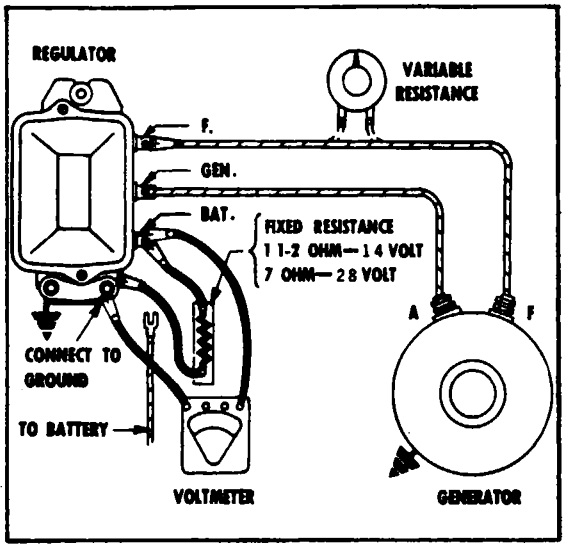

Figure 11-7. Checking Voltage Setting - Fixed Resistance Method

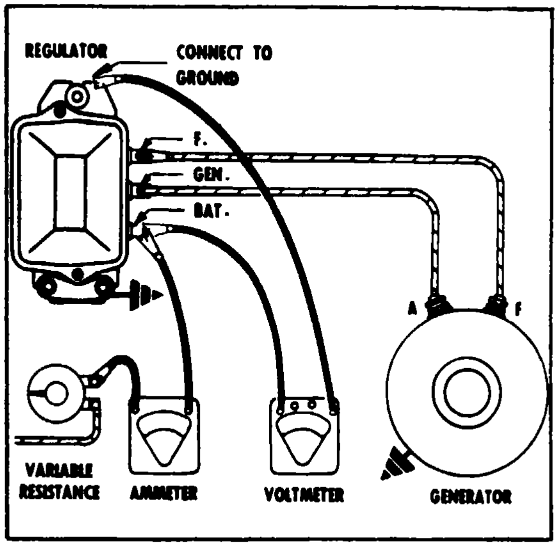

Figure 11-8. Checking Voltage Setting - Variable Resistance Method

b. Voltage Setting: There are two ways to check the voltage setting; the fixed resistance method and the variable resistance method. (Refer to Figures 11-7 and 11-8.)

1. Fixed Resistance Method:

(a) Connect a fixed resistance between the battery terminal and ground as shown in Figure 11-7 after disconnecting the battery lead from the battery terminal of the regulator. The resistance must be one and one-half ohms for 14-volt and seven ohms for 28-volt units. It must be capable of carrying 10 amperes without any change of resistance with temperature changes.

(b) Connect a voltmeter from regulator BAT terminal to ground.

(c) Place the thermometer within 0.25 inch of regulator cover to measure regulator ambient temperature.

(d) Operate generator at specified speed for 15 minutes with regulator cover in place to bring the voltage regulator to operating temperature.

(e) Cycle the generator:

Method 1: Move voltmeter lead from BAT to GEN terminal of the regulator. Retard generator speed until generator voltage is reduced to 4-volts. Move voltmeter lead back to BAT terminal of the regulator. Bring the generator back to specified speed and note voltage setting.

Method 2: Connect a variable resistance into the field circuit as in Figure 11-7. Turn out all resistance. Operate the generator at specified speed. Slowly increase (turn in) resistance until generator voltage is reduced to 4-volts. Turn out all resistance again and note voltage setting (with voltmeter connected as shown in Figure 11-7). Regulator cover must be in place.

(f) Note the thermometer reading and select the Normal Range of Voltage for this temperature as listed in specifications paragraph 11-44.

(g) Note the voltmeter reading with regulator cover in place.

(h) To adjust voltage setting, turn adjusting screw. (Refer to Figure 11-9.) Turn clockwise to increase setting and counterclockwise to decrease setting.

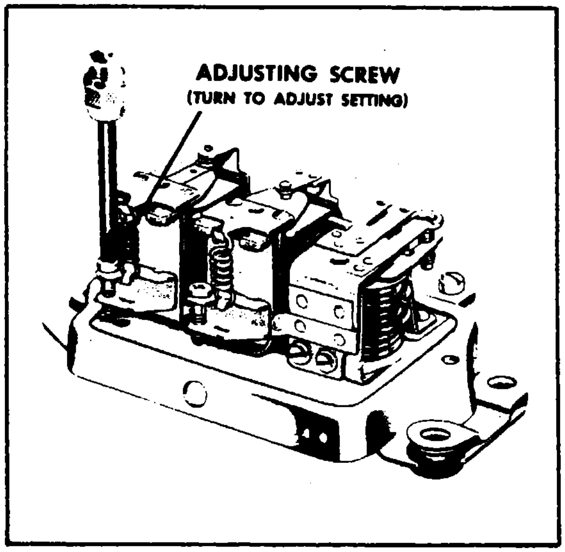

Figure 11-9. Adjusting Voltage Regulator Setting

CAUTION

If adjusting screw is turned down (clockwise) beyond range, spring support may not return when screw is backed off. In such case, turn screw counterclockwise until there is ample clearance between screw head and spring support. Then bend spring support up carefully until it touches the screw head. Final setting of the unit should always be made by increasing spring tension, never by reducing it. If setting is too high, adjust unit below required value and then raise to exact setting by increasing the spring tension. After each adjustment and before taking reading, replace the regulator cover and cycle the generator.

2. Variable Resistance Method:

(a) Connect ammeter and one-quarter ohm variable resistor in series with the battery as shown in Figure 11-7.

NOTE

It is very important that the variable resistance be connected at the BAT terminal as shown in Figure 11-7 rather than at the GEN terminal even though these terminals are in the same circuit. An examination of the wiring diagram, Figure 11-3, will show that regulation begins at the point where the shunt windings are connected to the series circuit. Any small resistance added to the circuit between the generator and this point will simply be offset by a rise in generator voltage without affecting the output shown at the ammeter.

(b) Connect voltmeter between BAT terminal and ground.

(c) Place thermometer within one-quarter inch of regulator cover to measure regulator ambient temperature.

(d) Operate generator at specified speed. Adjust variable resistor until current flow is 8 to 10-amperes. If less current than is required above is flowing, it will be necessary to turn on airplane lights to permit increased generator output. Variable resistance can then be used to decrease current flow to the required amount.

Allow generator to operate at this speed and current flow for 15 minutes with regulator cover in place in order to bring the voltage regulator to operating temperature.

(e) Cycle the generator by either method listed in "Fixed Resistance Method" of "Voltage Setting" procedure.

(f) Note the thermometer reading and select the "Normal Range" of voltage for this temperature as listed in specifications paragraph 11-44.

(g) Note the voltmeter reading with regulator cover in place.

(h) Adjust voltage regulator as required as described in step (h) of "Fixed Resistance Method" of "Voltage Setting Procedure." In using the variable resistance method, it is necessary to readjust the variable resistance after each voltage adjustment to assure that 8 to 10-amperes are flowing. Cycle generator after each adjustment before reading voltage regulator setting with cover in place.

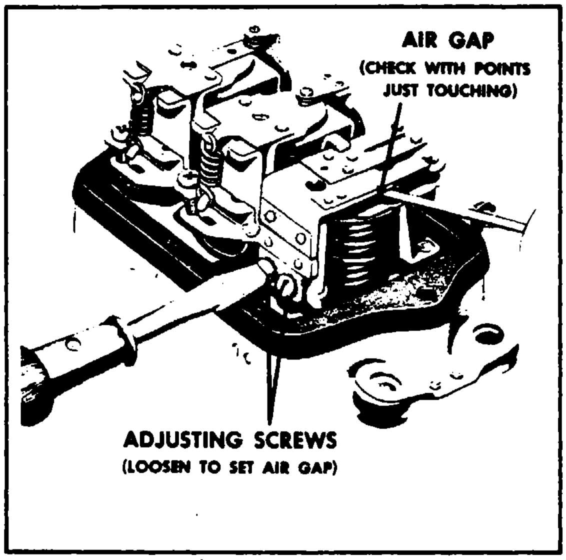

Figure 11-10. Cutout Relay Air Gap Check and Adjustments

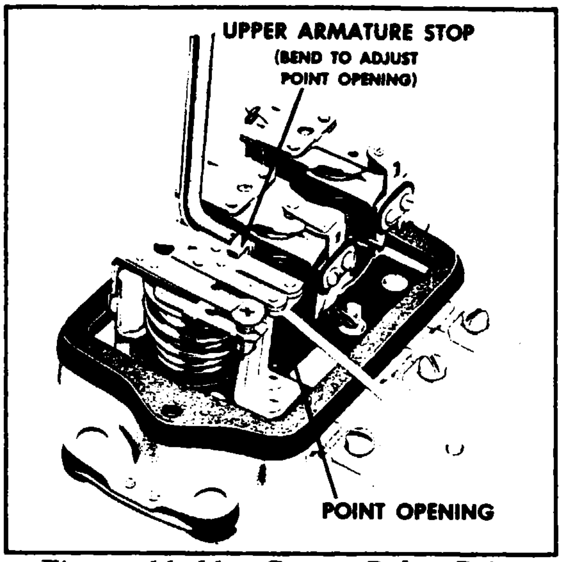

Figure 11-11. Cutout Relay Point Opening Check and Adjustment

11-37. CUTOUT RELAY. The cutout relay requires three checks and adjustments: air gap, point opening and closing voltage. The air gap and point opening adjustments must be made with the battery disconnected.

a. Air Gap: Place fingers on armature directly above core and move armature down until points just close and then measure air gap between armature and center of core. (Refer to Figure 11-10.) On multiple contact point relays, make sure that all points close simultaneously. If they do not, bend spring finger so they do. To adjust air gap, loosen two screws at the back of relay and raise or lower the armature as required. Tighten screws after adjustment.

b. Point Opening: Check point opening and adjust by bending the upper armature stop. (Refer to Figure 11-11.)

c. Closing Voltage: Connect regulator to proper generator and battery. Connect voltmeter between the regulator GEN terminal and ground. (Refer to Figure 11-12.)

Method 1: Slowly increase generator speed and note relay closing voltage. Decrease generator speed and make sure the cutout relay points open.

Method 2: Make connections as in Step c; but, in addition, add a variable resistor connected into the field circuit. (Refer to Figure 11-12.) Use a 25-ohm - 25-watt resistor. Operate generator at medium speed with variable resistance turned all in. Slowly decrease (turn out) the resistance until cutout relay points close. Note closing voltage. With cover in place, slowly increase (turn in) resistance to make sure points open.

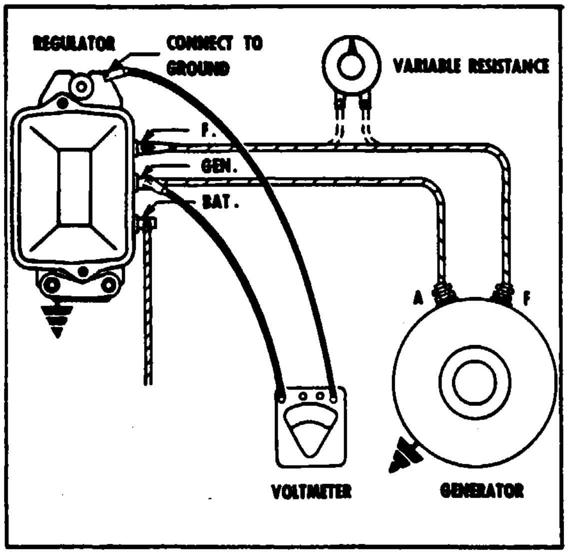

Figure 11-12. Checking Cutout Relay Closing Voltage

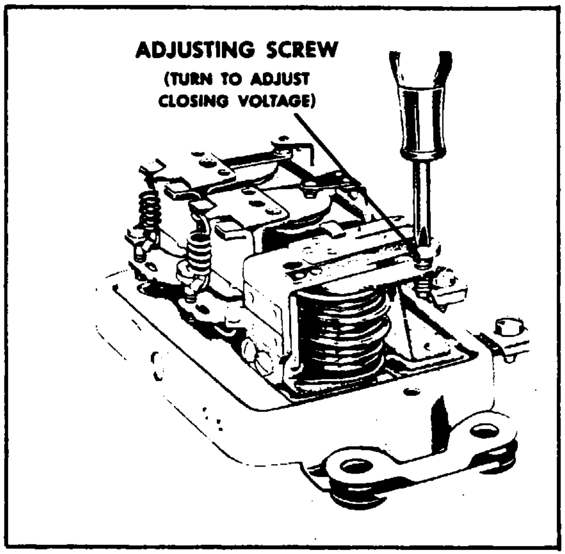

Figure 11-13. Adjustment of Cutout Relay Closing Voltage

d. Adjust closing voltage by turning adjusting screw. (Refer to Figure 11-13.) Turn screw clockwise to increase setting and counterclockwise to decrease setting.

11-38. CURRENT REGULATOR. Two checks and adjustments are required on the current regulator; air gap and current setting.

a. Air Gap: Check and adjust in exactly the same manner as for the voltage regulator.

b. Current Setting: Current regulator setting on current regulators having temperature compensation should be checked by the following method:

1. Load Method:

(a) Connect ammeter into charging circuit as in Figure 11-13.

(b) Turn on all accessory load (lights, radio, etc.) and connect an additional load across the battery (such as a carbon pile or band of lights) so as to drop the system voltage approximately one-volt below the voltage regulator setting.

(c) Operate generator at specified speed for 15 minutes with cover in place. (This establishes operating temperature; see steps (c) and (d) in paragraph 11-33.) If current regulator is not temperature-compensated, disregard 15 minute warm-up period.

(d) Cycle generator and note current setting.

(e) Adjust in same manner as described for voltage regulator. (Refer to Figure 11-9.)

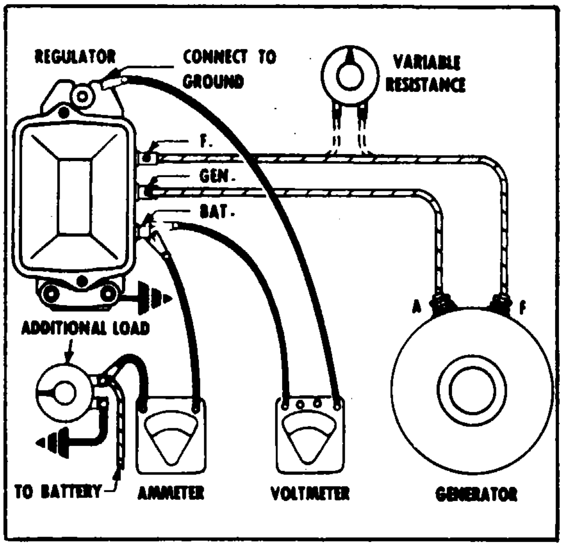

Figure 11-14. Checking Current Regulator, Load Method

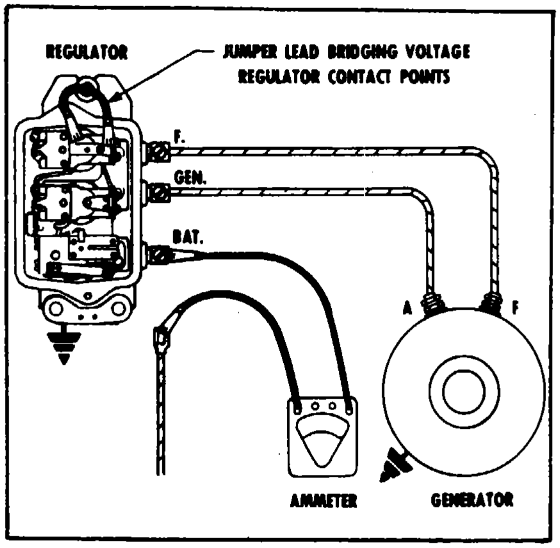

Figure 11-15. Checking Current Regulator, Jumper Lead Method

2. Jumper Lead Method: (Use only for current regulators without temperature compensation.)

(a) Connect ammeter into charging circuit as in Figure 11-15.

(b) Connect jumper lead across voltage regulator points as in Figure 11-14.

(c) Turn on all lights and accessories or load battery as in (b) under Load Method.

(d) Operate generator at specified speed and note current setting.

(e) Adjust in same manner as described for the voltage regulator. (Refer to Figure 11-9.)

11-39. REGULATOR REPAIRS.

11-40. REGULATOR SPRING REPLACEMENT. If it becomes necessary to replace the spiral spring on either the current or voltage regulator unit, the new spring should first be hooked on the lower spring support and then stretched up until it can be hooked at the upper end. Stretch the spring only by means of a screw driver blade inserted between the turns (or in a similar manner). Do not pry the spring into place as this is likely to bend the spring support. After installing a new spring, readjust the unit setting as already described.

11-41. RADIO BY-PASS CONDENSERS. The installation of radio by-pass condensers on the field terminal of the regulator or generator will cause the regulator contact points to burn and oxidize so that generator output will be reduced and a run down battery will result. If a condenser is found connected to either of these terminals, disconnect the condenser and clean the regulator contact points as previously explained.

11-42. REGULATOR ARMATURE REPLACEMENT. The armature may be replaced by drilling out the two rivets attaching the armature to the regulator frame. Support the frame to avoid bending. Center-punch the rivet heads and drill out with a 3/32 inch drill. Attach the new armature with screws, lockwashers and nuts supplied with the service armature. Assemble screws down so that they will not ground against cover.

11-43. HIGH POINTS ON REGULATOR PERFORMANCE AND CHECKS.

a. The voltage regulator unit limits the voltage of the circuit, thus protecting the battery, lights and other accessories from high voltage.

b. The current regulator unit provides protection to the generator, preventing it from exceeding its maximum rated output.

c. Never set the current regulator above the maximum specified output of the generator.

d. Many of the regulators are designed to be used with a positive grounded battery while others are designed to be used with a negative grounded battery only. Never attempt to use the wrong polarity regulator on an application.

e. The majority of reported regulator troubles arise from dirty or oxidized contact points which cause a reduced generator output. Clean the contact points with a spoon or riffler file. Never use emery cloth or sandpaper to clean points.

f. Always make sure that the rubber gasket is in place between the cover and base before replacing the cover. The gasket prevents entrance of moisture, dust and oil vapors which might damage the regulator.

g. The proper testing equipment in the hands of a qualified mechanic is necessary to assure proper and accurate regulator settings. Any attempt on the part of untrained personnel to adjust regulators is apt to lead to serious damage to the electrical equipment and should therefore be discouraged.

h. After any generator or regulator tests or adjustments, the generator must be polarized as explained in paragraph 11-33, step f, in order to avoid damage to the equipment.

i. It is recommended that following replacement or repair of a generator or regulator they be adjusted on a test bench as a matched unit.

11-44. REGULATOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 14 - and 28-volt regulators installed as standard equipment on PA-23 series airplanes are as follows:

Regulator Model	1119246[1]	1118976[1]	1119656[2]
Delco-Remy Ref. Service Bulletin	1R-116A	1R-116	1R-119A
Cutout Relay: Air Gap Point Opening Closing Voltage	 0.020 in. 0.020 in. 11.8-13.5-volts	 0.017 in. 0.032 in. 24 - 27-volts	 0.017 in. 0.032 in. 22.8-25.2 volts
Voltage Regulator: Air Gap Current Setting	 0.075 in. 65°F - 14.2-15.7-volts 85°F - 14.4-15.4-volts 105°F - 14.2-15.0-volts	 0.075 in. 27.9 29.4-volts	 0.067 in. 65°F - 29.4-31.4-volts[3] 85°F - 28.9-30.8-volts[3] 105°F - 28.3-30.1-volts[3]
Current Regulator: Air Gap Current Setting	 0.075 in. 48 - 52-amps	 0.075 in. 23 - 27-amps	 0.075 in. 48 - 52-amps

[1] Paralleling: With no load on battery terminal, add 5-amp load at P-terminal - voltage regulator to operate 2 to 3-volts lower.

[2] Paralleling: With no load on battery terminal, add 2.5-amp load at P-terminal - voltage regulator to operate 2 to 3-volts lower.

[3] Operation on lower contacts must be 0.2 to 0.6-volts lower than on upper contacts.

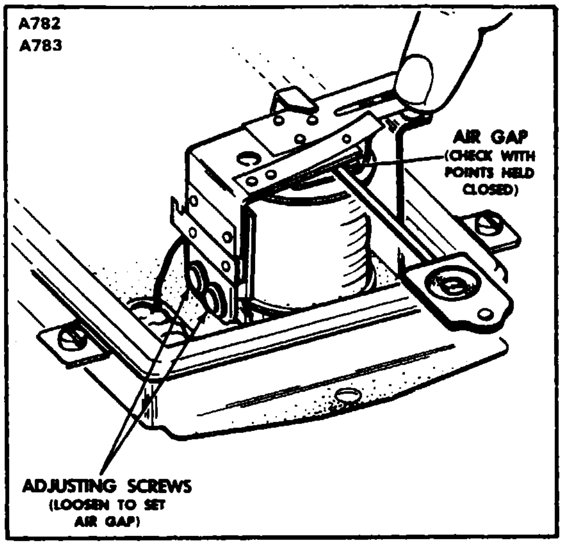

Figure 11-16. Checking and Adjusting Relay Air Gap

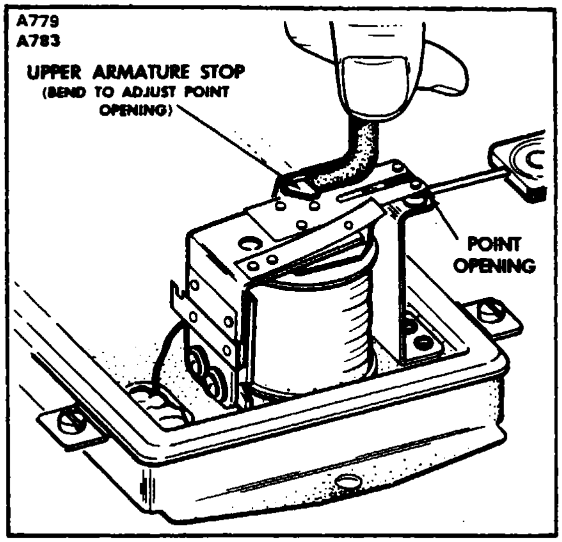

Figure 11-17. Checking and Adjusting Relay Point Opening

11-45. PARALLELING RELAY (Delco-Remy).

11-46. RELAY CHECKS AND ADJUSTMENTS. The cutout relay requires three checks and adjustments: air gap, point opening and closing voltage. The air gap and point opening adjustments must be made with the battery disconnected. (Refer to specifications given in paragraph 11-50.

11-47. AIR GAP. With the armature pushed down so the points are closed, check the air gap between the armature and core. (Refer to Figure 11-16.) To adjust, loosen the two adjusting screws and raise or lower the armature as required. Be sure the points align and tighten the screws after adjustment.

11-48. POINT OPENING. Check point opening and adjust by bending the upper armature stop as illustrated in Figure 11-17.

11-49. CLOSING VOLTAGE. To check the closing voltage of the cutout relay, connect a voltmeter from the GEN terminal of the relay to the relay base or ground as shown in Figure 11-20. Slowly increase the generator speed until the contact points close and read the voltage on the meter. To adjust the closing

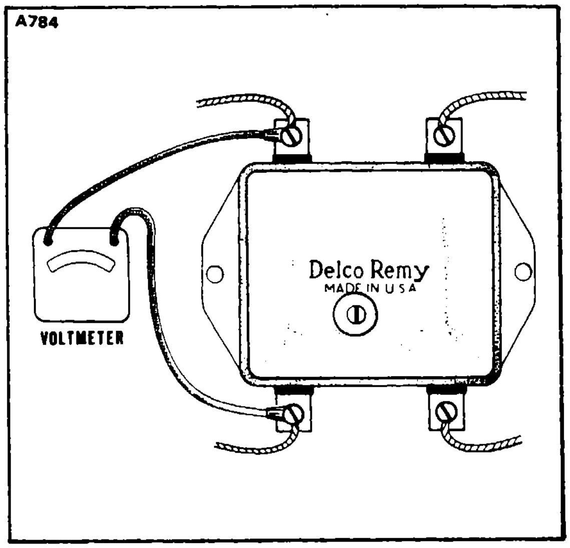

Figure 11-18. Checking Relay Closing Voltage

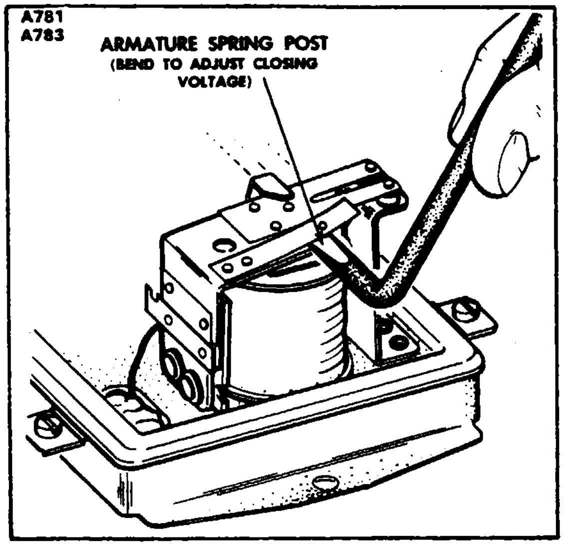

Figure 11-19. Adjusting Relay Closing Voltage

voltage, shut down the engine and bend the armature spring post (Refer to Figure 11-19.) up to increase the closing voltage and bend down to decrease the closing voltage. After each adjustment for both armatures, stop the generator and then slowly increase its speed and check the setting.

11-50. RELAY SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 14 and 28-volt relays installed as standard equipment on the model PA-23 series airplanes are as follows:

Relay Model	1116887	1116903
Delco-Remy Ref. Service Bulletin	1R100	1R100
Air Gap at Core, Points Closed	0.022 ± 10% in.	0.022 ± 10% in.
Point Opening	0.028 in.	0.028 in.
Closing Voltage (Range)	10.5 to 12.3	21 to 24.6
Opening Voltage (Range)	8 minimum	16 minimum

11-51. ALTERNATOR SYSTEM.

11-52. DESCRIPTION OF ALTERNATOR. For each alternator, the alternator output circuit is connected by means of a 90-ampere circuit breaker, a filter in the line to eliminate radio interference and a shunt to monitor alternator output.

The field circuit consists of a 10-ampere thermal circuit breaker, a volt-regulator, selector switch, over voltage relay, radio noise filter and a special switch ganged to the 90-ampere circuit breaker to remove field voltage from the alternator should the circuit breaker open.

The field and output circuit of both alternators are joined by a bus bar which directs current to the battery. A shunt is installed between the battery and bus to measure current flow to and from the battery. The field circuit is combined with the master switch to turn off the alternator when the master switch is turned off.

A second set of components is installed in the field circuit should a failure of the main regulating system occur.

The 90-ampere alternator circuit breakers should not be switched on and off under load for testing or any other reason.

11-53. CHECKING ALTERNATOR SYSTEM. The ammeter is equipped with a selector switch which enables an independent output check of each alternator, as well as the electrical output-input of the battery. Should either alternator show no output on the ammeter, check the appropriate circuit breakers. If a further check of the ammeter shows no output from both alternators, switch to the auxiliary voltage regulator and over voltage relay. If switching to the auxiliary system indicates no electrical output, further check the alternator system. (Refer to Figure 11-20.)

a. Ascertain that the ammeter is operating properly.
b. Disconnect the battery and field leads at the alternator.
c. Ascertain that all electrical units are off and the battery is fully charged.
d. Turn on the master switch.
e. To check the alternator output circuit, connect a voltmeter or 14 or 28-volt test light to the battery lead and to ground. If a reading of approximately 14 or 28-volts registers on the voltmeter or the test light lights, the battery circuit is operational.
f. Should there be no indication of voltage, trace back through the output circuit until voltage is indicated. (Refer to Figure 11-20.) A component that allows no voltage to pass through it should be replaced.
g. To check the field circuit, connect a voltmeter or 14 or 28-volt test light to the field lead and to ground. Test the field circuit using the same procedure

as in steps e and f. Both the main and auxiliary field systems may be checked in a like manner.

h. If voltage is indicated at both the battery lead and field lead, the alternator should be checked for possible malfunction. (Refer to Paragraph 11-55.)

11-54. ADJUSTMENTS. The only adjustments necessary to maintain the alternator system is the adjustment of the voltage control on the voltage regulator. A voltage of 14 or 28-volts is maintained. All other control adjustments are made at time of installation and need not be reset.

IMPORTANT

Since the alternator and regulator are designed for use on only one polarity system, the following precautions must be observed when working on the charging circuit. Failure to observe these precautions will result in serious damage to the electrical equipment.

a. When installing a battery, always check the ground polarity of the alternator to ensure correct battery grounding.

b. When connecting a booster battery, make certain to connect the negative battery terminals together.

c. When connecting a charger to the battery, connect the charger positive lead to the battery positive terminal and the charger negative lead to the battery negative terminal.

d. Never operate the alternator on open circuit. Make absolutely certain all connections in the circuit are secure.

e. Do not short across or ground any of the terminals on the alternator or regulator.

f. Do not attempt to polarize the alternator.

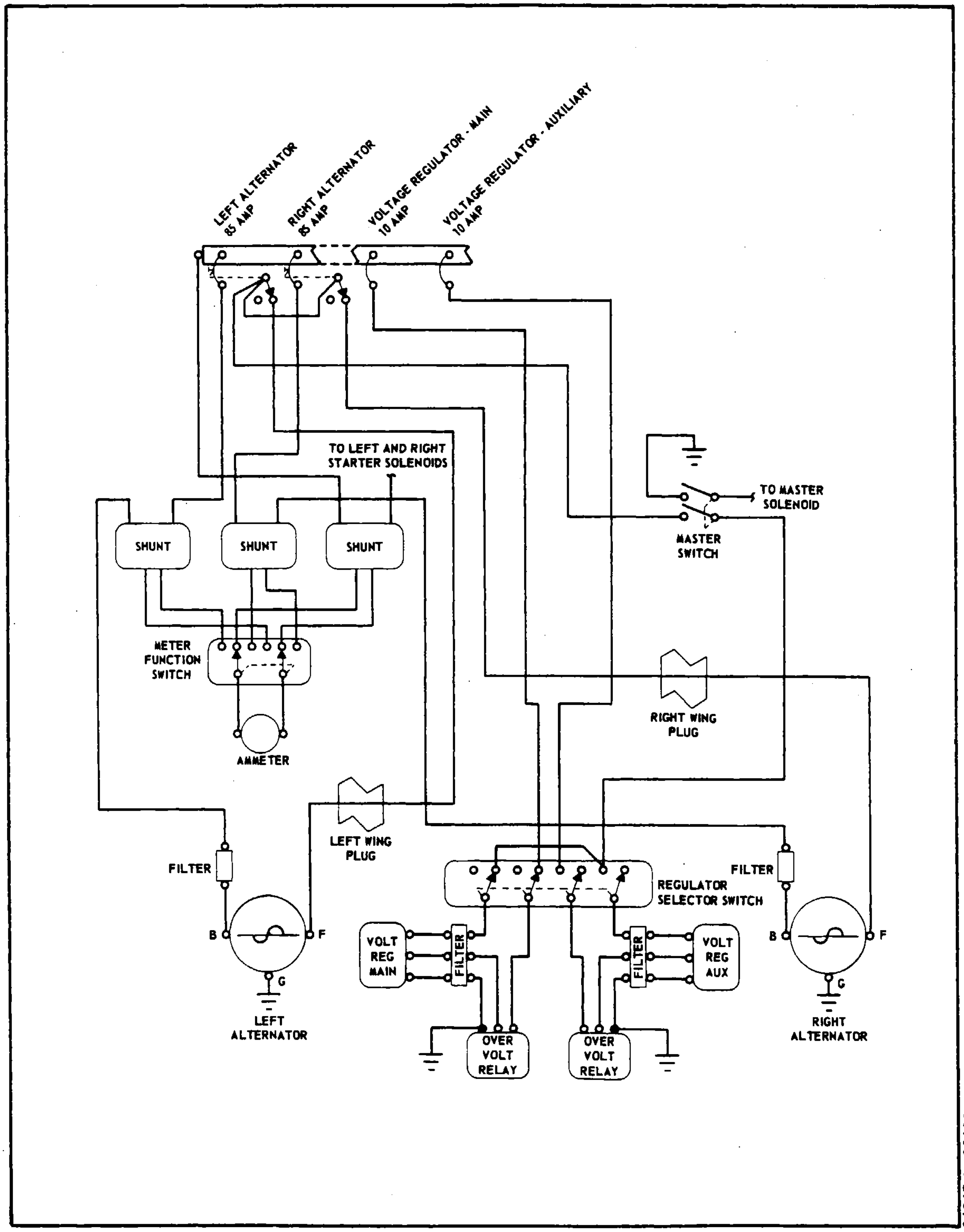

Figure 11-20. Alternator System Wiring Schematic (Delco-Remy)

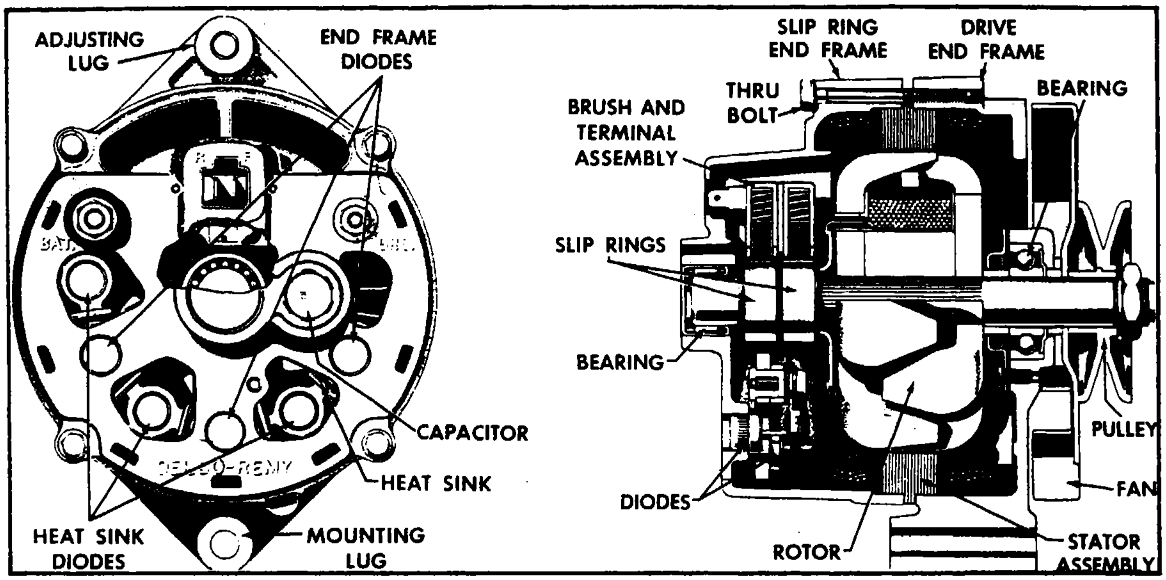

Figure 11-21. Cross-Sectional View of Alternator

11-55. ALTERNATOR AND COMPONENTS (Delco-Remy).

11-56. INSPECTION. At regular intervals, inspect the terminals for corrosion and loose connections, and the wiring for frayed insulation. Check the mounting bolts for tightness, and the belt for alignment, proper tension and wear. Belt tension should be adjusted in accordance with engine manufacturer's recommendations. When tightening belt tension, apply pressure against the stator laminations between the end frames, and not against either end frame.

Noise from an alternator may be caused by worn or dirty bearings, loose mounting bolts, a loose drive pulley, a defective diode, or a defective stator.

11-57. DISASSEMBLY. After extended periods of operation, or at time of engine overhaul, the alternator may be removed for a thorough inspection and cleaning of all parts. The alternator consists of four main components - the two end frames, the stator and the rotor.

To disassemble the alternator, take out the four thru-bolts and separate the drive end frame and rotor assembly from the stator assembly by prying apart with a screwdriver at the stator slot. A mark will help locate the parts in the same position during assembly. The fit between stator and frame is not tight and the two can be separated easily. Note that the separation is to be made between the stator frame and drive end frame. After disassembly, place a piece of tape over the slip ring end frame bearing on both sides to prevent entry of dirt and other

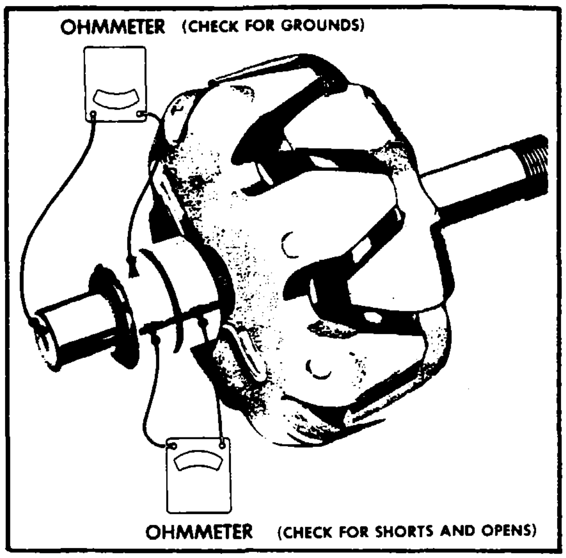

Figure 11-22. Checking Rotor

foreign material, and also place a piece of tape over the shaft on the slip ring end. If brushes are to be re-used, clean with a soft, dry cloth.

CAUTION

Do not use black friction tape. Use only pressure sensitive tape that will not leave any contamination on the shaft surface.

To remove the drive end frame from the rotor, place the rotor in a vise and tighten only enough to permit removal of the shaft nut.

CAUTION

Avoid excessive tightening as this may cause distortion. Remove the shaft nut, washer, pulley, fan and the collar, and then seperate the drive end frame from the rotor shaft.

Additional disassembly procedures are covered in the following sections.

11-58. CHECKS.

a. ROTOR CHECKS: The rotor may be checked electrically for grounded, open, or short circuited field coils. To check for grounds, connect a 110-volt test lamp or an ohmmeter from either slip ring to the rotor shaft or to the rotor poles. If the lamp lights, or if the ohmmeter reading is low, the field winding is grounded. (Refer to Figure 11-21.)

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light, or if the ohmmeter reading is high (Infinite), the winding is open. (Refer to Figure 11-21.)

The winding is checked for short circuits by connecting a battery and ammeter in series with the two slip rings. Note the ammeter reading and refer to paragraph 11-66 for specifications. An ammeter reading above the specified value indicates shorted windings. An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings. (Refer to Figure 11-21.) If the resistance reading is below the specified value, the winding is shorted. The specified resistance value can be determined by dividing the voltage

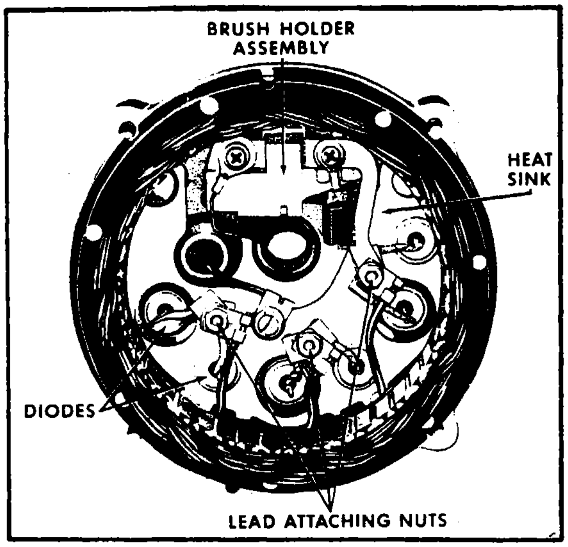

Figure 11-23. Slip Ring End Frame

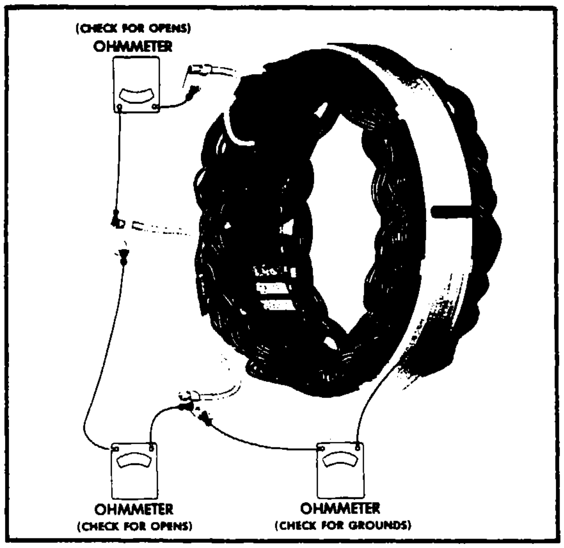

Figure 11-24. Checking Stator

by the current given in paragraph 11-66. If the rotor is not defective, and the alternator fails to supply rated output when checked as covered in the section entitles Output Check, the trouble is in the stator or rectifying diodes.

b. STATOR CHECKS: To check the stator windings, remove all three stator lead attaching nuts (Refer to Figure 11-23), and then separate the stator assembly from the end frame. The fit between stator frame and end frame is not tight, and the two can be separated easily.

The stator windings may be checked with a 110-volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to the frame, the windings are grounded. If the lamp fails to light, or if meter reading is high when successively connected between each pair of stator leads, the windings are open. (Refer to Figure 11-24.)

A short circuit in the stator windings is difficult to locate without laboratory test equipment due to the low resistance of the windings. However, if all other electrical checks are normal and the alternator fails to supply rated output, shorted stator windings are indicated. Also, another possibility is a ground which may have existed between stator windings and either end frame before disassembly. Visually inspect very carefully for this possibility.

c. DIODE CHECKS: Each diode may be checked electrically for a shorted or open condition. Any one of the following methods may be used.

Ohmmeter Method: One method of checking diodes is to use an ordinary ohmmeter. The lowest range scale on the ohmmeter should be used, and the ohmmeter should have a one and one-half volt cell. To determine the cell voltage turn the selector to the lowest scale, and then connect the ohmmeter leads to a voltmeter. The voltmeter will indicate the cell voltage.

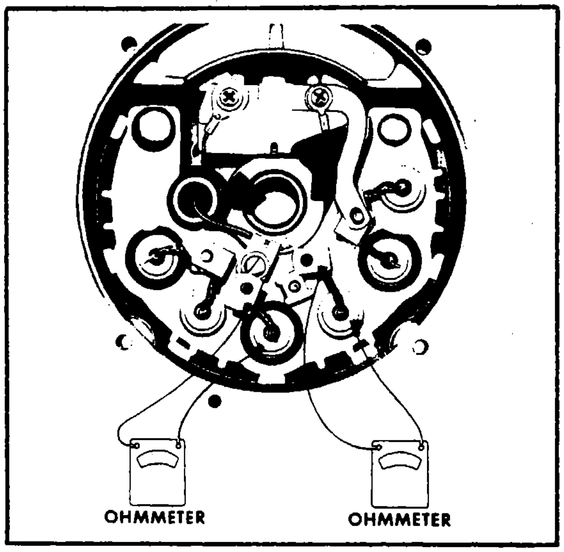

Figure 11-25. Checking Diodes

With the stator disconnected, check a diode in the heat sink by connecting one of the ohmmeter leads to the heat sink, and the other ohmmeter lead to the diode lead, and note the reading. (Refer to Figure 11-25.) Then reverse the ohmmeter lead connections, and note the reading. If both readings are very low, or if both readings are very high, the diode is defective. A good diode will give one low reading and one high reading. Check the other two diodes in the heat sink in the same manner.

To check a diode mounted in the end frame, connect one of the ohmmeter leads to the end frame, and the other ohmmeter lead to the diode lead (Refer to Figure 11-25.), and note the reading. Then reverse the ohmmeter lead connections, and note the reading. If both readings are very low, or if both readings are very high, the diode is defective. A good diode will give one low reading and one high reading. Check the other two diodes in the end frame in the same manner:

Test Lamp Method: An alternate method of checking the diodes is to use a test lamp of not more than 14 or 28-volts (depending on voltage of system) in place of the ohmmeter.

CAUTION

Do not use 110-volt test lamps to check diodes.

With the stator disconnected, connect the test lamp leads across each diode as previously described first in one direction and then in the other. If the lamp lights in both checks, or fails to light in both checks, the diode is defective.

Special Tester Method: Special testers are available which operate without disconnecting the stator. To use these testers, follow the tester manufacturer's recommendations.

11-59. DIODE REPLACEMENT. To replace a diode, use a suitable tool to support the end frame or heat sink, and use an arbor press or vise to push the diode out. Also use a special tool which fits over the outer diode edge to push the diode in, and support the heat sink and end frame with a suitable tool.

NOTE

Diode replacement tools are available from various manufacturers normally supplying tools and test equipment to the aviation industry.

CAUTION

Do not strike the diode, as the shock may damage the other diodes.

11-60. SLIP RING SERVICING. If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor in a lathe, or otherwise spin the rotor, and hold the polishing cloth against the slip rings until they are clean.

CAUTION

The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

11-61. BEARING REPLACEMENT AND LUBRICATION. The bearing in the drive end frame can be removed by detaching the retainer plate screws, and then pressing the bearing from the end frame. If the bearing is in satisfactory condition, it may be re-used, and it should be filled one-quarter full with Delco-Remy lubricant No. 1960373 before reassembly.

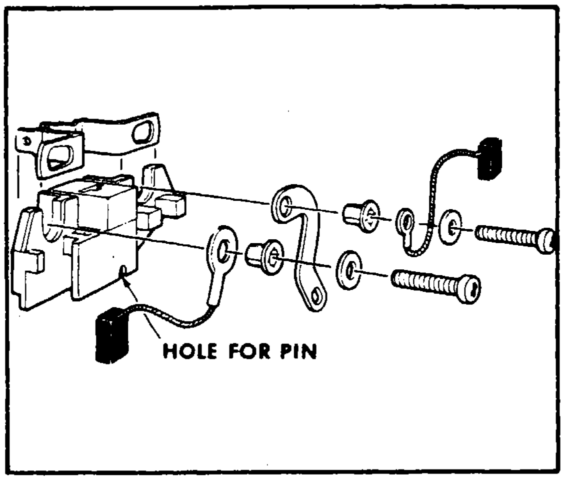

Figure 11-26. Brush Holder Assembly

CAUTION

Do not overfill, as this may cause the bearing to overheat, and use only 1960373 lubricant.

To install a new bearing, press in with a tube or collar that just fits over the outer race. It is recommended that a new retainer plate be installed if the felt seal in the retainer plate is hardened or excessively worn.

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to re-lubricate and re-use the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

To install a new bearing, place a flat plate over the bearing and press in from the outside towards the inside of the frame until the bearing is flush with the outside of the end frame. Support the inside of the frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing.

Saturate the felt seal with S. A. E. 20 oil, and then reassemble the felt seal and steel retainer.

11-62. BRUSH REPLACEMENT. When the slip ring end frame assembly is separated from the rotor and drive end frame assembly, the brushes will fall down onto the shaft and come in contact with the lubricant. If the brushes are to be re-used, they must be thoroughly cleaned with a soft dry cloth. Also, the shaft must be thoroughly cleaned before reassembly.

The brush springs should be inspected for any evidence of damage or corrosion. If there is any doubt as to the condition of the brush springs, they should be replaced.

To install new brushes, remove the brush holder assembly from the end frame by detaching the two brush holder assembly screws. Install the springs and brushes into the brush holder, and insert a straight wire or pin into the holes at the bottom of the holder to retain the brushes. (Refer to Figure 11-26.) Then attach the brush holder assembly onto the end frame, noting carefully the proper stack-up of parts as shown in Figure 11-26. Allow the straight wire to protrude

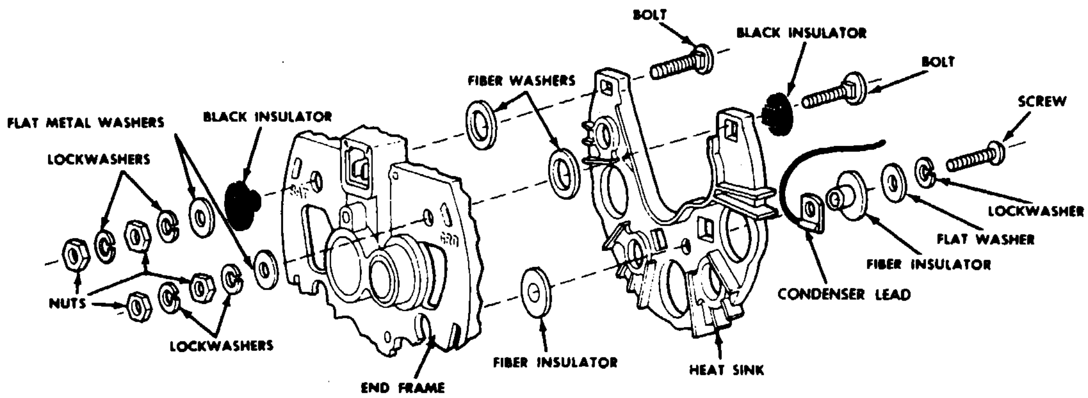

Figure 11-27. Exploded View of Heat Sink Assembly

through the hole in the end frame.

11-63. HEAT SINK REPLACEMENT. The heat sink may be replaced by removing the BAT and GRD terminals from the end frame, and the screw attaching the condenser lead to the heat sink. During reassembly, note the proper stack-up of parts as shown in Figure 11-27.

11-64. REASSEMBLY. Reassembly is the reverse of disassembly. Remember when assembling the pulley to secure the rotor in a vise only tight enough to permit tightening the shaft nut to 50 to 60 foot pounds. If excessive pressure is applied against the rotor, the assembly may become distorted. To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft, and make sure the shaft is perfectly clean after removing the tape.

Insert a straight wire as previously mentioned through the holes in the brush holder and end frame to retain the brushes in the holder. Then withdraw the wire after the alternator has been completely assembled. The brushes will then drop onto the slip rings.

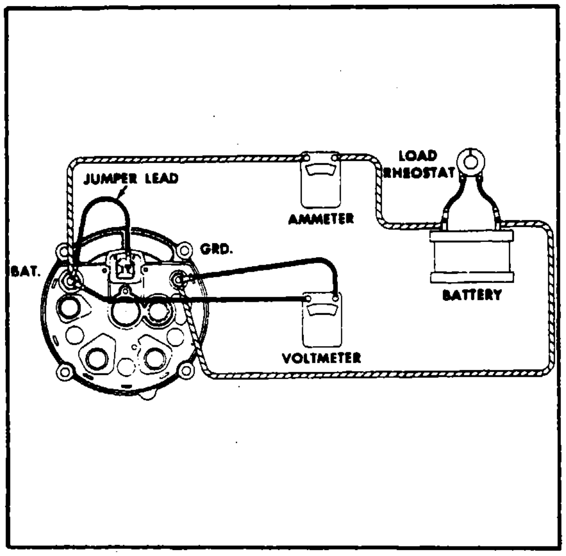

Figure 11-28. Alternator Output Check

11-65. OUTPUT CHECK. To check the alternator on a test bench, make electrical connections as shown in Figure 11-28, operate at specified speed, and check for rated output as given in paragraph 11-66. Adjust the load rheostat, if necessary, to obtain the desired output.

NOTE

A special adapter which can be used for making connections to the alternator is available from tool companies and test equipment manufacturers normally supplying equipment to the aviation trade.

CAUTION

Do not polarize alternator.

11-66. ALTERNATOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 14 or 28-volt alternators installed as standard equipment on the PA-23 series airplanes are as follows:

Alternator	1100660	1100717	1100718
Delco-Remy, Ref. Service Bulletin	1G-186, 1G-262	1G-187, 1G-262	1G-187, 1G-262
Field Current (80° F) Amps Volts	 2.2 - 2.6 12.0	 2.2 - 2.6 12.0	 1.2 - 1.3 24.0
Cold Output: Spec. Volts Amps Approx. R.P.M. Amps Approx. R.P.M.	 14.0 25 2000 65 5000	 14.0 25 2000 65 5000	 24.0 6 2000 46 5000
Hot Output: Amps	 70	 70	 70

TABLE XI-II. SUMMARY OF ALTERNATOR CHECKS

COMPONENT	CONNECTION	READING	RESULTS
Rotor	Ohmmeter from slip ring to shaft	Very low	Grounded
	110 volt test lamp from slip ring to shaft	Lamp lights	Grounded
	Ohmmeter across slip rings	Very high	Open
	110 volt test lamp across slip ring	Lamp fails to light	Open
	Battery and ammeter to slip rings, across slip rings	Observe voltmeter and ammeter readings	Compare with specifieations in 1G-186 for shorts
Stator	Ohmmeter from lead to frame	Very low	Grounded
(Disconnected from diodes)	110 volt test lamp from lead to frame	Lamp lights	Grounded
	Ohmmeter across each pair of leads	Any reading very high	Open
	110 volt test light across each pair of leads	Fails to light	Open
Diode	Ohmmeter across diode, then reverse connections	Both readings very low	Shorted
(Disconnected from diodes)		Both readings very high	Open
	14 or 28-volt test lamp across diode, then reverse connections.	Lamp fails to light in both checks	Open
		Lamp lights in both checks	Shorted

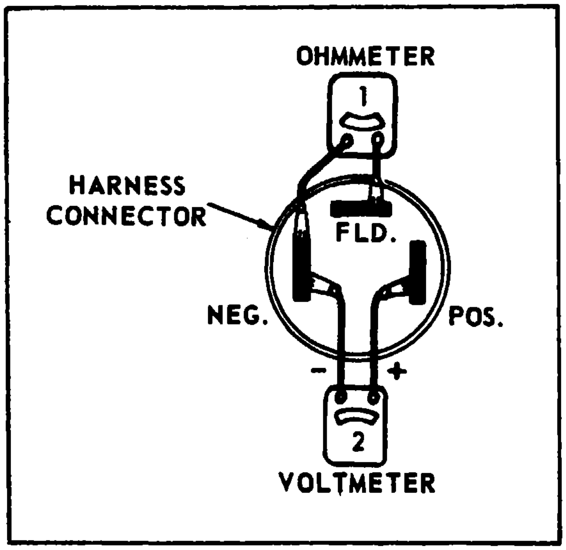

Figure 11-29. Volt - Ohmmeter Test

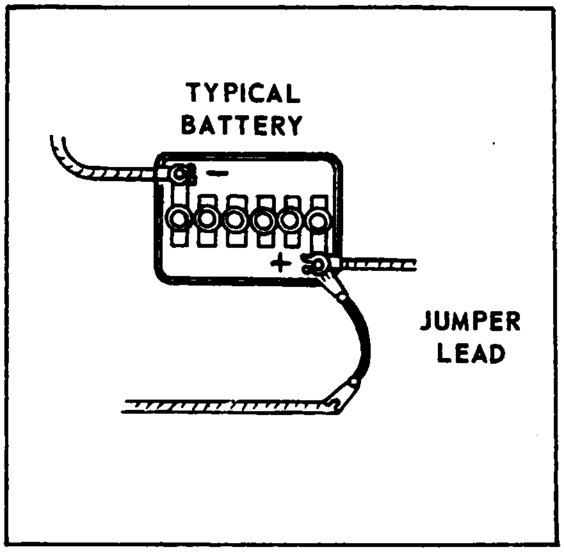

Figure 11-30. Jumper Connection

11-67. REGULATOR (Delco-Remy).

11-68. CHECKING REGULATOR CIRCUIT. Alternator failures may be caused by circuit misconnections, such as reversed leads or shorted or grounding of terminals with a screw driver, etc. The following provides a means of locating circuit misconnections. It also covers the different types of regulator panel board circuit trace defects which indicate a certain type of wiring harness misconnections. A burned circuit trace on the regulator panel board is proof that a circuit misconnection exists, or occurred at some time. However, a misconnection will not always cause a burned circuit trace even though circuit component failures have been caused.

Before installing a new regulator, it is very important to make sure that no wiring circuit defects or wiring harness misconnections exist. If the wiring harness is defective, or if misconnections exist, the new regulator will fail too. Furthermore, repeated replacement of regulators will only result in repeated regulator failures, and this will continue until the circuit defect is corrected.

To check the wiring harness for defects or misconnections before installing the new regulator, observe the following procedure.

NOTE

Meter connections are made to the harness connector that has been unplugged from the regulator.

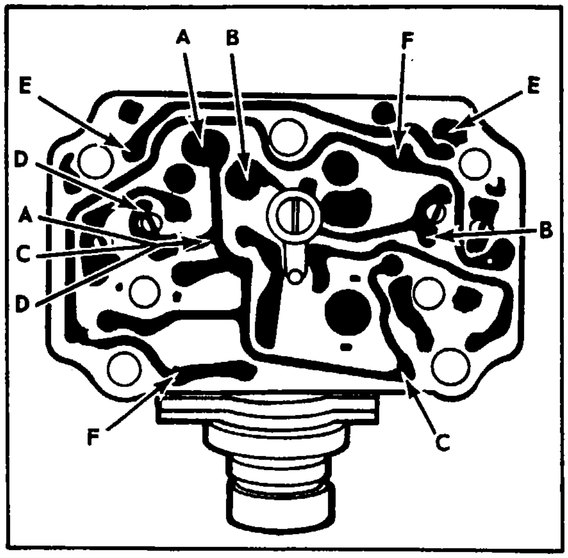

Figure 11-31. Regulator Checks

a. Check the alternator field resistance with an ohmmeter as shown in Step 1, Figure 11-29, and note the reading. Make sure the master switch is OFF. Readings of less than 2-ohms, or more than 8-ohms indicate a defective field winding in the alternator or a defective wiring harness. If the reading is within the 2 to 8-ohm range, check the reading against the allowable resistance in the circuit which can be calculated by dividing the specified voltage for the alternator by the current rating. The specified voltage and the current rating values are found in paragraph 11-66.

1. If the reading is the same as the calculated value, proceed to part b.
2. If reading is much higher (infinite) than the calculated value, proceed to part b.
3. If reading is zero, check for short between NEG and FLD leads, or for a grounded FLD lead. Circuit trace will be burned open between points A-A, B-B or C-C, Figure 11-31.
4. If reading is low, alternator fieldwinding is shorted. Circuit trace may be burned between points A-A, B-B, or C-C, Figure 11-31.

NOTE

To expose the printed circuit for viewing, remove the bottom plate from the regulator, the three panel board attaching screws, the transistor attaching screws, and then separate the heat sink from the panel board.

b. With switch turned ON, connect voltmeter as shown in Step 2, Figure 11-29. Make sure positive (+) and negative (-) voltmeter leads are connected as shown.

c. If meter reads battery voltage, disconnect lead at alternator "Fl" (field) terminal.

1. If reading is still battery voltage, wiring is not defective, and no more wiring tests need be made.
2. If voltage reading is zero, the NEG and FLD leads are reversed. Circuit trace will be burned open between points A-A, B-B or C-C, Figure 11-31.

d. If meter reads zero voltage, disconnect lead at alternator "Fl" (field) terminal, and connect a jumper lead from this lead to battery positive (+) post. (Refer to Figure 11-30.)

1. If meter now reads battery voltage, the POS and FLD leads are reversed. This misconnection alone will not cause the circuit trace to be burned open.

2. If meter now reads backwards, alternator field terminal is connected to regulator negative terminal, the positive line is connected to regulator field terminal, and regulator positive terminal is connected to negative side of circuit. Either the circuit trace will be burned between points C-C, D-D, or E-E, 11-31; or the driver transistor will be open. In either case, the driver bias resistor will have been overheated.

e. If voltmeter reads backwards, disconnect lead at alternator "F1" (field) terminal.

1. If meter still reads backwards, the POS and NEG leads are reversed. The circuit trace may be burned between points C-C, D-D, E-E or F-F, Figure 11-31. The transient suppression diode always will be open or shorted.

2. If meter now reads zero, the positive line is connected to regulator NEG terminal, the negative line is connected to the regulator FLD terminal, and the alternator "F1" (field) terminal is connected to the regulator POS terminal. The circuit trace will be burned open between points F-F, Figure 11-31.

IMPORTANT

For further assistance, follow the procedure in Delco-Remy Service Bulletin 1R-273 when troubleshooting circuits containing this regulator.

11-69. RELAY (Delco-Remy).

11-70. CHECKING RELAY. The relay is a protective device against high voltage that may appear in the electrical system. The relay will open the circuit to the alternator field winding if the system voltage should ever reach a predetermined value. When the circuit opens, the alternator voltage will be eliminated. The relay is designed so that the battery will continue to hold the relay contacts open until the engine is stopped or the master switch is opened. The No. 1 terminal on the relay is connected to the master switch, and the No. 2 terminal to the regulator POS terminal. For connections, refer to the aircraft wiring diagram.

With the relay removed from the aircraft, an electrical check can be made on a test bench to determine if the relay is operating properly.

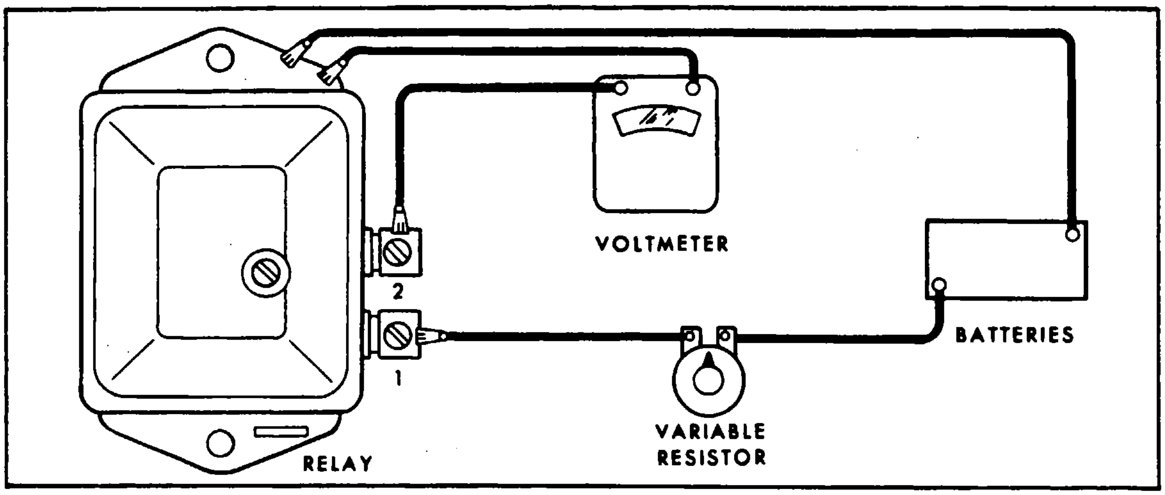

Figure 11-32. Relay Tests

CAUTION

Do not remove the cover and attempt to make adjustments on this relay. If the assembly does not pass the following electrical check, discard the relay. If the relay does pass the following electrical check, it may be re-used.

a. Turn to the "open" or maximum resistance position a 100 ohm variable resistor having a wattage rating of one and one-half watts or above.

b. Connect this resistor with a voltmeter and two 12 volt batteries (for 14 volt systems or three 12 volt batteries for 28 volt systems) in series to the relay as shown in Figure 11-32. Connect the negative battery post to the relay base, and the positive battery post to the variable resistor.

c. Slowly decrease the resistance and observe the maximum voltmeter reading obtained. This reading will be the voltage at which the contacts open.

d. The contacts should open at 16 to 17 volts (14 volt system) or 32 to 36 volts (28 volt system). If they do not, discard the relay.

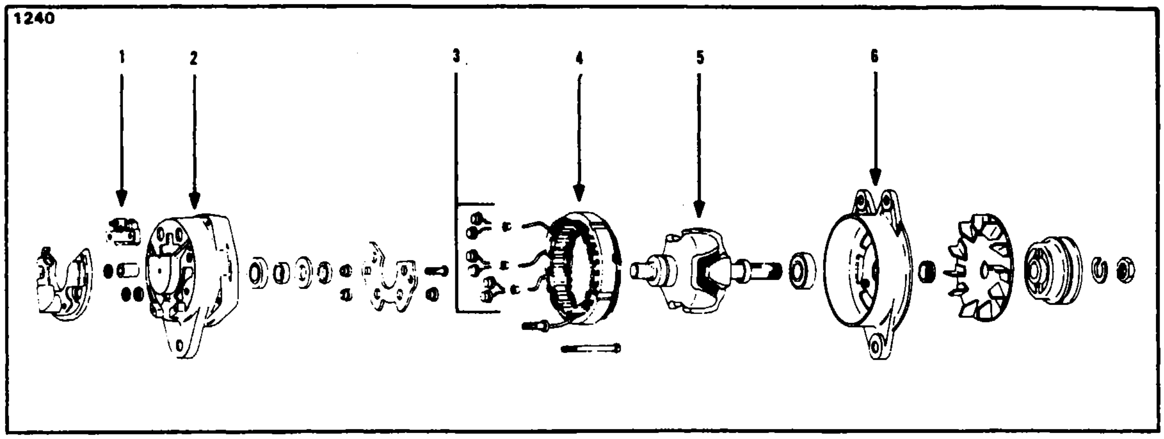

Figure 11-33. Exploded View of Alternator

11-71. ALTERNATOR AND COMPONENTS (Prestolite).

11-72. DESCRIPTION OF ALTERNATOR. (Refer to Figure 11-33.) The principal components of the alternator are the brush holder assembly (1), the slip ring end head (2), the rectifiers (3), the stator (4), the rotor (5) and the drive end head (6).

a. The brush and holder assembly contains two brushes, two brush springs, a brush holder and insulators. Each brush is connected to a separate terminal stud and is insulated from ground. The brush holder assembly can easily be removed for inspection or brush replacement purposes.

b. The slip ring end head provides the mounting for the rectifiers and rectifier mounting plate, output and auxiliary terminal studs, and the brush and holder assembly. The slip ring end head contains a roller bearing and outer race assembly and a grease seal.

c. The rectifiers used in these units are rated at 150 peak inverse voltage (PIV) minimum for transient voltage protection. Three positive rectifiers are mounted in the rectifier mounting plate while the three negative rectifiers are mounted in the slip ring end head. Each pair of rectifiers is connected to a stator lead with high temperature solder. The stator leads are anchored to the rectifier mounting plate with epoxy cement for vibration protection.

d. The stator contains a special lead which is connected to the center of the three phase windings and is used to activate low voltage warning systems or relays. The stator has been treated with a special epoxy varnish for high temperature resistance.

e. The rotor contains the slip ring end bearing inner race and spacer on the slip ring end of the shaft. The rotor winding and winding leads have been specially treated with a high temperature epoxy cement to provide vibration and temperature resistance characteristics. High temperature solder is used to secure the winding leads to the slip rings.

f. The drive end head supports a sealed, prelubricated ball bearing in which the drive end of the rotor shaft rotates.

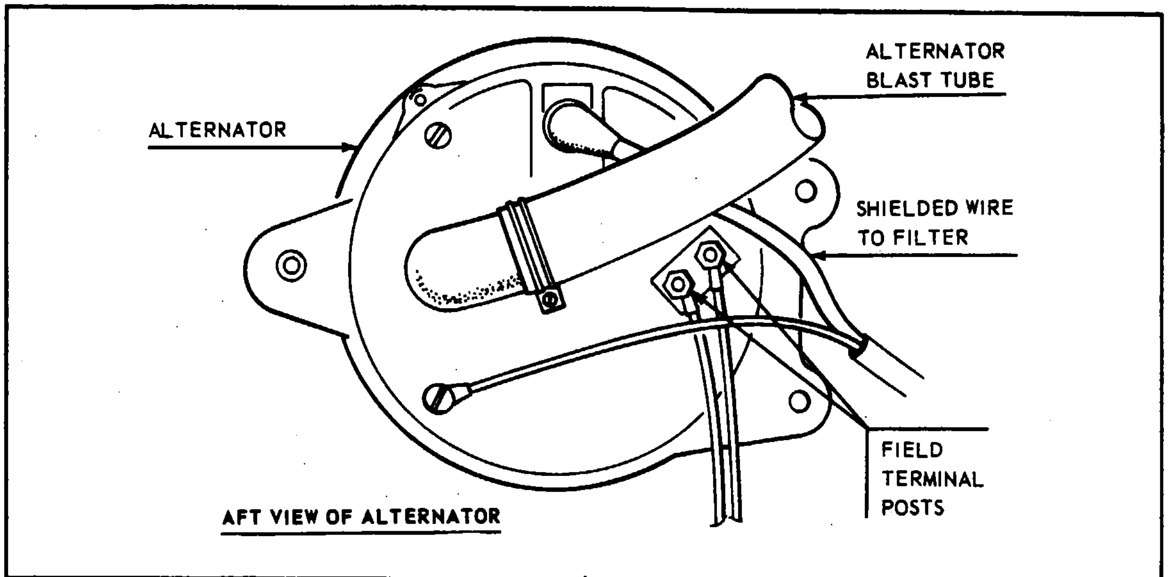

Figure 11-34. Alternator Blast Tube Routing

11-73. OVERHAUL OF ALTERNATOR. When repairing the alternator, complete disassembly may not be required. In some cases it will only be necessary to perform those operations which are required to effect the repair. However, in this section, the complete overhaul is covered step-by-step to provide detailed information on each operation. In actual service practice, these operations may be used as required.

11-74. ALTERNATOR SERVICE INSPECTION. This inspection should be accomplished whenever any service is being done on or around the alternator or during a 100 hour inspection. The inspection consists of visually checking the routing of the alternator blast tube to insure it's not being chafed against the field terminal posts on the alternator. This condition could expose the coiled wire in the blast tube which would then short out the field terminals on the alternator, with subsequent alternator failure. This tube should be routed over the shielded wire to the filter, to clear the field terminal posts. (Refer to Figure 11-34.)

These alternators should also have insulation used to provide protection against bridging the field terminals with a wrench or in the event of a loose connection to keep the field terminal leads from contacting one another. If either of these conditions exist with the master switch on, the regulator will be destroyed. This insulation will deteriorate after a period of time and will no longer provide protection and should be replaced. Refer to latest revision of Lycoming Service Instruction No. 1253 for the proper material.

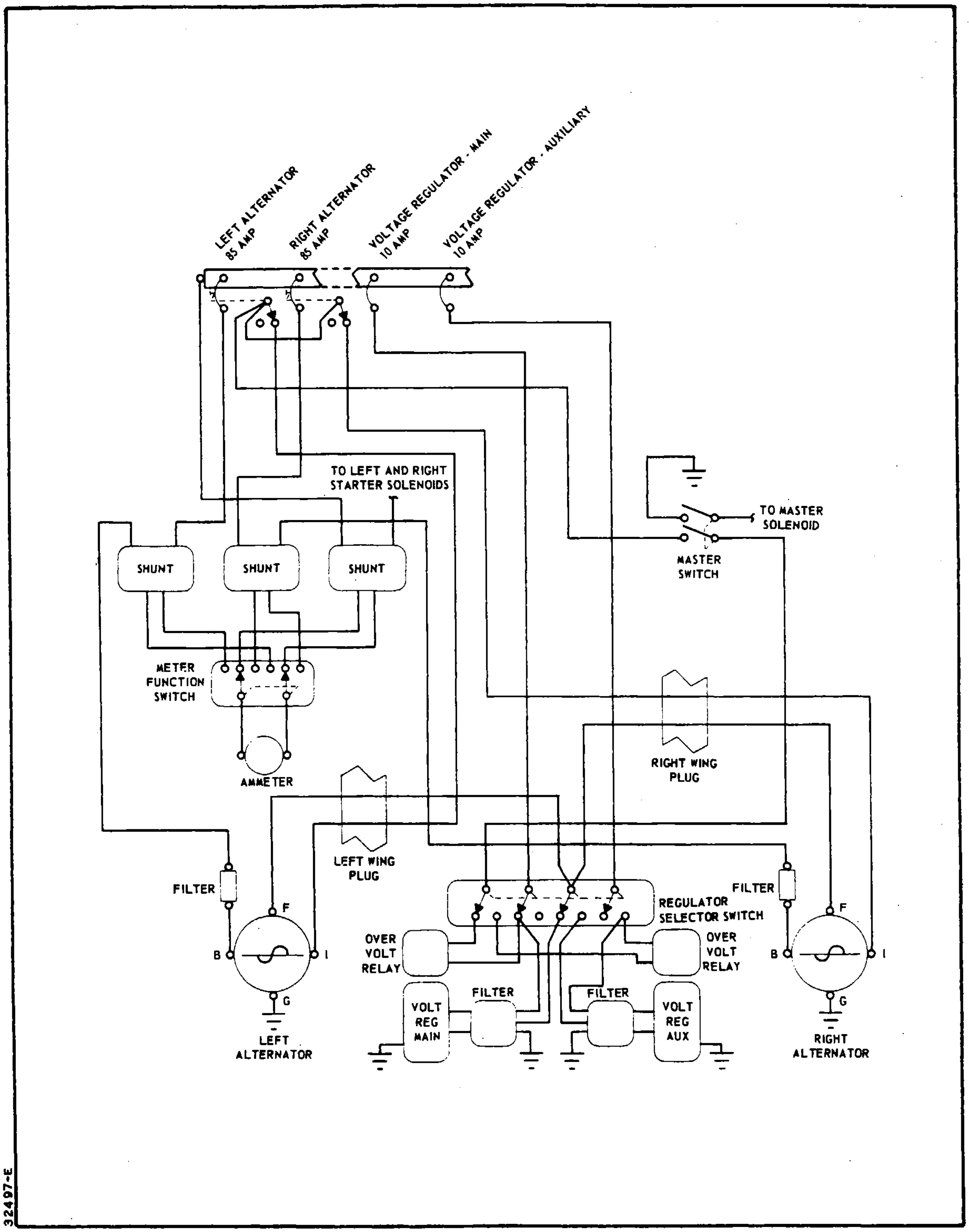

Figure 11-35. Alternator System Wiring Schematic (Prestolite)

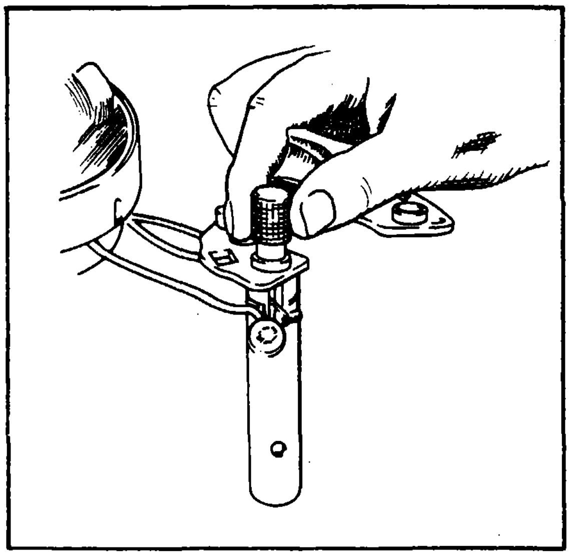

Figure 11-36. Removal of Rectifier

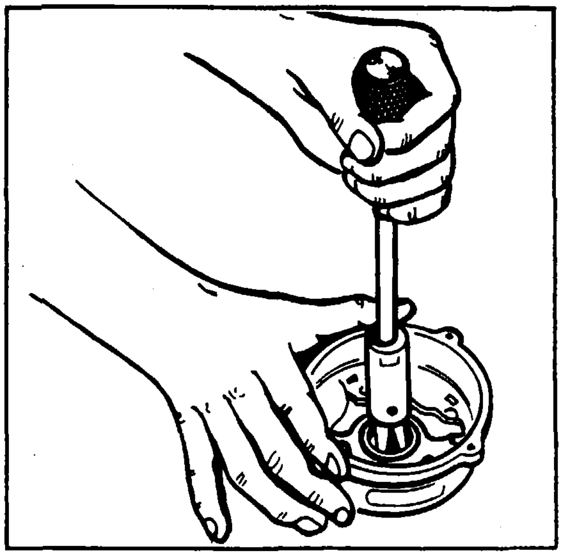

Figure 11-37. Removal of Slip Ring End Bearing

11-75. DISASSEMBLY OF ALTERNATOR.

a. Remove the two Number 10-24 screws holding the brush holder assembly in the slip ring end head. Remove the brush and holder assembly from the end head.

b. Remove the safety wire from the through bolts. Hold the pulley with a strap wrench and remove the pulley nut. The pulley must be removed with a puller. Remove the fan, woodruff key and spacer from the shaft.

c. Remove the four through bolts and tap the drive end head lightly to separate the drive end head and rotor, as a unit, from the stator and slip ring end head.

d. Remove the nuts, lock washers, flat washers and insulators from the output and auxiliary terminal studs. Note carefully the correct assembly of the insulator washers and bushings. Using the special tools shown in Figure 11-36, support the end head and press out the three negative rectifiers. The end head can now be separated from the stator assembly.

e. To remove the slip ring end bearing and grease seal, it will be necessary to have a hook type or impact type bearing puller as shown in Figure 11-37. Do not remove the bearing unless replacement is necessary.

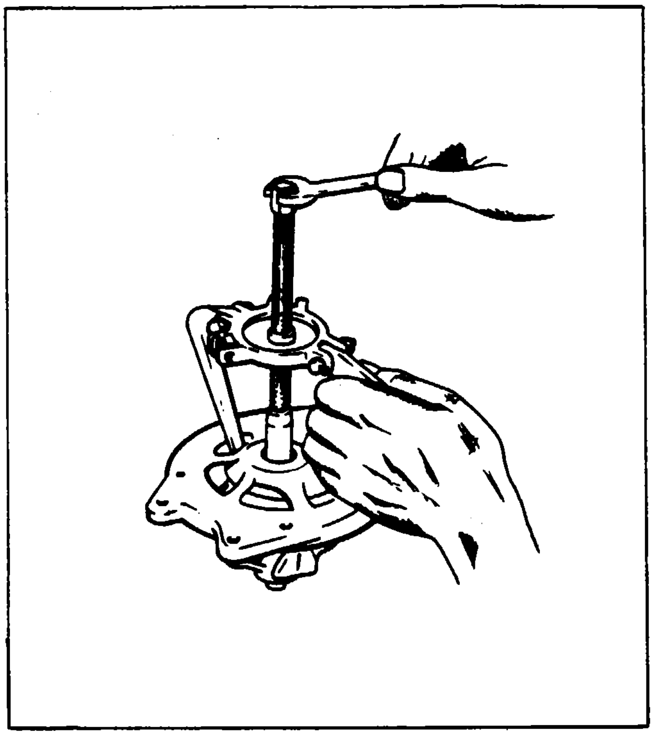

Figure 11-38. Removal of Drive End Head

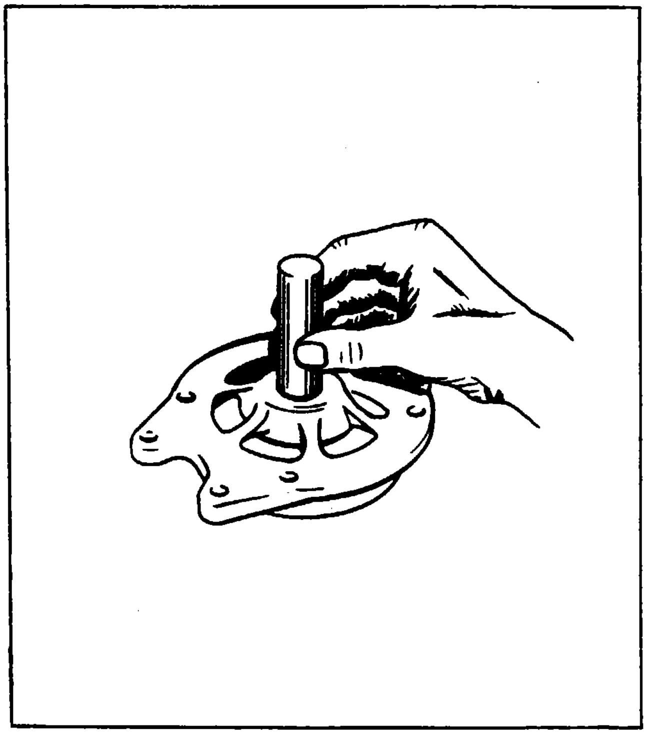

Figure 11-39. Removal of End Head Bearing

NOTE

The inner race of the slip ring end bearing is pressed onto the rotor shaft. When bearing replacement is necessary, always replace the complete bearing assembly, including the inner race.

f. To remove the drive end head from the rotor shaft, use a puller that grips on the bearing retainer plate as shown in Figure 11-38. Do not attempt to remove by supporting the end head and pressing on the shaft, as this may result in distortion of the end head or stripping of the retainer plate screws. Remove the three retainer plate screws and press the bearing out of the end head. (Refer to Figure 11-39.)

11-76. INSPECTION AND TESTING OF COMPNENTS. Upon completion of the disassembly, all parts should be cleaned and visually inspected for cracks, wear or distortion and any signs of overheating or mechanical interference.

a. Rotor: The rotor should be tested for grounded or shorted windings. The ground test can be made with test probes, connected in series with a 110-volt test lamp, an ohmmeter or any type of continuity tester. (Refer to Figure 11-40.) There must not be any continuity between the slip rings and the rotor shaft or poles. To test for shorted turns in the rotor winding, connect a voltmeter, ammeter and rheostat as shown in Figure

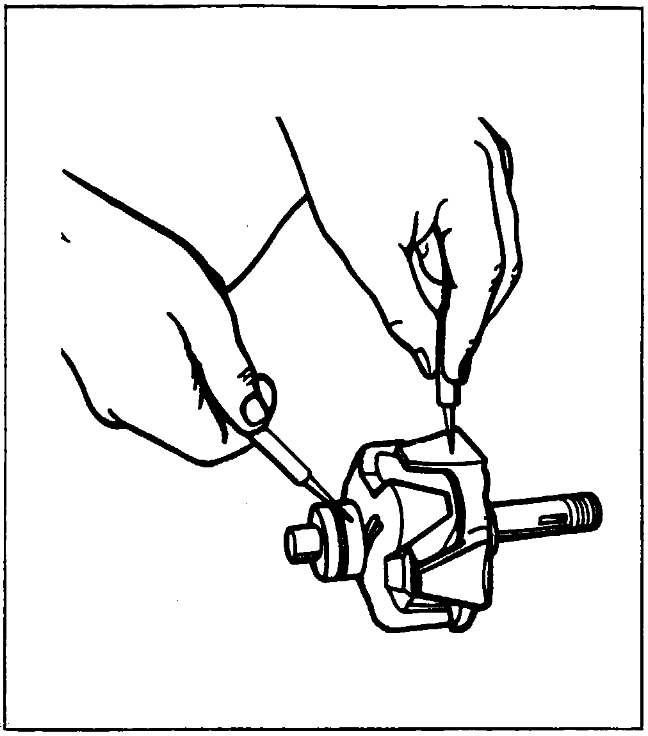

Figure 11-40. Testing Rotor for Grounds

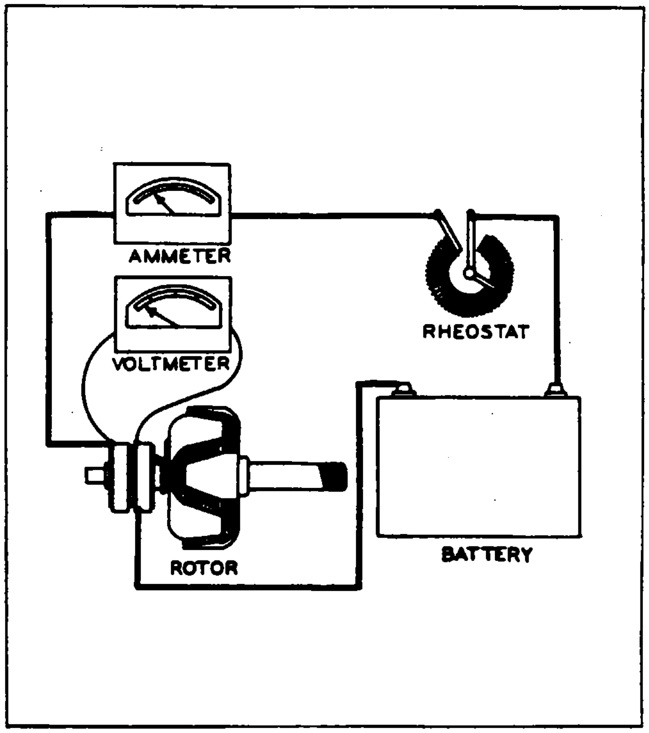

Figure 11-41. Testing Rotor for Shorts

or use an ohmmeter. Rotor current draw and resistance are listed in the individual specification pages. Excessive current draw or a low ohmmeter reading indicates shorted windings. No current draw or an infinite ohmmeter reading would indicate an open winding.

b. Rectifiers: A diode rectifier tester will detect and pinpoint open or shorted rectifiers without going through the operation of disconnecting the stator leads. However, if a tester is not available, test probes and a No. 57 bulb, connected in series with a 12-volt battery, can be used in the following manner. Touch one test probe to a rectifier heat sink and the other test probe to a lead from one of the rectifiers in that heat sink. Then reverse the position of the leads. The test bulb should light in one direction and not light in the other direction. If the test bulb lights in both directions, one or more of the rectifiers in that heat sink is shorted. To pinpoint the defective rectifier, the stator leads must be disconnected and the above test repeated on each rectifier. Open rectifiers can only be detected, when using the test bulb, by disconnecting the stator leads. The test bulb will fail to light in either direction if the rectifier is open.

c. Stator: The stator can be tested for open or grounded windings with a 12-volt test bulb, described in the rectifier section, or an ohmmeter, in the following manner. Separate the stator from the slip ring end head just far enough to insert a fold of rags or blocks of wood. In other words, insulate the stator from the end head. To test for grounded windings, touch one test bulb or ohmmeter probe to the stator frame. If the test bulb lights, or the ohmmeter indicates continiuty, the stator is grounded. To test for open windings, connect one test probe

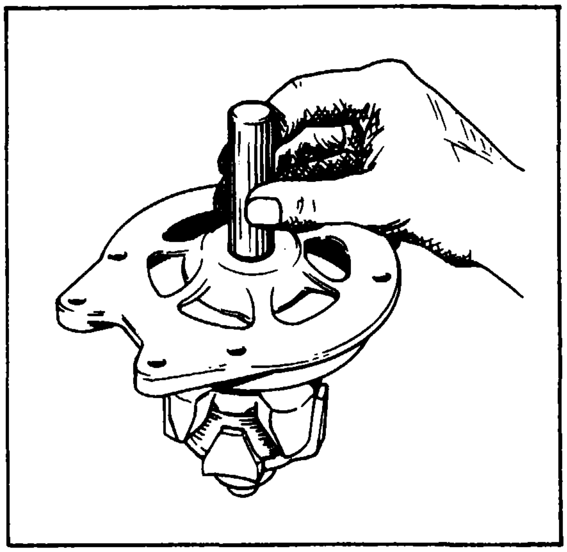

Figure 11-42. Installation of Bearing

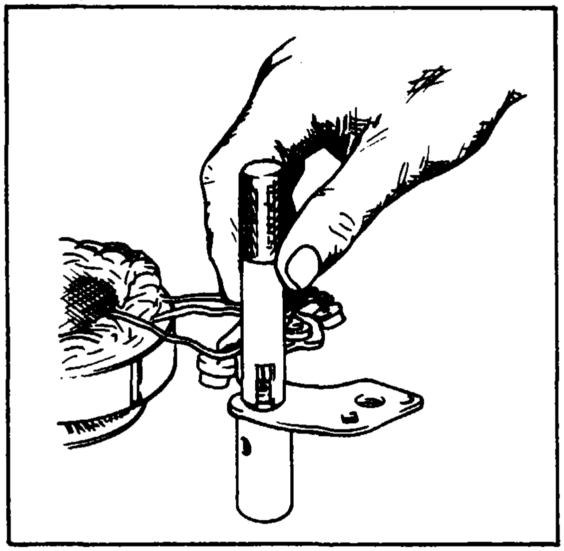

Figure 11-43. Installation of Rectifier

to the auxiliary terminal or the stator winding center connection and touch each of the three stator leads. The test bulb must light, or the ohmmeter must show continuity. Due to the low resistance in the stator windings, shorted windings are almost impossible to locate. However, shorted stator windings will usually cause the alternator to "growl" or be noisy during operation and will usually show some signs of overheating. If all other electrical checks are normal and the alternator fails to supply its rated output, the stator should be replaced to determine whether or not it is the faulty component.

d. Bearings and Seals: Whenever the alternator is overhauled, new bearings and oil or grease seals are recommended, even though the bearings and seals appear to be in good condition. A faulty seal can cause an alternator to fail within a very short period of time.

11-77. ASSEMBLY OF ALTERNATOR.

a. Press the ball bearing into the drive end head using a flat block approximately two inch square so that the pressure is exerted on the outer race of the bearing. Install the retainer plate. With the snap ring and retainer cup in place on the rotor shaft, use a tool that fits over the shaft and against the inner bearing race, and press until the inner bearing race is against the snap ring retainer cup. (Refer to Figure 11-42.)

b. Carefully install the rectifiers in the slip ring end head or rectifier mounting plate by supporting the unit and using the special tools illustrated in Figure 11-43.

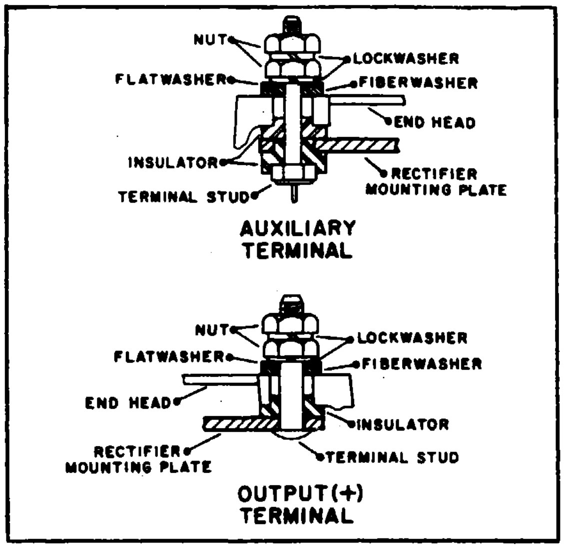

Figure 11-44. Terminal Assembly

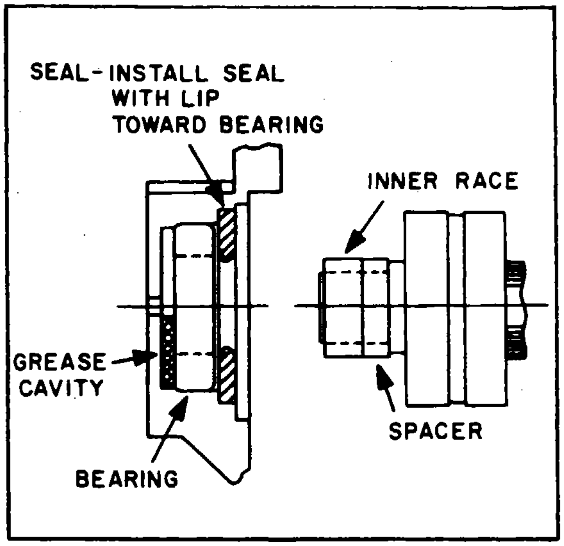

Figure 11-45. Slip Ring End Bearing Assembly

CAUTION

Use an arbor press, do not hammer. Reconnect the stator leads to the rectifiers. When soldering these connections, use pliers as a heat dam on the lead between the solder joint and the rectifier. Too much heat will damage the rectifiers.

c. Reassemble the rectifier mounting plate studs and insulators, making sure they are in the correct order. (Refer to Figure 11-44.)

d. After the slip ring end head is completely assembled, the stator and rectifier leads must be secured to the rectifier mounting plate with epoxy. Make sure the stator leads are positioned so that they do not interfere with the rotor.

e. Install the slip ring end bearing and oil seal. Make sure the lip of the oil seal is toward the bearing and stake the seal in place. Correct assembly of bearing, seal, inner race and spacer is shown in Figure 11-45.

f. Assemble the alternator and install the through bolts. Spin the rotor to make sure there is no mechanical interference. Torque the through bolts to 30 to 35 inch pounds. Safety wire should be installed after the unit has been bench tested for output. Install spacer, woodruff key, fan, pulley, lockwasher and nut. Torque the nut to 35 foot pounds, using a strap wrench to hold the pulley. Do not install the blast tube assembly until after the unit has been bench tested.

g. Install the brush and holder assembly and retaining screws. Spin the rotor and check for interference between the brush holder and rotor. Check across the

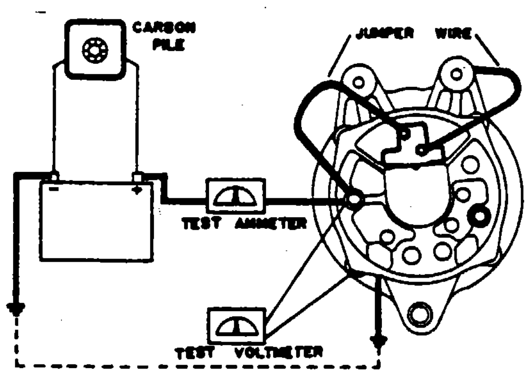

Figure 11-46. Testing Alternator

field terminals with an ohmmeter. The ohmmeter must indicate the amount of rotor resistance listed on the individual specifications page.

11-78. TESTING OF ALTERNATOR.

a. Wiring connections for bench testing the alternator are shown in Figure 11-46. Refer to the individual specification pages for output test figures. Adjust the carbon pile, if necessary, to obtain the specified voltage.

b. After bench testing the alternator, install the safety wire and blast tube and install the alternator on the engine.

NOTE

Always refer to the wiring diagram (Refer to Figure 11-35) when installing the alternator or testing the alternator.

11-79. PRECAUTIONS. The following precautions are to be observed when testing or servicing the electrical system.

a. Disconnect the battery before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter or accessories, will cause severe damage to the units and/or wiring.

b. The alternator must not be operated on open circuit with the rotor winding energized.

c. Do not attempt to polarize the alternator. No polarization is required. Any attempt to do so may result in damage to the alternator, regulator or circuits.

d. Grounding of the alternator output terminal may damage the alternator and/or circuit and components.

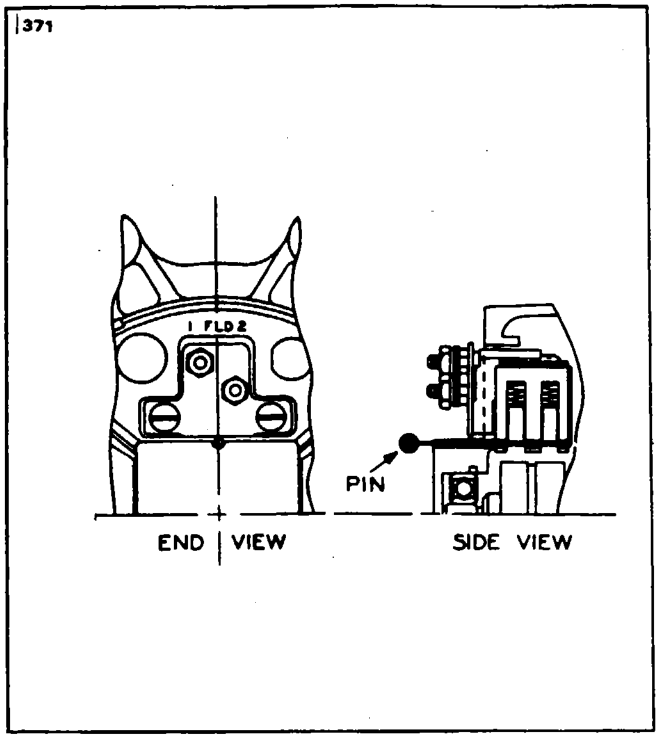

Figure 11-47. Brush Installation

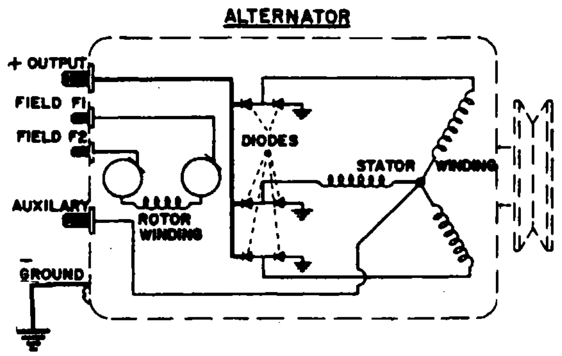

Figure 11-48. Internal Wiring Diagram

e. Reversed battery connections may damage the rectifiers, wiring or other components of the charging system. Battery polarity should be checked with a voltmeter before connecting the battery. Most aircraft are negative ground.

f. If a booster battery or fast charger is used, its polarity must be connected correctly to prevent damage to the electrical system components.

11-80. ALTERNATOR NOMENCLATURE.

a. Bearings: These units have a sealed ball bearing at the drive end and a two-piece roller bearing at the slip ring end. The inner race is presssed onto the rotor shaft and the rest of the bearing is in the slip ring end head. When the unit is assembled, the inner race aligns with the bearing. When the bearing is replaced, the new inner race must be installed on the rotor shaft.

b. Lubrication: The slip ring end bearing should be lubricated whenever the alternator is disassembled. The bearing should be thoroughly cleaned and repacked with Shell Alvania No. 2 or an equivalent bearing lubricant. The cavity behind the bearing should be packed on-third to one-half full with the same lubricant.

c. Brushes: These units have a separate brush holder assembly that is installed after the alternator has been assembled. The brush holder has a small hole that intersects the brush cavities. Use a pin or a piece of wire, as shown in Figure 11-47, to hold the brushes in the holder during assembly. Remove the pin after the brush holder retaining screws have been tightend. Make a continuity check to be sure the brushes are seated against the slip rings.

d. Drive Pulley: Torque the drive pulley retaining nut to 35 foot pounds.

e. Ventilation: The 8400 series units use a slip ring end cover that has a hose type connection for air pressure ventilation. Remove this cover when bench testing the alternator.

11-81. ALTERNATOR SERVICE TEST SPECIFICATIONS. Prestolite specifications for the 14 or 28-volt alternators installed as standard equipment on PA-23 series airplanes are as follows:

Alternator Model	ALX8403		ALU8403	
Voltage	14-volts		28-volts	
Rated Output	70 amperes		70 amperes	
Ground Polarity	Negative		Negative	
Rotation	Bi-Directional		Bi-Directional	
Rotor:				
Current Draw (77° F)	2.9 to 3.3 amps @ 12.0-volts		2.0 to 2.2 amps @ 24.0-volts	
Resistance (77° F)	3.7 to 4.1 ohms		11.3 to 11.9 ohms	
Output Test (77° F):				
Volts	13.0	14.2	26.3	28.4
Amperes Output	10.0	71.5	10.0	51.0
Field Amperes	2.85	3.15	2.05	2.05
Alternator RPM	1780 min.	5000 min.	3220 min.	5000 min.

11-82. ALTERNATOR PARALLELING SYSTEM. (PA-23-250 (six place), Serial Nos. 27-4794 and up.)

11-83. DESCRIPTION OF ALTERNATOR PARALLELING SYSTEM. The positive output terminal of each alternator is connected to the aircraft electrical bus through separate 90 ampere circuit breaker switches. Each alternator has a shunt installed between aircraft electrical bus and its positive output terminal in order to monitor output current on an ammeter.

The field circuit for each alternator is wired through a section of a Dual Master Switch (L or R as appropriate), an auxiliary switch which is ganged to the circuit breaker switch, an overvoltage relay and a voltage regulator. Field voltage can be manually disconnected from either alternator by turning off the appropriate section (L or R) of the Dual Master Switch. Turning both sections of the master switch off completely disconnects all electrical power from the aircraft bus bar. Field voltage will be automatically removed from an alternator whenever its overvoltage relay actuates or its circuit breaker switch trips.

The system has one ammeter installed to measure system currents. The output current of either alternator may be checked by rotating the switch, located below the ammeter to the "Left" or "Right" position. A shunt is installed between aircraft electrical bus and the positive terminal of the battery to allow measuring of the battery charge and discharge current with the ammeter.

An alternator inoperative ("INOP") warning light is provided for each alternator. The appropriate light will illuminate whenever its respective alternator fails to provide output voltage. Whenever the engines are operating at a high differential RPM, the alternator inoperative light for the slower engine may come on.

The 90 ampere circuit breaker switches should not be turned off when their associated alternator is operating normally. Turning "OFF" one of these switches while it is carrying current could cause a high voltage transient to occur on the electrical bus with possible subsequent damage to the semiconductor equipment attached to it.

11-84. DESCRIPTION OF ALTERNATOR. For a complete description of the alternator, refer to Paragraph 11-73.

11-85. CHECKING ALTERNATOR PARALLELING SYSTEM. The alternator paralleling system incorporates an ammeter which provides for an independent check of each alternator, as well as the charge/discharge current of the battery. In the event either ALTERNATOR INOPERATIVE light begins to glow or the ammeter check for either alternator fails to indicate an output, check the appropriate alternator circuit breaker switch, also the voltage regulator circuit breaker. If the circuit breakers are in their normal operating position a further check of the alternator system should be accomplished. (Refer to Figure 11-49.)

a. Verify that the ammeter is operating properly.
b. Disconnect the output (+) lead at the alternator.
c. Disconnect the field F-2 lead at the alternator.

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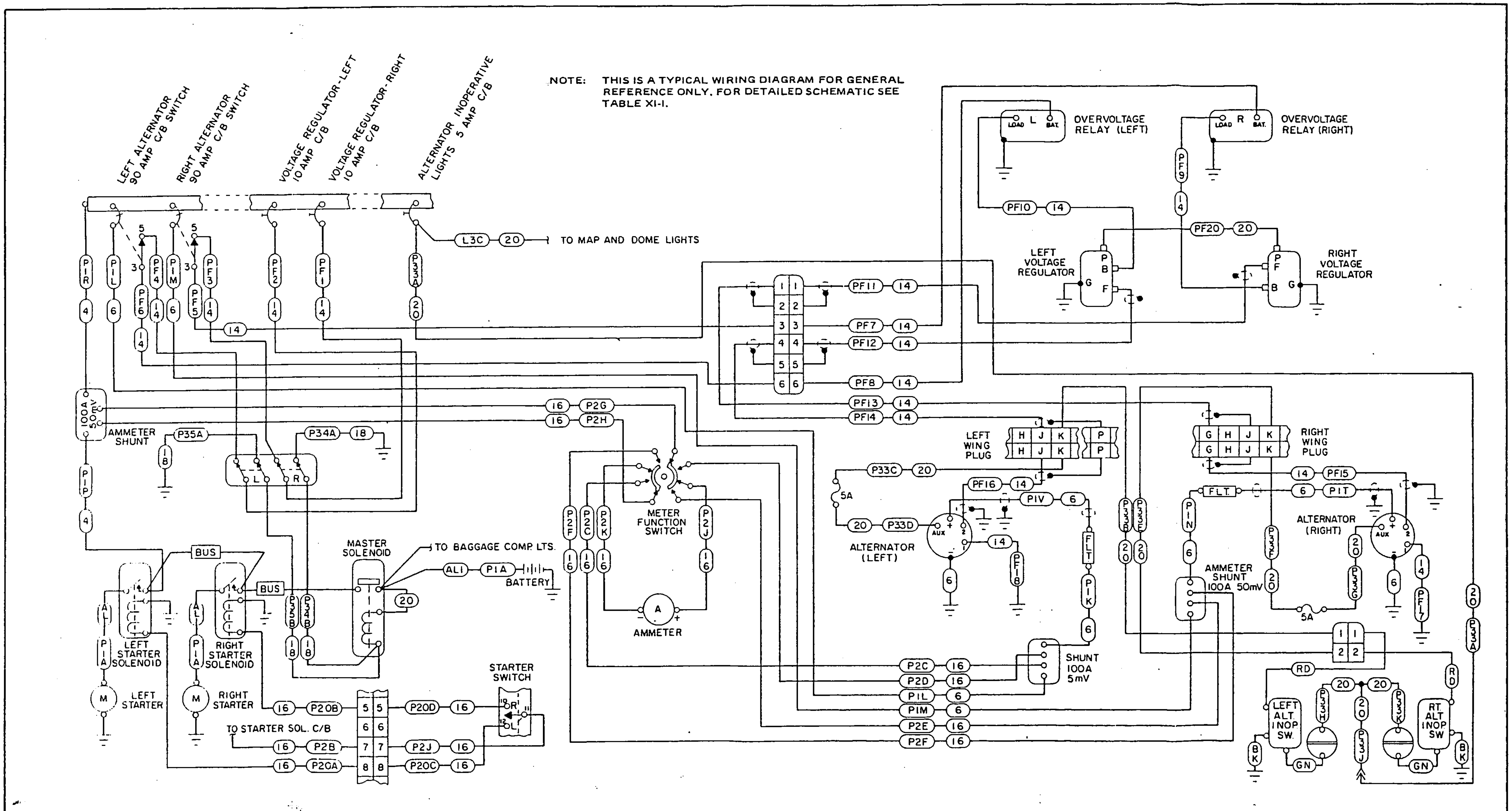

Figure 11-49. Alternator Paralleling System Wiring Diagram (Typical)

CAUTION

DO NOT ALLOW THE FIELD LEAD TO COME IN CONTACT WITH AIRFRAME GROUND WHEN THE MASTER SWITCH IS ON AS THE VOLTAGE REGULATOR WILL BE DAMAGED.

d. Verify that all electrical units are off and the battery is fully charged.

e. Turn ON the section of the master switch for the alternator being tested. (L or R.)

f. To check the alternator output circuit, connect a voltmeter or 14-volt test light to the previously disconnected output (+) lead. Check that the circuit breaker switch for the alternator under test is turned on. If a reading of approximately 14-volts is obtained on the voltmeter, or the test light glows, the output circuit is operational.

g. Should there be no indication of voltage, trace back through the output circuit until voltage is indicated. (Refer to Figure 11-35.) A component that does not indicate voltage at both its input and output terminals should be replaced.

h. Check the field circuit by connecting a voltmeter to previously disconnected field (F-2) lead. If a reading of approximately 14 volts is obtained on the voltmeter, the field circuit is operative.

i. If voltage is present at both the output and field leads, the alternator should be checked for a possible malfunction. (Refer to Paragraph 11-76.)

11-86. REGULATOR.

11-87. REGULATOR COMPONENTS. (Prestolite). Alternator output voltage can, within the limits of the design capability of the alternator, be controlled by properly varying the average level of current flow in the rotor winding of the Prestolite full electronic solid state regulator. The Prestolite alternator has self-limiting current characteristics and needs no current-limiting unit in the regulator.

a. Transistor: The transistor (Symbol "Q") is an electronic device which can control the flow of current in an electric circuit. It has no mechanical or moving parts to wear out.

b. Rectifier Diode: The rectifier diode (Symbol "D") will pass current in only one direction (forward direction); and in this respect it may be compared to a check valve.

c. Zener Diode: The zener diode (Symbol "Z") in addition to passing current in the forward direction, will also pass current in the reverse direction when a particular value of reverse voltage is applied. This property makes it useful as a voltage reference device in the regulator.

d. Capacitor: The capacitor (Symbol "C") is a device which will store electrical energy for short periods of time. This property makes it useful as a filter element to smooth variations of voltage.

e. Resistor: The resistor (Symbol "R") is a device which is used to limit current flow.

11-88. REGULATOR COMPONENTS (Lamar). Alternator output voltage can, within limits of the design capability of the alternator, be controlled by properly varying the average level of current flow in the rotor winding of the Lamar solid state electronic regulator. The Prestolite alternator has self-limiting current characteristics and therefore needs no current-limiting element in the regulator.

a. Transistor: The transistor (Symbol "Q") is an electronic device which can control the flow of current in an electric circuit. It has no mechanical or moving parts to wear out.

b. Rectifier Diode: The rectifier diode (Symbol "D") will pass current in only one direction (forward direction); and in this respect it may be compared to a check valve.

c. Zenor Diode: The zener diode (Symbol "Z") in addition to passing current in the forward direction, will also pass current in the reverse direction when a particular value of reverse voltage is applied. This property makes it useful as a voltage reference device in the regulator.

d. Capacitor: The capacitor (Symbol "C") is a device which will store electrical energy for short periods of time. This property makes it useful as a filter element to smooth variations of voltage.

e. Resistor: The resistor (Symbol "R") is a device which is used to limit current flow.

11-89. OPERATION OF REGULATOR (PRESTOLITE). (Refer to Figure 11-50.)

a. When the alternator switch is turned on, battery voltage is applied to the "I" terminal of the regulator.

b. The npn (negative-positive-negative) power transistor, T3, is turned on by current flow from the ignition terminal through R6 and the collector emitter junction of T2 through D2 through the base emitter junction of T3 to ground.

c. Whenever the power transistor, T3, is on (T2 is also on and T1 is off), current will flow from the ignition terminal through the field winding, through the collector - emitter of T3 to ground.

d. With the master switch on, current will flow from the regulator "I" terminal to ground through a voltage dividing network consisting of R1, R2 and P1. This network determines the system operating voltage relative to the Zenor diode, Z1, reverse conducting voltage.

e. When the system voltage connected to "I" terminal reaches a value at which the Zener diode connected to the divider network conducts, current will flow from the "I" terminal through R1 through Z1 and through the base emitter junction of T1 to ground. This causes the collector emitter junction of T1 to conduct which diverts the base current of T2 flowing from "I" terminal through R4 to ground, turning off T2 which turns off T3, de-energizing the rotor winding; then, when the alternator output voltage falls to a value which permits Z1 to cease conduction, T1 will turn off which turns on T2 and T3, re-energizing the rotor winding.

f. This sequence is performed so rapidly that the rotor current average appears as values usually less that full rotor current depending on rotor RPM and system load connected.

g. Each time the power transistor, T3, is turned off, current flow in the rotor winding is reduced. This causes the rotor magnetic field to collapse which would generate high voltage at the power transistor, T3, if a path were not provided so that the field current can decay at a slower rate. The field suppression diode, D1, provides this path, thus protecting the system and regulator from possible damage.

h. Temperature compensation is flat which means the regulator will hold the alternator output voltage constant with temperature increase or decrease after initial warm-up.

i. The Prestolite solid state regulator uses three npn silicon transistors.

j. Capacitor, C1, is used to filter ripple and alternator diode switching spike when operating without a battery.

k. Neon lamp, L1, provides transient voltage protection acting as a surge suppressor.

l. Control P1 is used to provide a limited range of voltage adjustment.

11-90. OPERATION OF REGULATOR (LAMAR). (Refer to Figure 11-51.)

a. When the alternator is turned on, battery voltage is applied to the "BUS" terminal of the regulator and via Q4 through the "FIELD" terminal of the regulator to the alternator field terminal F2. The amount of voltage applied to the field of the alternator is controlled automatically by action of the regulator in response to alternator output as described below.

b. Current flow through R6 and Z1 establishes a reference voltage across Z1.

c. Resistors R1 and R2+R3 comprise a voltage divider which is adjustable by means of the variable portion R3. Voltage at the junction of R1 and R2 and the reference voltage across Z1 are applied to comparison transistor Q1. R3 is adjusted so that these voltages are balanced with the desired alternator output voltage present on the "BUS" terminal of the regulator.

d. Thereafter, whenever alternator output voltage (as applied to the "BUS" terminal) falls below the desired regulation value, the comparison transistor Q1 will supply increased current to driver transistors Q2/Q3, which in turn will drive power transistor Q4 to a higher value of field current. This will result in alternator output voltage increasing to a value which will restore balance between the two voltages applied to Q1.

e. Conversely, if alternator output voltage (as applied to the "BUS" terminal) increases due to a greater engine speed or reduced loading of the electrical system, the comparison transistor Q1 will act to reduce current flow to the driver transistors Q2/Q3, and thus reduce the drive to power transistor Q4. This will result in a reduction of alternator field current and automatically restore balance between the two voltages applied to comparison transistor Q1.

f. Capacitors C1 and C2 function, together with their related transistors, in a way to smooth alternator output ripple and voltage spikes so that the alternator field current is controlled at a steady value.

g. The LAMAR solid state regulator controls alternator field current to a steady value as required by the electrical load conditions and engine speed. It does not continuously switch field current between high and low values as do mechanical regulators and the switching type of electronic regulators.

h. The design of this unit is such as to provide an alternator output voltage that does not vary with ambient temperature.

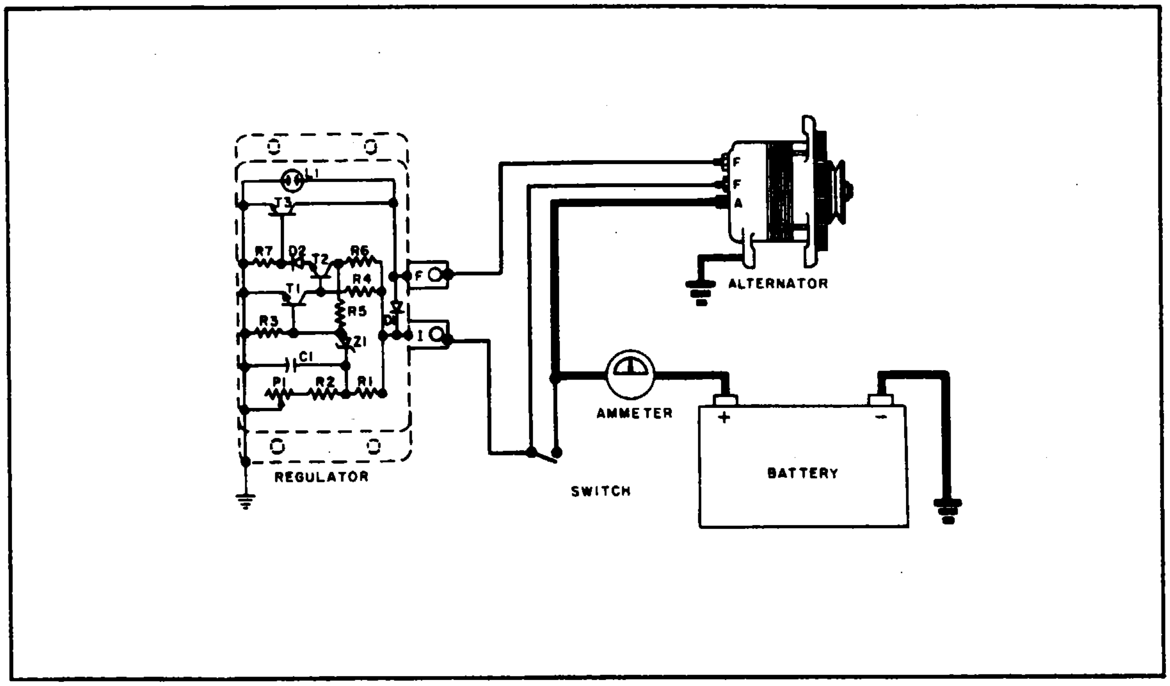

Figure 11-50. Regulator Diagram (Prestolite)

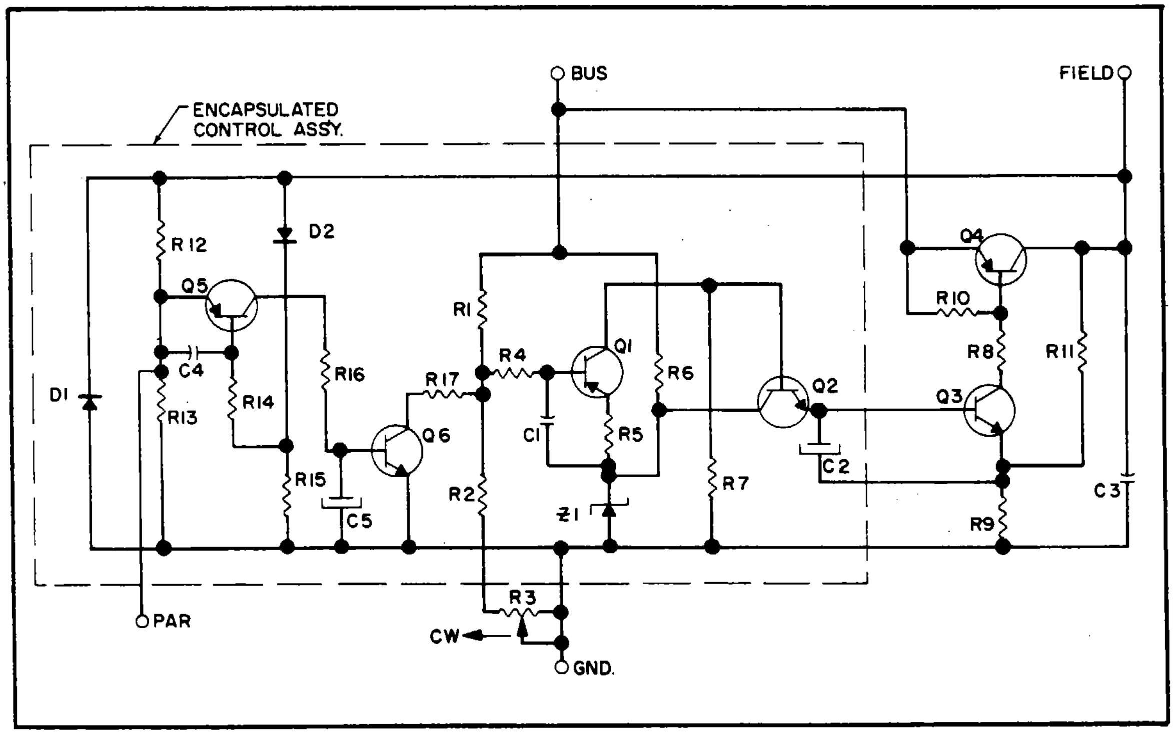

Figure 11-51. Regulator Diagram (Lamar)

11-91. BALANCING CIRCUIT OPERATION. (Considering two identical alternators and regulators having the "PAR" terminals of the regulators connected.)

a. Balancing circuit operation is initiated within one regulator whenever individual field voltages delivered by the regulator units to their related alternators are not equal.

b. When a difference in individual field voltages occurs, one-half the difference is impressed across R12 within each regulator and is thus applied to the input of Q5.

c. In that regulator which is delivering the lower field voltage, the polarity of R12 voltage drop causes Q5 collector current flow.

d. Q5 collector current flow results in conduction occurring in the collector circuit of Q6.

e. Q6 collector current flows from regulator divider R1/R2 + R3 through limiting resistor R17 to ground.

f. Conduction through R17 effectively alters the ratio of the regulator divider R1/R2 + R3 in the direction to increase Q1 collector current flow.

g. As described above under REGULATING CIRCUIT OPERATION, increased Q1 current results in increased output from the regulator to the field of its related alternator.

h. Feedback action results in Q6 collector current stabilizing at a value that results in nearly equal field voltage being delivered by the two regulators to their respective alternator fields.

i. The balancing circuit will thus automatically maintain, at a proper value, the difference voltage applied to the alternator fields. In a parallel system having identical alternators operating at the same RPM, the output currents of the alternators will thus be maintained nearly equal.

j. In whichever regulator of a pair is set to deliver the highest voltage, the balancing circuits are inactive. Thus system voltage is determined by the regulator of a pair which is set to higher voltage. The lower set regulator will adjust itself automatically, as described above, to deliver the same field voltage as the one which is set higher, within the limits of its design capability.

k. The balancing regulator system as described provides for automatic load balancing of parallel operated alternators having independent field excitation circuits. The pilot can, while in flight, remove either alternator system completely from the aircraft system and maintain operation of the other system.

11-92. PREPARATION FOR TESTING. (Regulators may be tested using the aircraft's alternator or an alternator test stand.)

CAUTION

Do not interchange regulator leads. This will destroy regulator and void warranty.

a. The aircraft technician or other electrical systems specialist, must disconnect the battery ground cable at the battery before connecting or disconnecting a test ammeter or other test equipment or before making wiring changes in the electrical system.

b. Voltmeters with test probes or clips are not recommended. Fully insulated bolted terminal connections are best, and these should be attached when all power is removed as described above.

c. When installing a battery in an aircraft, be sure that the battery negative terminal is in a position so that this terminal can be connected to the battery ground cable for negative ground systems.

d. The regulator under test is to be mounted on a grounded metallic surface using three No. 8 screws pulled up tight. For extended test periods the heat transfer from regulator to the mounting surface is significant.

e. A ground wire between the regulator "GND" terminal and the aircraft or test stand structure is essential for proper operation. The alternator frame must also be solidly bonded to the system ground.

f. The alternator does not need to be polarized; therefore, never connect ground, even momentarily, to either the regulator field terminal or to the alternator field terminals. Do not interchange I and F leads to regulator as this will destroy the regulator.

g. The LAMAR regulator is intended for use with alternator systems having one field terminal grounded at the alternator. The other field terminal F2 of the alternator is connected to the "FIELD" terminal of the regulator. NEVER UNDER ANY CIRCUMSTANCE PERMIT A GROUND TO CONTACT THIS CIRCUIT EVEN FOR AN INSTANT WHILE POWER IS APPLIED TO THE SYSTEM. Due to this precaution, the mechanic should not use tools near these circuits while power is applied.

h. The alternator should be in good condition and capable of producing full output, and the alternator drive belt must be adjusted tight enough to prevent slippage. (Refer to Paragraph 11-102.)

i. The battery must be in good condition and should be fully charged.

j. The voltmeter and ammeter should be of the best quality and should be accurate.

k. A carbon-pile connected across the battery may be used to load the charging circuit while testing the regulator.

11-93. TESTING REGULATOR (PRESTOLITE).

a. The procedure for testing the regulator, whether on the airplane or on the test bench, remains the same. Connect test meters as shown in Figure 11-52.

b. All circuit connections should be clean and tight. This includes the test instrument connections which must not come loose or open the charging circuit at any time while the system is operating.

c. The voltmeter will not indicate the true regulator setting until the regulator has been operating in the charging system or on the test bench for at least one minute, at a charge rate of from 10 to 15 amperes.

d. Connect the voltmeter and the ammeter as shown in Figure 11-52. Start the engine and adjust its speed to obtain 900 to 1200 RPM or 3,000 to 4,000 alternator RPM on a test bench setup. Turn on the accessories as needed to establish 10 to 15 amperes electrical load, or use a carbon-pile across the battery to obtain this charge rate.

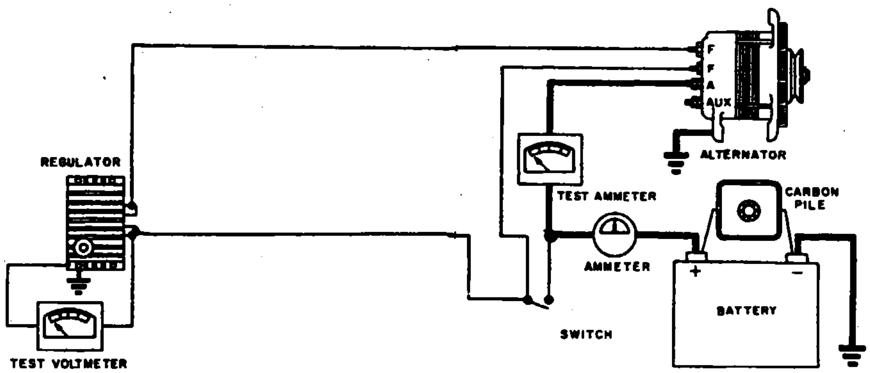

Figure 11-52. Testing Regulator (Prestolite)

e. After one minute operating time, check the regulator operating voltage as indicated by the voltmeter. Refer to Alternator Service Test Specifications, Paragraph 11-81 for the correct operating voltage. The operating voltage is shown for the ambient temperature in which the regulator is operating.

f. If the voltmeter indicates that the operating voltage is not within limits, lift the plastic plug from top of regulator and adjust the voltage to the desired value. Replace the plug after adjustment. Before condemning the regulator, recheck the alternator and the battery; making sure that they are in good condition. Recheck all circuit connections and all wiring for unwanted resistance (voltage drop test). Recheck the voltmeter for accuracy and repeat the entire operating test.

11-94. TESTING REGULATOR (LAMAR).

a. The procedure for testing the regulator, whether on the airplane or on the test bench, remains the same. Connect the test meters and regulator wiring as shown in Figure 11-53.

b. All circuit connections should be clean and tight. This includes the test instrument connections which must not come loose or open the charging circuit at any time while the system is operating.

c. The voltmeter will not indicate the true regulator setting until the regulator has been operating in the charging system or on the test bench for at least five minutes, at a charge rate of from 10 to 15 amperes.

d. With the connections made as shown in Figure 11-53, start the engine and adjust speed to obtain 900 to 1200 RPM or 3,000 to 4,000 alternator RPM on a test bench setup. Adjust the carbon pile or accessory load to establish the 10 to 15 ampere load value. Note that the battery charge current is indicated by the ammeter. Therefore, the current value may change downward at the beginning of a test run. This will be especially true if the battery was used for engine starting.

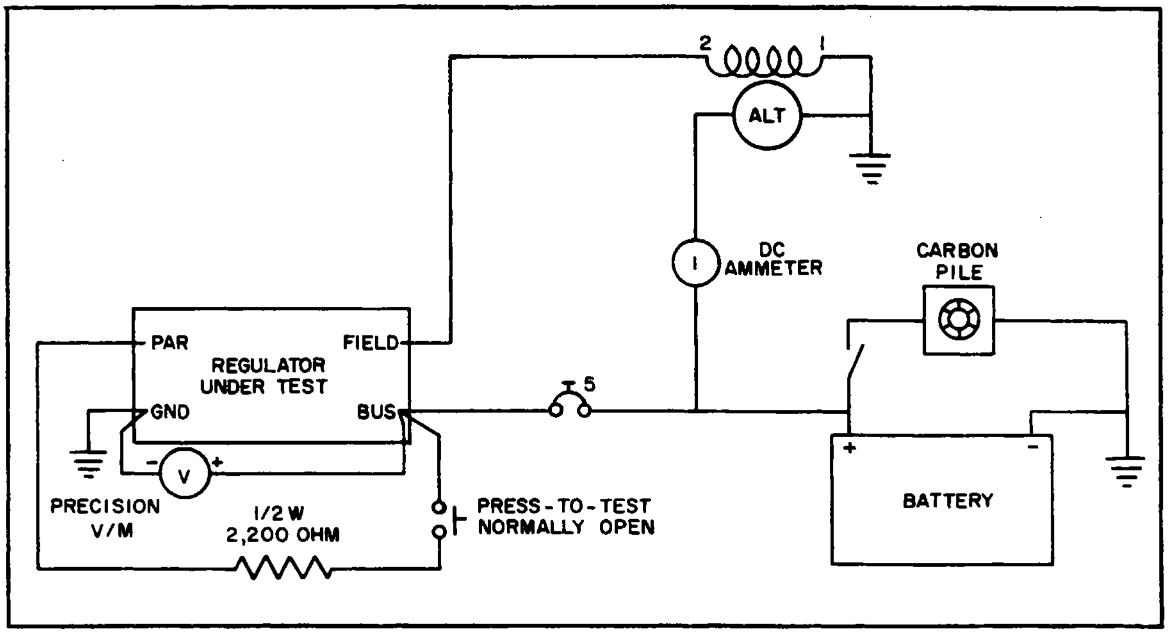

Figure 11-53. Testing Regulator (Lamar)

e. After five minutes operating time, check the regulator operating voltage as indicated by the voltmeter. Refer to Alternator Service Test Specifications as outlined in Paragraph 11-81 for correct operating voltage. The operating voltage is shown for ambient temperature in which the regulator is operating.

f. If the voltmeter reading indicates that the operating voltage is not within limits, carefully insert a small screwdriver (Phillips #O) in the voltage adjustment access hole on top of the regulator and adjust voltage adjustment slowly to obtain desired value. Before condemning the regulator, recheck the alternator and the battery; making sure that they are in good condition. Recheck all circuit connections and all wiring for unwanted resistance (voltage drop test). Recheck the voltmeter for accuracy and repeat the entire operating test.

g. Balance circuit operation is confirmed by closing the press-to-test switch momentarily and observing that the alternator output current increases abruptly to a higher level. Upon release of this switch, the alternator output will be restored to its previous level, except that minor differences may be noted which are due to battery charge conditions.

11-95. ADJUSTING REGULATOR (PRESTOLITE).

a. Adjustment: These units have an external adjustment located under the plastic plug on top of the regulator. The regulator has an adjustment spread ranging from 13.0-volts to 15.0-volts for the 14-volt electrical system or 26.0-volts to 30.0-volts for the 28-volt system. Output is increased by turning the adjustment clockwise.

b. Operating Voltage: The regulator should be adjusted to 14.2-volts (14-volt system) or 28.4-volts (28-volt system) when controlling a load of 10 to 15-amps after one minute operation. These units are not affected by ambient temperatures. The voltmeter must be connected from the "I" or switch terminal to ground.

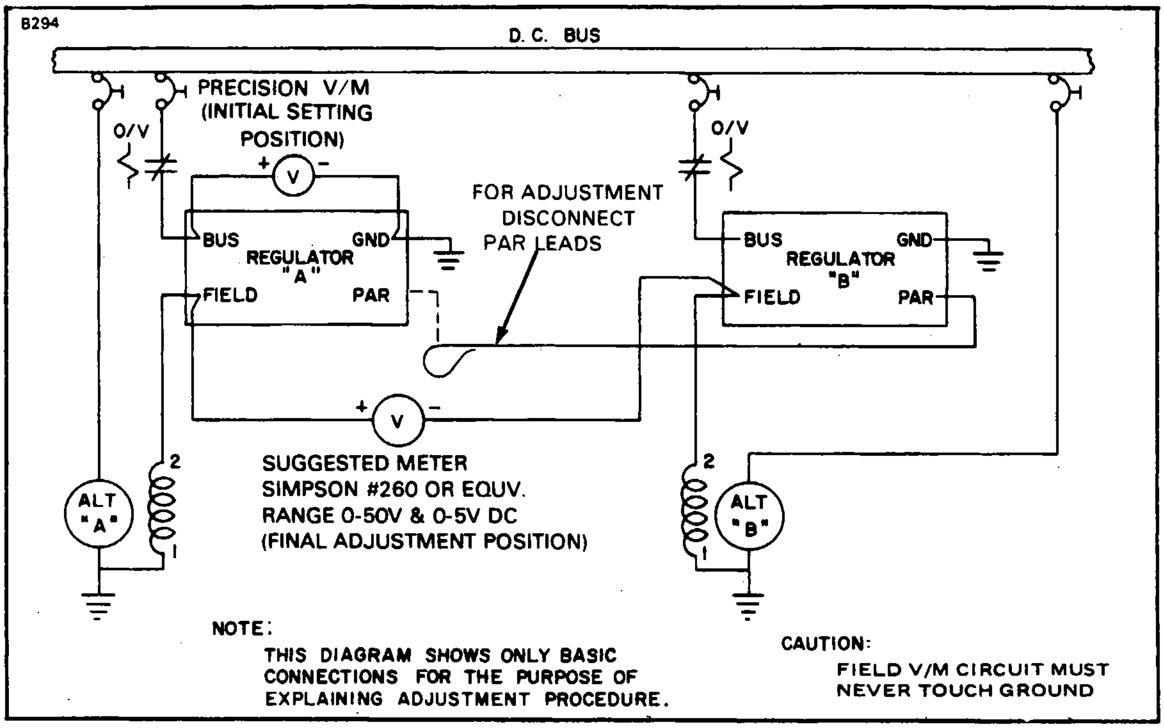

Figure 11-54. Adjusting Regulator (Lamar)

c. Caution Notes:
   1. Use only with insulated (ungrounded) field alternators.
   2. Regulator base must have a good ground connection.
   3. Do not connect ground power to aircraft until voltage regulator "I" terminal has been disconnected from electrical system.
   4. Do not (even momentarily) connect the two voltage regulator terminals together.
   5. Do not connect battery into system with polarity reversed.
   6. Do not force the voltage adjustment screw.
   7. This is a sealed unit and not repairable. Replace with a new unit.

11-96. ADJUSTING REGULATOR (LAMAR). (Refer to Figure 11-54.)

a. These regulators are normally used in parallel alternator systems of multi-engine aircraft. Their final adjustment should be made in actual operation in the aircraft system with test equipment connected as shown in Figure 11-54. The balance adjustment is made while operating only one engine, either left or right. The engine to be operated must be selected so as to permit the technician a completely safe access to both of the regulators, so that they may be adjusted while the engine is operating without danger. We shall designate the engine selected to be operated as "LEFT" and the inoperative engine as "RIGHT" for purposes of discussion.

b. Lift the wire from the "PAR" terminal of either regulator and insulate the free end so it will not contact other circuits or ground during the adjustment procedure. Breaking this circuit disables the balancing circuits in both regulators.

c. Turn off the "RIGHT" alternator field switch. All the "LEFT" alternator switches are to be on.

d. Operate the left engine and alternator system with a load of at least 15 amperes and engine speed of 900 to 1500 RPM for at least one minute for warm-up of the system. Place the positive (+) lead of a precision voltmeter on the bus terminal of the left regulator and the negative (-) lead of the voltmeter on the ground terminal of the "LEFT" regulator. If required, carefully set the "LEFT" regulator voltage adjustment to 14.3 or 28.5 volts as per aircraft system. Replace the snap plug in the "LEFT" regulator adjustment access hole.

CAUTION

DO NOT MAKE ANY FURTHER ADJUSTMENT OF THE "LEFT" REGULATOR.

c. While continuing "LEFT" engine operation with electrical load the same as before, turn on the "RIGHT" alternator system switches. (The "RIGHT" engine, however is NOT operating.)

f. Connect a Simpson #260 (or equivalent voltmeter, range 0-50 and 0-5 VDC, as indicated in Figure 11-54. The positive (+) lead of the voltmeter is conneted to the "field" terminal of the "LEFT" regulator and the negative (-) lead of the voltmeter is connected to the "field" terminal of the "RIGHT" regulator. Now very slowly rotate the "RIGHT" regulator voltage adjustment while observing the field circuit voltmeter. (Suggested voltmeter range setting, 0-50V.) If a reverse (downscale) reading is obtained turn the "RIGHT" regulator adjustment counterclockwise to bring the meter up scale. Then, very slowly turn the "RIGHT" regulator adjustment clockwise to make the field voltmeter read near zero. A stable reading should not be expected. A correct adjustment has been achieved when the meter will remain briefly in the vicinity of zero, swinging both upscale and downscale. The use of a low range on the voltmeter is recommended for the final adjustment. (Suggested voltmeter range setting, 0-5V.)

g. Replace the snap plug in the "RIGHT" regulator adjustment hole.

h. Shut down the engine and master switch, then replace the connection to the "PAR" terminal which was removed in step b. Remove all voltmeter leads and test equipment.

11-97. OVERVOLTAGE CONTROL.

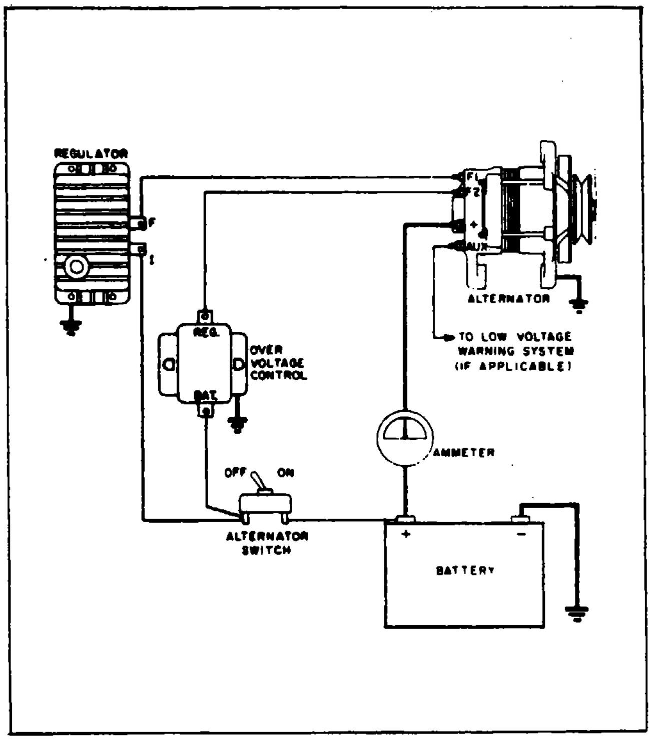

Figure 11-55. Application of Over-Voltage Control

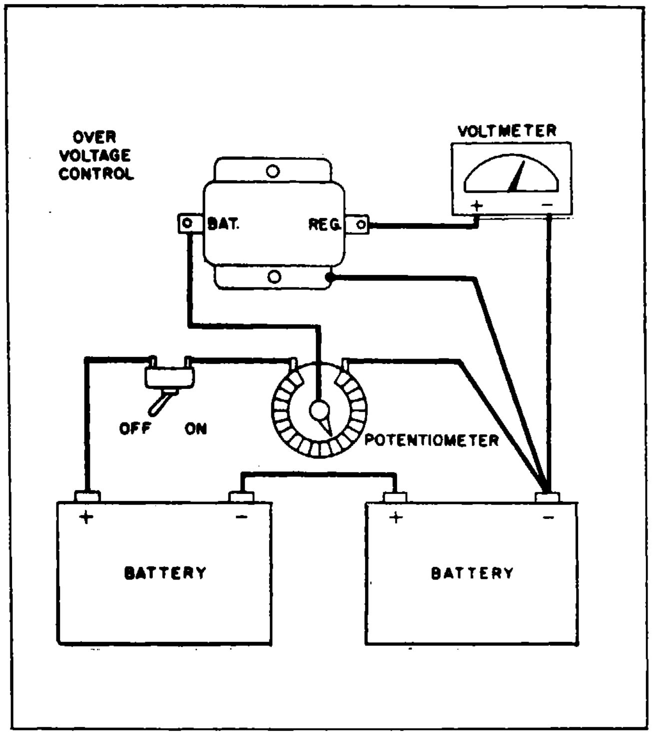

Figure 11-56. Testing Over-Voltage Control

11-98. PURPOSE AND OPERATION.

a. The overvoltage control is used to protect electrical circuits and electronic equipment from excessive voltage in the event of a charging circuit malfunction.

b. The overvoltage control consists of a mechnical relay and a solid state triggering device. The solid state triggering device activates the mechanical relay, when the voltage reaches a present value, thereby opening the relay contacts and disconnecting the field circuit of the alternator.

c. The relay contacts will remain open until the alternator switch is turned off. Figure 11-55 illustrates the overvoltage control connected in a typical Prestolite insulated field alternator.

11-99. TEST PROCEDURE. Connect the relay as shown in Figure 11-56. Use a 100 ohm potentiometer of 15 watt rating, or more, to adjust the voltage. The voltmeter is used to read the voltage until the relays opens, at which time the voltmeter reading will drop to zero. See tabulation for voltage reading. Test figures are at 75 degrees Fahrenheit.

a. 14-volt system: Relay contacts open between 15.5 and 16.5 volts. Use 18 or 24 volts to test.

b. 28 volt system: Relay contacts open between 31.5 and 32.5 volts. Use 36 volts to test.

NOTE

These units are not adjustable. Replace the overvoltage control if it does not test to specifications.

11-100. OVERVOLTAGE RELAY OPERATIONAL CHECK. This check should be made at each 500 hour inspection, per the following instructions:

a. Determine that aircraft master switch is OFF.

b. Pull out (OFF) all circuit breakers except the main and auxiliary voltage regulators (10 amp).

c. Turn off the right and left alternator output circuit breaker switches (90 amp).

d. Set the voltage regulator to MAIN.

e. Obtain a variable D.C. voltage power supply and set it to zero output.

f. Connect the power supply to the aircraft through the external power receptacle.

NOTE

On aircraft without an external power receptacle, disconnect the battery cables and connect the power supply to the cables.

CAUTION

Connections must be positive to positive and negative to negative.

g. Obtain a volt/ohmmeter and set the selector to a D.C. voltage scale of no less than 16.5 volts. Connect the meter VOM lead to the output (REG.) terminal of the MAIN overvoltage relay. Connect the meter COM lead to the airframe ground.

h. Increase the output voltage of the variable D.C. power supply until the MAIN overvoltage relay trips out. When the relay operates, the VOM needle should drop to zero volts. Record the power supply voltmeter reading which was indicated just prior to the overvoltage relay operating. Voltage limits are: Min. 15.5-volts - Max. 16.5-volts for the 14-volt system and Min. 31.5-volts - Max. 32-5-volts for the 28-volt system.

CAUTION

Limit overvoltage operation to two minutes maximum.

i. Reduce the power supply voltage to zero.

j. Set the VOM to resistance scale and determine continuity between battery terminal (BAT) and regulator terminal (REG.) on the overvoltage relay, to insure that the relay is reset.

k. Change the voltage regulator selector switch from MAIN to AUX. Reconnect the volt/ohmmeter to the AUX overvoltage relay and repeat steps i thru l.

l. Reset circuit breakers, turn on alternator output circuit breakers, reset voltage regulator selector to MAIN, disconnect VOM, and reconnect the battery cables if previously removed.

11-101. OVERVOLTAGE RELAY OPERATIONAL CHECK (PARALLELING SYSTEM). This check should be accomplished at each 500 hour inspection, per the following instructions:

a. Pull all circuit breakers to the out (OFF) position except the left and right voltage regulator (10 amp) circuit breakers and the alternator (90 amp) circuit breaker switches.

b. Obtain a variable D.C. voltage power supply and set it to zero output.

c. Connect the power supply to the aircraft through the external power receptacle.

d. Turn ON the left alternator section of the Dual Master Switch.

e. Obtain a volt/ohmmeter and set to 60-volts D.C. Connect the positive lead of the VOM to the output (LOAD) terminal of the LEFT overvoltage relay. Connect the negative lead of the VOM to airframe ground.

f. Increase the output voltage of the variable D.C. power supply until the LEFT overvoltage relay trips out. (An audible click will be heard whenn the relay operates and the VOM needle must drop to zero volts.) Record the power supply voltmeter reading which was indicated just prior to the overvoltage relay operating. Voltage limits are: Min. 15.50-volts-Max. 16.50-volts.

g. Reduce the power supply to zero. Turn OFF the left alternator section of the Dual Master Switch. Another click will be heard when the overvoltage relay resets itself for normal operation.

h. Turn ON the right alternator section of the Dual Master Switch. Reconnect the volt/ohmmeter to the right overvoltage relay and repeat steps f and g.

Width of Belt	Condition	Torque Indicated at Generator or Alternator Pulley
3/8 inch	New	11 to 13 ft. lbs.
3/8 inch	Used	7 to 9 ft. lbs.
1/2 inch	New	13 to 15 ft. lbs.
1/2 inch	Used	9 to 11 ft. lbs.

11-102. CHECKING GENERATOR OR ALTERNATOR BELT TENSION. If properly installed, tensioned and checked periodically, the generator or alternator drive belt will give very satisfactory service. However, an improperly tensioned belt will wear rapidly and may slip and reduce generator or alternator output. Consequently, a belt should be checked for proper tension at the time it is installed, again after 24 hours of operaion and each 100 hours thereafter.

There are two satisfactory methods of checking generator or alternator belt tension; however, the first method described will be found preferable by most maintenance personnel because it is technically simple and requires little time for accomplishment.

a. Torque Method: This method of checking belt tension consists of measuring torque required to slip the belt at the small pulley and is accomplished as follows:

1. Apply a torque indicating wrench to the nut that attaches the pulley to the generator and alternator and turn it in a clockwise direction. Observe the torque shown on the wrench at the instant the pulley slips.

2. Check the torque indicated in step b with torqe specified in the following chart. Adjust belt tension accordingly.

NOTE

The higher tension specified for a new belt is to compensate for the initial stretch that takes place as soon as it is operated. These higher tension values should not be applied to belts which previously have been used.

b. Deflection Method: Belt tension may be checked by measuring the amount of deflection caused by a predetermined amount of tension. This is accomplished in the following manner:

1. Attach the hook of a small spring-scale to the belt at the approximate mid-point between the rear gear support and the generator or alternator.

2. Pull on the scale until a reading of 14 pounds is obtained. (10 pounds for used belts.)

3. Measure the distance the belt has moved with the 10 or 14 pound load applied. The distance (deflection) should be 5/16 inch. If less than 5/16 inch, the belt is too tight.

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11-103. STARTING MOTOR (Delco-Remy).

11-104. OPERATION OF STARTING MOTOR. When the starting motor switch is closed, the armature begins to rotate. The drive pinion, being a loose fit on the drive sleeve located on the armature shaft, does not pick up speed as fast as the armature. Therefore, the drive pinion, having internally matched splines with respect to the splined drive sleeve, moves endwise on the shaft and into mesh with the flywheel. As the pinion hits the pinion stop, it begins to rotate with the armature and cranks the engine.

When the engine starts, the flywheel begins to spin the pinion faster than the armature. Again, because of the splined action of the pinion and drive sleeve assembly, the pinion backs out of mesh with the flywheel ring gear protecting the armature from excessive speeds.

Some Bendix drives incorporate a small anti-drift spring between the drive pinion and the pinion stop which prevents the pinion from drifting into mesh when the engine is running. Others use a small anti-drift pin and spring inside the pinion which provides enough friction to keep the pinion from drifting into mesh.

Never operate the motor for more than 30 seconds without pausing for two minutes to allow it to cool.

11-105. CHECKING STARTING MOTOR. Several checks, both visual and electrical, should be made in a defective starting circuit to isolate trouble before removing any unit. Many times a component is removed from the airplane only to find it is not defective after reliable tests. Therefore, before removing a unit in a defective starting system, the following checks should be made:

a. Determine the condition of the battery.

b. Inspect the wiring for frayed insulation or other damage. Replace any wiring that is damaged. Inspect all connections to the starting motor, solenoid switch, starting switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections and wiring as required. The engine manufacturer specifies allowable voltage drop in the starting circuit. For this information, refer to the manufacturer's shop manual.

c. Inspect starting and solenoid switches to determine their condition. Connect a jumper lead around any switch or solenoid suspected of being defective. If the system functions properly using this method, repair or replace the bypassed unit.

d. If specified battery voltage can be measured at the motor terminal of the starting motor, allowing for some voltage drop in the circuit and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

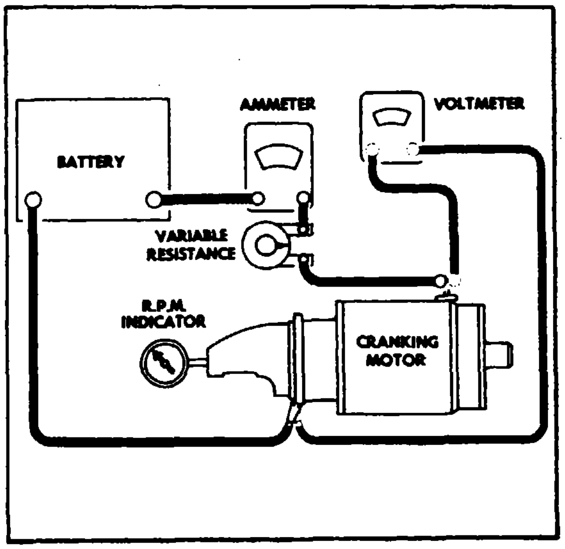

Figure 11-57. No-load Test Hookup

11-106. TEST AND MAINTENANCE OF STARTING MOTORS.

11-107. INSPECTION. With the starting motor removed from the engine, the pinion should be checked for freedom of operation by turning it on the screw shaft. The armature should be checked for freedom of operation by turning the pinion. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoe screw will cause the armature to drag and it will not turn freely. If the armature does not turn freely, the motor should be disassembled immediately. However, if the armature does operate freely, the motor should be given electrical tests before disassembly.

11-108. NO LOAD TEST. (Refer to Figure 11-57.) Connect the starting motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated, from the motor terminal to the motor frame. An RPM indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit. Then read the current draw and the armature speed and compare these readings with the values listed in paragraph 11-114. Interpret the test results as follows:

a. Rated current draw and no load speed indicate normal condition of the starting motor.

b. Low free speed and high current draw indicate:

1. Too much friction - tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.

2. Shorted armature. This can be further checked on a growler after disassembly.

c. Failure to operate with high current draw indicates:

1. A direct ground in the terminal or fields.

2. "Frozen" bearings (this should have been determined by turning the armature by hand).

d. Failure to operate with no current draw indicates:

1. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

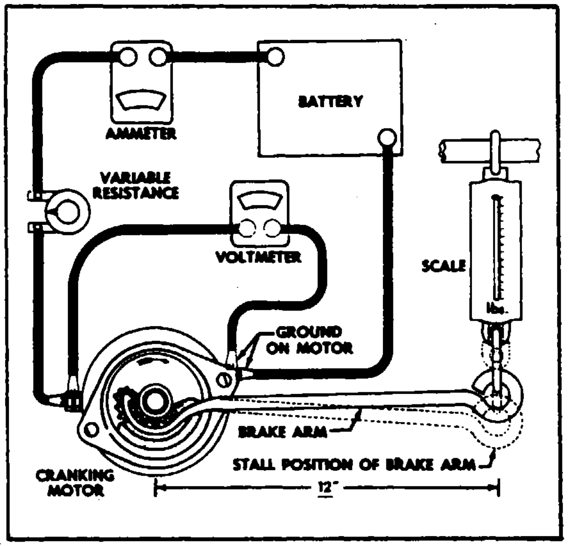

Figure 11-58. Lock-Torque Test Hookup

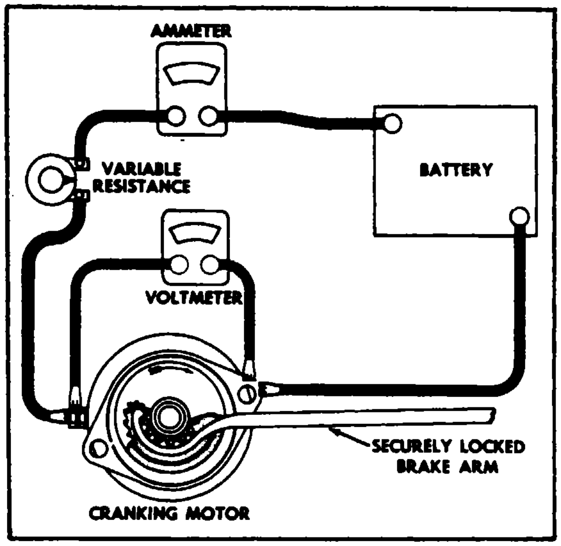

Figure 11-59. Resistance Test Hookup

2. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

3. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

e. Low no-load speed and low current draw indicate high internal resistance due to poor connections, defective leads, dirty commutator and causes listed under, step d.

f. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

11-109. LOCK-TORQUE TEST. (Refer to Figure 11-58.) The lock-torque test requires the equipment illustrated. A variable resistance with a high current capacity should be used. The starting motor should be securely mounted and a brake arm hooked to the drive pinion. Use extreme caution during this test to make sure the end of the brake arm does not slip off the pinion when current is applied. When specified current is applied, the torque can be computed from the reading on the scale. A one foot brake arm will directly indicate pound-feet. Compare the pound-feet of torque as read on the scale with that listed in paragraph 11-114. If the torque is low, the motor must be disassembled for further tests and repair.

11-110. RESISTANCE TEST. (Refer to Figure 11-59.) This test requires equipment similar to the lock-torque test, with the exception that the pinion is locked secureley so it cannot rotate. When the specified voltage is applied, the current should fall in a range as indicated in paragraph 11-114. A high current indicates grounded or shorted condutors, and a low current indicates excessive resistance.

11-111. DISASSEMBLY. If the motor does not perform in accordance with published specifications, it may need to be disassembled for further testing of the components. Normally the starting motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the starting motor. Following are general instructions for disassembling a typical Bendix drive starting motor.

a. Remove the cover band, if present, and detach the field coil leads from the brush holders.

b. If gear reduction, remove the drive housing and reduction housing.

c. Remove the bolts attaching the drive housing and commutator end frame to the field frame assembly. Discard the tang lock washers.

d. Separate the commutator end frame, armature assembly, field frame and drive housing.

e. Remove and disassemble the drive from the armature shaft by first identifying the type Bendix drive and then following one of the guides below:

1. Standard Bendix Drive: Remove the head spring screw and slip it off the armature shaft.

2. Folo-Thru-Bendix Drive: Push in the outer anchor plate so the pilot screw or pin can be removed.

NOTE

Some Folo-Thru drives use a rubber cushion in place of a drive spring. To remove from shaft, screw pinion out to drive position, then force pin from shaft through screw sleeve holes.

CAUTION

Do not disassemble this drive, service is by complete replacement.

11-112. COMPONENT INSPECTION AND REPAIR.

a. Brushes and Brush Holders: Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator with proper spring tension (Refer to Paragraph 11-114.) to give good, firm contact. Brush leads and screws should be tight and clean.

b. Armature: The armature should be checked for short circuits, opens and grounds:

1. Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between the bars. Undercutting the insulation will eliminate these shorts.

2. Opens: Inspect the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, resolder the leads in the riser bars and turn the commutator down in a lathe. Then undercut the insulation between the commutator bars .031 of an inch.

3. Grounds in the armature can be detected by the use of a test lamp and prods. If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded. If the commutator is worn, dirty, out of round, or has high insulation, the commutator should be turned down and undercut as previously described.

c. Field Coils: The field coils should be checked for grounds and opens using a test lamp.

1. Grounds: Disconnect field coil ground connections. Connect one test prod to the field frame and the other to the field connector. If the lamp lights, the field coils are grounded and must be repaired or replaced.

2. Opens: Connect test lamp prods to ends of field coils. If lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screwdriver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened into place. Where the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

11-113. ASSEMBLY. To reassemble the motor, follow the disassembly procedures in reverse. Install new tang lock washers where removed.

CAUTION

If Folo-Thru drive is manually rotated to locked position, do not attempt to force it in a reverse direction. Proceed to install with pinion meshing with flywheel. When engine starts, the drive will return to the demeshed position.

11-114. STARTING MOTOR SERVICE TEST SPECIFICATIONS. Delco-Remy specifications for 14 and 28-volt starting motors installed as standard equipment on PA-23 series airplanes are as follows:

Motor Model	1109688	1109511	1109696
Delco-Remy, Ref, Service Bulletin	1M-110	1M-110	1M-110
Minimum Brush Tension	24 oz.	24 oz.	24 oz.
No-Load Test			
Volts	10.6	10.6	23.5
Min. Amps	----	----	----
Max. Amps	60	60	55
Min. RPM	3000	3000	2800
Max. RPM	----	----	----
Lock Test			
Amps	300	300	150
Torque (ft-lbs)	18	18	14
Approx. Volts	7.3	7.3	21.0

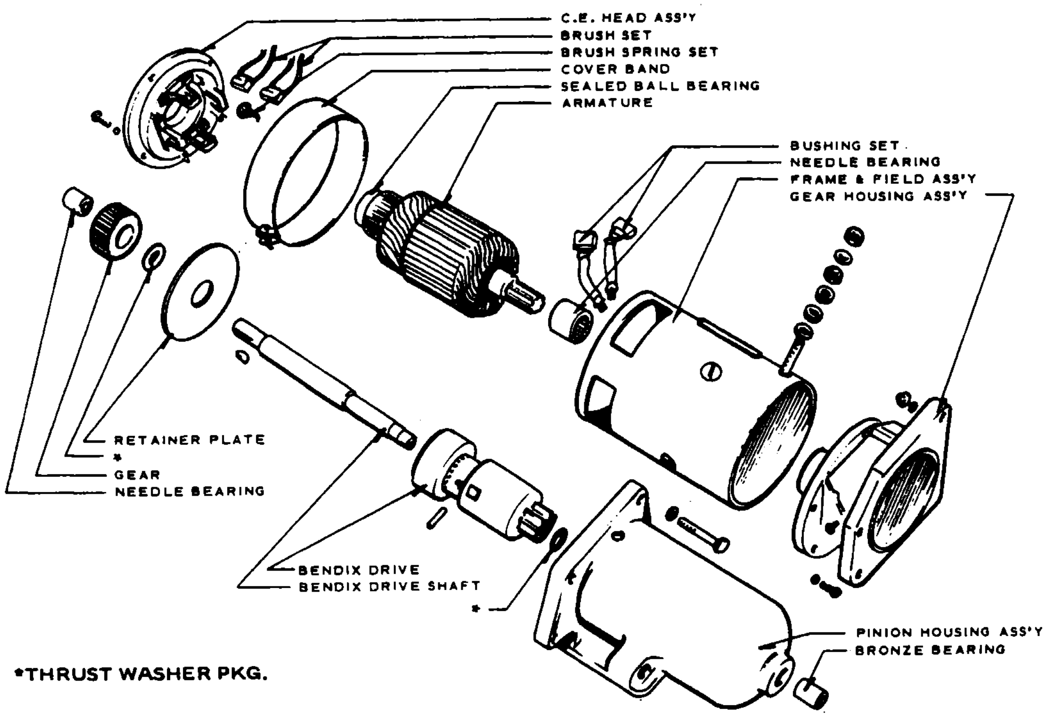

Figure 11-60. Exploded View of Gear Reduction Starting Motor

11-115. STARTING MOTORS (Prestolite).

11-116. DESCRIPTION. The gear reduction starting motor consists of six major components: The Commutator End Head Assembly, The Armature, The Frame and Field Assembly, The Gear Housing, The Pinion Housing, and The Bendix Drive Assembly. (Refer to Figure 11-60.)

11-117. OPERATION. When the starting circuit is energized, battery current is applied to the starting motor terminal. Current flows through the field coils, creating a strong magnetic field. At the same time, current flows through the brushes to the commutator, through the armature windings to ground. The magnetic force created in the armature combined with that created in the field windings begins to turn the armature.

The gear cut on the drive end of the armature shaft extends through the gear housing, where it is supported by a roller bearing. The gear mates with the teeth of the reduction gear that drives the Bendix shaft. The shaft is keyed to the reduction gear. The Bendix drive is held in position on the shaft by a "spirol" pin. The shaft is supported in the gear housing by a closed end roller bearing and in the pinion housing by a graphitized bronze bearing.

When the armature turns the reduction gear, the Bendix drive pinion meshes with the flywheel ring gear by inertia and action of the screw threads within the Bendix sleeve. A detent pin engages in a notch in the screw threads which prevents demeshing if the engine fails to start when the starting circuit is de-energized.

When the engine reaches a predetermined speed, centrifugal action forces the detent pin out of the notch in the screw shaft and allows the pinion to demesh from the flywheel.

11-118. MAINTENANCE. The starting circuit should be inspected at regular intervals, the frequency of which should be determined by the amount of service and the conditions under which the airplane is operated. It is recommended that such inspection be made at least twice a year and include the following:

a. The battery should be checked with a hydrometer to be sure it is fully charged and filled to the proper level with approved water. A load test should be made to determine battery condition. If dirt and corrosion have accumulated on the battery, it should be cleaned with a solution of baking soda and water. Be sure none of the solution enters the battery cells.

b. The starting circuit wiring should be inspected to be sure that all connections are clean and tight and that the insulation is sound. A voltage loss test should be made to locate any high-resistance connections that would affect starting motor efficiency. This test is made with a low-reading voltmeter while cranking the engine or at approximately 100 amperes, and the following limits should be used:

1. Voltage loss from insulated battery post to starting motor terminal - 0. 3-volt maximum.

2. Voltage loss from battery ground post to starter frame - 0.1-volt maximum.

NOTE

If voltage loss is greater than the above limits, additional tests should be made over each part of the circuit to locate the high-resistance connections.

c. No lubrication is required on the starting motor except at the time of overhaul. Then lubricate the entire shaft under Bendix Drive, fill grooves in armature shaft at drive end and pack gear box with 1. 3 to 2. 0 ounces of Lithium Soap Base Grease #1925 Molytex "O" or equivalent.

d. The starting motor should be operated for a few seconds with the ignition switch off to make sure that the pinion engages properly and that it turns freely without binding or excessive noise. Then the engine should be started two or three times to see that the pinion disengages properly when the engine is turned off.

11-119. OVERHAUL. If, during the above inspection, any indication of starting motor difficulty is noted, the starting motor should be removed from the engine for cleaning and repair.

11-120. REMOVAL. To remove the starting motor from the engine, first disconnect the ground cable from the battery post to prevent short circuiting. Disconnect the lead from the starting motor terminal, then take out the mounting bolts. The motor can then be lifted off and taken to the bench for overhaul.

11-121. DISASSEMBLY.

a. Remove the frame screws from the commutator end head and pull end head and armature from frame. Lift the brushes and lock in elevated position with brush springs. Use a puller to remove the end head from the armature. Use a special bearing puller to remove the sealed ball bearing from the armature shaft.

b. Remove the frame screws that secure the gear housing to the frame. Remove bolts and nuts holding the gear housing to the pinion housing and separate the two units. Pull Bendix shaft from pinion housing. Do not lose the steel spacer that is located on the pinion end of the shaft. Remove reduction gear, woodruff key and steel spacer from shaft.

c. Turn the Bendix pinion until it locks in the extended position. Locate "spirol" pin and use a punch to remove. Slide drive assembly off the shaft. Do not attempt to disassemble the drive and do not dip it in cleaning solvent.

d. To remove the roller bearings from the gear housing, use an arbor press and the correct bearing arbor. DO NOT HAMMER OUT. Each part should be cleaned and inspected for excessive wear or damage. Bearings should be checked for proper clearance and evidence of roughness or galling. Oil and dirt should be removed from insulation and the condition of the insulation checked.

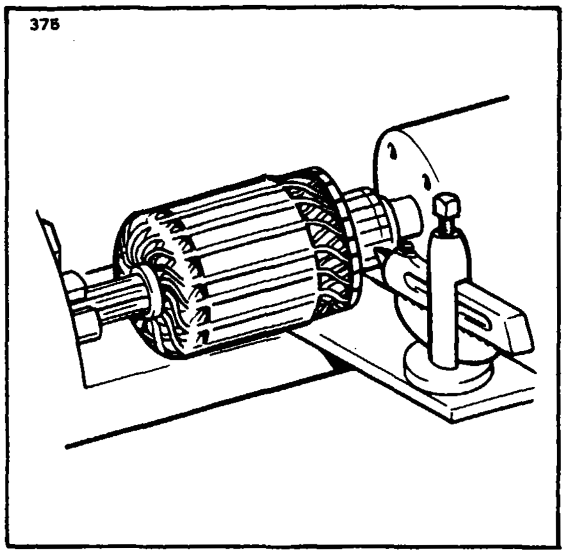

Figure 11-61. Turning Starting Motor Commutator

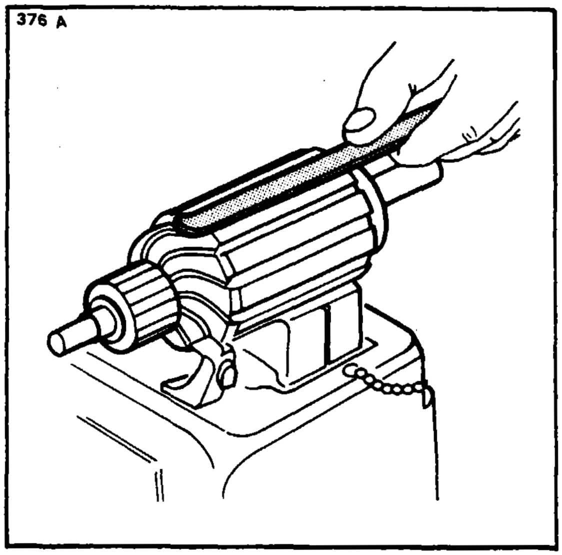

Figure 11-62. Testing Motor Armature for Shorts

11-122. BRUSHES. Check the brushes to see that they slide freely in their holders and make full contact on the commutator. If worn to half their original length or less, they should be replaced.

11-123. ARMATURE.

a. Check the commutator for uneven wear, excessive glazing or evidence of excessive arcing. If only slightly dirty, glazed or discolored, the commutator can be cleaned with 00 or 000 sandpaper. If the commutator is rough or worn, it should be turned in a lathe. (Refer to Figure 11-61.) The armature shaft should be inspected for rough bearing surfaces and rough or damaged splines.

b. To test the armature for grounds, a set of test probes connected in series with a 110-volt light should be used. Touch one probe to a commutator segment and the other to the armature core. If the test lamp lights, the armature is grounded and should be replaced.

c. To test for shorted armature coils, a growler is used. (Refer to Figure 11-62.) The armature is placed on the growler and slowly rotated by hand while a steel strip is held over the core so that it passes over each armature core slot. If a coil is shorted, the steel strip will vibrate.

d. A quick check for opens can be made by inspecting the trailing edge (in direction of rotation) of the commutator segments for excessive discoloration. This condition indicates an open circuit.

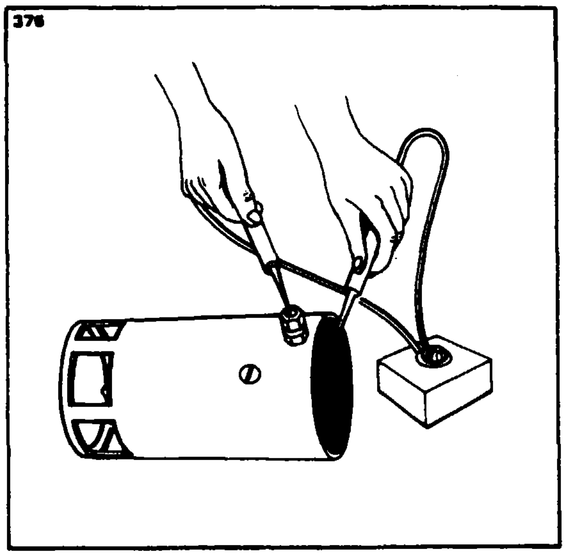

Figure 11-63. Testing Motor Fields for Grounds

11-124. FIELD COILS.

a. Check the field coils for grounds (Refer to Figure 11-63) by placing one test probe on the frame and the other on the starter terminal. Be sure the brushes are not accidentally touching the frame. If the lamp lights, the fields are grounded. Repair or replace.

b. Inspect all connections to make sure they are clean and tight and inspect insulation for deterioration.

11-125. BRUSH HOLDERS.

a. To test brush holders, touch one test probe to the brush plate and the other to each brush holder.

b. The test lamp should light when the grounded brush holders are touched and should not light when the insulated brush holders are touched.

11-126. GEAR AND PINION HOUSING. Inspect housings for cracks and bearings for excessive wear. Remove rust, paint or grease from mounting surfaces.

11-127. BENDIX DRIVE. The Bendix Drive should be wiped clean with a dry cloth. The pinion should turn smoothly in one direction and should lock in the other direction. Replace drive if it fails to check as above or if the pinion teeth are excessively worn or damaged.

11-128. ASSEMBLY.

a. When assembling the starting motor, always use an arbor press and the proper bearing arbor for installing graphitized bronze and roller bearings. The Bendix shaft should have a thin film of Lubriplate #777 or equivalent on the Bendix portion of the shaft. End play should be 0. 005 to 0. 050 of an inch

b. New brushes should be properly seated when installing by wrapping a strip of 00 sandpaper around the commutator (with the sanding side out) 1-1/4 to 1-1/2 times maximum. Drop brushes on sandpaper covered commutator and turn the armature slowly in the direction of rotation. Dust should be blown out of the motor after sanding.

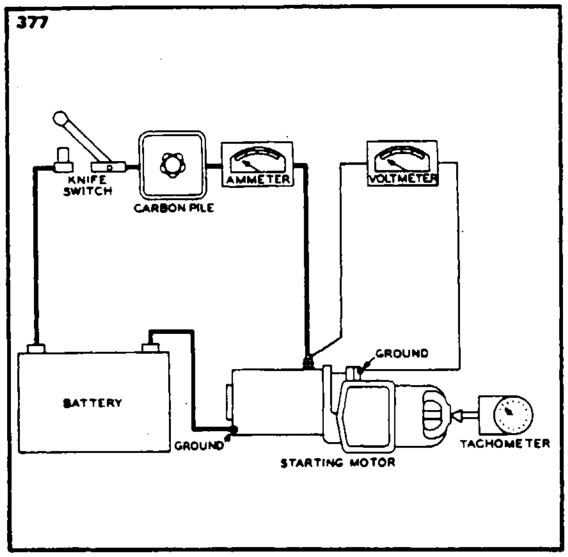

Figure 11-64. No-Load Test Hook-up

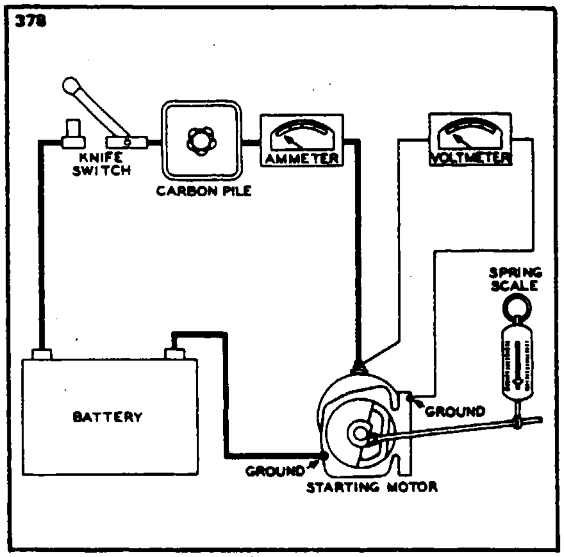

Figure 11-65. Stall-Torque Hook-up

NOTE

The spring tension is 32 to 40 ounces with new brushes. This tension is measured with the scale hooked under the brush spring near the brush and the reading is taken at right angles to the line of force exerted by the brush spring.

c. Check the position of the pinion to be sure the unit will mesh properly with the flywheel ring gear. See specifications for unit for correct dimensions. (Refer to paragraph 11-131.) '.)

11-129. BENCH TESTS.

a. After the starting motor is reassembled, it should be tested to see that the no-load current at a certain voltage is within specifications as given in paragraph 11-131. To make this test, connect as shown in Figure 11-64. If current is too high, check the bearing alignment and end play to make sure there is no binding or interference. Two or three sharp raps on the frame with a rawhide hammer will often help to align the bearings and free the armature.

b. If no difficulty is indicated in the above test, a stall torque test may be made to see if the starting motor is producing its rated cranking power. Make test connections as shown in Figure 11-65.

c. If torque and current are not within specifications, check the seating of the brushes and internal connections for high resistance. If these checks are made and found to be in good order, replace frame and field assembly and retest starter.

11-130. STARTING MOTOR CONTROL CIRCUIT.

a. Inspect the control circuit wiring between the battery, solenoid and manual starting switches for breaks, poor connections and faulty insulation. Tighten all connections and make sure solenoid is firmly mounted and makes a good ground connection.

b. Check the voltage loss across the switch contacts during normal starting. If loss is in excess of 0.2 volts per 100 amperes, the solenoid should be replaced.

c. If solenoid fails to operate when the manual is turned on or if it fails to release when the manual switch is released, it should be removed and tested to specifications. If either opening or closing voltages are not specified, replace the solenoid.

11-131. STARTING MOTOR SERVICE TEST SPECIFICATIONS. Prestolite specifications for 14 and 28-volt starting motors installed as standard equipment on the PA-23 series airplanes are as follows:

Motor Model	MZ-4206	MHB4001
Min. Brush Tension Max. Brush Tension	32 oz. 40 oz.	32 oz. 40 oz.
No-Load Test (77° F) Volt Max. Amps Min. RPM	 10 75 2000	 29 35 1800
Stall-Torque Amps Min. Torque, ft. lbs Approx. Volts	 560 38.0 4.1	 275 42.7 16.0
Pinion Position[1] Drive at rest Drive extended	 1.748 to 1.855 in. 2.388 to 2.495 in.	 1.748 to 1.855 in. 2.388 to 2.495 in.

[1] This dimension is measured from the centerline of the mounting hole nearest the drive end head to the edge of the pinion.

11-132. BATTERY.

11-133. SERVICING THE BATTERY. Access to the battery is through the access panel on the right side of the nose. The stainless steel box has a plastic drain tube located on the bottom side near the right rear corner which is normally closed off with a clamp and should be opened occasionally to drain off any accumulation of liquid. The battery should be checked for fluid level, but must not be filled above the baffle plates. A hydrometer check should be performed to determine the percent of charge present in the battery. All connections must be clean and tight.

11-134. REMOVAL OF BATTERY.

a. Remove the access panel from the right side of the nose section.
b. Remove the wing nuts from either side of the box and remove the lid.
c. Disconnect the battery cables.

NOTE

Always remove the ground cable first and install last to prevent accidental short circuiting or arcing.

d. Remove the battery from the box.

11-135. INSTALLATION OF BATTERY

a. Ascertain that the battery and battery box has been cleaned and is free of acid.
b. Install the battery with the terminals inboard.
c. Connect the battery cables.
d. Install the lid and secure with wing nuts.

11-136. CHARGING BATTERY. If the battery is not up to normal charge, remove the battery and recharge starting with a charging rate of 4 amperes and finishing with 2 amperes.

HYDROMETER READING AND BATTERY CHARGE PERCENT

Hydrometer Readings	Percent of Charge
1280	100
1250	75
1220	50
1190	25
1160	Very little useful capacity
1130 or below	Discharged

11-137. BATTERY BOX CORROSION PREVENTION. The following check against corrosion within the battery box should be performed at least every 30 days.

a. Open the clamp at bottom right rear corner of the battery box and drain off any electrolyte that may have overflowed into the box.

b. Check terminals and connections for corrosion. Corrosion effects may be neutralized by applying a solution of baking soda and water mixed to the consistency of thin cream. Repeat application until all bubbling action has ceased.

CAUTION

Do not allow soda solution to enter battery.

c. Wash battery and box with clean water and dry.
d. Close battery box drain tube clamp.
e. As necessary, paint the battery box with an acid resistant paint.

11-138. CHECKING ELECTRICAL SWITCHES AND CIRCUIT BREAKERS. Electrical switches and circuit breakers, located on the lower left instrument panel, control the navigation and instrument lights, one landing light, one taxi light, the electric turn and bank indicator and other electrical components. The circuit breakers automatically break the electrical circuit if an overload is applied to the system, thus preventing damage to the electrical wiring. To reset the circuit breakers, simply push in the buttons. Allow sufficient time for cooling before resetting circuit breakers. The time for resetting circuit breakers may vary considerably, depending on the nature of the overload and the temperature.

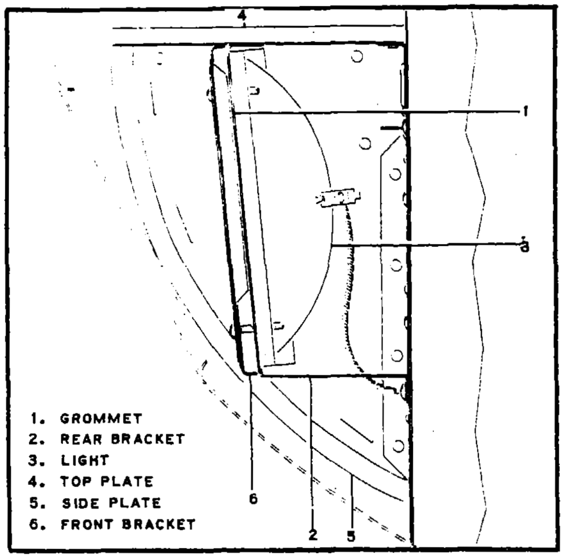

Figure 11-66. Landing Light Inst.
PA-23-250 and PA-23-235

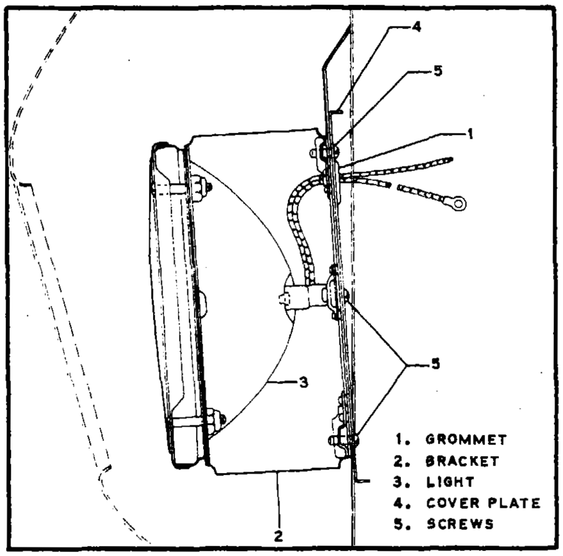

Figure 11-67. Landing Light Inst.
PA-23-250 (six place)

11-139. LANDING LIGHT.

11-140. REMOVAL OF LANDING LIGHT. (PA-23-250 and PA-23-235.)

a. Remove fuselage nose cone fairing.

b. Remove the two self-locking nuts from the lower screws passing through both rear and front brackets (2 and 6, Figure 11-66.)

c. Loosen the two self-locking nuts on the upper screws passing through the brackets.

d. Disconnect the electrical leads from the rear of the light (3) and remove the light.

11-141. INSTALLATION OF LANDING LIGHT. (PA-23-250 and PA-23-235.)

a. Install the light between the brackets, making sure the key on the back of the light is in the rear bracket slot at the left of the bracket.

b. Install the two self-locking nuts on the two lower bracket screws, tighten them and the two upper nuts until the edges of both brackets are parallel. Connect the electrical leads to the rear of the light.

c. Prior to removal of the housing, disconneet the electrical leads and use caution not to drop the light when the front and rear brackets are separated.

11-142. REMOVAL OF LANDING LIGHT. (PA-23-250 (six place.) Access for the replacement of the landing light is achieved through the front baggage compartment.

a. Remove the access panel to the nose section.
b. Remove six screws that secure the cover plate and light assembly. (Refer to Figure 11-67.) To prevent the light assembly from dropping, it may be held by reaching through the nose opening.
c. Withdraw the light assembly through the panel opening, disconnect the electrical leads, disassemble and remove light.

11-143. INSTALLATION OF LANDING LIGHT. (PA-23-250 (six place.)

a. Install the light between the brackets, making sure the key on the back of the light is in the rear bracket slot. Connect the electrical leads.
b. Reinstall the light assembly through the panel opening, hold the light in position by reaching through the nose opening, reinstall the panel cover and screws.

11-144. REMOVAL OF LANDING LIGHT. (PA-23-250 Serial Nos. 27-4426 and 27-4574 and up.)
a. Remove the screws securing the plexiglas cover on the bottom of the nose cone.
b. Remove the screws from the front of the lamp attachment plate and remove the plate from the mounting bracket. Do not drop the lamp.
c. Disconnect the electrical leads and remove the light.

11-145. INSTALLATION OF LANDING LIGHT. (PA-23-250 Serial Nos. 27-4426 and 27-4574 and up.)
a. Connect the electrical leads to the lamp and position the lamp on the mounting bracket.
b. Position the front attachment plate over the lamp and secure the plate and lamp to the mounting bracket with four screws.
c. Install the plexiglas cover on the bottom of the nose cone and secure in place with screws.

11-146. REMOVAL OF LAMP IN ANTI-COLLISION WING TIP STROBE LIGHT. The lights are located in both wing tips next to the navigation lights.

a. Remove the screw securing the navigation light cover and remove cover.
b. Remove the three screws securing navigation light bracket assembly and remove light assembly.
c. Remove the strobe lamp by cutting the wires on the lamp beneath the mounting bracket.
d. Remove the defective lamp.
e. Remove and discard the plug with the cut wires from the electrical socket.

11-147. INSTALLATION OF LAMP IN ANTI-COLLISION WING TIP STROBE LIGHT.

a. Route the wires from the new lamp down through the hole in the navigational light bracket.
b. Insert the wire terminals in the plastic plug supplied with the new lamp. Wire according to schematic diagram located in electronics section.
c. Position strobe lamp on navigational light bracket.
d. Secure navigational light assembly and bracket with appropriate screws.
e. Replace navigational light cover and secure with appropriate screws.

11-148. REMOVAL OF LAMP IN ANTI-COLLISION STROBE LIGHT. There is one anti-collision strobe light located on the rudder tip.

a. Loosen the screw in the clamp securing the light cover.
b. Remove the light cover.
c. Remove the defective lamp from the socket.

11-149. TROUBLESHOOTING PROCEDURE FOR ANTI-COLLISION AND WING TIP STROBE LIGHT SYSTEMS. The strobe light assembly functions as a condenser discharge system. A condenser in the power supply is charged to approximately 450 volts D. C., then discharged across the xenon flash tube at intervals approximately 45 flashes per minute. The condenser is parallel across the xenon flash tube which is designed to hold off the 450 volt D. C. applied until the flash tube is triggered by an external pulse. This pulse is generated by a solid state timing circuit in the power supply.

When troubleshooting the strobe light system, it must first be determined if the trouble is in the flash tube or the power supply. Replacement of the flash tube will confirm if the tube is defective. A normal operating power supply will emit an audible tone of 1 to 1.5 KHC. If there is no sound emitted check the system according to the following instructions. When troubleshooting the system utilize the appropriate schematic in this manual.

a. Ascertain the input voltage at the power supply is correct.

CAUTION

When disconnecting and connecting the power supply input connections do not get the connection reversed. Reversed polarity of the input voltage for just an instant will permanently damage the power supply. The reversed polarity destroys a protective diode in the power supply, causing self-destruction from overheating of the power supply. This damage is sometimes not immediately apparent, but will cause failure of the system in time.

b. Check for malfunction in interconnecting cables.

1. Ascertain pins 1 and 3 of interconnecting cable are not reversed.

2. Using an ohmmeter check continuity between pin 1 and 3 of interconnecting cable. If you obtain a reading on the meter the cable is shorted and should be replaced.

NOTE

A short of the type described in steps 1 and 2 will not cause permanent damage to the power supply but the system will be inoperative if such a short exists. Avoid any connection between pin 1 and 3 of interconnecting cable as this will discharge the condenser in the power supply and destroy the trigger circuit.

CAUTION

When disconnecting the power supply allow five minutes of bleed down time before handling the unit.

c. Check interconnecting cables for shorts.

1. Disconnect the output cables from the power supply outlets.

2. The following continuity checks can be made with an ohmmeter.

3. Check for continuity between the connectors of each interconnecting cable by checking from pin 1 to pin 1, pin 2 to pin 2 and pin 3 to pin 3. When making these checks if no continuity exists the cable is shorted and should be replaced.

4. Check continuity between pins 1 and 2, 1 and 3 and 2 and 3 of the interconnecting cable. If continuity exist between any of these connections the cable is shorted and should be replaced.

5. Check for continuity from pins 1, 2 and 3 to airplane ground. If continuity exists the cable is shorted and should be replaced.

d. Check tube socket assembly for shorts.

1. Disconnect the tube socket assembly of the anti-collision light from the interconnecting cables.

2. The following continuity checks can be made with an ohmmeter.

3. Check for continuity between pin 1 of amp connector to pin 1 of tube socket, pin 2 of amp connector to pin 6 and 7 of tube socket and pin 3 of amp connector to pin 4 of tube socket. When making these tests if no continuity exists the tube socket assembly is shorted and should be replaced.

11-150. INSTALLATION OF ANTI-COLLISION LIGHT.

a. Plug in new lamp using correct number.
b. Replace light cover.
c. Tighten screw in clamp to secure light cover.

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TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING

Trouble	Cause	Remedy
GENERATOR		
Generator operating within rated speed range but voltage output low.	If the voltage is low, the generator is operating on residual magnetism.	Check for loose or high resistance connections; clean and tighten.
	Loose or high-resistance electrical connections.	Clean and tighten all electrical connections.
	Brushes excessively worn.	When brush wears down to 1/2 inch, replace with a new one. The new brush must be seated to at least 75% of the contact surface by running the generator without load (with the line switch open) for at least 15 minutes during the engine warm-up period. CAUTION Do not use abrasives of any description to assist in seating the brushes.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range but voltage output low. (cont.)	Brushes binding in the brush boxes.	The brushes should be a free fit without excessive side play in the brush boxes. Binding brushes and the brush boxes should be wiped clean with a cloth moistened in Varsol or undoped gasoline.
		Replace the brushes as outlined above.
	Brushes not properly seated.	Reseat brushes as outlined above.
	Low brush spring tension.	Brush spring should bear centrally on the top of the brushes, insuring full brush contact with the face of the commutator.
	Dirty commutator.	Clean the commutator with a cloth moistened in Varsol or undoped gasoline.
	Scored or pitted commutator.	Remove and turn commutator down on a lathe.
	Shorted or open armature coils.	Replace armature.
	Improper operations of the voltage regulator.	Adjust regulator.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range but voltmeter indicates zero.	Loose or high resistance field coil assembly terminals.	Clean and tighten the terminals.
	Wiring not properly connected.	See airplane wiring diagram.
	Grounded field coil assembly.	Replace entire yoke assembly.
	Open field coil assembly.	Remove the generator and replace with one known to be in good condition.
Generator operating within rated speed range, but voltage output is erratic.	Unstable operation of voltage regulator. Same as "Generator operating within rated speed range but voltage output low," above.	Replace voltage regulator. Use remedy under "Generator operating within rated speed range but voltage output low," above.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Generator operating within rated speed range, with line switch closed, but system ammeter indicates low or no output.	None.	Since the voltage regulator holds the generated voltage at an almost constant value, the current output depends entirely upon the condition of the battery and the amount of external load. Therefore, when the battery is fully charged and there is no load on the system, the difference in voltage between the generator and the battery is so small that little or no current will flow between them.
	Improper operation of the reverse-current relay.	Readjust the relay.
	Generator field demagnetized.	Flash field.
	Burned-out ammeter.	Replace ammeter.
Generator operating within rated speed range but system ammeter reads off scale in the wrong direction.	Generator field magnetized in the wrong direction.	Flash field as explained above and check to see that reverse-current relay is operating properly.

NOTE

Flash the generator field by turning the generator and battery switch to the "ON" position and momentarily connect the "Bat" and "Gen" terminals of the regulator.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
System ammeter shows full charge but battery is discharged.	Generator of improper capacity installed in the system.	Install a generator of larger capacity.
	Battery too small for load requirements.	Install a battery of sufficient capacity.
System ammeter fluctuates excessively when indicating full rated load.	Generating system is overloaded.	Check the system for abnormal loads.
	Improper operation of generator reverse-current relay.	Readjust to operate properly.
Burned-out system ammeter or line fuse.	Discharged battery.	Replace with a fully charged battery.
	Defective wiring.	Replace all defective wiring.
ALTERNATOR		
No output from alternatur.	Malfunction of alternator output circuit or field circuit.	Check alternator output and field circuits. (Refer to paragraph 11-58.)
		Check alternator. (Refer to paragraph 11-58.)
Reduced output from alternator.	Open diode.	Check alternator. (Refer to paragraph 11-58.)

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
STARTER		
Starter fails to operate.	Low battery charge.	Check and recharge if necessary.
	Defective or improper wiring or loose connections.	Refer to wiring diagram and check all wiring.
	Defective starter solenoid or control switch.	Replace faulty unit.
	Binding, worn or improperly seated brush, or brushes with excessive play.	Brushes should be a free fit in the brush boxes without excessive side play. Binding brushes and brush boxes should be wiped clean with a gasoline (undoped) moistened cloth. A new brush should be run in until at least 50% seated; however, if facilities are not available for running in brushes, then the brush should be properly seated by inserting a strip of No. 0000 sandpaper between the brush and commutator, with the sanded side side next to the brush. Pull sandpaper in direction of rotation, being careful to keep it in the same contour as the commutator.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Starter fails to operate. (cont.)	Binding, worn, or improperly seated brush, or brushes with excessive side play. (cont.)	CAUTION Do not use coarse sand paper or emery cloth. After seating, clean thoroughly to remove all sand and metal particles to prevent excessive wear. Keep motor bearing free from sand or metal particles.
	Dirty commutator.	If commutator is rough or dirty, smooth and polish with No. 0000 sandpaper. If too rough and pitted, remove and turn down. Blow out all particles.
	Shorted, grounded, or open armature.	Remove and replace with an armature known to be in good condition.
	Grounded or open field circuit.	Test and then replace new part.
Starter operates at proper speed but fails to crank engine.	Faulty Bendix drive.	Remove Bendix drive assembly. Clean and check, replace.
Low starter and cranking speed.	Worn, rough, or improperly lubricated motor or starter gearing.	Disassemble, clean, inspect and relubricate, replacing ball bearings, if worn.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Low starter and cranking speed. (cont.)	Same electrical causes as listed under "Starter fails to operate."	Same remedies listed for these troubles.
Excessive arcing of starter brushes.	Binding, worn or improperly seated brush or brushes, with excessive side play.	See information above dealing with this trouble.
	Dirty commutator, rough, pitted or scored.	Clean as already outlined above.
	Grounded or open field circuit.	Test and replace defective parts.
Excessive wear and arcing of starter brushes.	Rough or scored commutator.	Remove and turn commutator down on a lathe.
	Armature assembly not concentric.	Reface commutator.
BATTERY 12V		
Battery will not hold hold charge.	Battery worn out.	Replace battery.
	Charging rate not set right.	Reset.
	Discharge too great to replace.	Reduce use of starter on the ground; use external power wherever possible.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Battery will not hold charge. (cont.)	Standing too long.	Remove and recharge battery if left in unused airplane one week or more.
	Equipment left "ON" accidentally.	Remove and recharge. (Refer to paragraph 11-120.)
	Impurities in electrolyte.	Replace.
	Short circuit (ground) in wiring.	Check wiring.
	Broken cell partitions.	Replace.
Battery life is short.	Overcharge due to level of electrolyte being below tops of plates.	Maintain electrolyte level.
	Heavy discharge.	Replace.
	Sulfation due to disuse.	Replace.
	Impurities in electrolyte.	Replace battery.
Cracked cell.	Hold down loose.	Replace battery and tighten.
	Frozen battery.	Replace.
Compound on top of battery melts.	Charging rate too high.	Reduce.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
Electrolyte runs out of vent plugs.	Too much water added to battery.	Drain and keep at proper level.
Excessive corrosion inside container.	Spillage from overfillings.	Use care in adding water.
	Vent lines leaking or clogged.	Repair or clean.
Battery freezes.	Discharged battery.	Replace.
	Water added and battery not charged immediately.	Always recharge battery at least 1/2 hour when adding water in freezing weather.
	Leaking jar.	Replace.
Battery polarity reversed.	Connected backwards on airplane or charger.	Battery should be slowly discharged completely and then charged correctly and tested.
Battery consumes excessive water.	Charging rate too high (if in all cells).	Correct charging rate.
	Cracked jar (one cell only.	Replace battery.

TABLE XI-III. ELECTRICAL SYSTEM TROUBLESHOOTING (cont.)

Trouble	Cause	Remedy
BATTERY-DISCONNECT SOLENOID		
Does not operate.	Open circuit.	Replace wiring.
	Dirty contacts on connector plug.	Clean contacts.
	Open circuited solenoid coil.	Replace unit.
	Plunger binding.	Remove and wash plunger and housing thoroughly with carbon tetrachloride. Change spring compression only as a last resort.
Intermittent operation.	Short-circuited coil. Loose electrical connection.	Replace coil. Clean and tighten electrical connections.
	Plunger binding.	See remedy pertaining to "Plunger binding" under "Does not operate".
	Badly burned points.	If points cannot be dressed down, replace the unit.

TABLE XI-IV. LAMP REPLACEMENT GUIDE

Location		Piper Part No.	Bulb No.
AltiMatic Pilot Light (Console)		751 461	65-S28
AltiMatic Pilot Light (Effort)		751 460	65-S19
Baggage Compartment Light	14V	472 753	30-31
Baggage Compartment Light	28V	472 755	30-32
Compass Light	28V	472 028	327
Compass Light	14V	472 037	330
De-Icer Light		752 343	MS25041-3
Dome Light	28V	472 029	303
Dome Light	14V	472 036	89
Door Ajar	28V	472 028	327
Door Ajar	14V	472 037	330
Gear Indicator Light	28V	472 028	327
Gear Indicator Light	14V	472 037	330
Generator Indicator	28V	472 028	327
Instrument Panel Lights	28V	472 028	327
Instrument Panel Lights	14V	472 037	220
Instrument Panel Spot Light	14V	752 322	90
Instrument Panel Spot Light	28V	753 323	304
Landing Light 100 watt	14V	472 661	4509
Landing Light 100 watt	28V	472 708	4591
Landing Light 250 watt	14V	472 654	4522
Landing Light 250 watt	28V	472 706	4553
Map Light	14V	472 026	90
Map Light	14V	472 040	1816
Map Light	28V	472 052	304
Marker Beacon Light		752 318	47
Nav. Lights - Wing Tips	14V	751 381	1512
Nav. Lights - Wing Tips	28V	751 438	1524
Reading Light	28V	472 027	1495
Reading Light	14V	472 040	1816
Receiver Lights		472 028	327
Receiver Lights		752 324	(1401) (262 0464 00)

TABLE XI-IV. LAMP REPLACEMENT GUIDE (cont.)

Location		Piper Part No.	Bulb No.
Rotating Beacon - Grimes	14V	752 307	A7079
Rotating Beacon - Grimes	28V	752 316	7079B
Rotating Beacon - Grimes	28V	753 440	1939
Rotating Beacon - Whelan	14V	751 448	WRM 44
Rotating Beacon - Whelan	28V	751 457	WRM 4S
Strobe Light (Red)	14V	757 635	A406
Strobe Light (White)	14V	761 157	A428
Tail Light	28V	751 437	305
Tail Light	14V	753 431	1073
Transmitter Lamp	28v	752 325	262 0179 00

TABLE XI-V. CIRCUIT LOAD CHART

CIRCUIT	CIRCUIT PRO-TECTOR RAT-ING IN AMPS.	ITEM	NO. OF UNITS OPERATING SIMULTAN-EOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT 12.0V	14.3V
STARTER	15*	STARTER SOLENOID	1	8.40	10.00
		STARTING VIBRATOR	1	4.00	4.77
VOLT REG. MAIN	10*	MAIN VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R	1 SYSTEM	5.88	6.96
VOLT REG. AUX.	10*	AUX. VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R			
FUEL PUMPS	15	LEFT & RIGHT FUEL PUMPS	2	5.04	6.00
STALL WARNING	5	FLASHER UNIT–LIGHT–STALL WARNING	1 SYSTEM	0.18	0.21
FUEL, HORN	5	FLASHER UNIT & HORN–LDG. GEAR WARNING	1 SYSTEM	0.70	0.80
CYL. HD. TEMP.		FUEL GAGES & ENG. INSTRUMENT CLUSTER	1 GROUP	0.51	0.60
TURN & BANK	5	TURN & BANK GYRO	1	0.25	0.30
GEAR & FLAP (INDICATORS)	5	DOOR AJAR LIGHT	1	0.08	0.09
		GEAR UP-GEAR DOWN LIGHTS	3	0.08	0.09
		FLAP INDICATOR	1	0.40	0.48
ELEC. TRIM	5*	PITCH TRIM SERVO	1	0.84	1.00
CABIN HEAT (& LIGHTER)	20*	CIGAR LIGHTER	1	6.64	7.90
		CABIN HEATER SYSTEM (GROUND OPERATION-HEATER IGNITION, VENT BLOWER, AND COMBUSTION BLOWER OPERATING)	MAX.	11.66	13.80
PITOT HEAT	15	PITOT HEATING ELEMENT	1	10.92	13.00
POS. LTS.	5	NAV WING TIP LIGHTS			
		NAV TAIL LIGHT	1 SYSTEM	4.44	4.95
PROP SYNC.	5	ARKORP PROP SYNCHRONIZER	1	1.00	1.19
LAND. LTS.	30	LANDING LIGHT	1	17.66	21.00
		TAXI LIGHT	1	7.13	8.47
INT. LTS. (INTERIOR LIGHTS)	5*	MAP LIGHTS	2	0.30	0.36
		CABIN READING LIGHTS	4	0.86	1.02
		TRIM INDICATOR LIGHTS	2	0.08	0.07
		INSTRUMENT SPOT LIGHTS	2	0.52	0.61
		DOME LIGHT	1	0.96	1.14
		COMPASS LIGHT	1	0.07	0.08
POST LIGHTS	5	AUTOPILOT CONSOLE LIGHT	1	0.08	0.09
		OMNI COUPLER LIGHT	2	0.04	0.05
		POST LIGHTS–GLAR-BAN	AS	0.08	0.09
		LIGHTED SWITCHES (ROCKER)	INSTALLED	0.08	0.09
WINDSHIELD HEAT	15	WINDSHIELD HEATING ELEMENT	1	11.58	13.75
DEICER–WING-TAIL	5*	SURFACE DEICE SYSTEM	1	4.06	4.84
DEICER–PROP	25*	PROPELLER DEICE SYSTEM	1 PR.	17.30	20.60

* CURRENT WILL VARY DUE TO INTERMITTENT LOADS (TYPICAL VALUES SHOWN). CIRCUIT BREAKER CAPACITY IS SUFFICIENT FOR NORMAL OPERATION.

TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PROTECTOR RATING IN AMPS.	ITEM		NO. OF UNITS OPERATING SIMULTANEOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT 12.0V	14.3V
ANTI-COL. RED	10	ROTATING RED BEACON		AS	4.03	4.80
	5	RED STROBE LIGHT W/POWER SUPPLY		INSTALLED	1.40	2.45
ANTI-COL. WHITE	5	WHITE WING TIP STROBES W/POWER SUPPLY		1 SET	3.80	4.45
COM-NAV 1	10	MK-12A OR MK-12B (NARCO)	(XMIT)	1	6.92	8.25
		TRANSCEIVER	(RCV)		4.03	4.79
		MK-16	(XMIT)	1	4.21	5.02
		TRANSCEIVER	(RCV)		0.63	0.75
		VOA-8 INDICATOR			0.36	0.39
		VOA-9 INDICATOR		AS	0.36	0.39
		VOA-40M		INSTALLED	0.06	0.07
		VOA-50M			0.07	0.07
COM-NAV 2	10	SIMILAR TO COM-NAV 1		AS INSTL.		
ADF	5	BENDIX T12-C ADF RECEIVER		AS INSTL.	0.66	0.78
		KING KR-85 ADF RECEIVER			0.87	1.04
M/B	5	MBT-12 NARCO MARKER BEACON OR PIPER PM-1		AS INSTL.	0.17	0.20
G/S	5	NARCO UGR-2 GLIDE SLOPE RECEIVER		AS INSTL.	0.17	0.23
A/P	5	ALTIMATIC IIIB		AS INSTL.	1.34	1.60
	OR	ALTIMATIC V FD/AP BENDIX			5.75	6.80
	10	AUTOCONTROL III			0.80	0.96
		GLIDE SLOPE COUPLER			0.15	0.18
DME	10	NARCO UDI-4		AS INSTL.	5.69	6.77
XPONDER	5	NARCO AT5-A OR AT6-A		AS INSTL.	1.76	2.09
		NARCO UAT-1			3.05	3.63
ACC. (ACCESSORIES)	5	AUDIO AMP, KING KA-25			0.96	1.14
		RADIO JUNCTION BOX			0.32	0.38
COM-NAV 11, 12, 14		NARCO NAV 11		AS INSTL.	0.60	0.65
		NARCO NAV 12			0.60	0.65
		NARCO NAV 14			0.85	1.00
		NARCO COM 11	(XMIT)	1	1.95	2.50
			(RCV)		0.80	1.00
		NARCO COM 11A	(XMIT)	1	2.40	3.00
			(RCV)		0.80	1.00
		KING KX-175 NAV/COM	(XMIT)	1	4.20	4.80
			(RCV)	AS INSTL.	COM 0.65	0.80
					NAV 0.49	0.65
		KING KX-170A NAV/COM	(XMIT)	1	4.20	4.80
			(RCV)	AS INSTL.	COM 0.65	0.80
					NAV 0.49	0.65
		KMA-20			1.30	1.60
		KT-76			0.95	1.35
		KN-65 DME			2.65	2.95
		KN-60C DME			2.90	3.20

TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PRO-TECTOR RAT-ING IN AMPS.	ITEM	NO. OF UNITS OPERATING SIMULTAN-EOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT	
				12.0V	14.3V
		KN-73 GLIDE SLOPE RECEIVER		0.20	0.20
		KN-77 VOR/LOC		0.10	0.10
		KNI-520 LOC/GLIDE SLOPE		0.20	0.20
		KNI-211C OMNI		0.30	0.32
		KI-201C OMNI		0.20	0.22
RADAR		AVQ-45/46 RADAR	AS INSTL.	--	--
		RDR-100 RADAR		--	--

TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PRO-TECTOR RAT-ING IN AMPS.	ITEM	NO. OF UNITS OPERATING SIMULTAN-EOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT	
				24.0 V.	28.5 V.
STARTER	15*	STARTER SOLENOID	1	5.20	--
		STARTING VIBRATOR	1	2.00	--
VOLT REG. MAIN	10*	MAIN VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R	1 SYSTEM	4.00	4.80
VOLT REG. AUX.	10*	AUX. VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R			
FUEL PUMPS	15	LEFT & RIGHT FUEL PUMPS	2	2.50	3.10
STALL WARNING	5	FLASHER UNIT–LIGHT–STALL WARNING	1 SYSTEM	0.10	0.13
FUEL, HORN	5	FLASHER UNIT & HORN–LDG. GEAR WARNING	1 SYSTEM	0.50	0.60
CYL. HD. TEMP.		FUEL GAGES & ENG. INSTRUMENT CLUSTER	1 GROUP	0.25	0.30
TURN & BANK	5	TURN & BANK GYRO	1	0.140	0.155
GEAR & FLAP (INDICATORS)	5	DOOR AJAR LIGHT	1	0.04	0.05
		GEAR UP-GEAR DOWN LIGHTS	3	0.04	0.05
		FLAP INDICATOR	1	0.05	0.06
ELEC. TRIM	5*	PITCH TRIM SERVO	1	0.48	0.55
CABIN HEAT (& LIGHTER)	20*	CIGAR LIGHTER	1	6.60	7.90
		CABIN HEATER SYSTEM (GROUND OPERATION-HEATER IGNITION, VENT BLOWER, AND COMBUSTION BLOWER OPERATING)	MAX.	6.00	7.10
PITOT HEAT	15	PITOT HEATING ELEMENT	1	3.20	3.70
POS. LTS.	5	NAV WING TIP LIGHTS NAV TAIL LIGHT	1 SYSTEM	2.48	2.94
PROP SYNC.	5	ARKORP PROP SYNCHRONIZER	1	1.00	1.19
LAND. LTS.	30	LANDING LIGHT	1	6.00	7.25
		TAXI LIGHT	1	3.06	3.64
INT. LTS. (INTERIOR LIGHTS)	5*	MAP LIGHTS	2	0.24	0.26
		CABIN READING LIGHTS	4	0.44	0.50
		TRIM INDICATOR LIGHTS	2	0.06	0.07
		INSTRUMENT SPOT LIGHTS	2	0.35	0.40
		DOME LIGHT	1	0.25	0.30
		COMPASS LIGHT	1	0.03	0.04
POST LIGHTS	5	AUTOPILOT CONSOLE LIGHT	1	0.05	0.06
		OMNI COUPLER LIGHT	2	0.04	0.05
		POST LIGHTS–GLAR-BAN	AS	0.03	0.04
		LIGHTED SWITCHES (ROCKER)	INSTALLED	0.03	0.04
WINDSHIELD HEAT	15	WINDSHIELD HEATING ELEMENT	1	5.80	6.90
DEICER–WING-TAIL	5*	SURFACE DEICE SYSTEM 6 SEC. OF EACH 3 MIN.	1	4.96	6.30
DEICER–PROP	25*	PROPELLER DEICE SYSTEM	1 PR.	10.15	12.00

* CURRENT WILL VARY DUE TO INTERMITTENT LOADS (TYPICAL VALUES SHOWN). CIRCUIT BREAKER CAPACITY IS SUFFICIENT FOR NORMAL OPERATION.

TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PROTECTOR RATING IN AMPS.	ITEM		NO. OF UNITS OPERATING SIMULTANEOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT 24.0 V.	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT 28.5 V.
ANTI-COL. RED	10	ROTATING RED BEACON		AS	2.60	3.10
	5	RED STROBE LIGHT W/POWER SUPPLY		INSTALLED	0.90	1.60
ANTI-COL. WHITE	5	WHITE WING TIP STROBES W/POWER SUPPLY		1 SET	2.00	2.30
COM-NAV 1	10	MK-12A OR MK-12B (NARCO)	(XMIT)	1	4.00	4.90
		TRANSCEIVER	(RCV)		1.90	2.35
		MK-16	(XMIT)	1	3.96	4.71
		TRANSCEIVER	(RCV)		0.38	0.45
		VOA-8 INDICATOR			0.31	0.36
		VOA-9 INDICATOR		AS	0.31	0.36
		VOA-40M		INSTALLED	0.06	0.07
		VOA-50M			0.06	0.07
COM-NAV 2	10	SIMILAR TO COM-NAV 1		AS INSTL.		
ADF	5	BENDIX T12-C ADF RECEIVER		AS INSTL.	0.46	0.54
		KING KR-85 ADF RECEIVER			0.87	1.04
M/B	5	MBT-12 NARCO MARKER BEACON OR PIPER PM-1		AS INSTL.	0.19	0.25
G/S	5	NARCO UGR-2 GLIDE SLOPE RECEIVER		AS INSTL.	0.10	0.15
A/P	5	ALTIMATIC IIIB		AS INSTL.	3.50	4.15
	OR	ALTIMATIC V FD/AP BENDIX & -1's			2.90	3.40
	10	AUTOCONTROL III			0.45	0.50
		GLIDE SLOPE COUPLER			0.80	0.95
DME	10	NARCO UDI-4		AS INSTL.	3.06	3.63
XPONDER	5	NARCO AT5-A OR AT6-A		AS INSTL.	1.30	1.55
		NARCO UAT-1			1.55	1.84
ACC. (ACCESSORIES)	5	AUDIO AMP, KING KA-25			1.00	1.15
		RADIO JUNCTION BOX			0.15	0.20
COM-NAV 11, 12, 14		NARCO NAV 11		AS INSTL.	0.60	0.65
		NARCO NAV 12			0.60	0.65
		NARCO NAV 14			1.50	1.95
		NARCO COM 11	(XMIT)	1	4.00	4.80
			(RCV)		1.75	1.90
		NARCO COM 11A	(XMIT)	1	4.75	5.80
			(RCV)		1.75	1.90
		KING KX-175 NAV/COM	(XMIT)	1	4.40	4.95
			(RCV)	AS INSTL.	COM 0.70	0.85
					NAV 0.55	0.70
		KING KX-170A NAV/COM	(XMIT)	1	4.40	4.95
			(RCV)	AS INSTL.	COM 0.70	0.85
					NAV 0.55	0.70
		KMA-20			1.20	1.50
		KT-76			0.95	1.35
		KN-65 DME			0.95	1.55
		KN-60C DME			1.00	1.50
		KN-73 GLIDE SLOPE RECEIVER			0.20	0.20
		KN-77 VOR/LOC			0.10	0.10

TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PROTECTOR RATING IN AMPS.	ITEM	NO. OF UNITS OPERATING SIMULTANEOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT	
				24.0 V.	28.5 V.
		KNI-520 LOC/GLIDE SLOPE		0.20	0.20
		KNI-211C OMNI		0.24	0.26
		KI-201C OMNI		0.14	0.16
RADAR		AVQ-45/46 RADAR	AS INSTL.	4.3	5.1
		RDR-100 RADAR		7.22	9.04

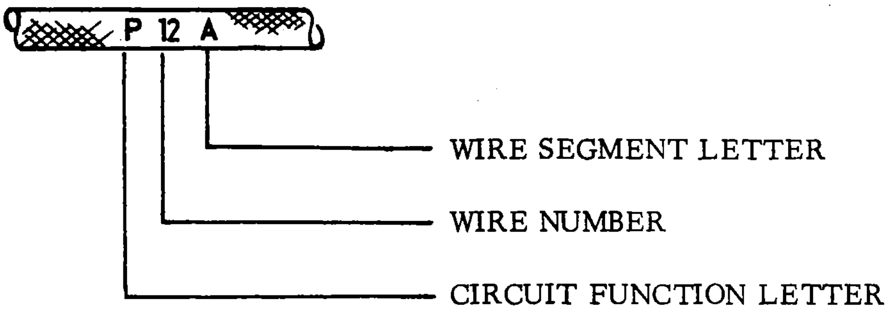
TABLE XI-V. CIRCUIT LOAD CHART (cont.)

CIRCUIT	CIRCUIT PROTECTOR RATING IN AMPS.	ITEM NOTE: 1975 MODELS AND UP.	NO. OF UNITS OPERATING SIMULTANEOUSLY	CURRENT DRAIN PER UNIT (MAX.) IN AMPERES AT 27.5 V.
STARTER	10*	STARTER SOLENOID STARTING VIBRATOR	1 1	
VOLT REG., LEFT	5*	MAIN VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R	1 SYSTEM	2.00 NOM 4.10 F.L.
VOLT REG., RIGHT	5*	AUX. VOLT REG. & OVERVOLT RELAY +ALTERNATOR FIELDS L & R		
FUEL PUMPS	15	LEFT & RIGHT FUEL PUMPS	2	3.10
STALL WARNING	5	FLASHER UNIT - HORN	1 SYSTEM	.20
FUEL, HORN	5	FLASHER UNIT & HORN - LDG. GEAR WARNING	1 SYSTEM	2.30
CYL. HD. TEMP.		FUEL GAUGES & ENG. INSTRUMENT CLUSTER	1 GROUP	2.30
TURN & BANK	5	TURN & BANK GYRO	1	.82
GEAR & FLAP (INDICATORS)	5	DOOR AJAR LIGHT GEAR UP - GEAR DOWN LIGHTS FLAP INDICATOR	1 3 1	.04 .04 .50
ELEC. TRIM	5*	PITCH TRIM SERVO	1	.50
CABIN HEAT (& LIGHTER)	10*	CIGAR LIGHTER CABIN HEATER SYSTEM (GROUND OPERATION - HEATER IGNITION, VENT BLOWER, AND COMBUSTION BLOWER OPERATING)	1 MAX.	7.60 7.10 GND 3.60 FLT
PITOT HEAT	5	PITOT HEATING ELEMENT	1	3.70
POS. LTS.	5	NAV WING TIP LIGHTS NAV TAILLIGHT	1 SYSTEM	2.80
PROP SYNC.	5	ARKORP PROP SYNCHRONIZER	1	1.00
LAND. LTS.	15	LANDING LIGHT TAXI LIGHT	1 1	9.00 3.60
INT. LTS. (INTERIOR LIGHTS)	5*	MAP LIGHTS CABIN READING LIGHTS TRIM INDICATOR LIGHTS INSTRUMENT SPOT LIGHTS DOME LIGHT COMPASS LIGHT	2 4 2 2 1 1	0.26 0.50 0.07 0.40 0.30 0.04
POST LIGHTS	5	AUTOPILOT CONSOLE LIGHT OMNI COUPLER LIGHT POST LIGHTS - GLAR-BAN LIGHTED SWITCHES (ROCKER)	1 2 AS INSTALLED	0.06 0.05 0.04 0.04
WINDSHIELD HEAT	10	WINDSHIELD HEATING ELEMENT	1	7.00
DEICER - WING-TAIL	5*	SURFACE DEICE SYSTEM 6 SEC. OF EACH 3 MIN.	1	3.90
DEICER - PROP	15*	PROPELLER DEICE SYSTEM	1 PR.	12.00

* CURRENT WILL VARY DUE TO INTERMITTENT LOADS (TYPICAL VALUES SHOWN). CIRCUIT BREAKER CAPACITY IS SUFFICIENT FOR NORMAL OPERATION.

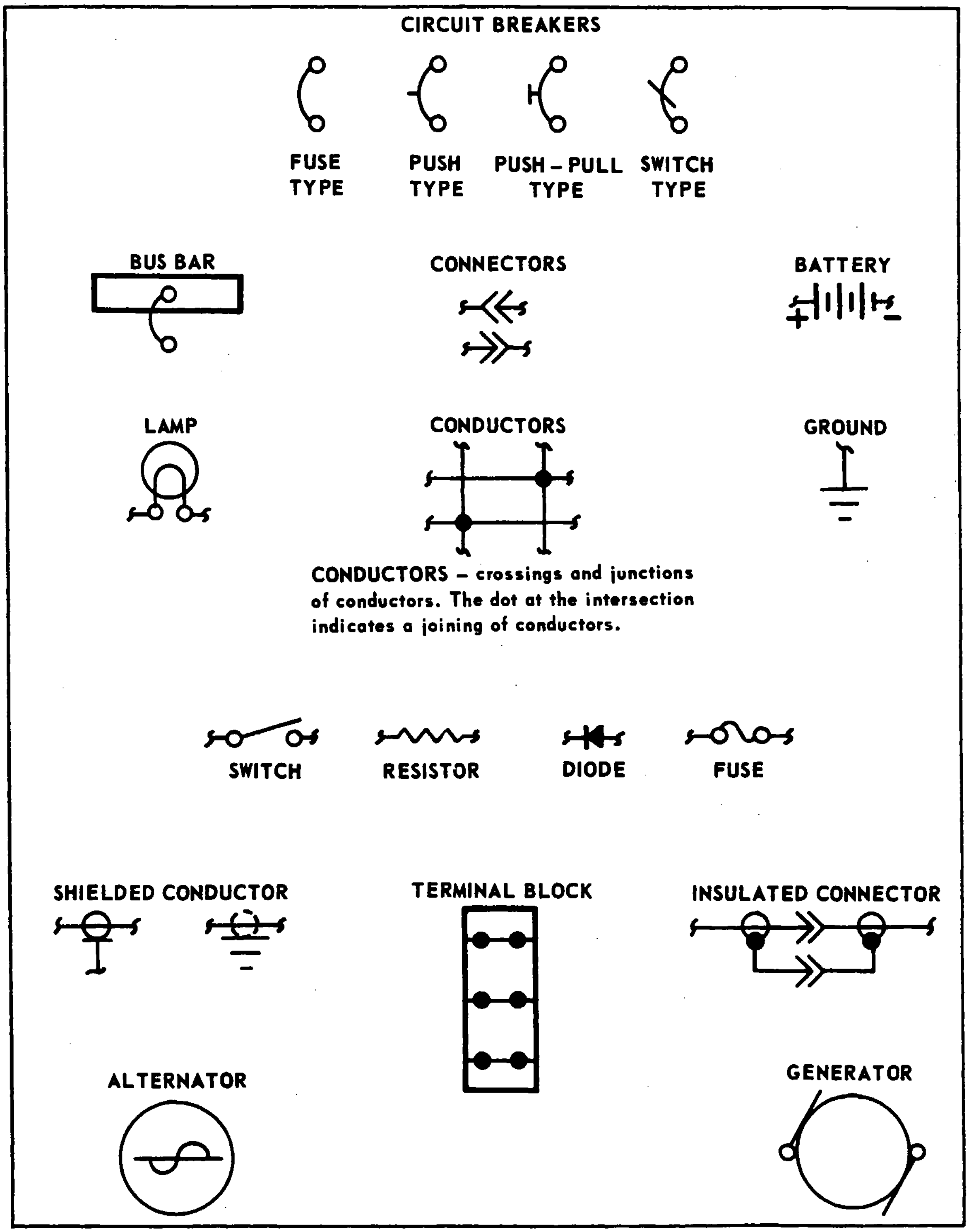
CURRENT AVAILABLE FOR OPTIONAL EQUIPMENT - 100 AMPS.

TABLE XI-VI. ELECTRICAL WIRE CODING



CIRCUIT FUNCTION LETTER	CIRCUITS
A	AUTOPILOT
C	CONTROL SURFACE
E	ENGINE INSTRUMENT
F	FLIGHT INSTRUMENT
G	LANDING GEAR
H	HEATER - VENTILATING & DE-ICING
L	LIGHTING
P	POWER
Q	FUEL & OIL
RP	RADIO POWER
RZ	RADIO AUDIO & INTERPHONE
J	IGNITION
RG	RADIO GROUND

TABLE XI-VII. ELECTRICAL SYMBOLS



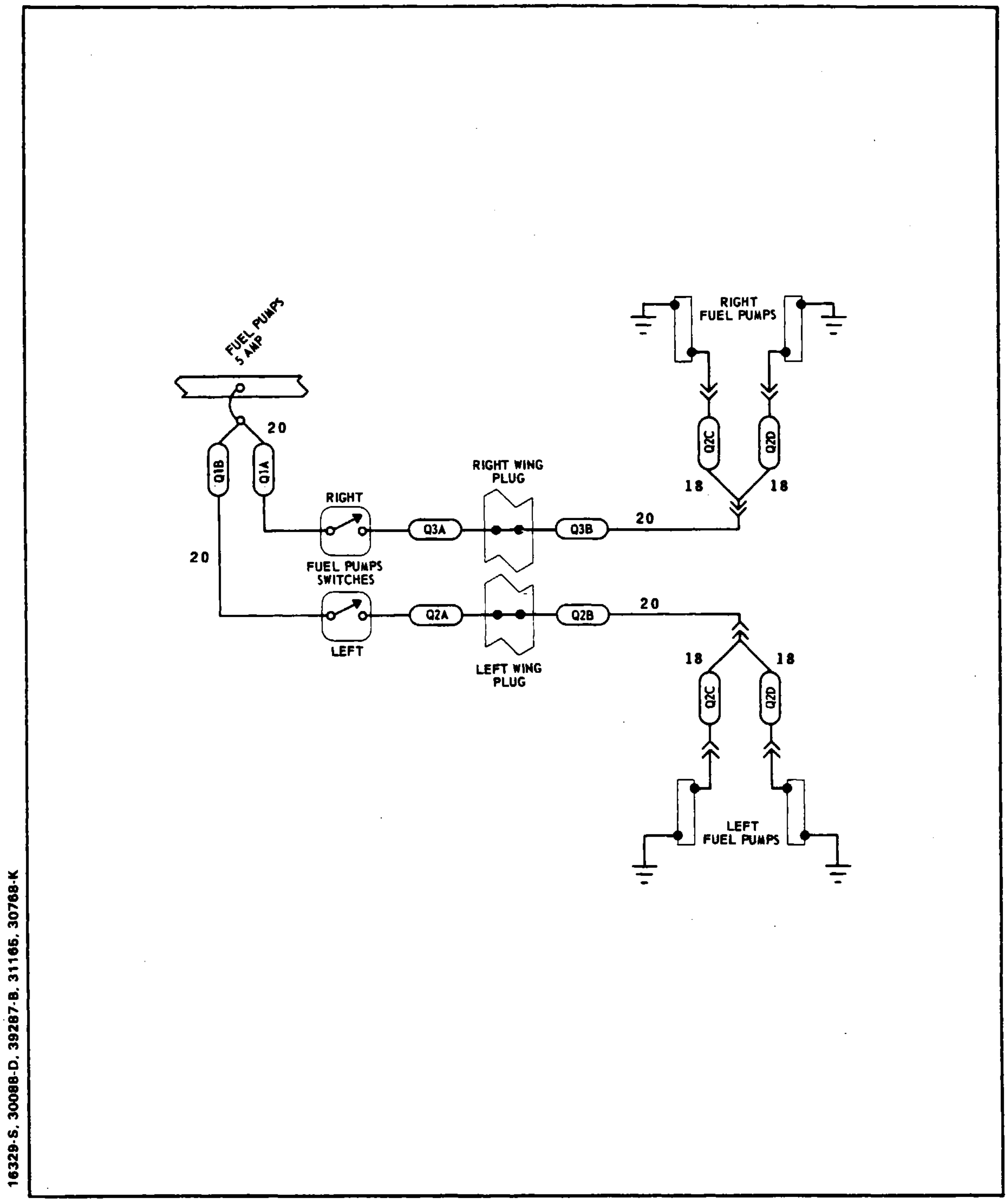


Figure 11-68. Fuel Pumps Schematic (14-volt and 28-volt)
PA-23-250; PA-23-235; and PA-23-250 (six place),
Serial Nos. 27-2000 to 27-2504 incl.

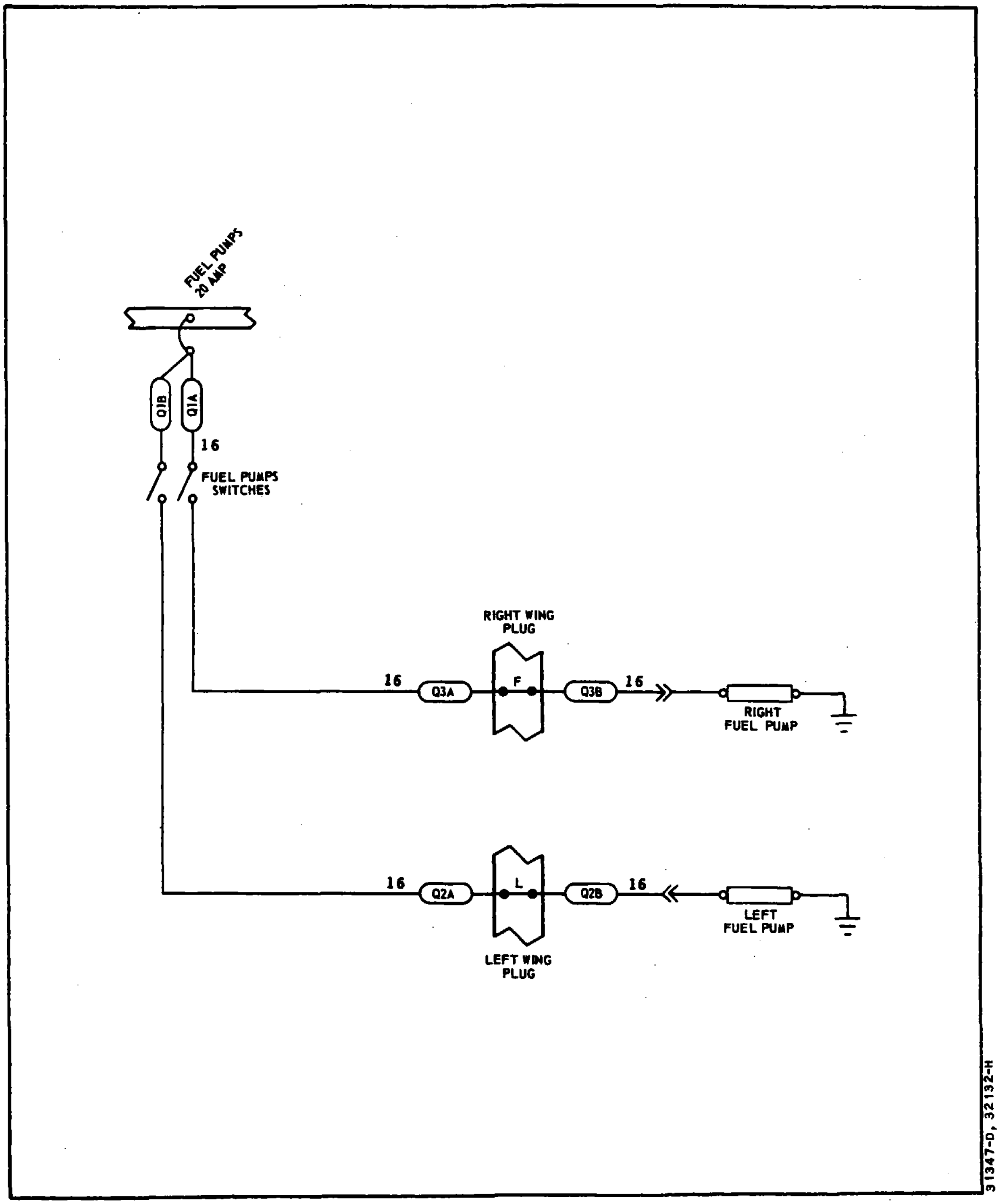


Figure 11-69. Fuel Pumps Schematic
PA-23-250 (six place), Serial Nos. 27-2505 to
27-3836 incl. and 27-3838 to 27-3943 incl.

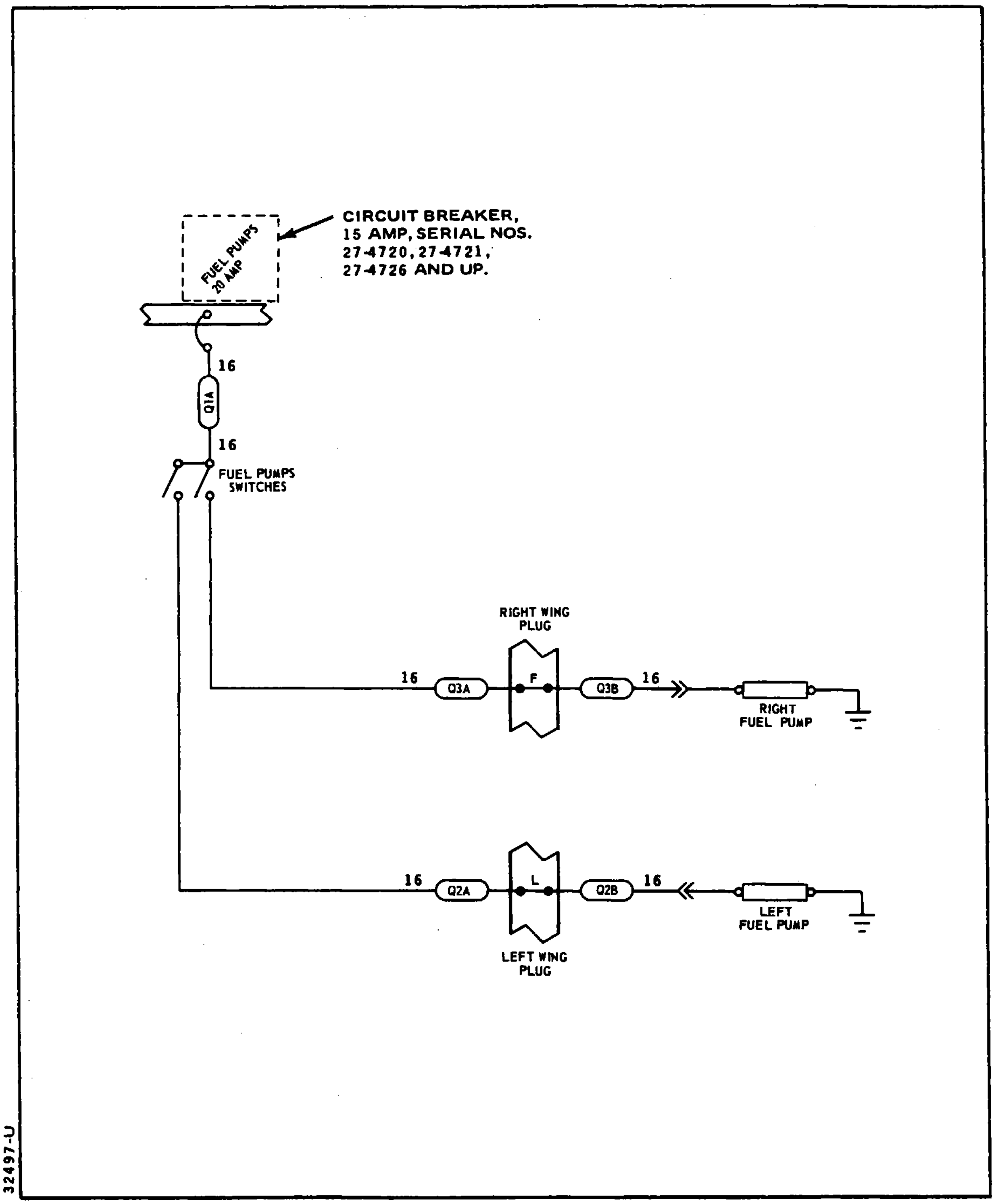


Figure 11-70. Fuel Pumps Schematic
PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.

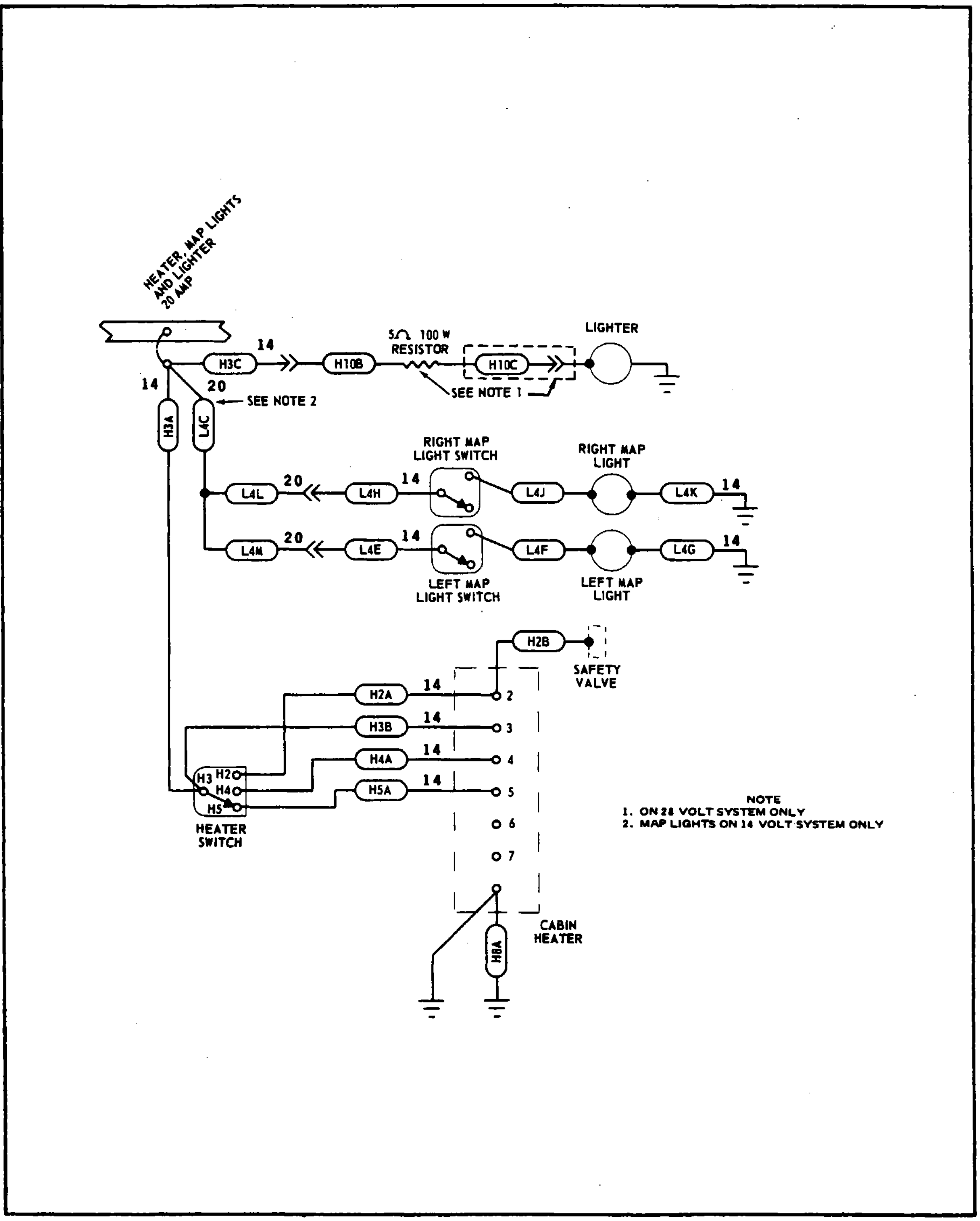


Figure 11-71. Heater, Map Lights and Cigar Lighter Schematic (14-volt and 28-volt), PA-23-250 and PA-23-235

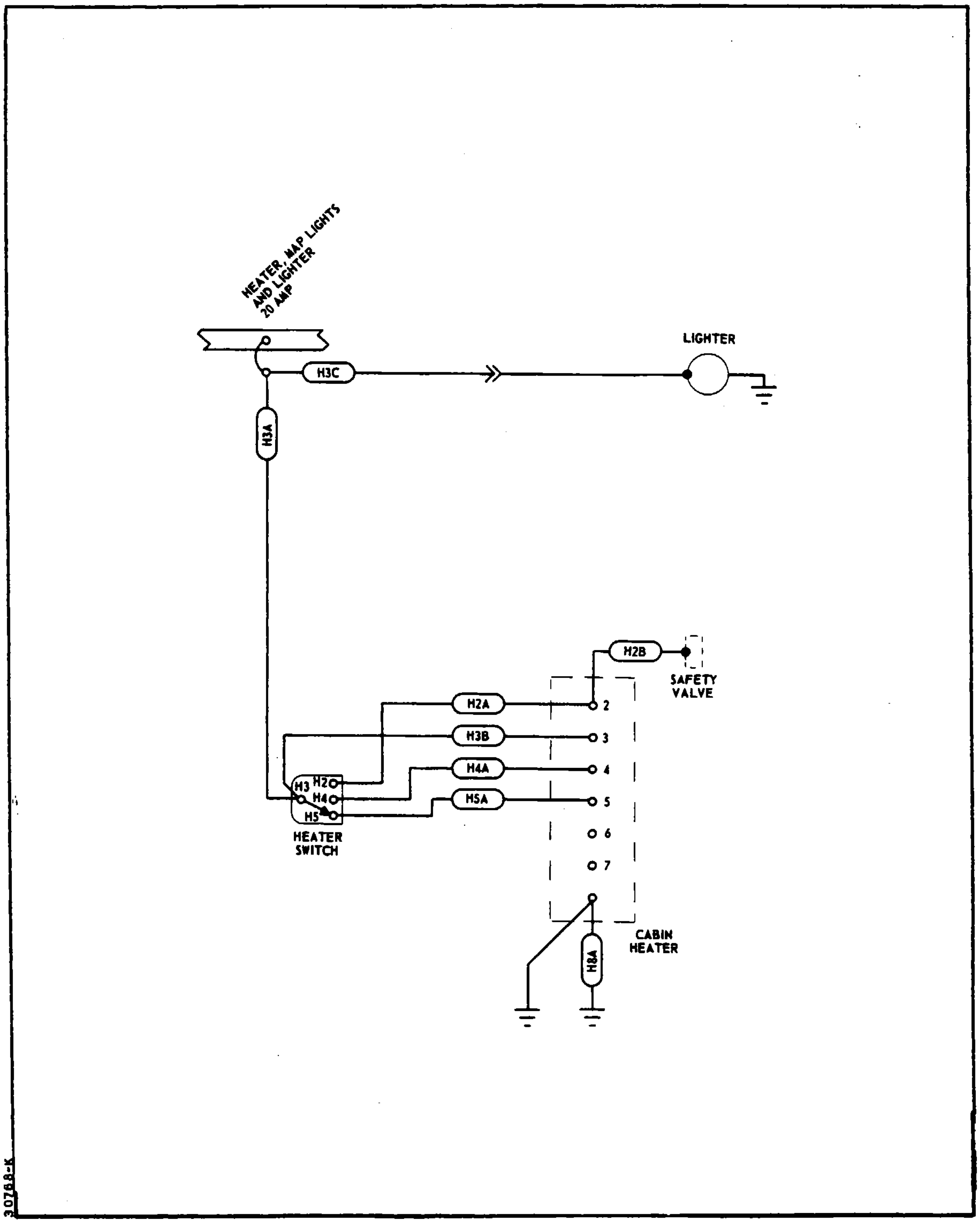


Figure 11-72. Heater, Map Lights and Cigar Lighter Schematic
PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.

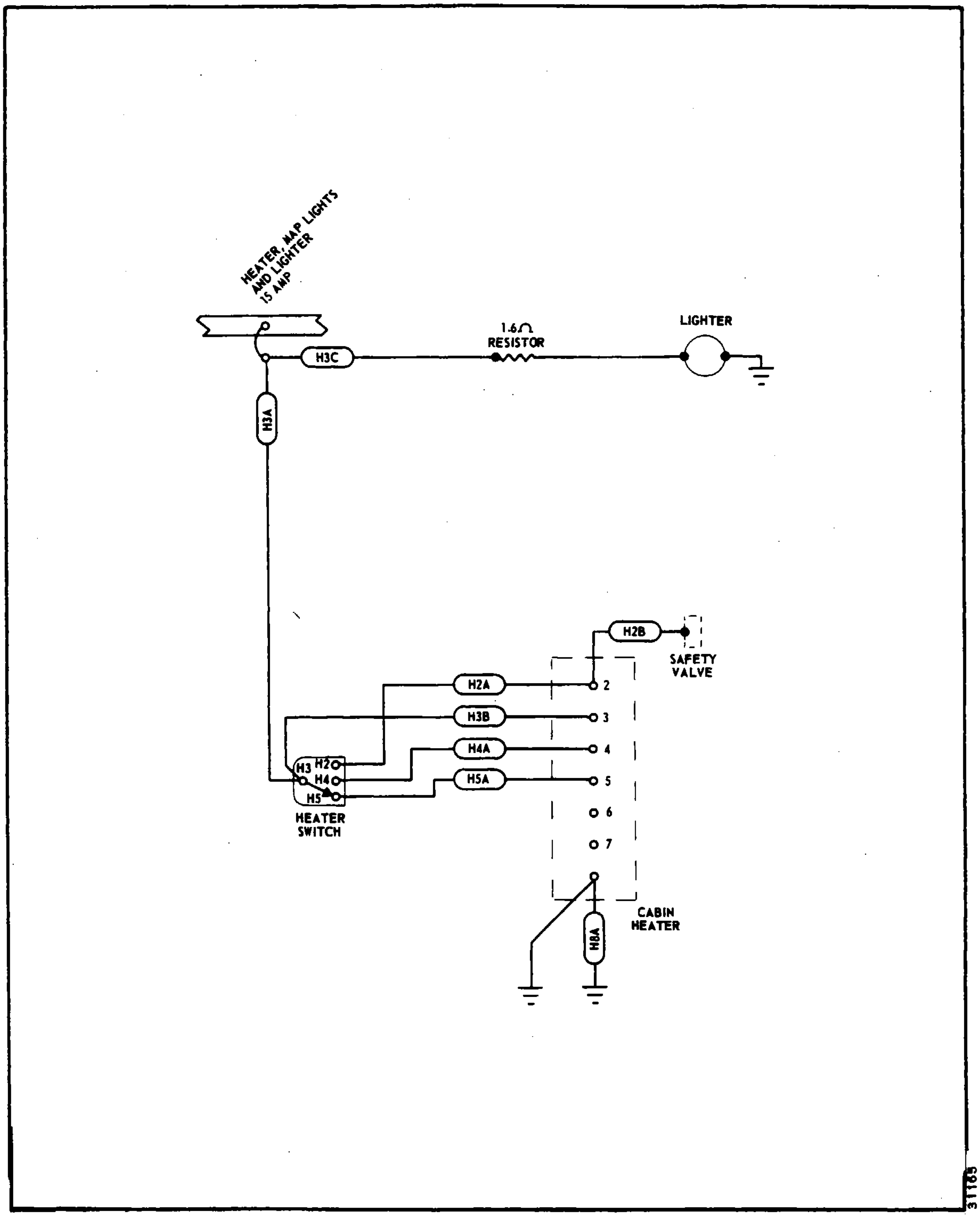


Figure 11-73. Heater, Map Lights and Cigar Lighter Schematic (28-volt)
PA-23-250 (six place), Serial Nos. 27-2298 and 27-2331

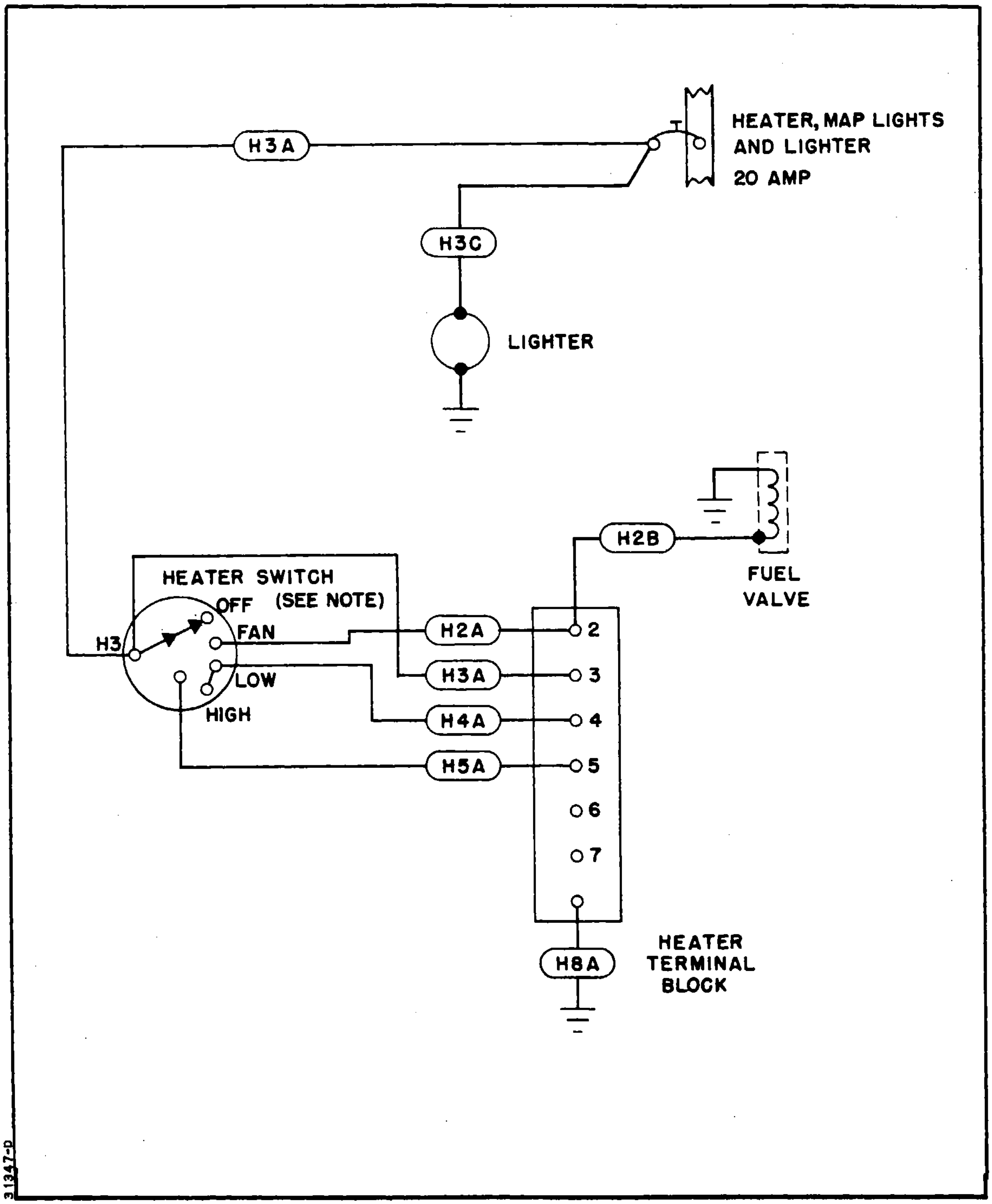


Figure 11-74. Heater, Map Lights and Cigar Lighter Schematic
PA-23-250 (six place) Serial Nos. 27-2505
to 27-3049 incl. and 27-3151 to 27-3154 incl.

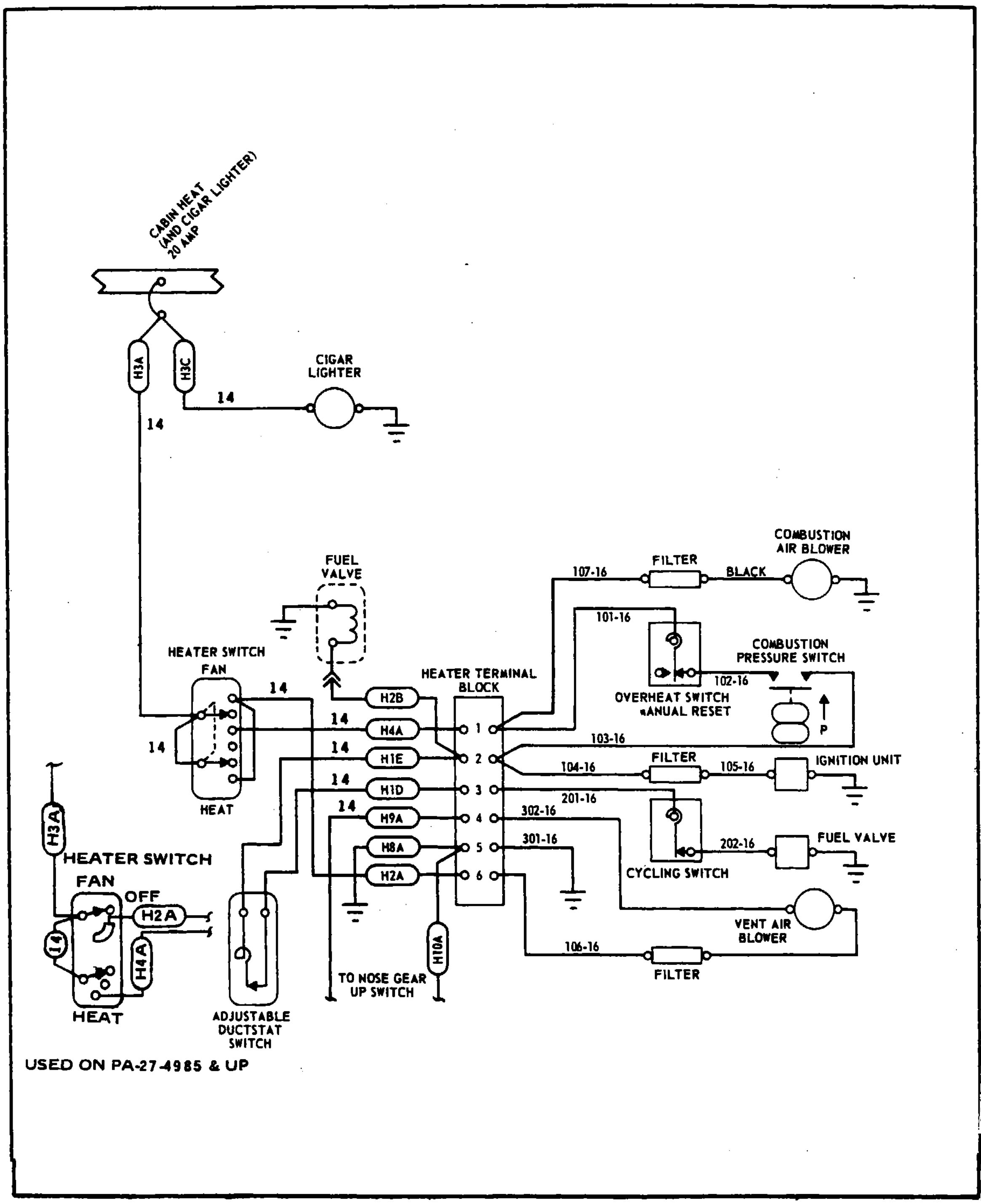


Figure 11-75. Heater, Map Lights and Cigar Lighter Schematic
PA-23-250 (six place), Serial Nos. 27-3050,
27-3154 to 27-7554168 incl.

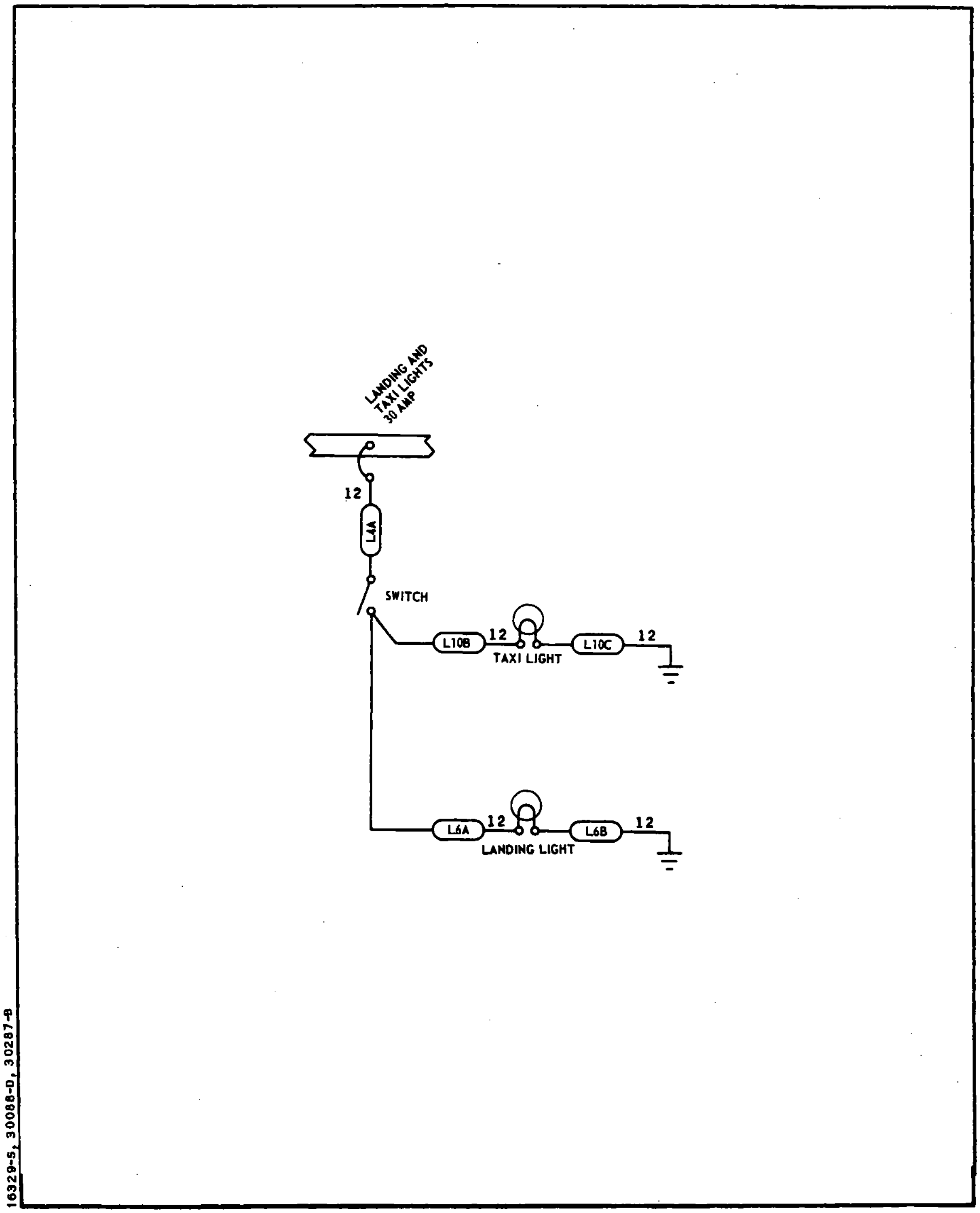


Figure 11-76. Landing and Taxi Lights (14-volt and 28-volt)
PA-23-250 and PA-23-235

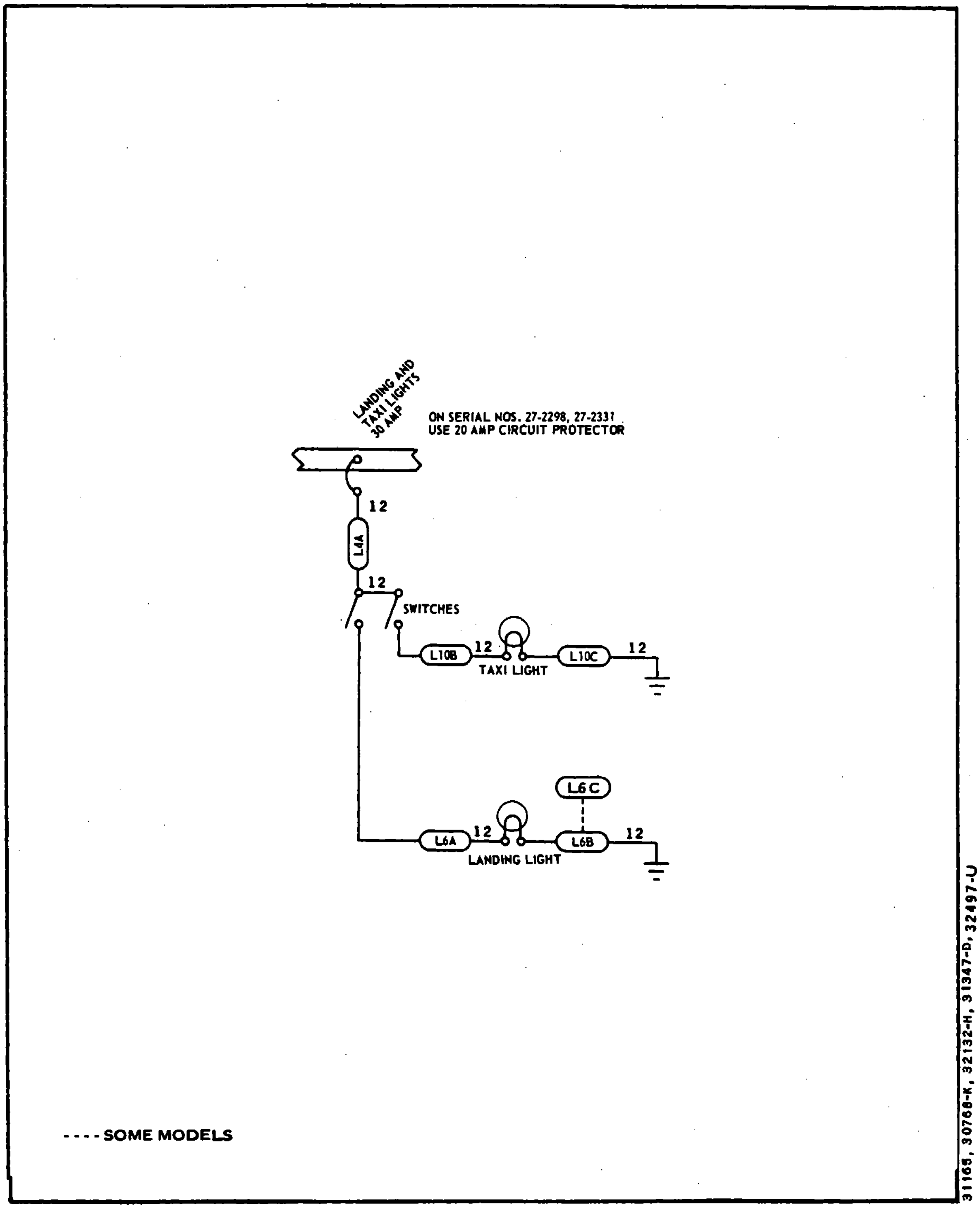


Figure 11-77. Landing and Taxi Lights (14-volt and 28-volt)
PA-23-250 (six place), Serial Nos. 27-2000 to 27-7554172 incl.

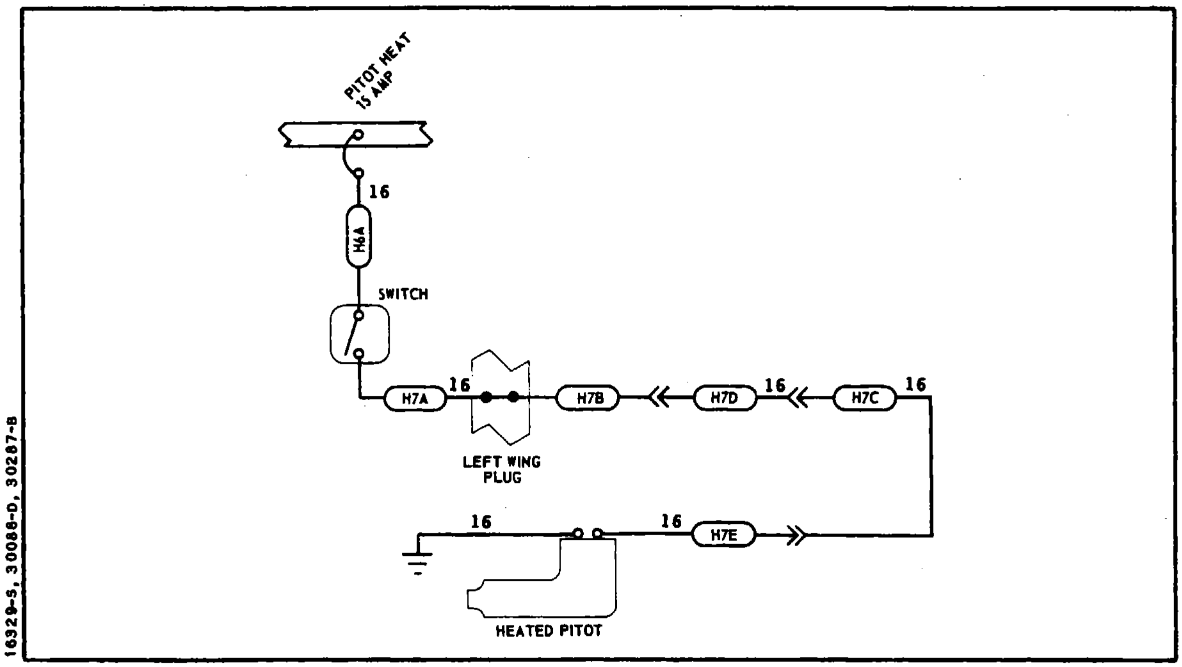


Figure 11-78. Pitot Heat Schematic. (14-volt and 28-volt)
PA-23-250 and PA-23-235

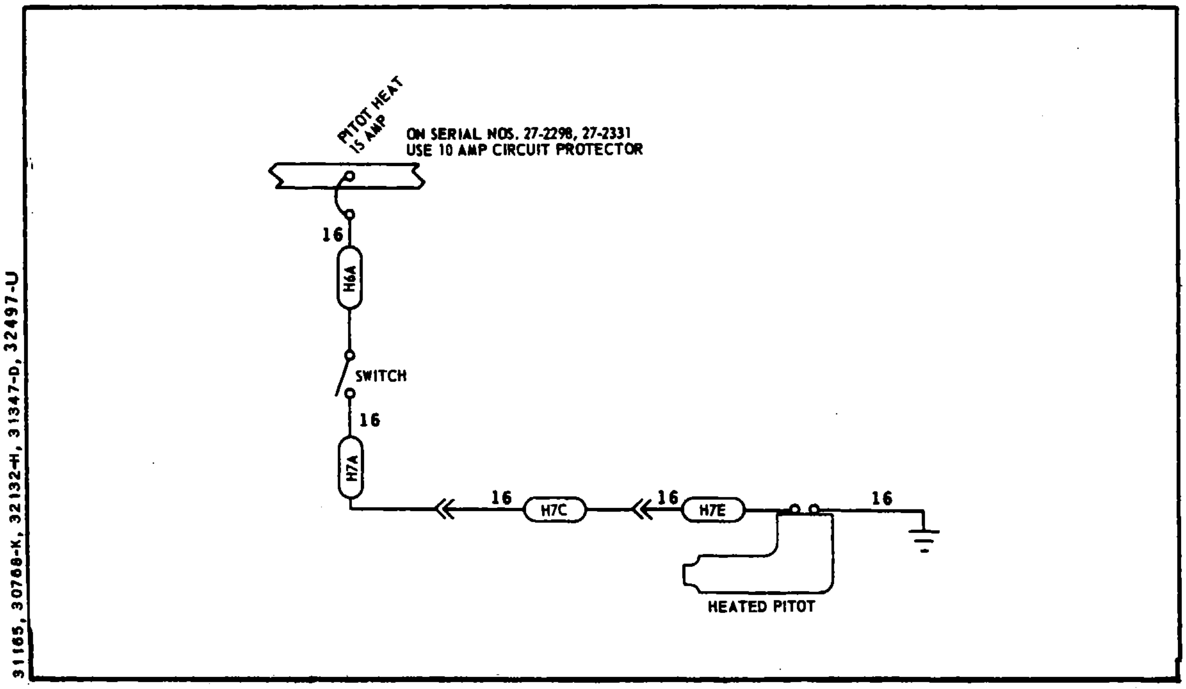


Figure 11-79. Pitot Heat Schematic (14-volt and 28-volt)
PA-23-250 (six place). Serial Nos. 27-2000 to 27-7554172 incl.

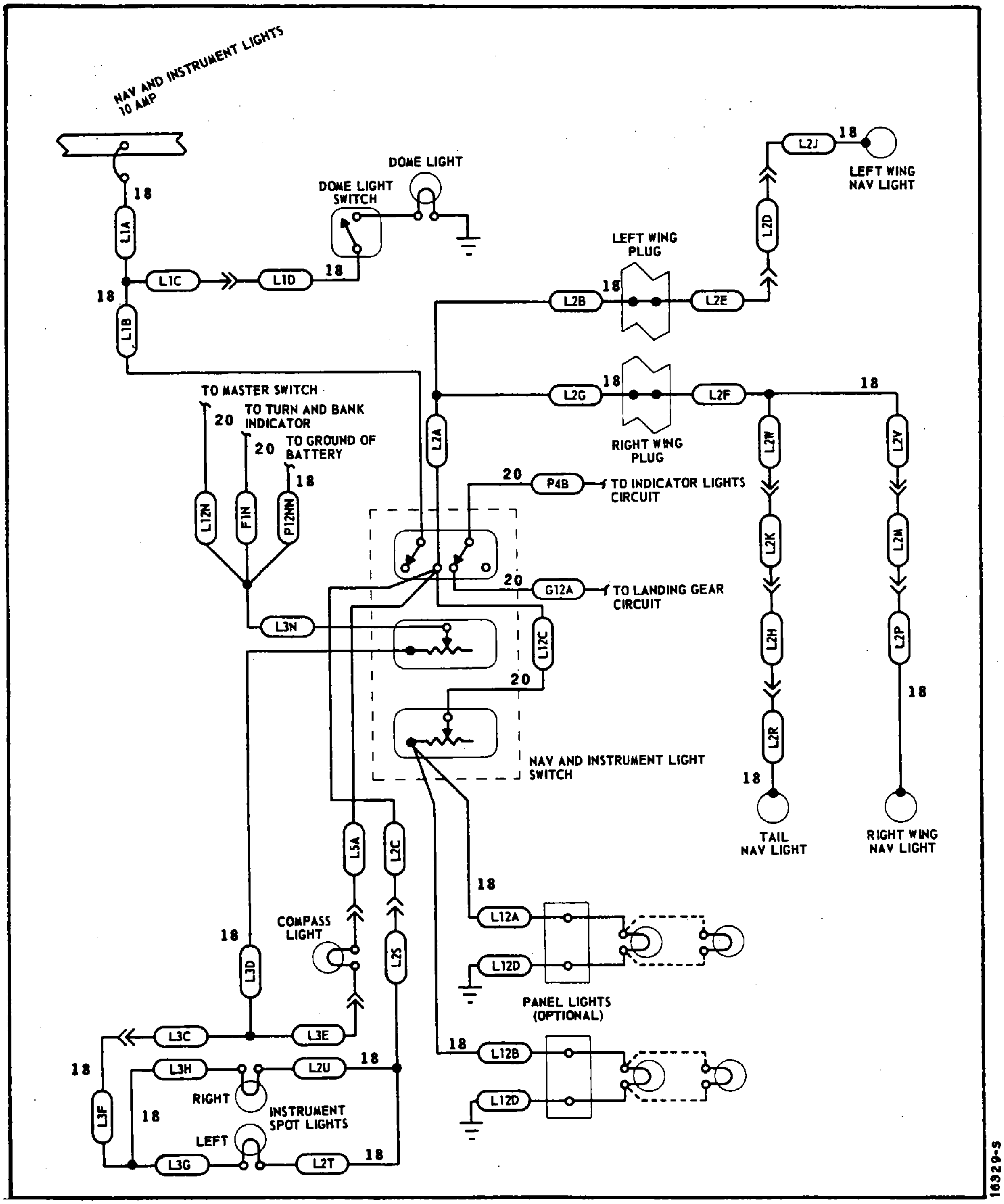


Figure 11-80. Navigation and Instrument Lights Schematic
PA-23-250, Serial Nos. 27-1 to 27-258 incl.; 27-365 to 27-401 incl.
and 27-403 to 27-504 incl. and PA-23-235

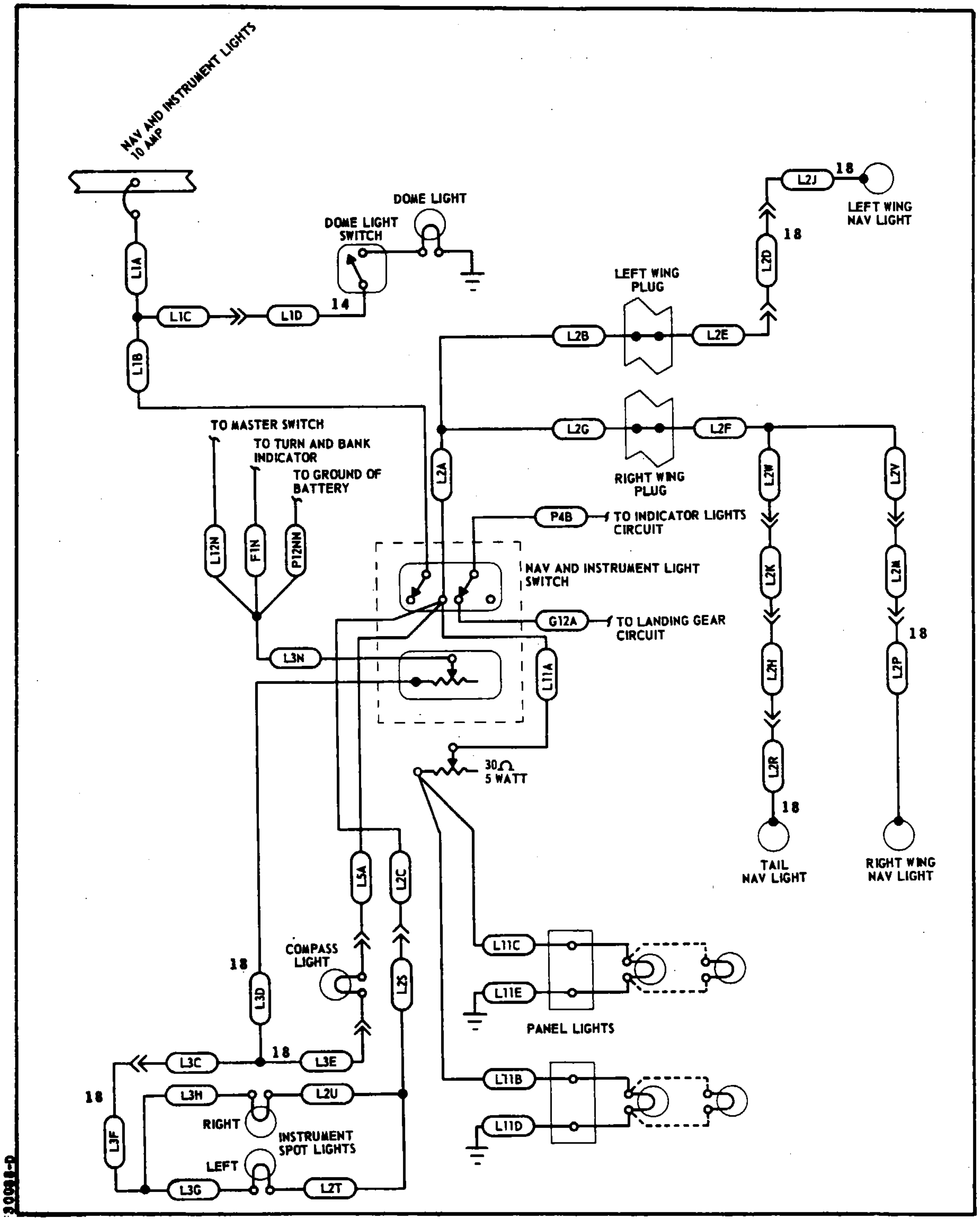


Figure 11-81. Navigation and Instrument Lights Schematic (28-volt)
PA-23-250, Serial Nos. 27-259 to 27-364 incl.

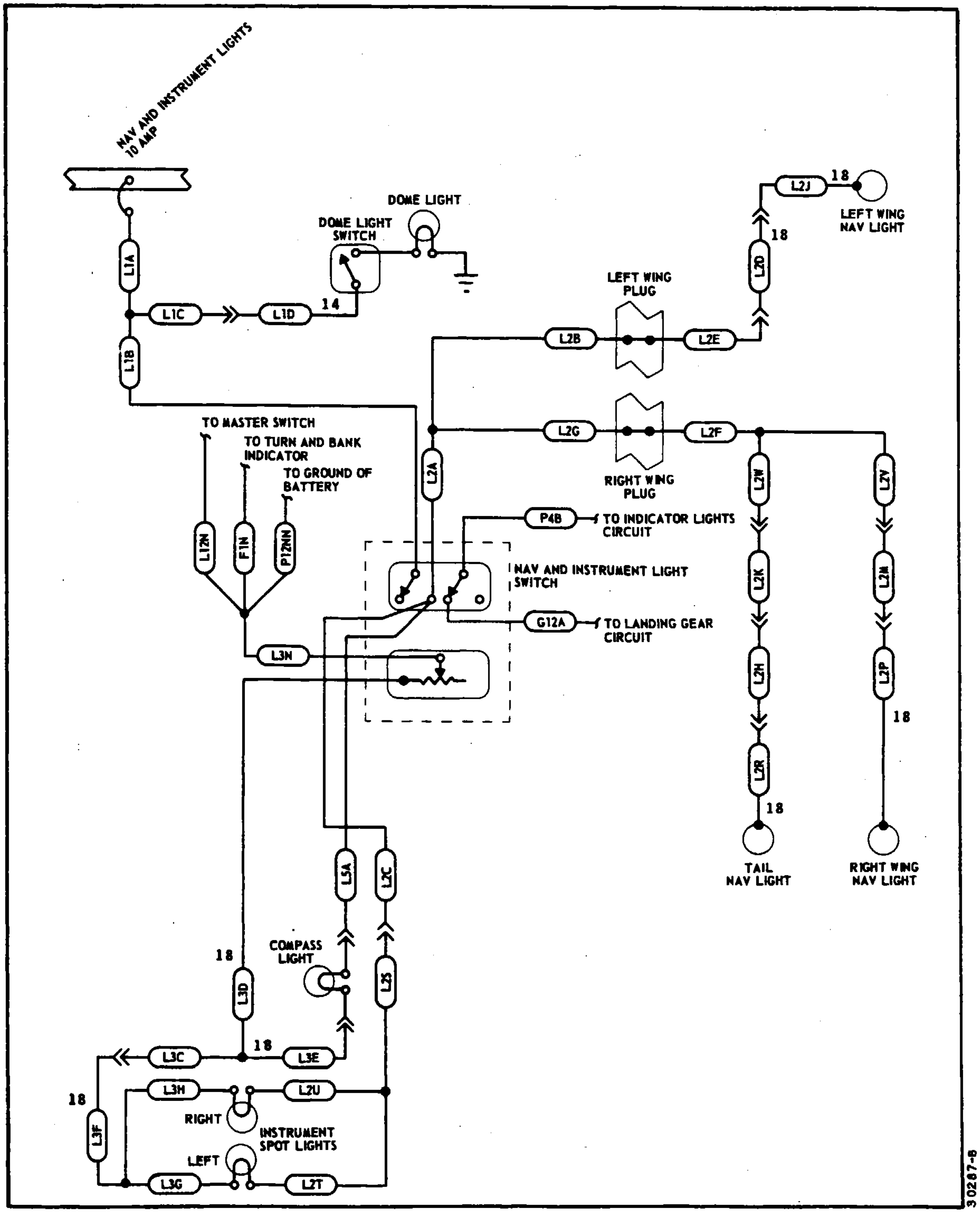


Figure 11-82. Navigation and Instrument Lights Schematic, (28-volt)
PA-23-250, Serial No. 27-402

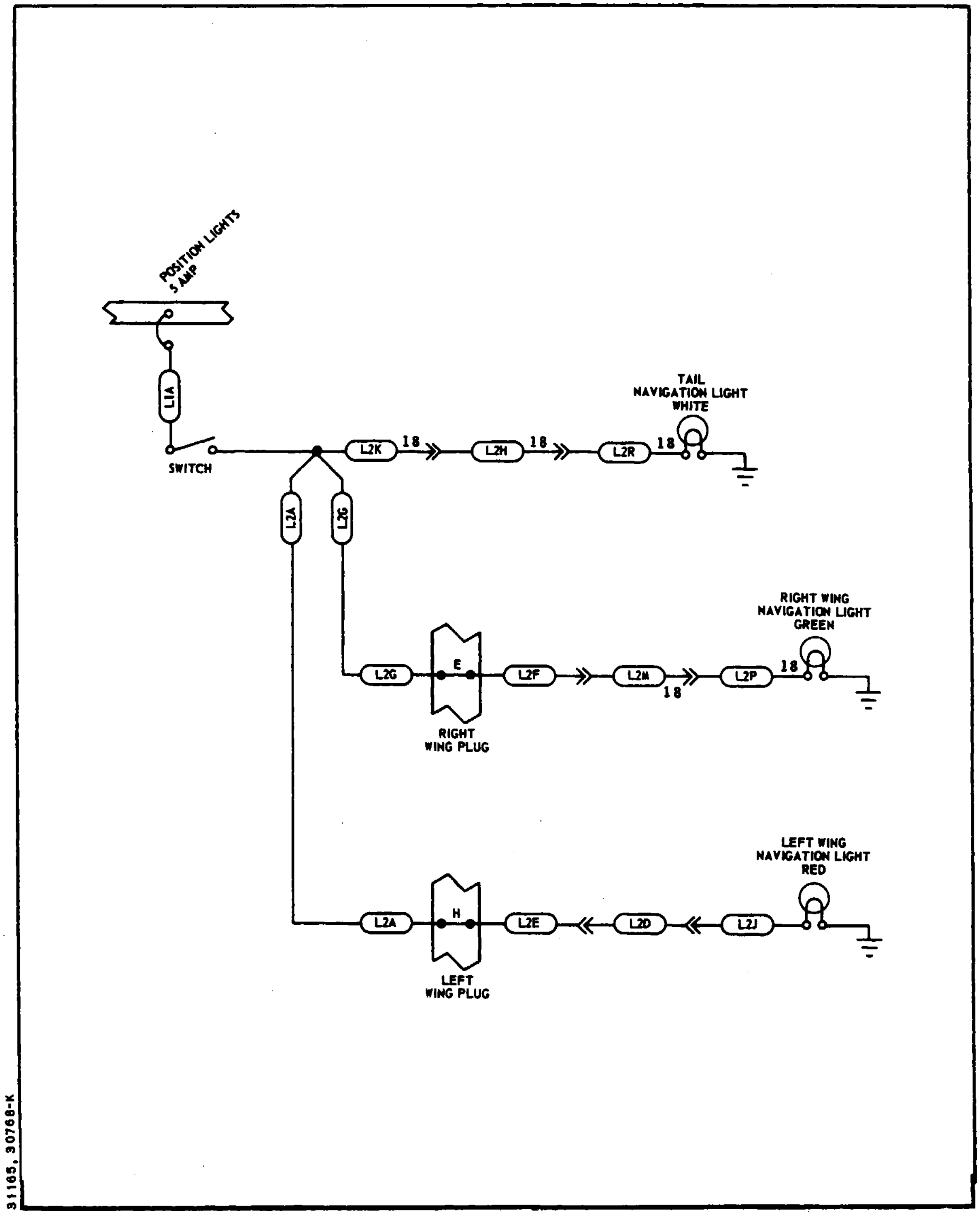


Figure 11-83. Position Lights Schematic (14-volt and 28-volt)
PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.

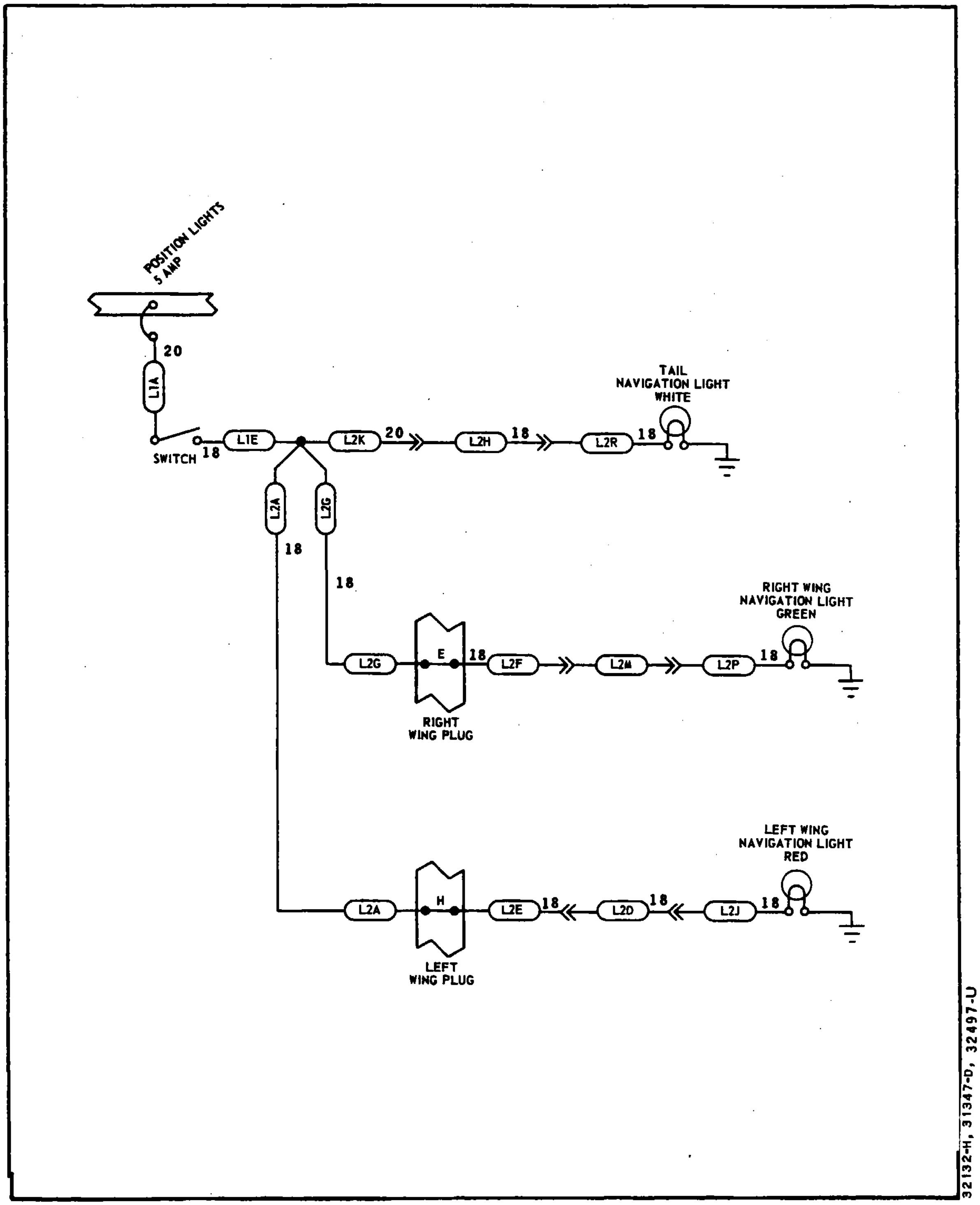


Figure 11-84. Position Lights Schematic
PA-23-250 (six place),
Serial Nos. 27-2505 to 27-7554172 incl.

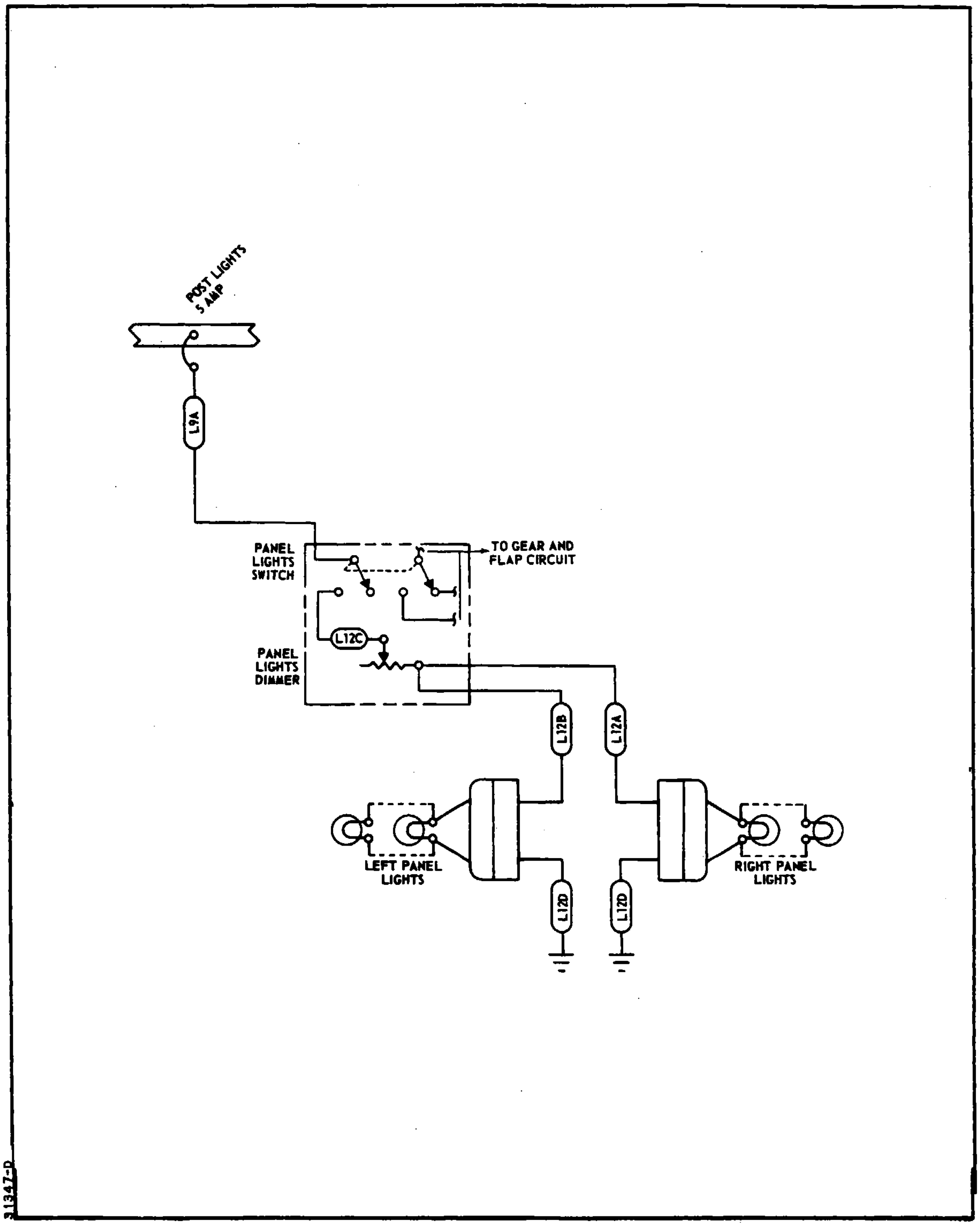


Figure 11-85. Post Lights Schematic
PA-23-250 (six place), Serial Nos. 27-2505 to 27-2704 incl.

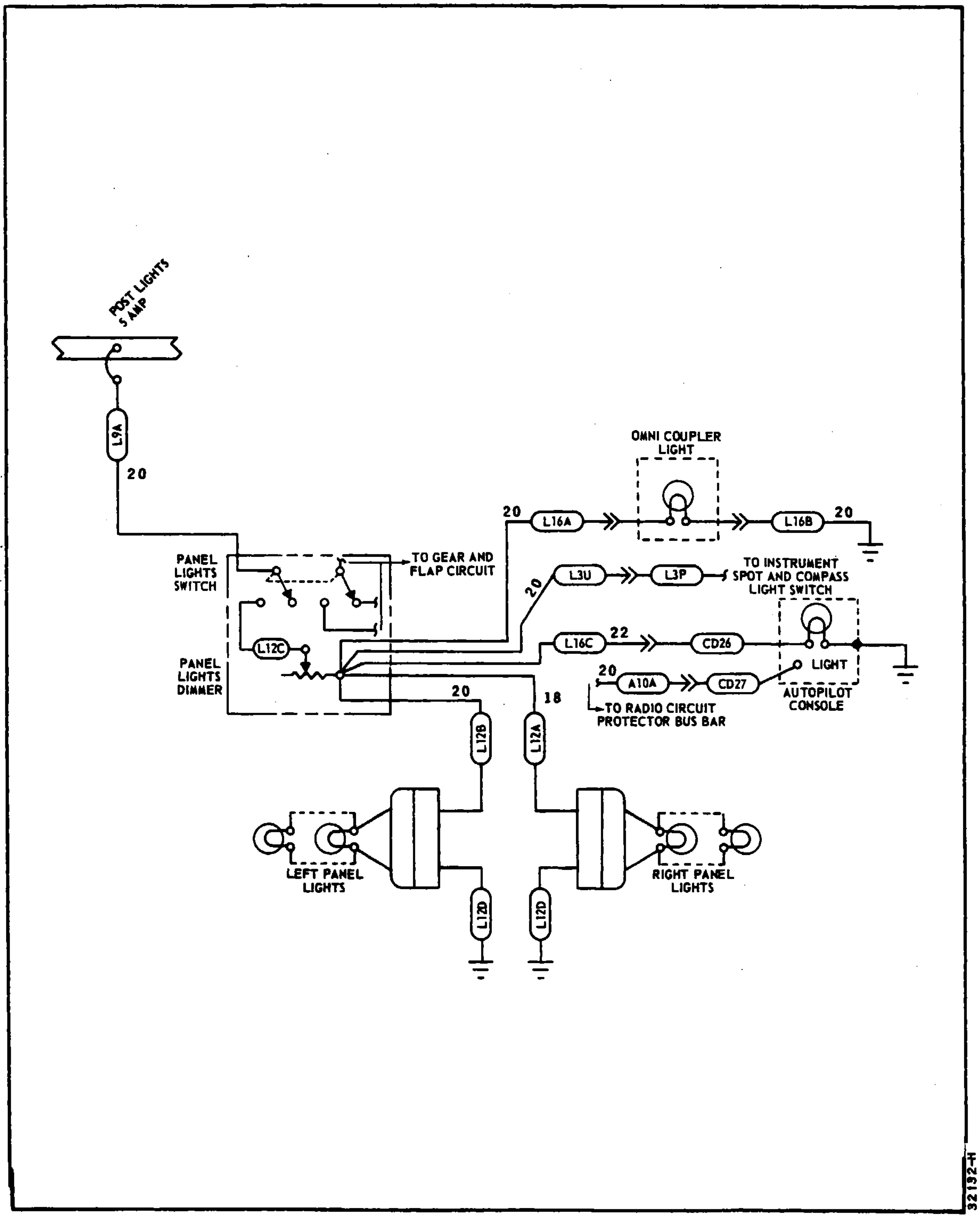


Figure 11-86. Post Lights Schematic. PA-23-250 (six place)
Serial Nos. 27-2705 to 27-3836 incl. and 27-3838 to 27-3943 incl.

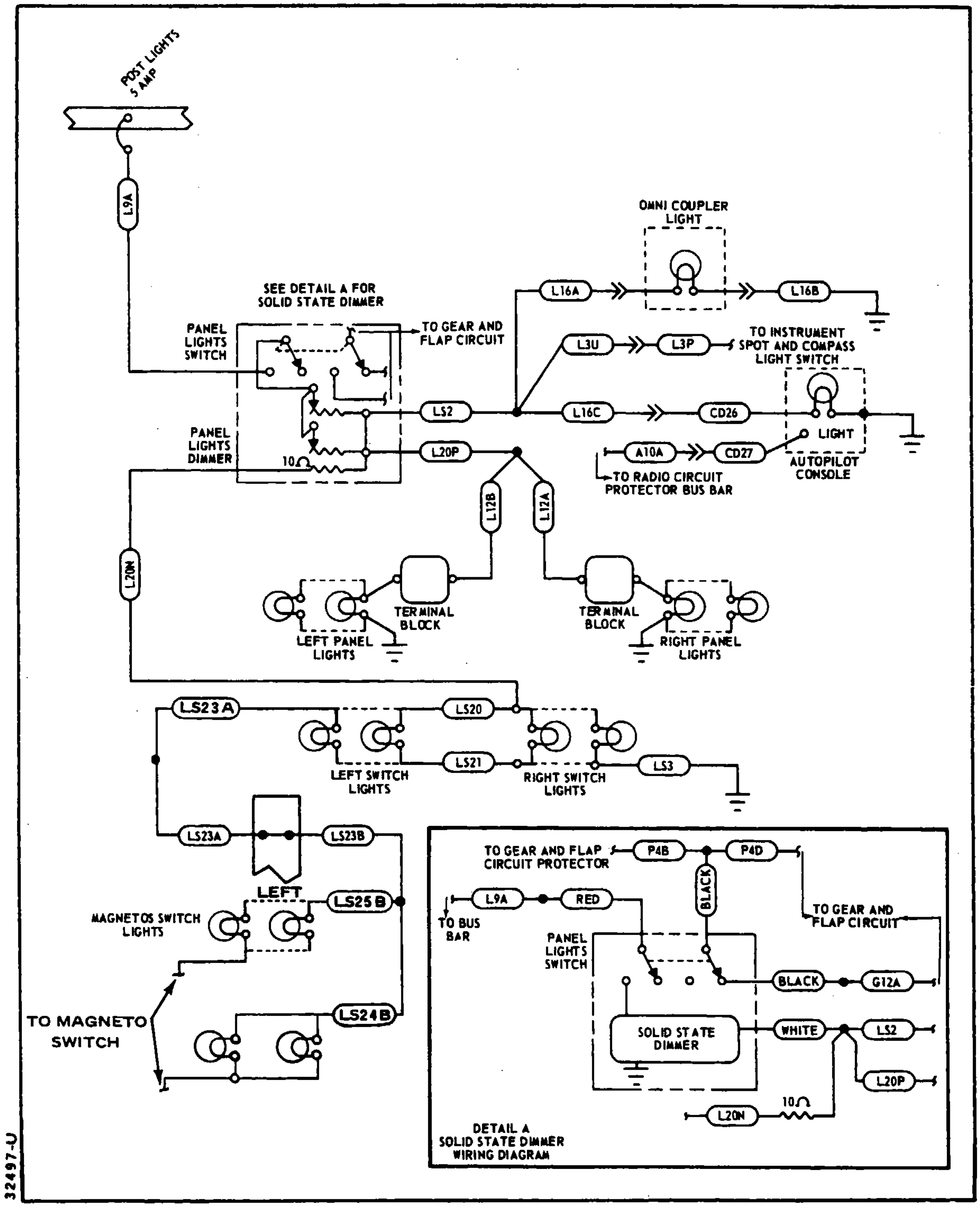


Figure 11-87. Post Lights Schematic
PA-23-250 (six place), Serial Nos. 27-4794 to 27-7554172 incl.

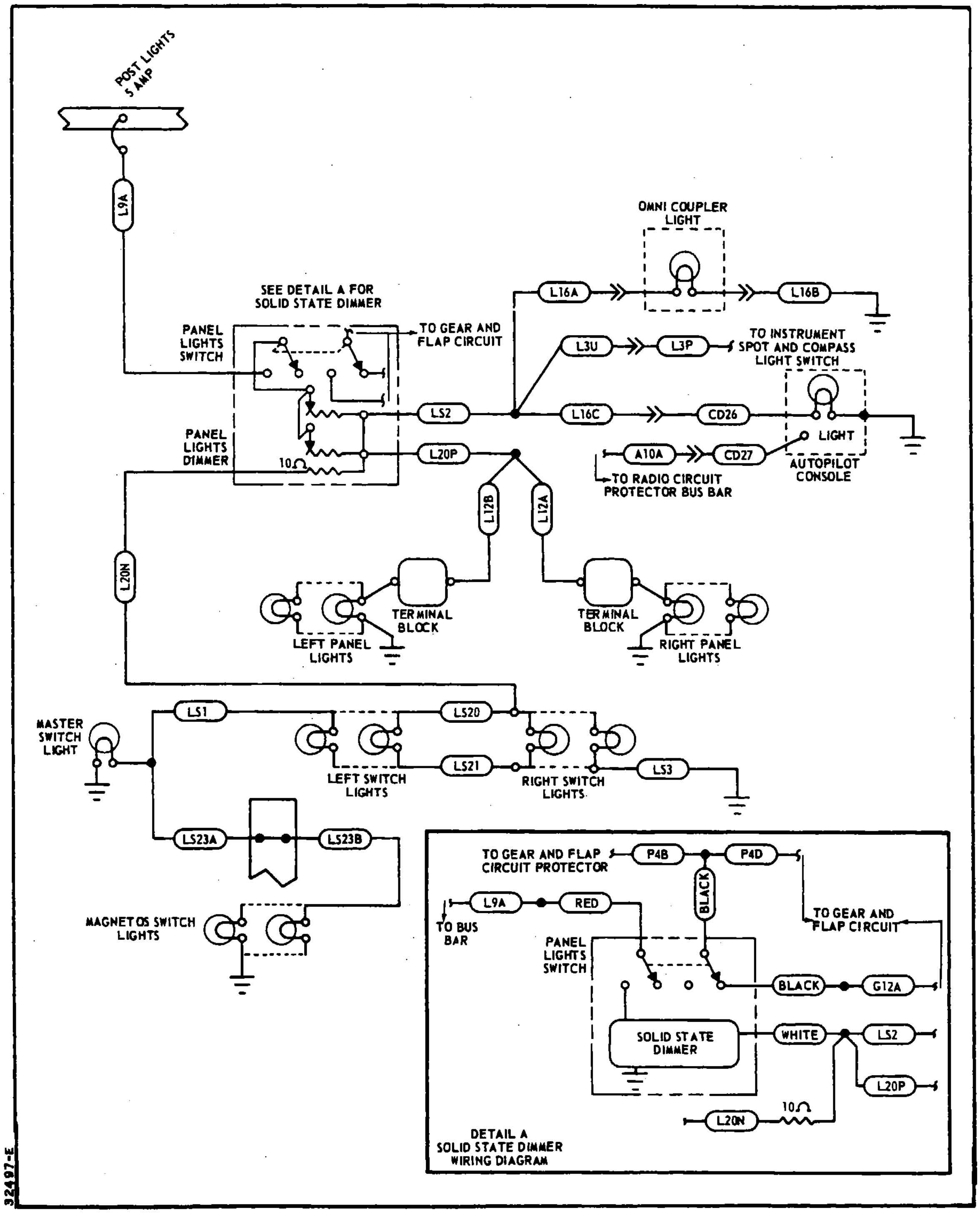


Figure 11-88. Post Lights Schematic
PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-4793

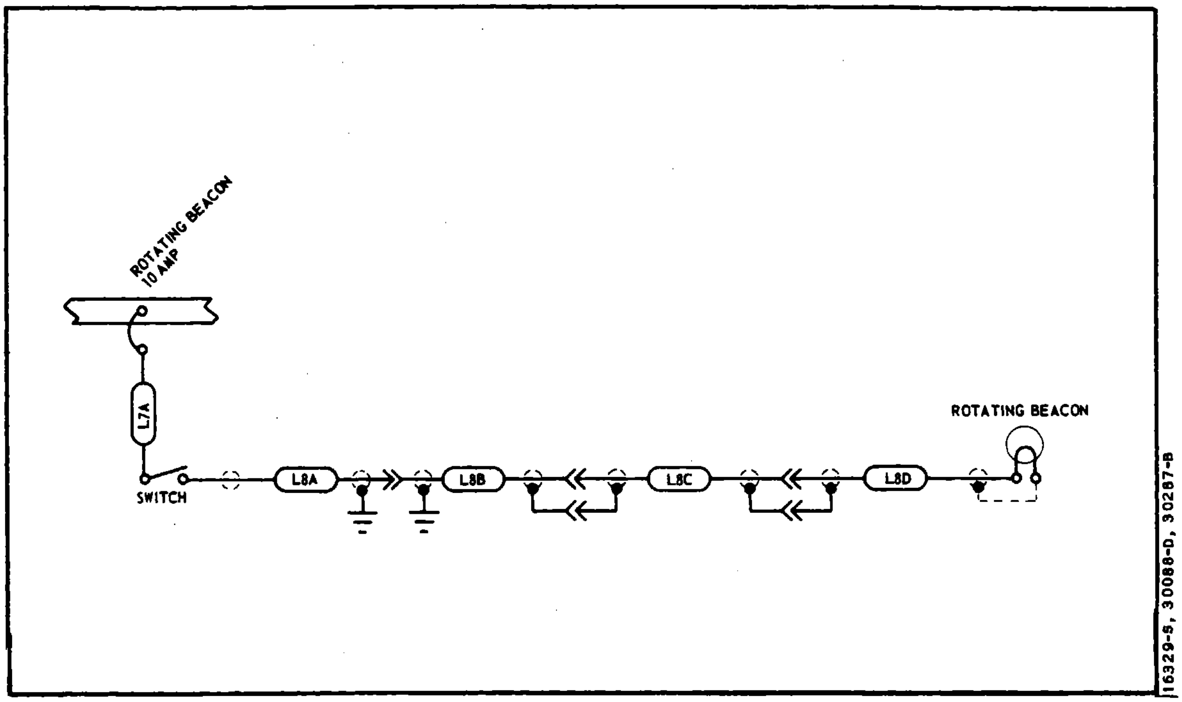


Figure 11-89. Rotating Beacon (14-volt and 28-volt)
PA-23-250 and PA-23-235

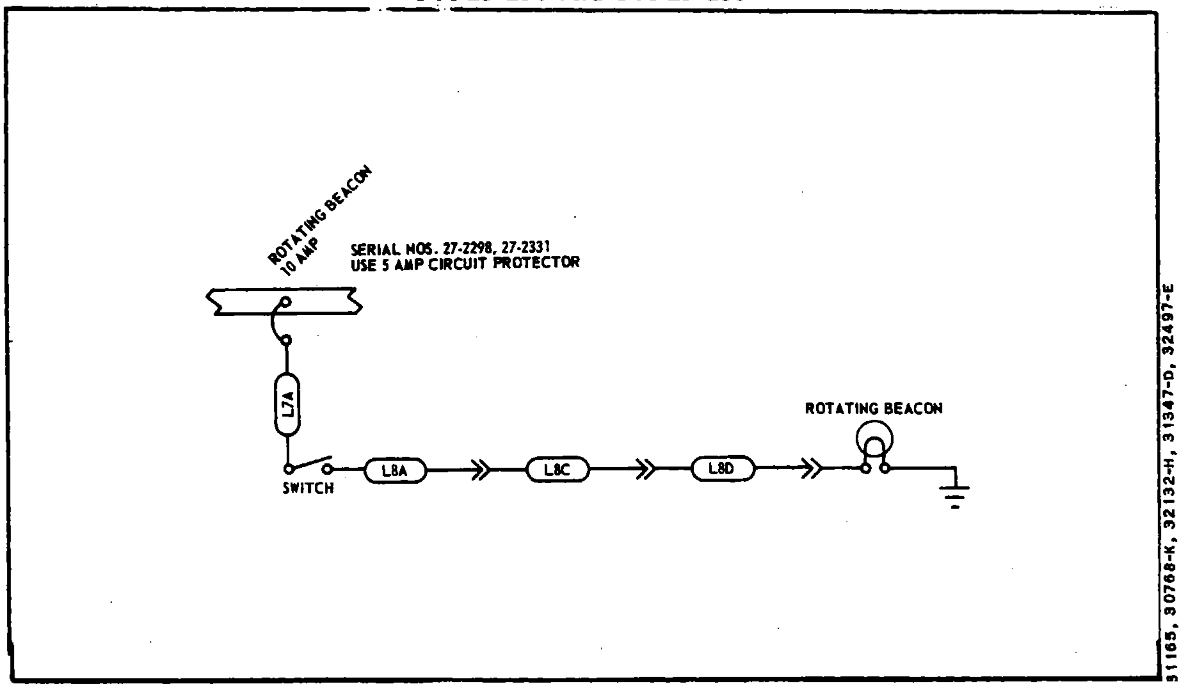


Figure 11-90. Rotating Beacon (14-volt and 28-volt)
PA-23-250 (six place)

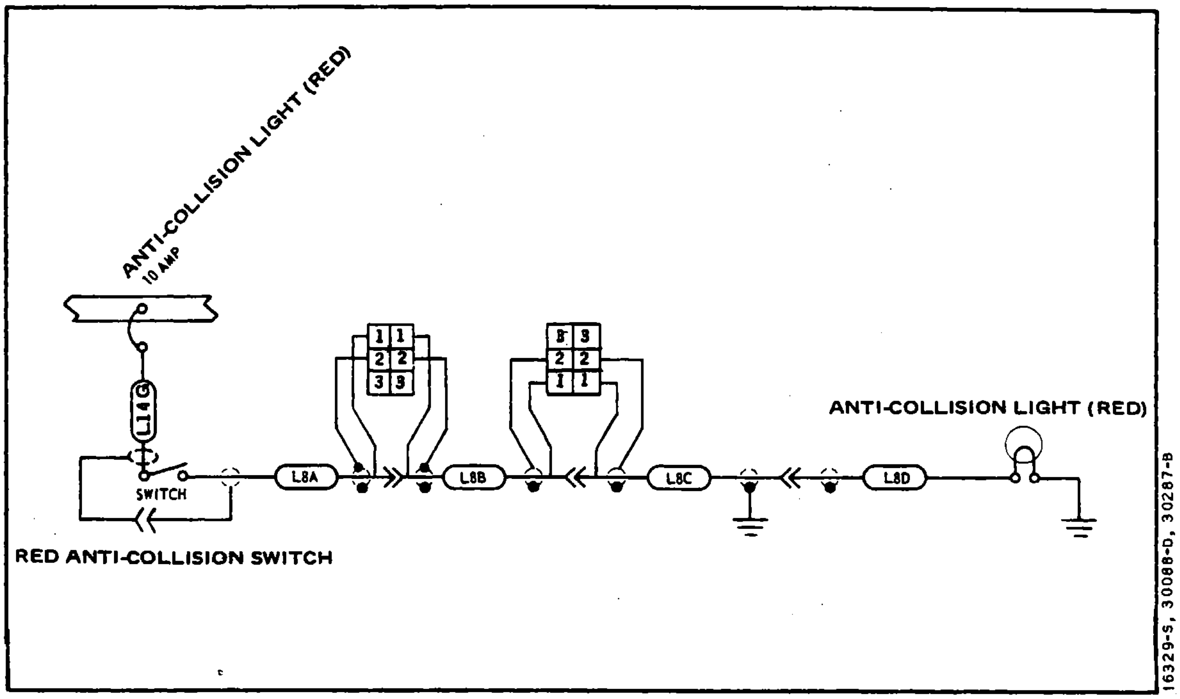


Figure 11-91. Anti-Collision Light (Red)
(14-volt and 28-volt PA-23-250 and PA-23-235

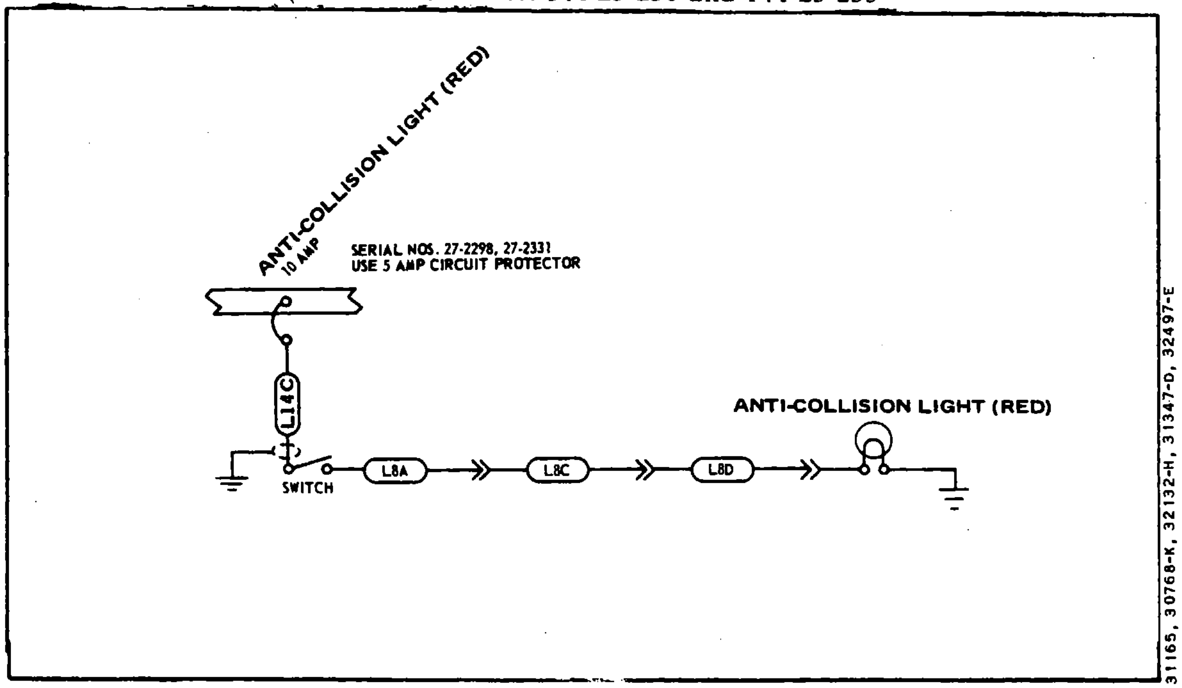


Figure 11-92. Anti-Collision Light (Red)
(14-volt and 28-volt) PA-23-250 (six place)

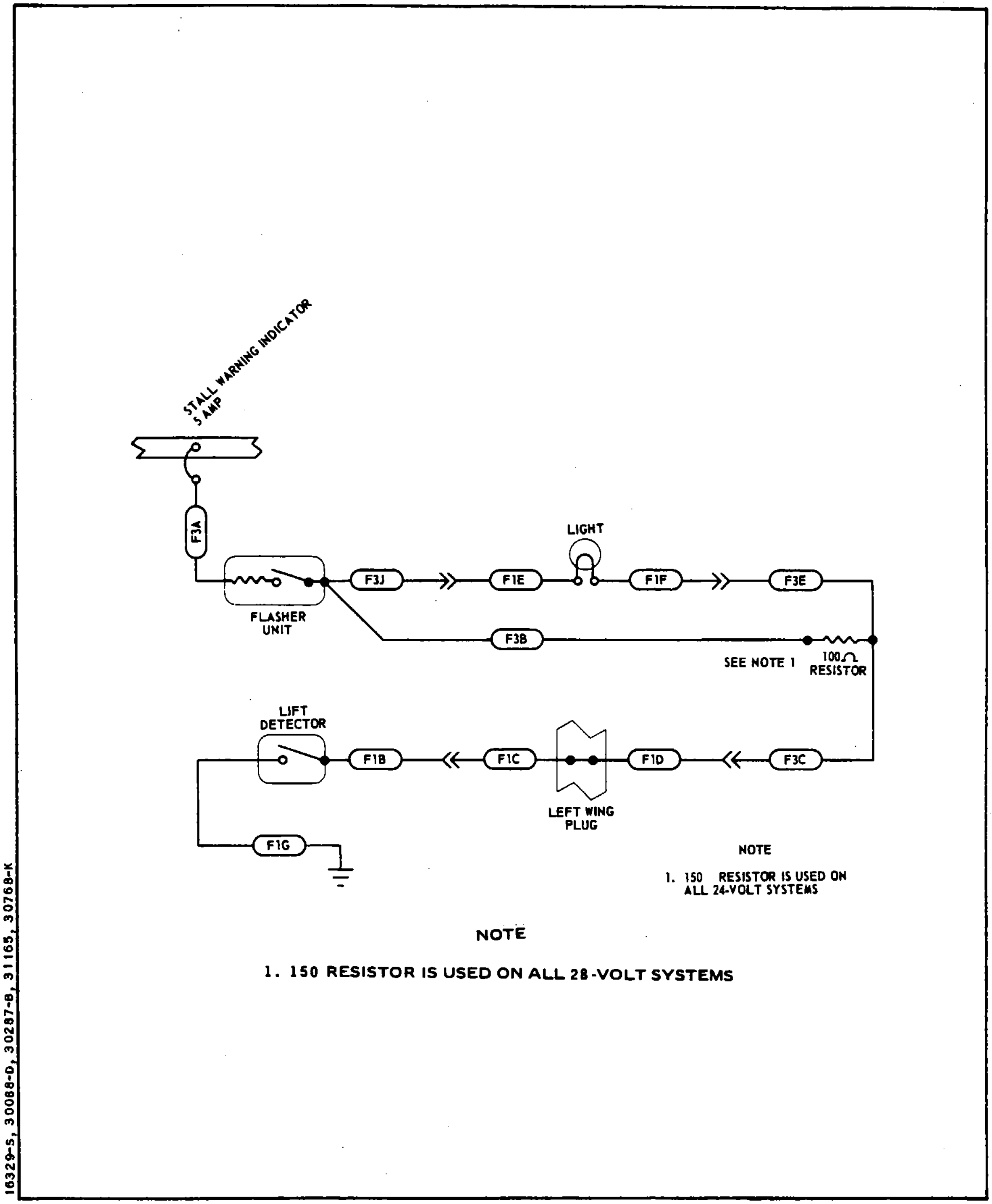


Figure 11-93. Stall Warning Schematic (14-volt and 28-volt)
PA-23-250; PA-23-235; and
PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504

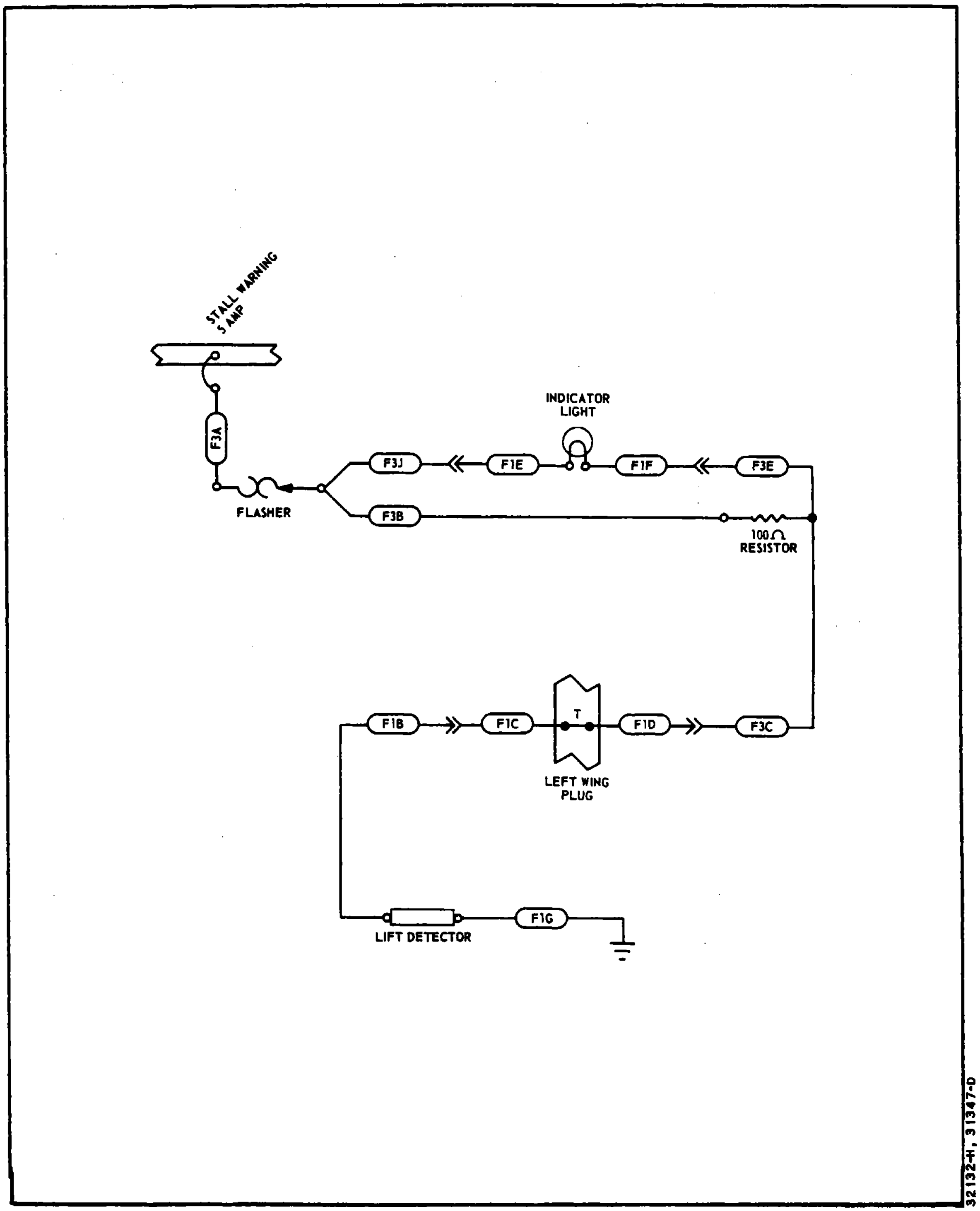


Figure 11-94. Stall Warning Schematic
PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.

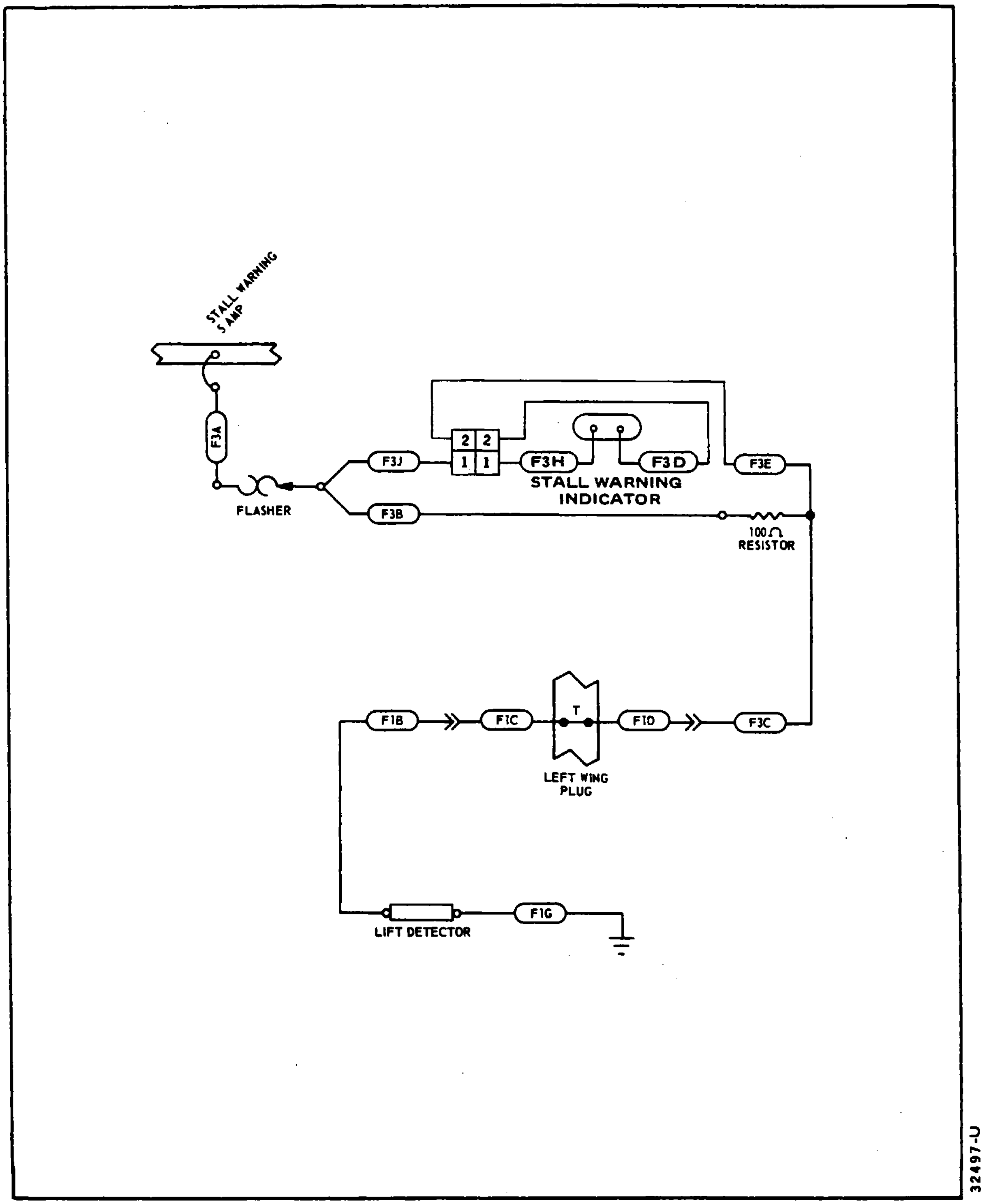


Figure 11-95. Stall Warning Schematic
PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.

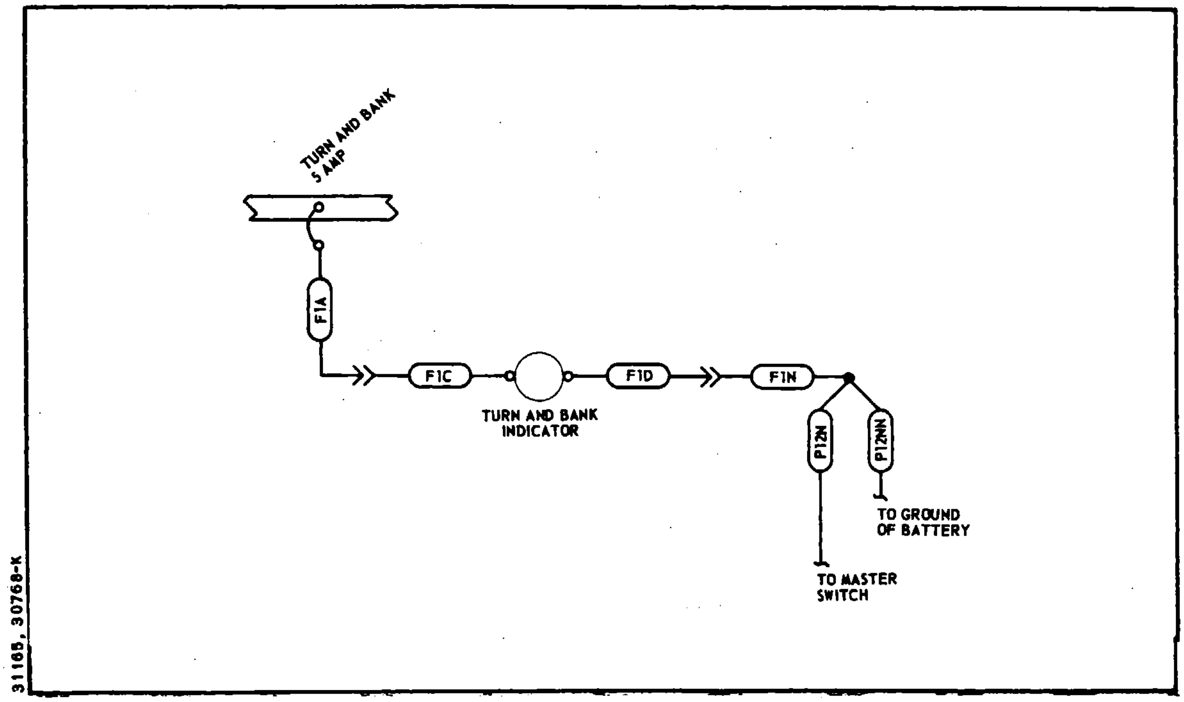


Figure 11-96. Turn and Bank Schematic (14-volt and 28-volt)
PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.

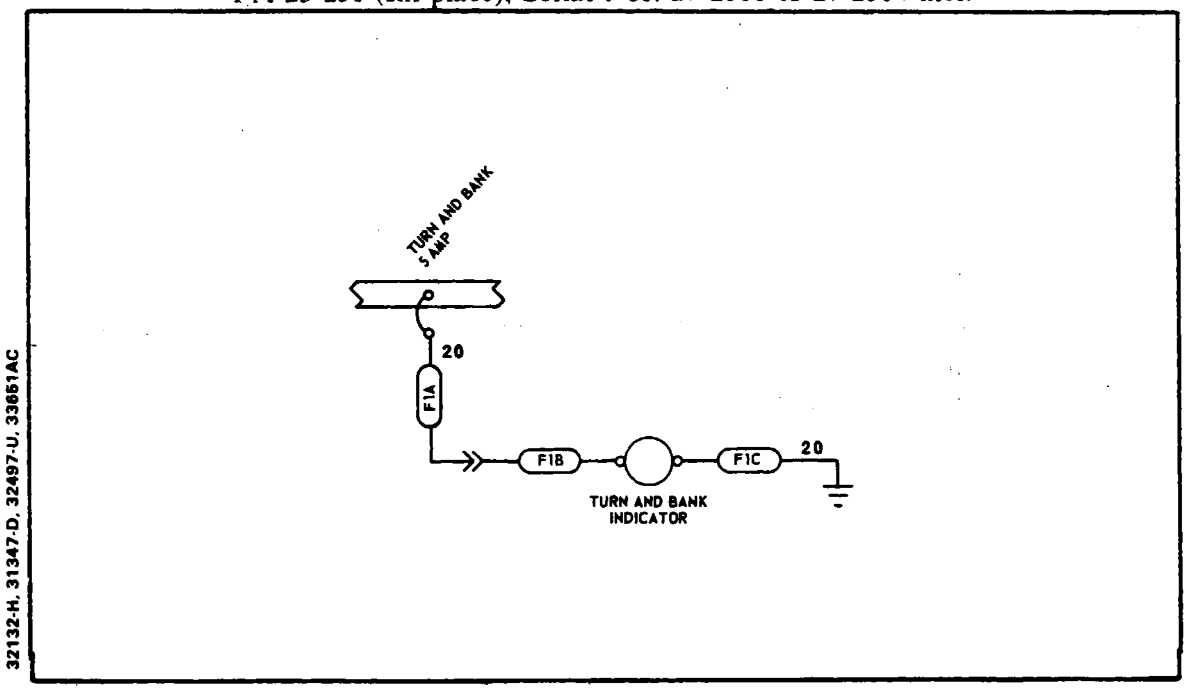


Figure 11-97. Turn and Bank Schematic
PA-23-250 (six place), Serial Nos. 27-2505 and up

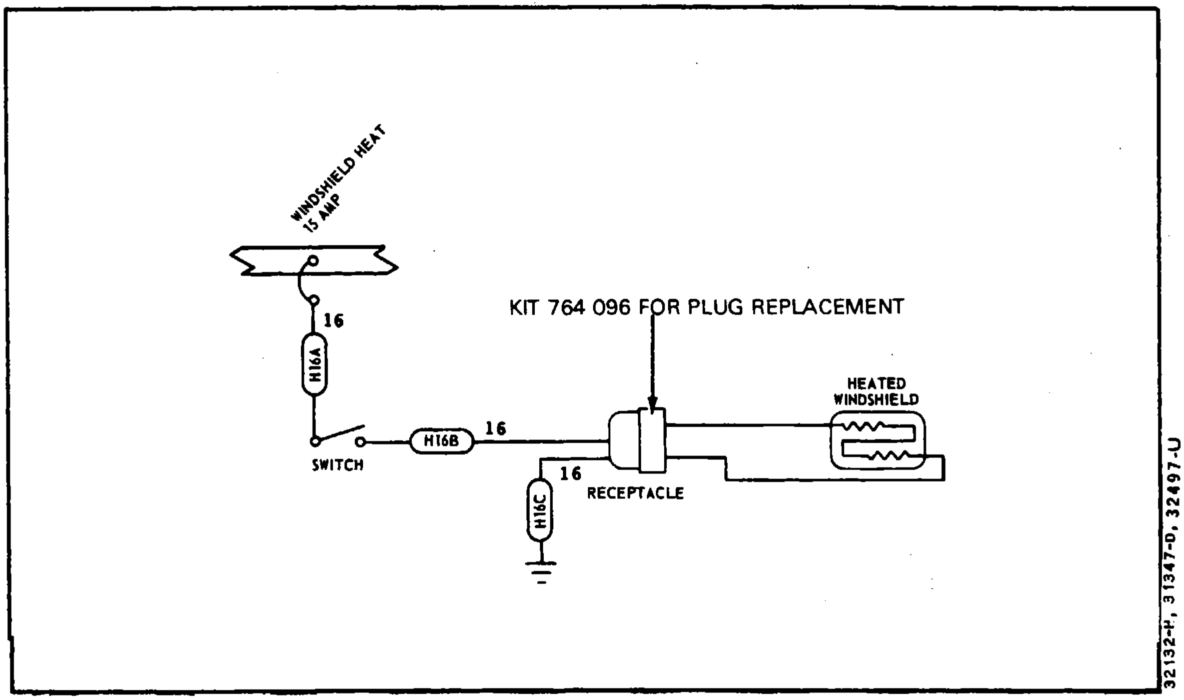


Figure 11-98. Heated Windshield Schematic
PA-23-250 (six place), Serial Nos. 27-2505 to 27-7554172 incl.

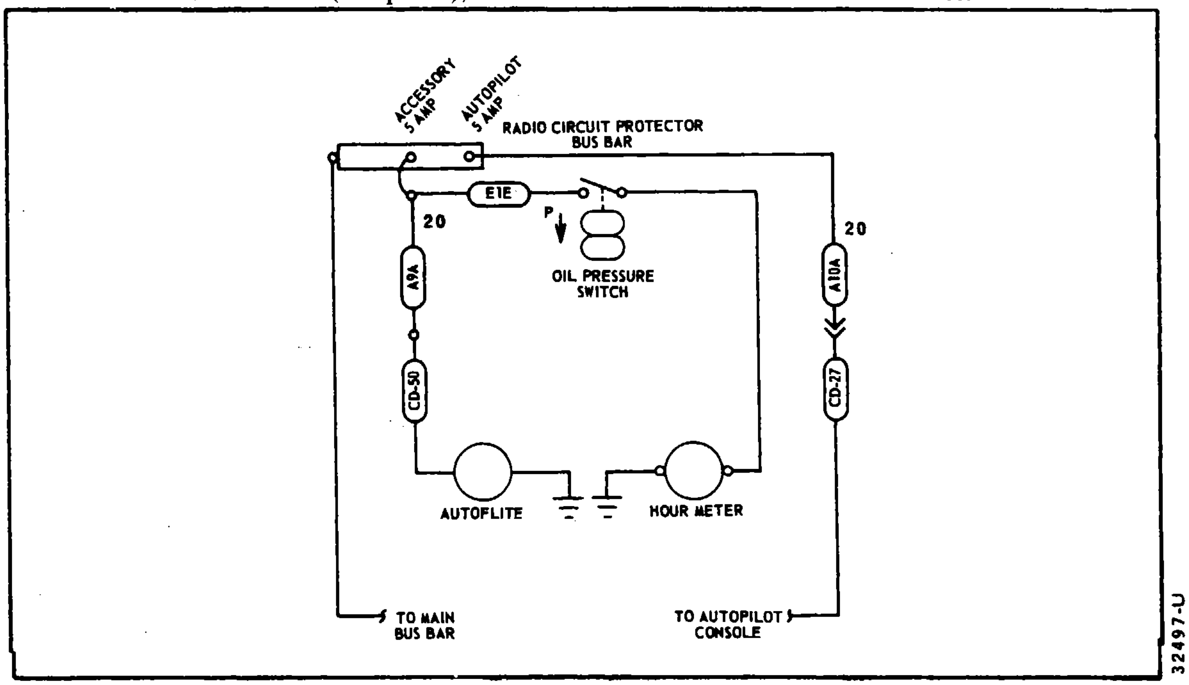
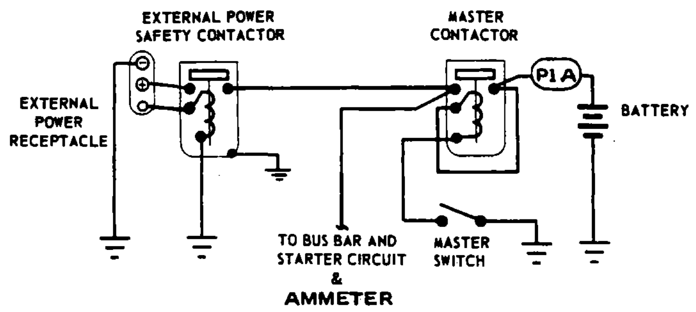
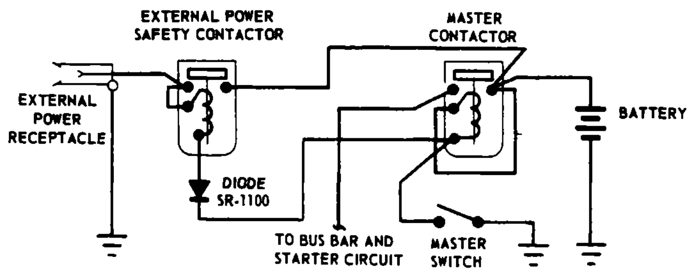


Figure 11-99. Accessory and AutoPilot Schematic
PA-23-250 (six place), Serial Nos. 27-3457 to 27-7554172 incl.



30826-F

Figure 11-100. External Power Supply
PA-23-250 and PA-23-250 (six place)



31681-B

Figure 11-101. External Power Supply
PA-23-250 and PA-23-235

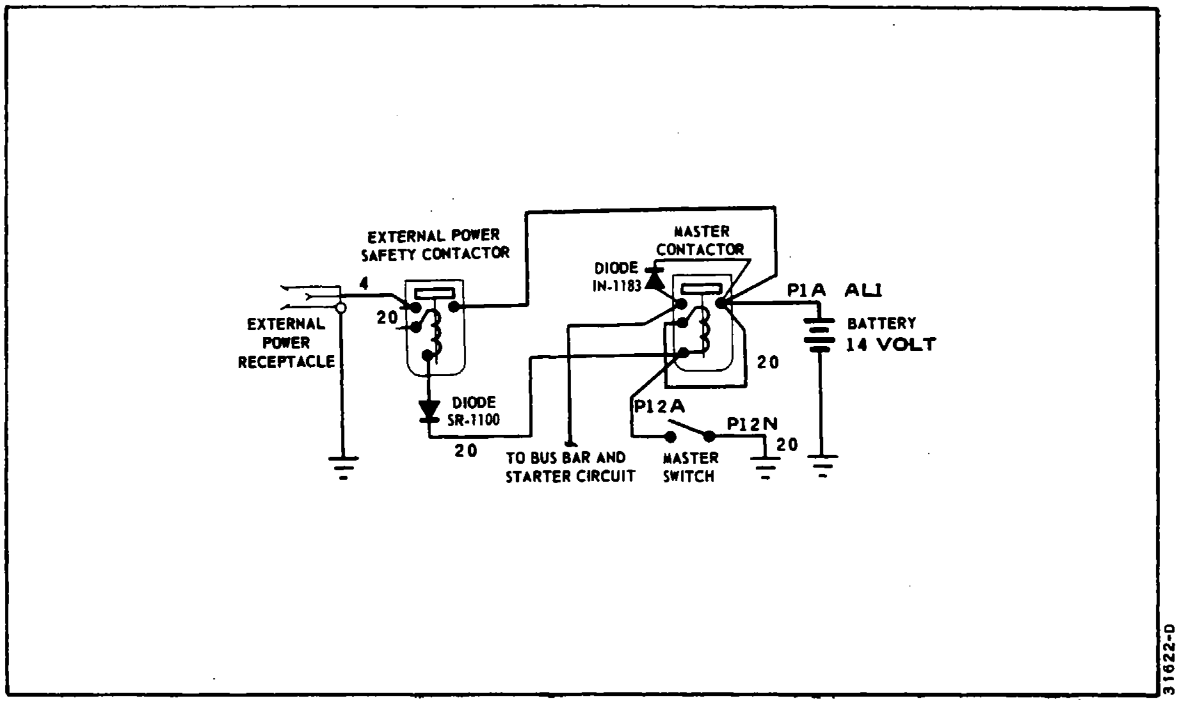


Figure 11-102. External Power Supply, PA-23-250 (six place) Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.

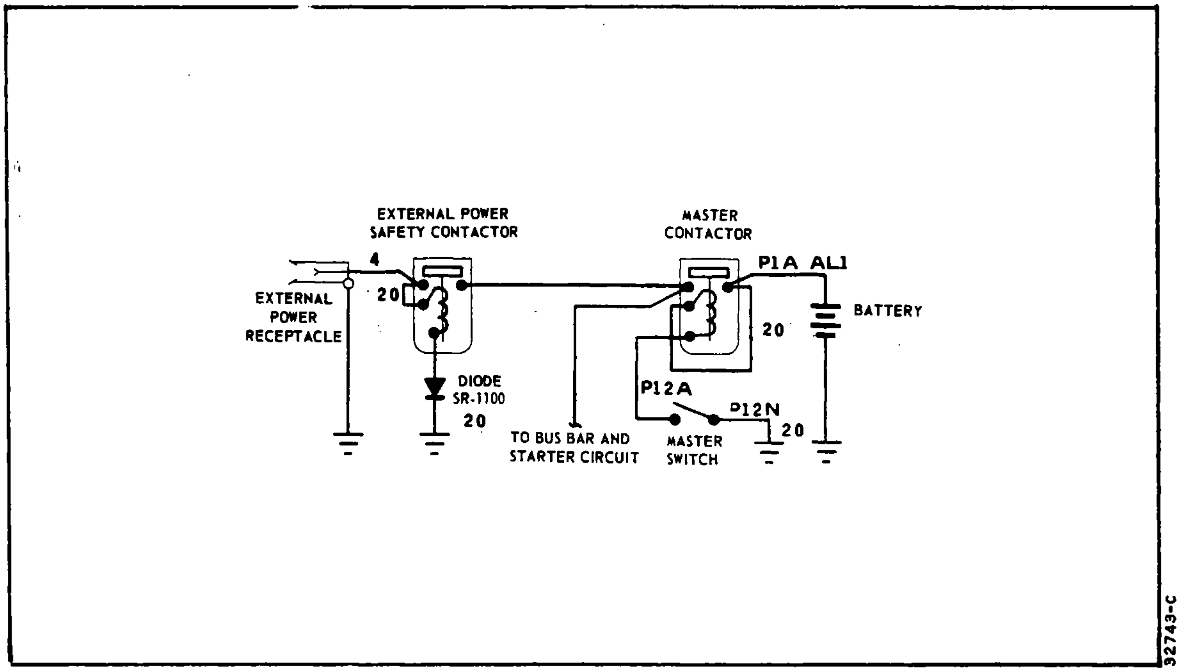


Figure 11-103. External Power Supply PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.

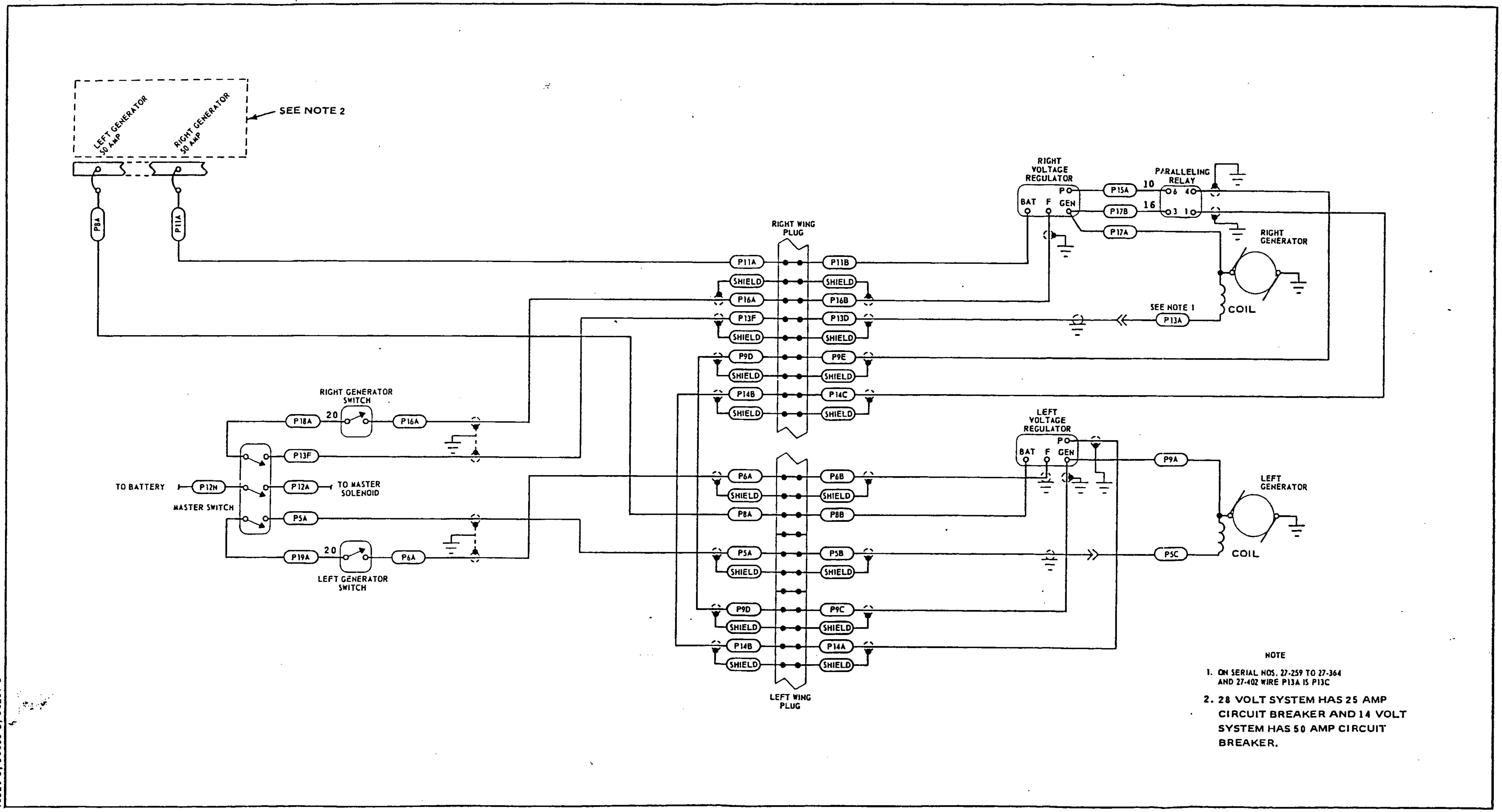


Figure 11-104. Generator System Schematic (Delco-Remy, 14-volt and 28-volt), PA-23-250 and PA-23-235

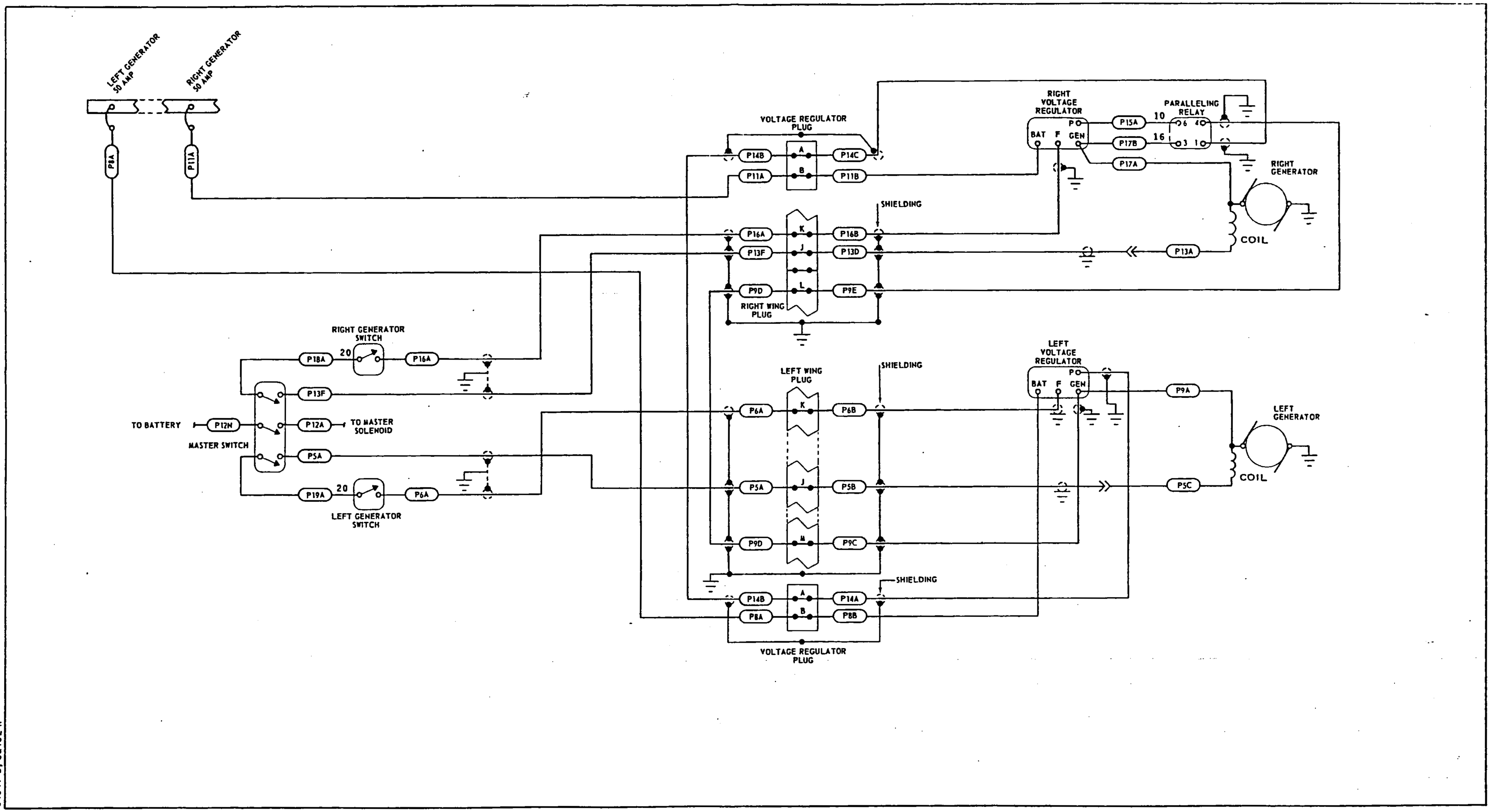


Figure 11-105. Generator System Schematic (Delco-Remy, 14-volt and 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.

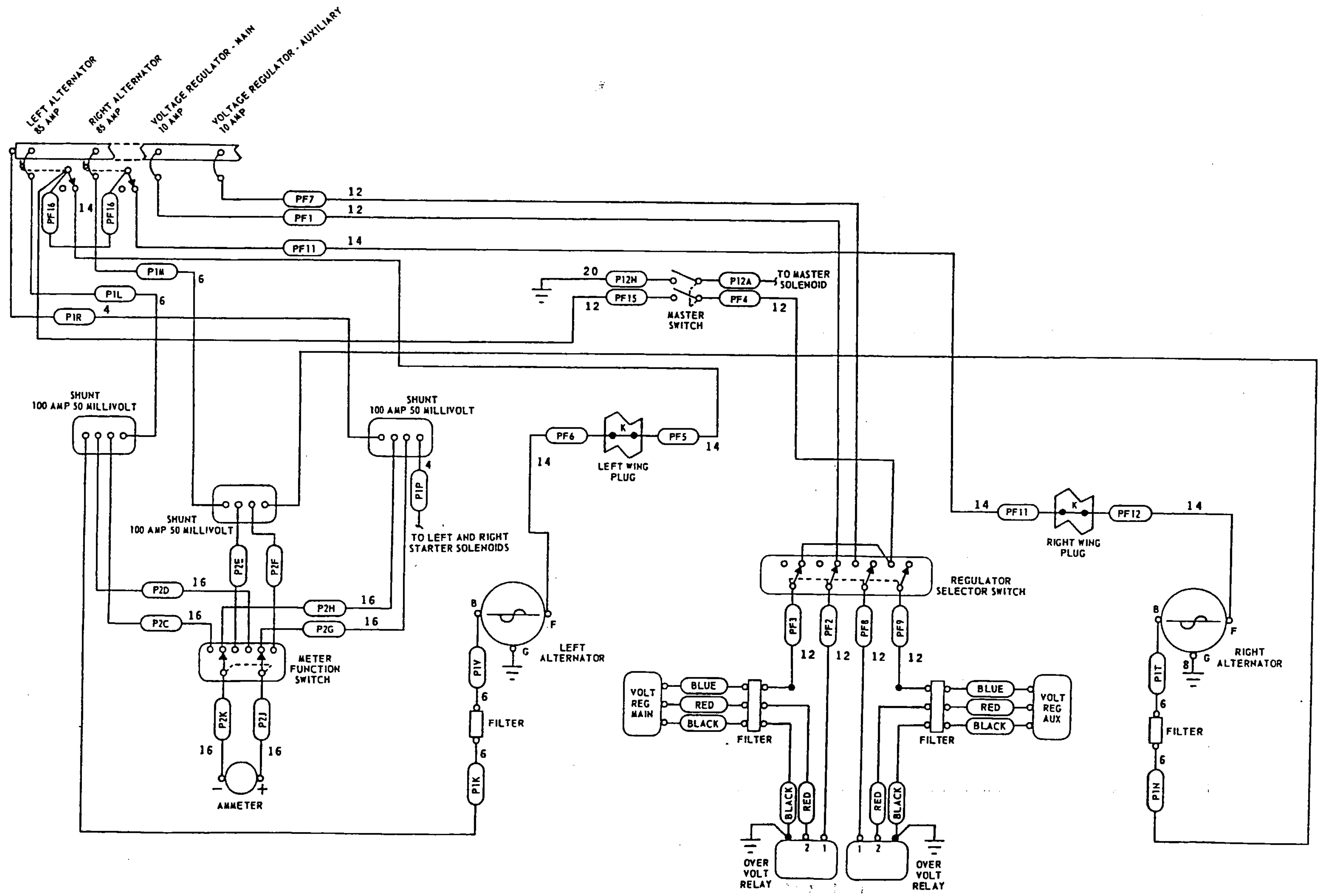


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Figure 11-106. Alternator System Schematic (Delco-Remy), PA-23-250 (six place)
Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.

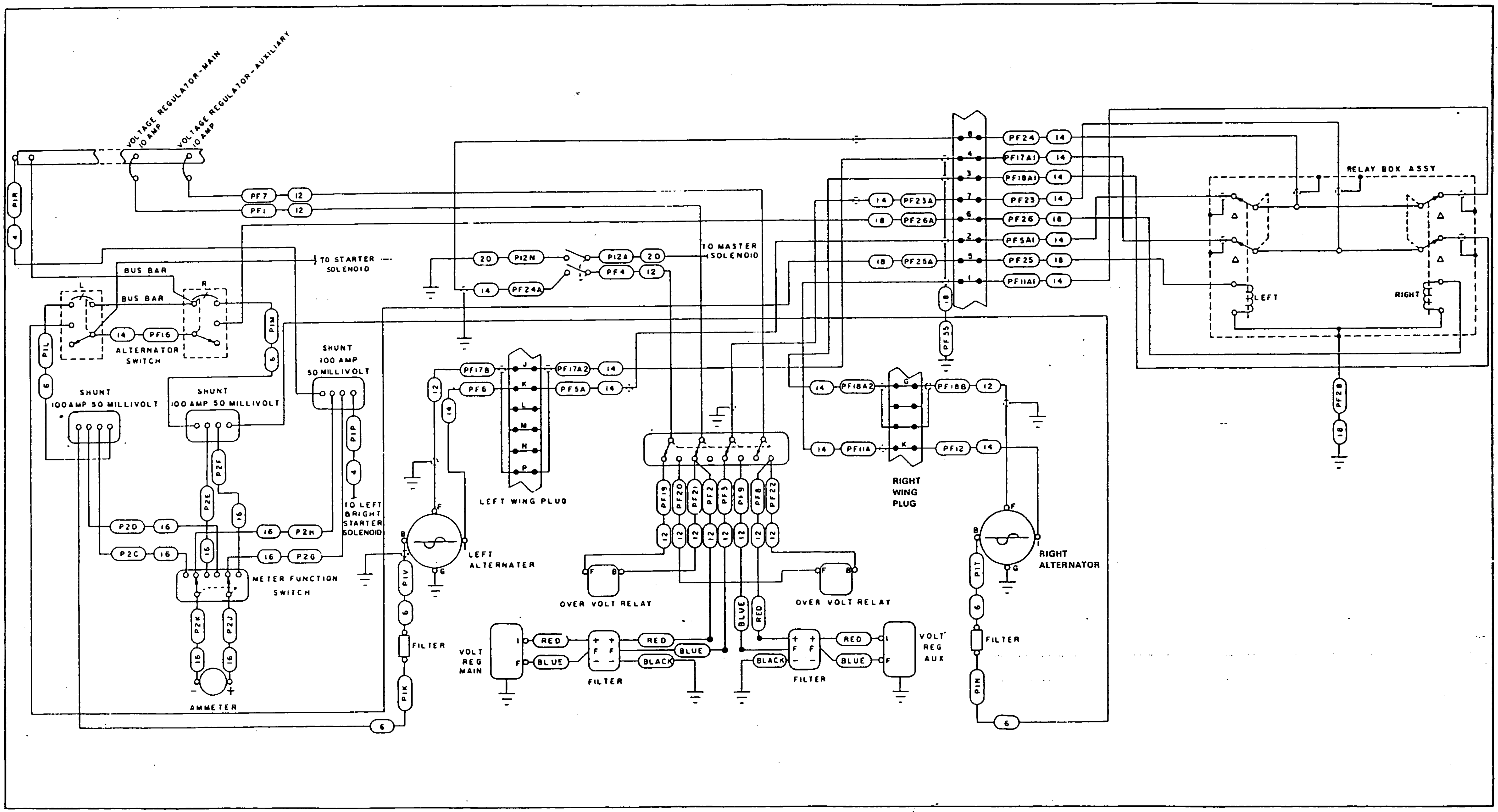

Figure 11-107. Alternator System Schematic (Prestolite), PA-23-250 (six place)
Serial Nos. 27-3837, 27-3944 to 27-4793

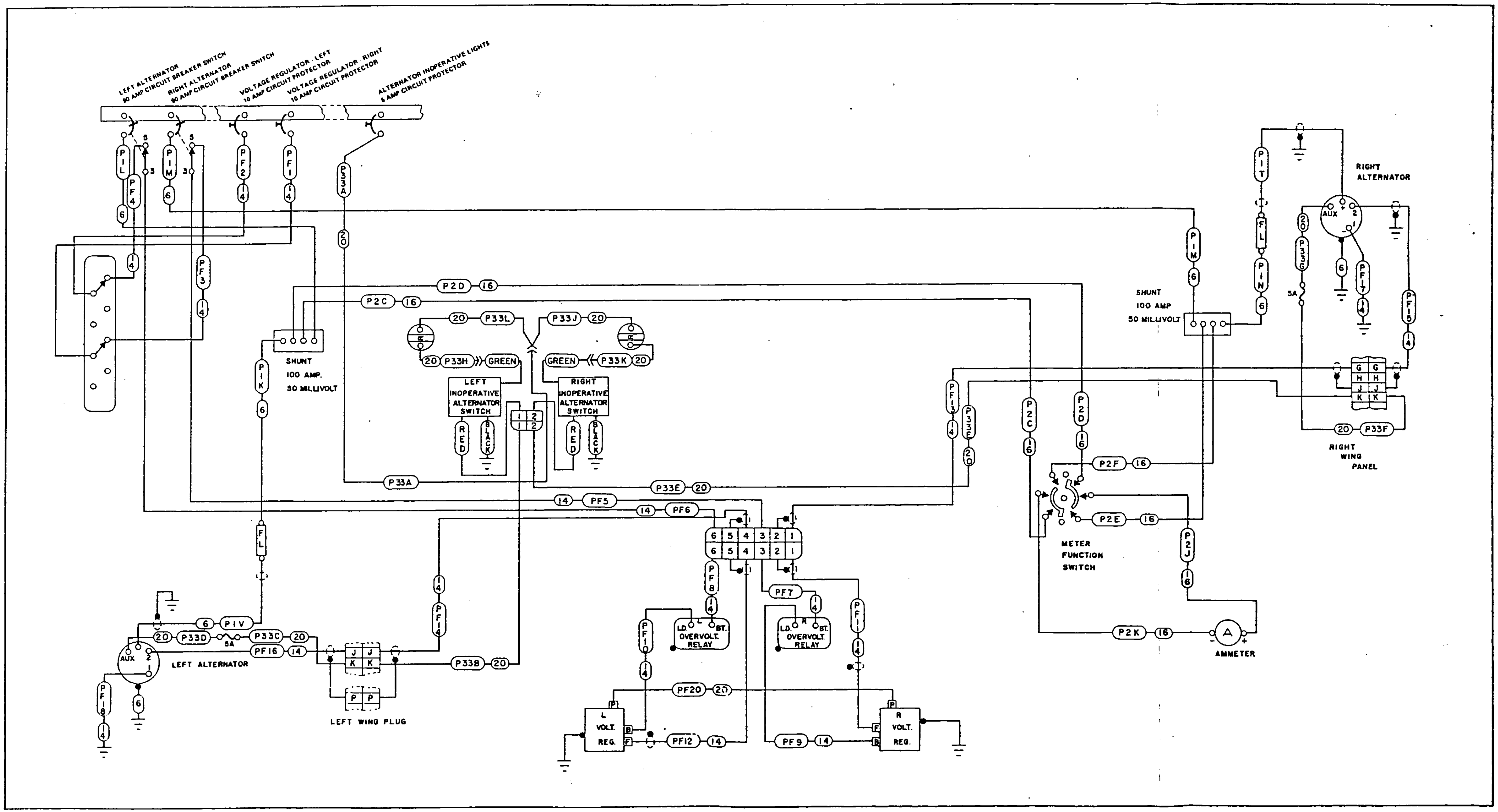

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Figure 11-108. Alternator Paralleling System Schematic (Prestolite), PA-23-250 (six place), Serial Nos. 27-5006 to 27-7554172 incl.

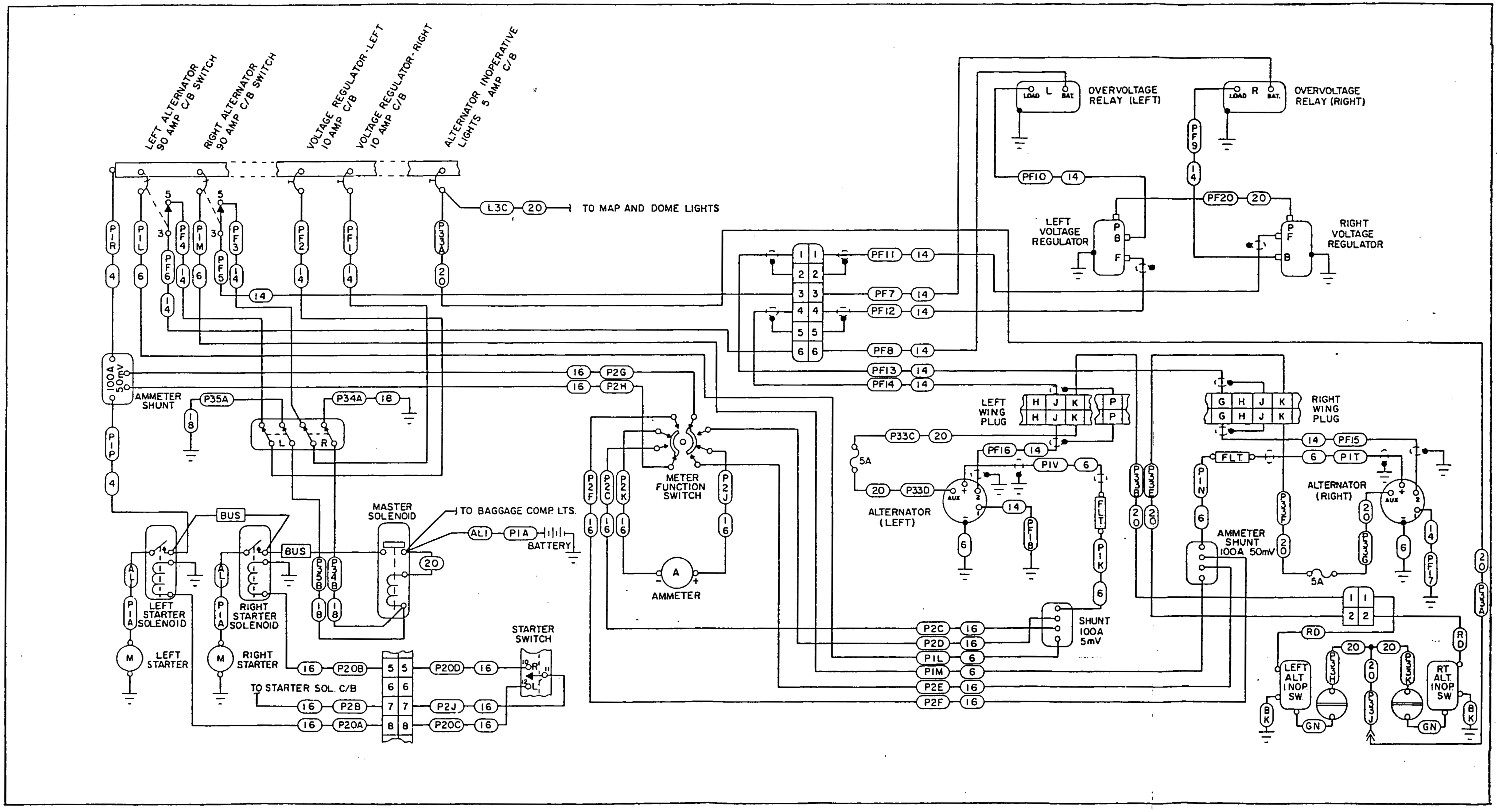

Figure 11-109. Alternator Paralleling System Schematic (Prestolite), PA-23-250 (six place), Serial Nos. 27-4794 to 27-5005

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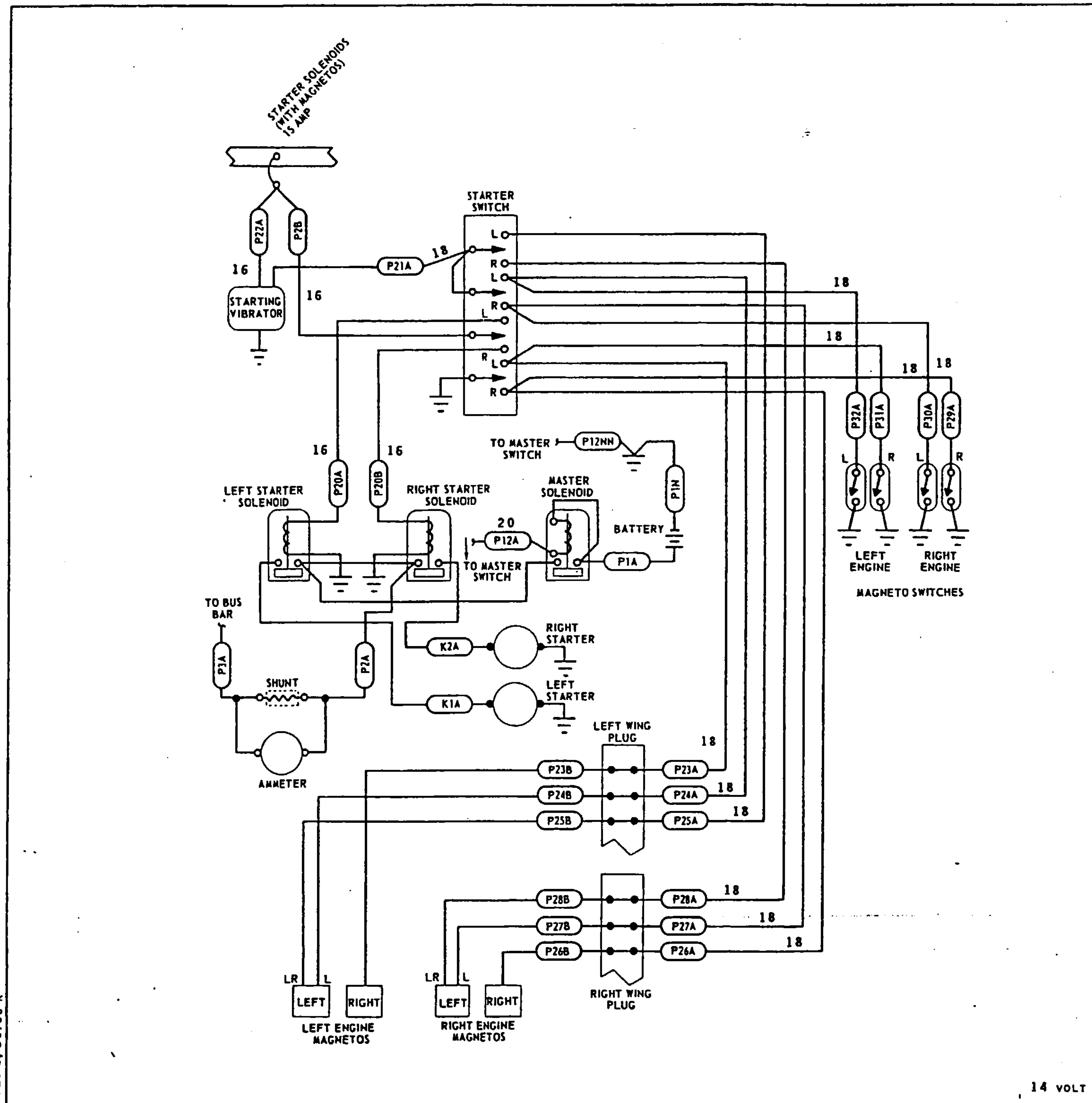

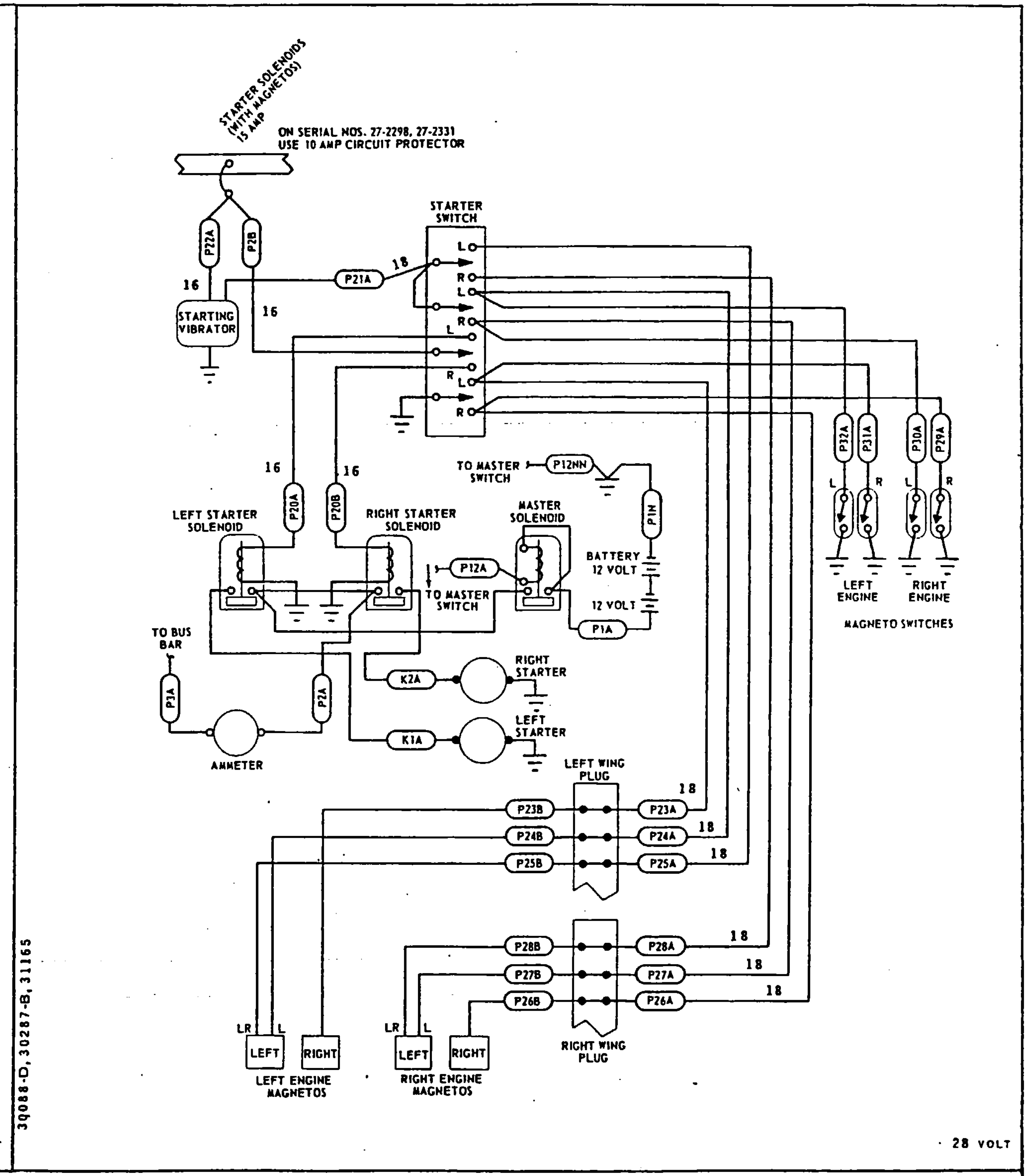

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39088-D, 30287-B, 31165

Figure 11-110. Starter System Schematic (Delco-Remy, 14-volt and 28-volt), PA-23-250; PA-23-235; and PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.

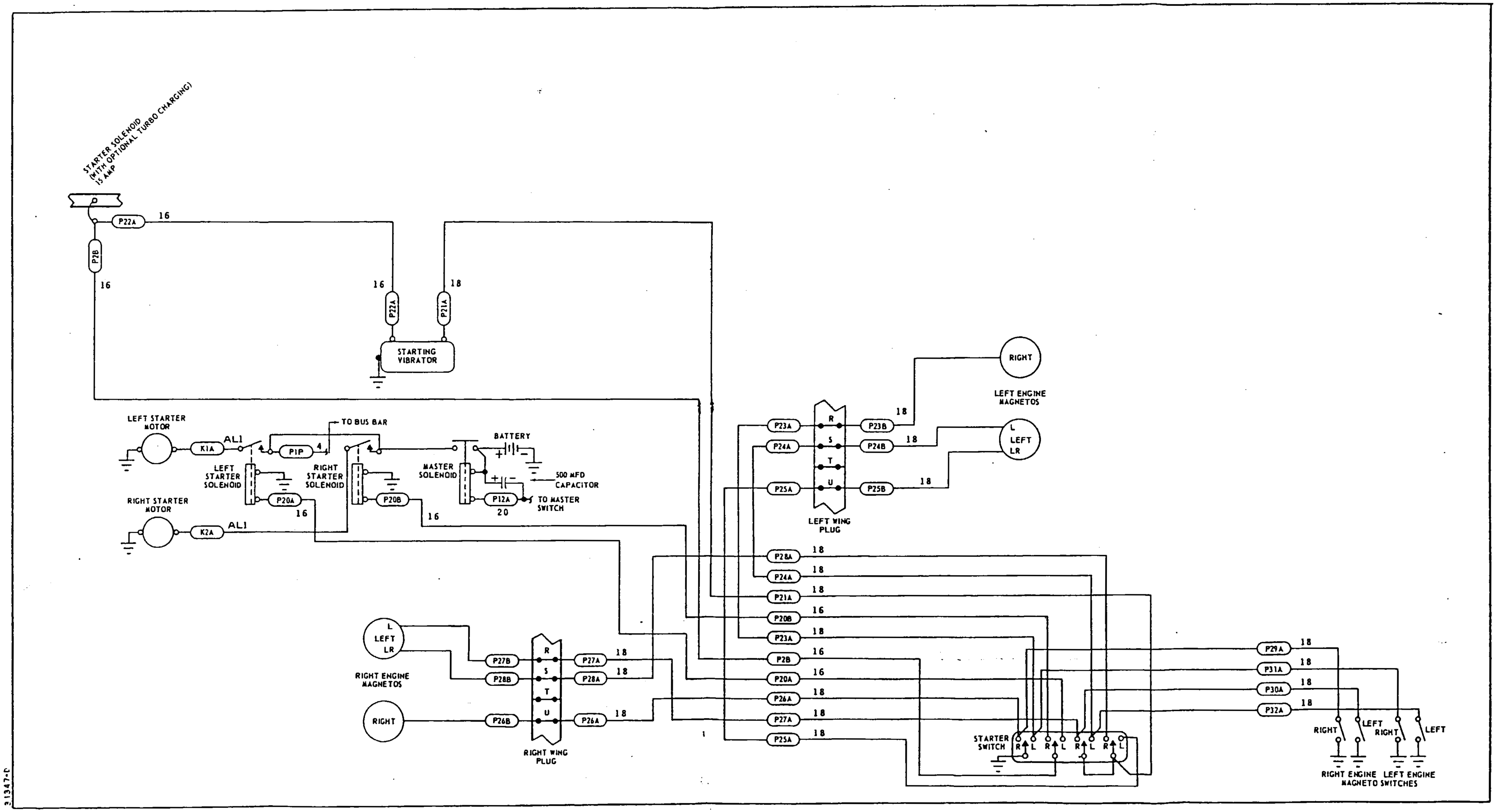

Figure 11-111. Starter System Schematic (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3831 incl.

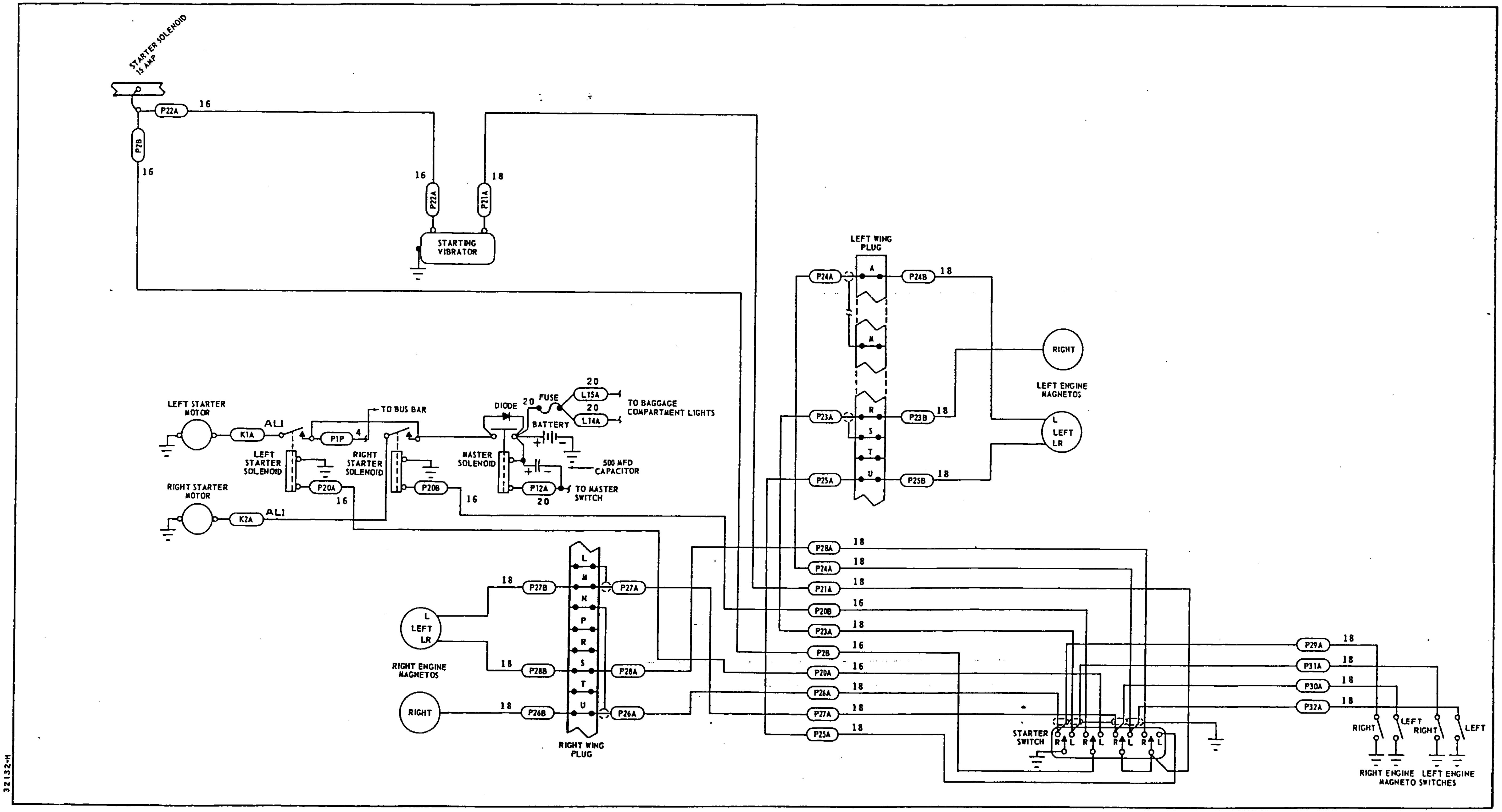

Figure 11-112. Starter System Schematic (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl.

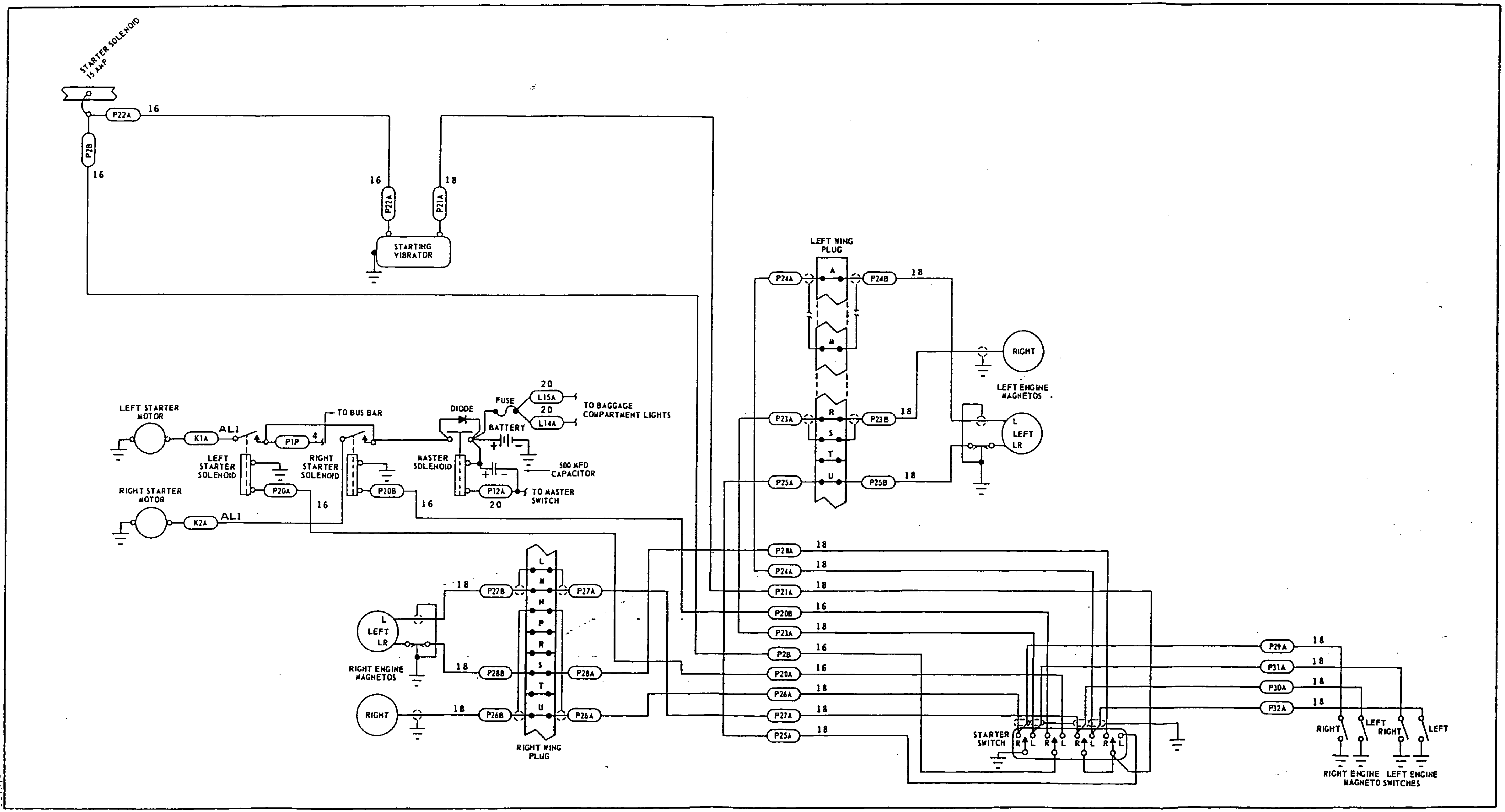

Figure 11-113. Starter System Schematic (Delco-Remy), PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-3838 to 27-3943 incl. with AiResearch Turbocharger Starter System Schematic

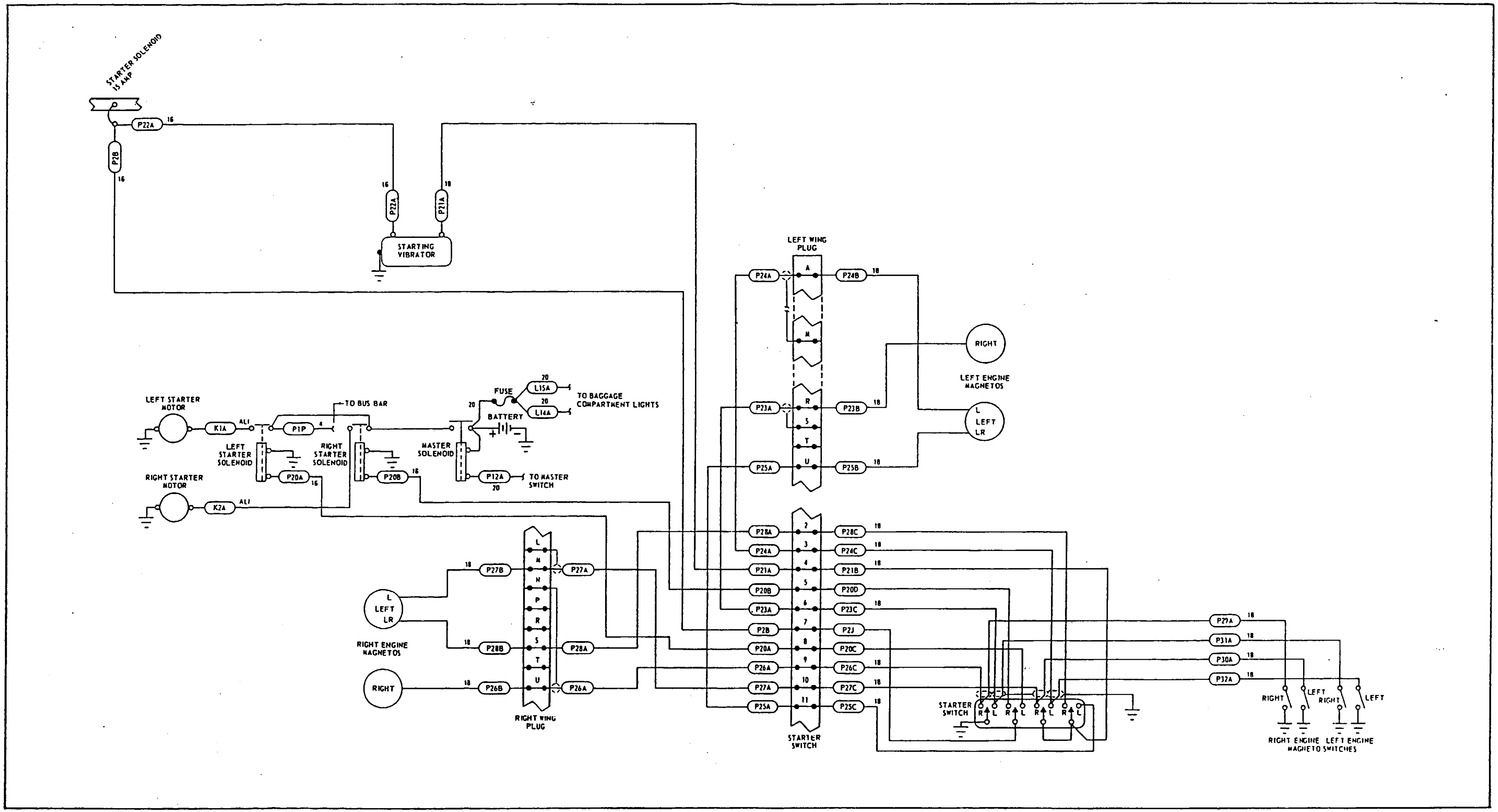

Figure 11-114. Starter System Schematic (Prestolite), PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.

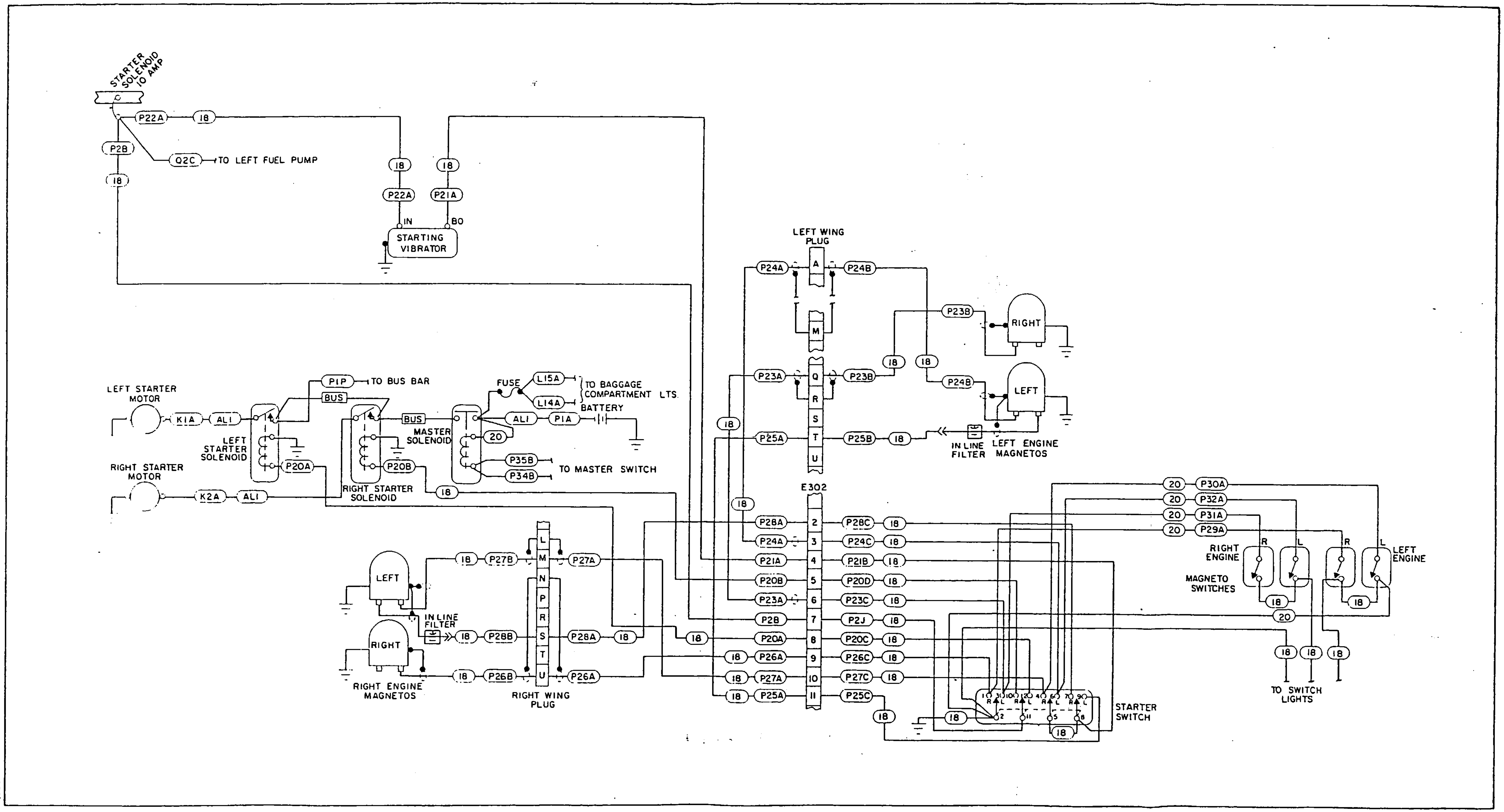

Figure 11-115. Starter System Schematic (Prestolite), PA-23-250 (six place) "F" Model
Serial Nos. 27-7654001 and up (Earlier Models)

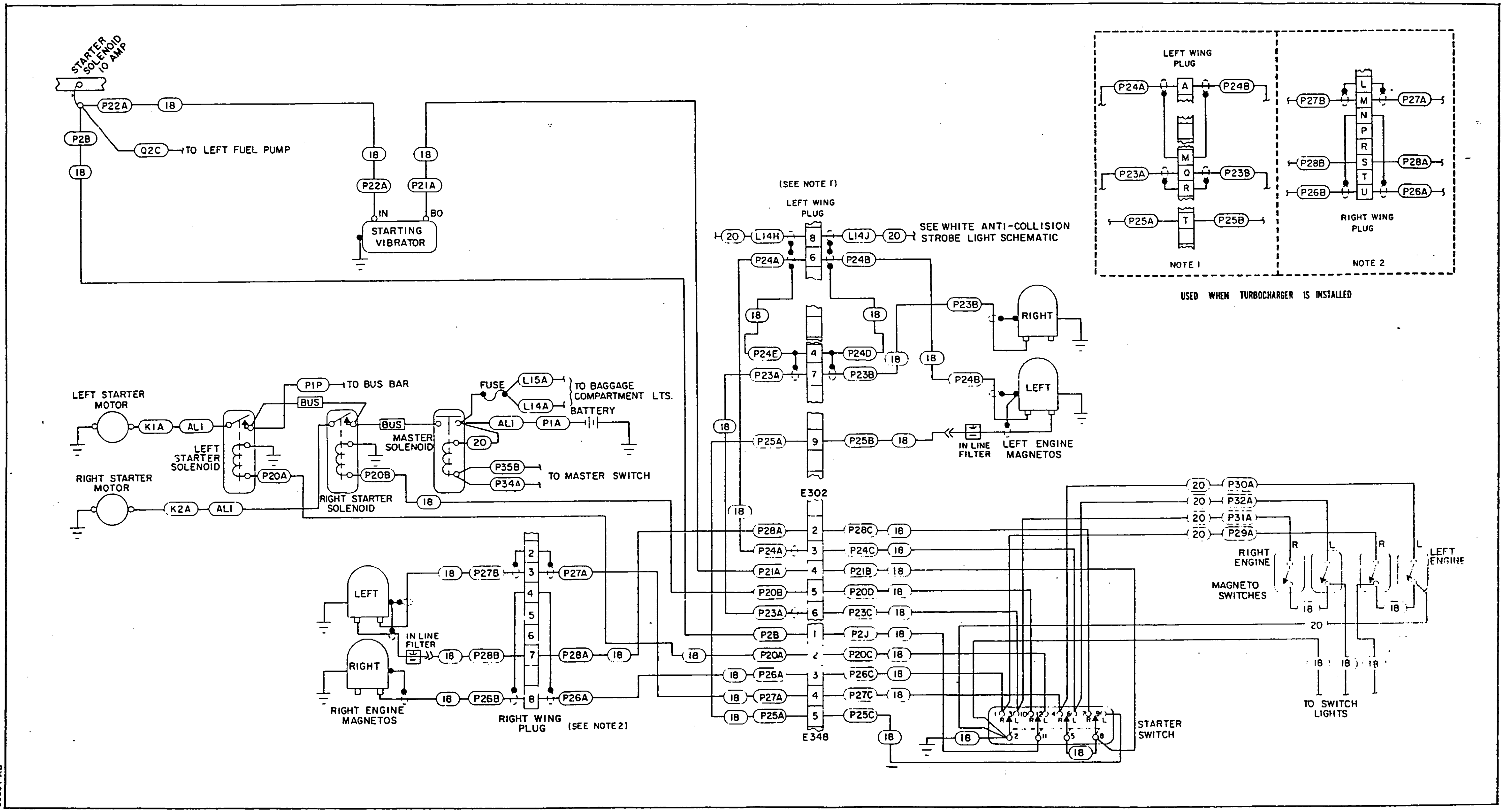

Figure 11-116. Starter System Schematic (Prestolite), PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)

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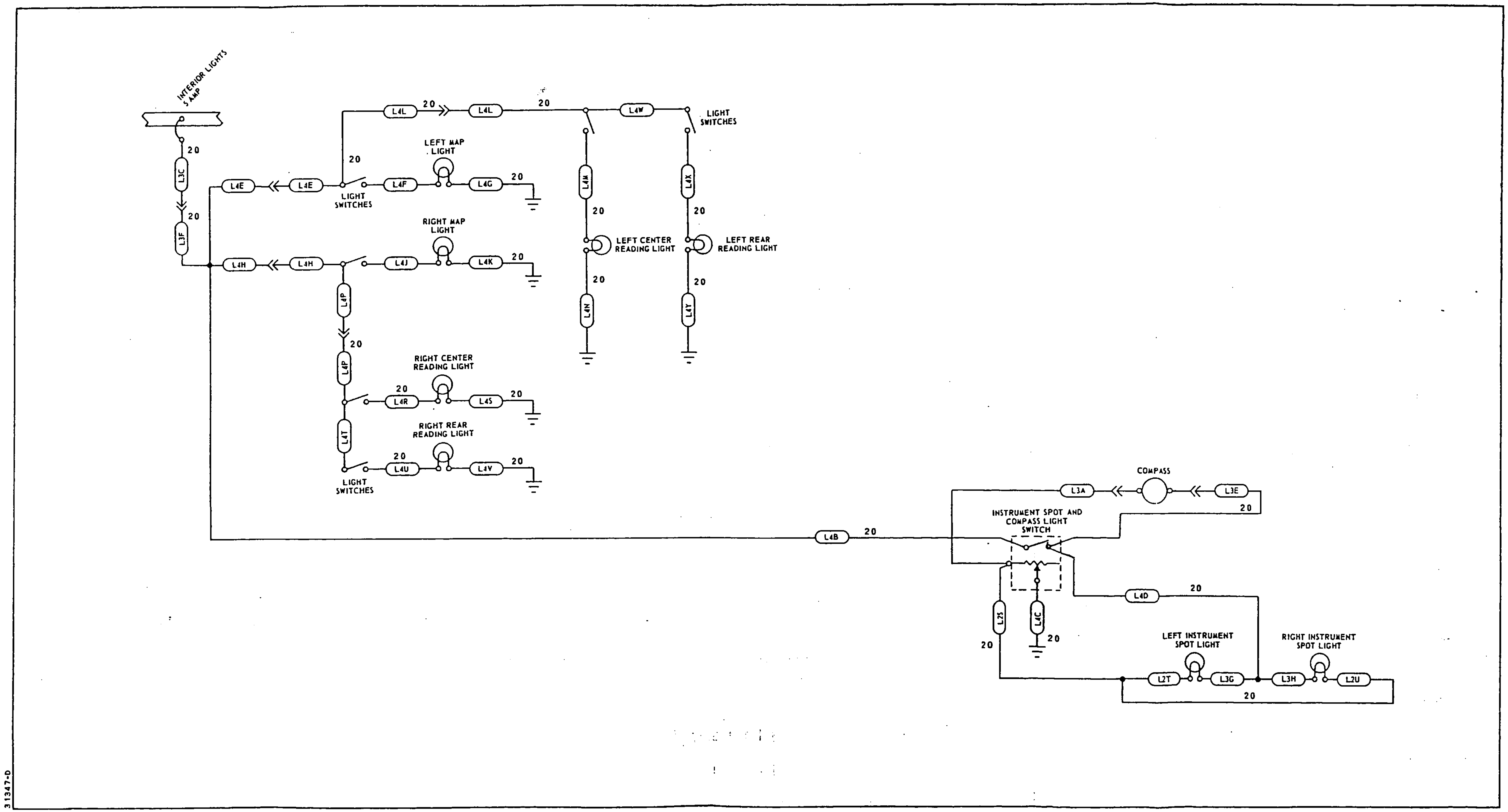

Figure 11-117. Interior Lights Schematic, PA-23-250 (six place), Serial Nos. 27-2505 to 27-3153 incl.

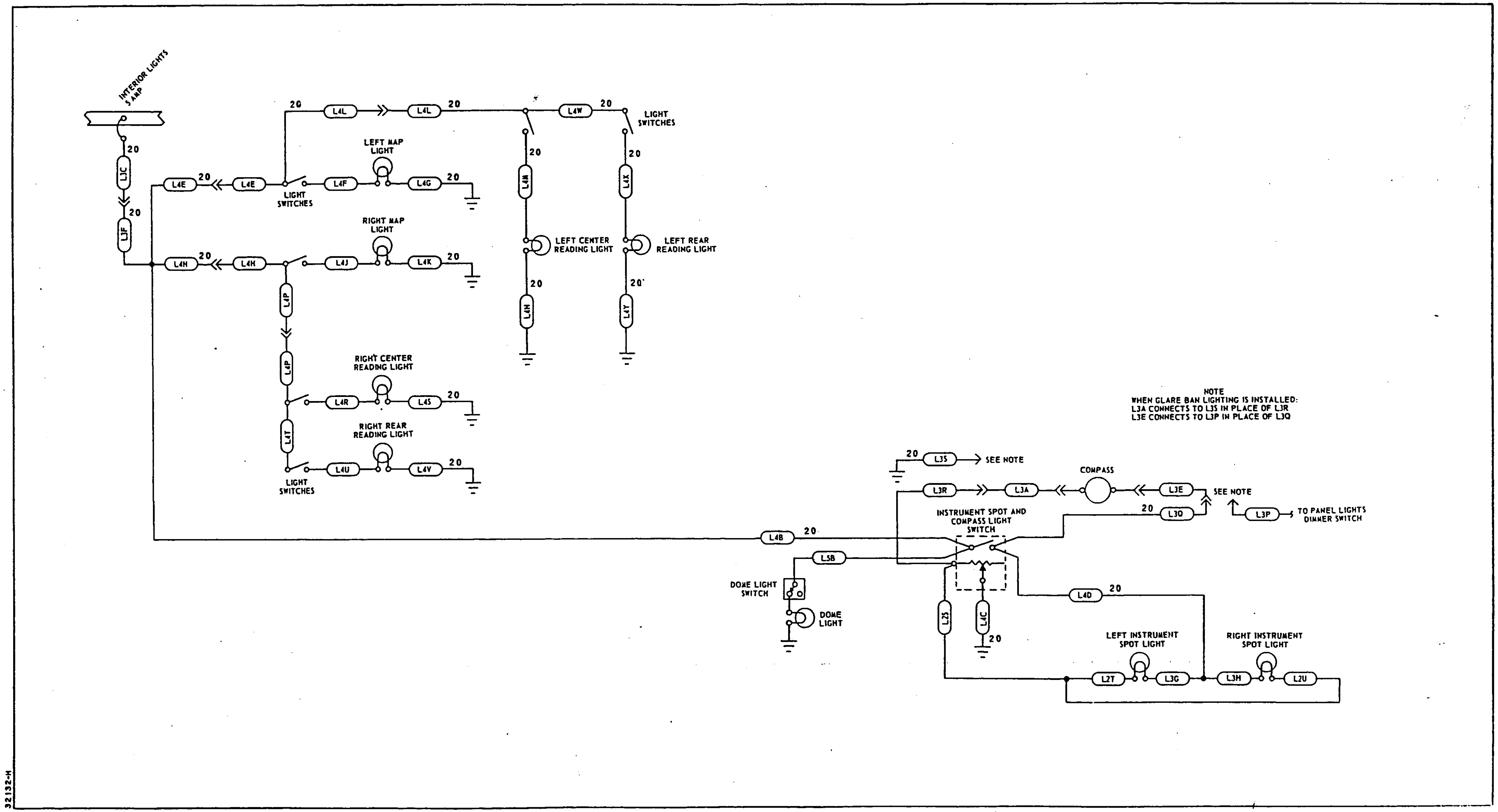

Figure 11-118. Interior Lights Schematic, PA-23-250 (six place), Serial Nos. 27-3154 to 27-3836 incl. and 27-3838 to 27-3943 incl.

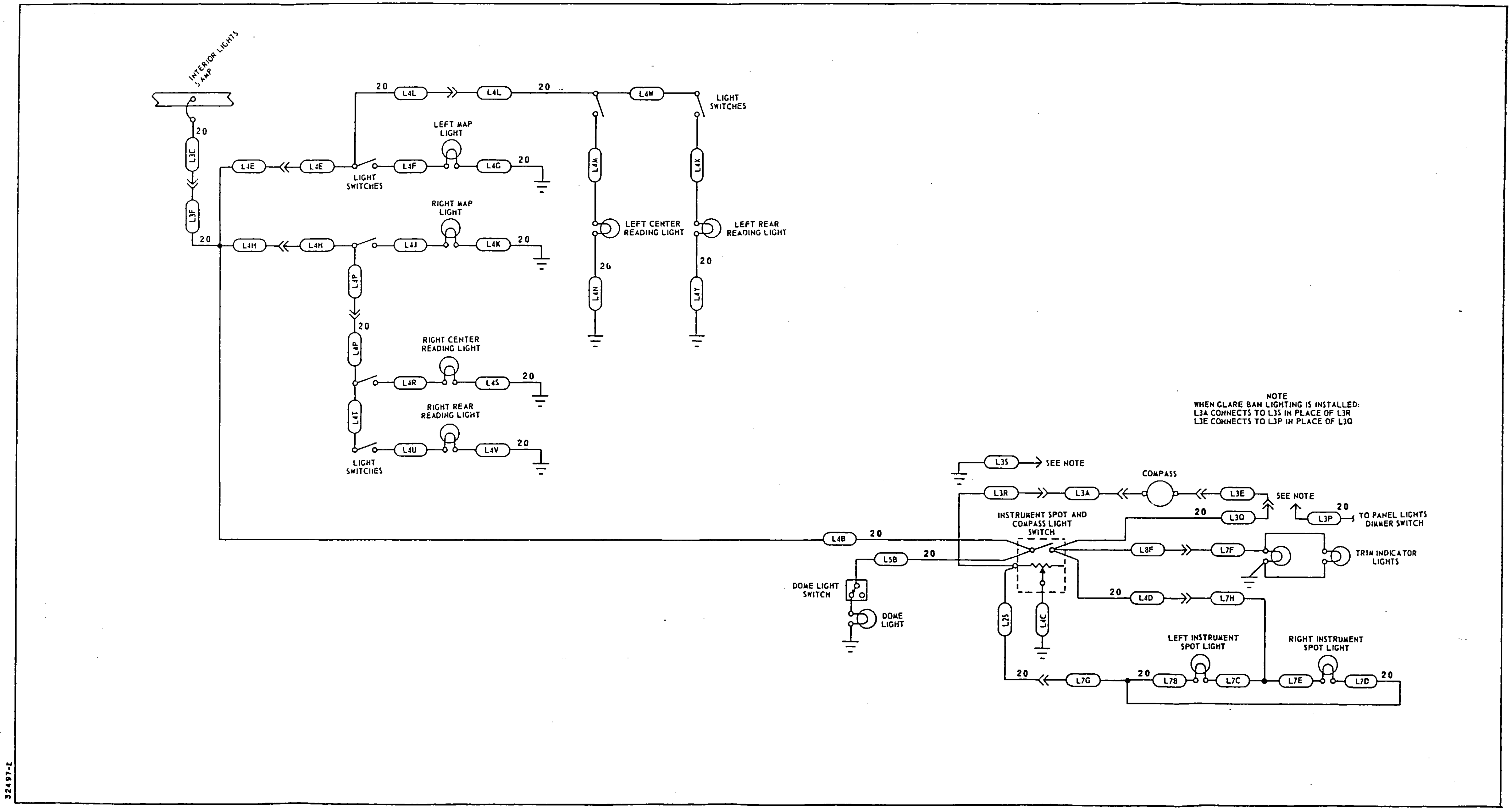

Figure 11-119. Interior Lights Schematic, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-4766 incl.

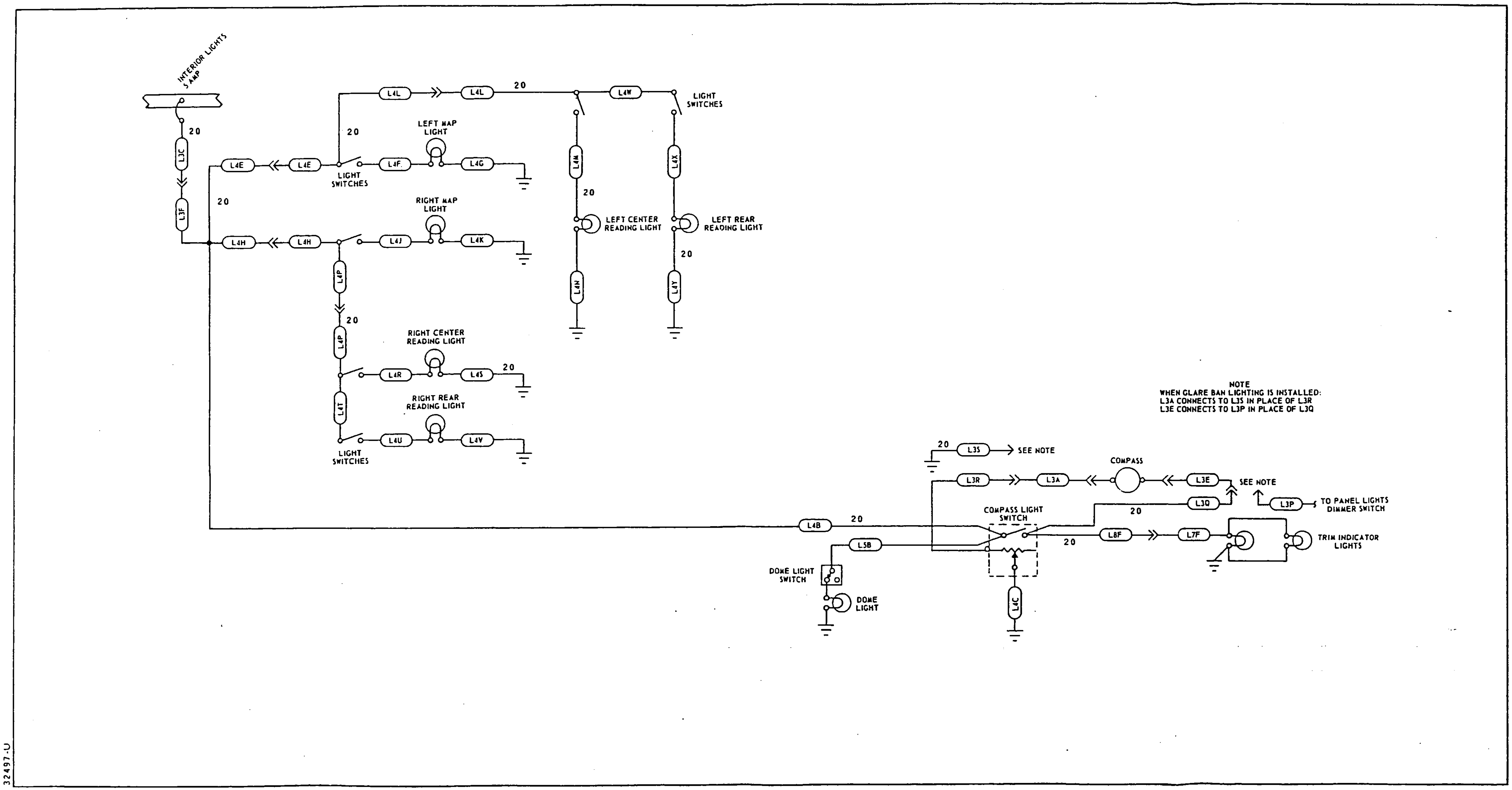

Figure 11-120. Interior Lights Schematic, PA-23-250 (six place), Serial Nos. 27-4767 to 27-7554172 incl.

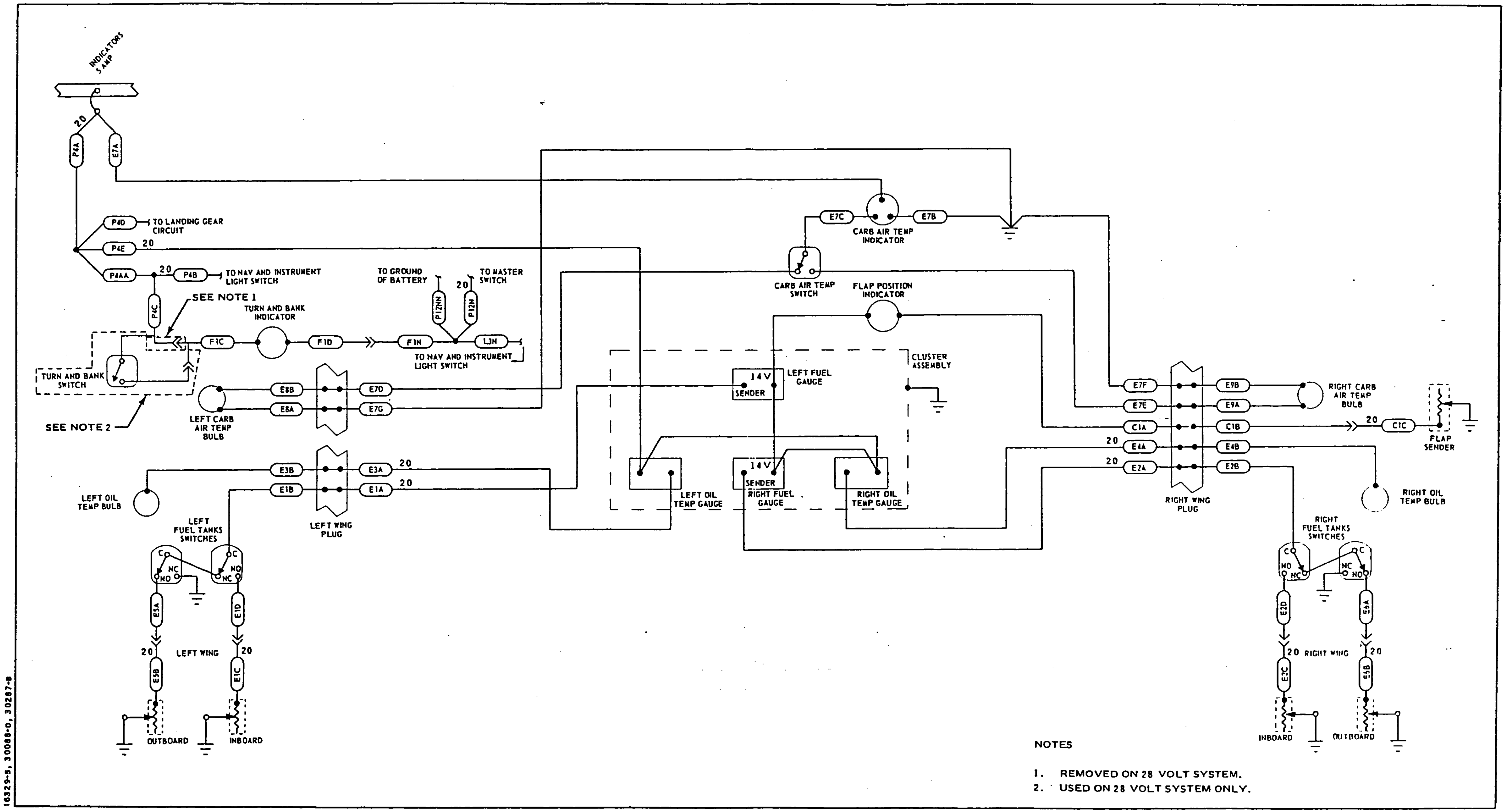

Figure 11-121. Instrument Cluster Wiring Schematic (14-volt and 28-volt systems). PA-23-250 and PA-23-235

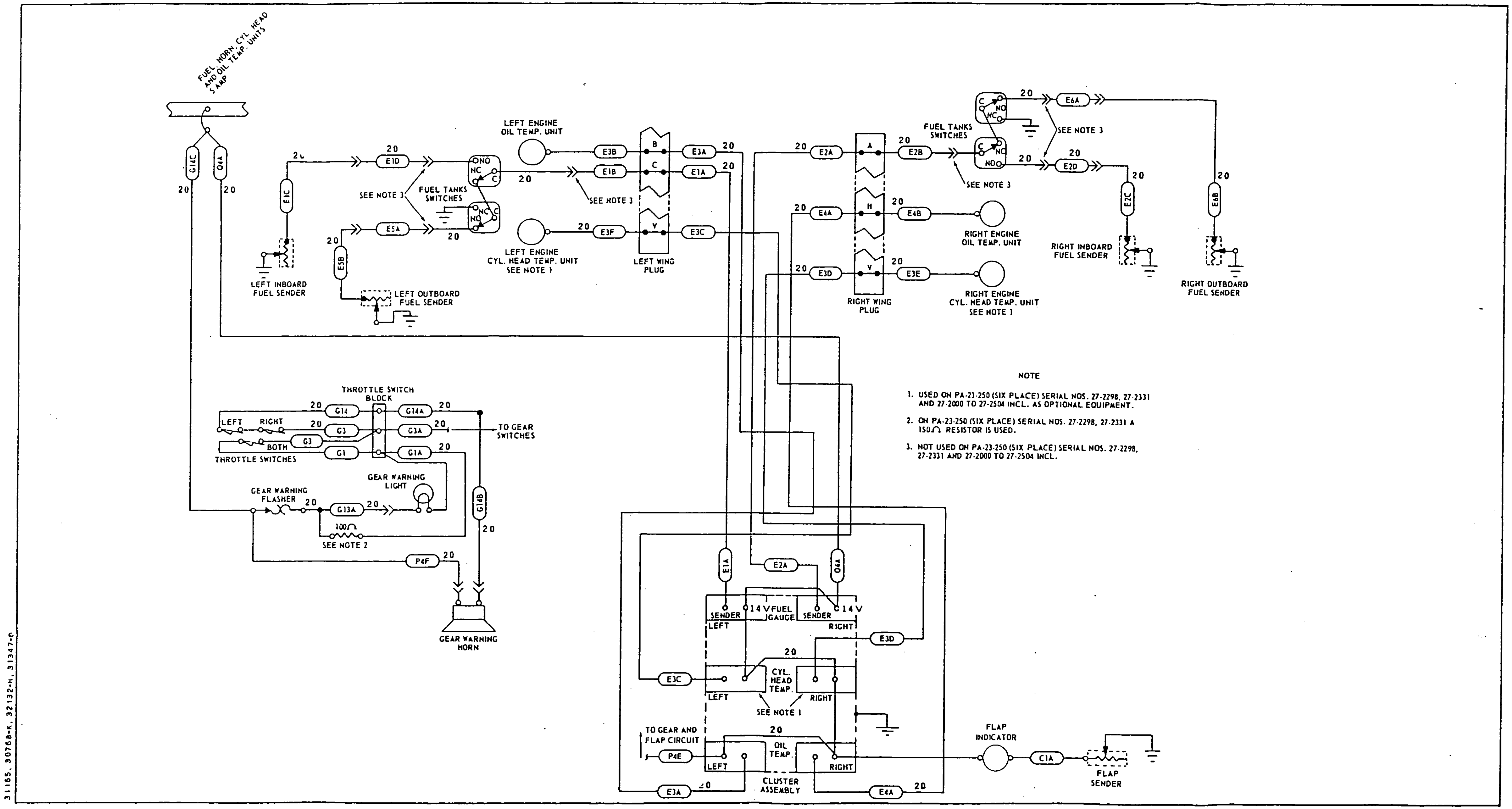

Figure 11-122. Instrument Cluster Wiring Schematic (14-volt and 28-volt systems), PA-23-250 (six place), Serial Nos. 27-2000 to 27-3837 incl. and 27-3838 to 27-3943 incl.

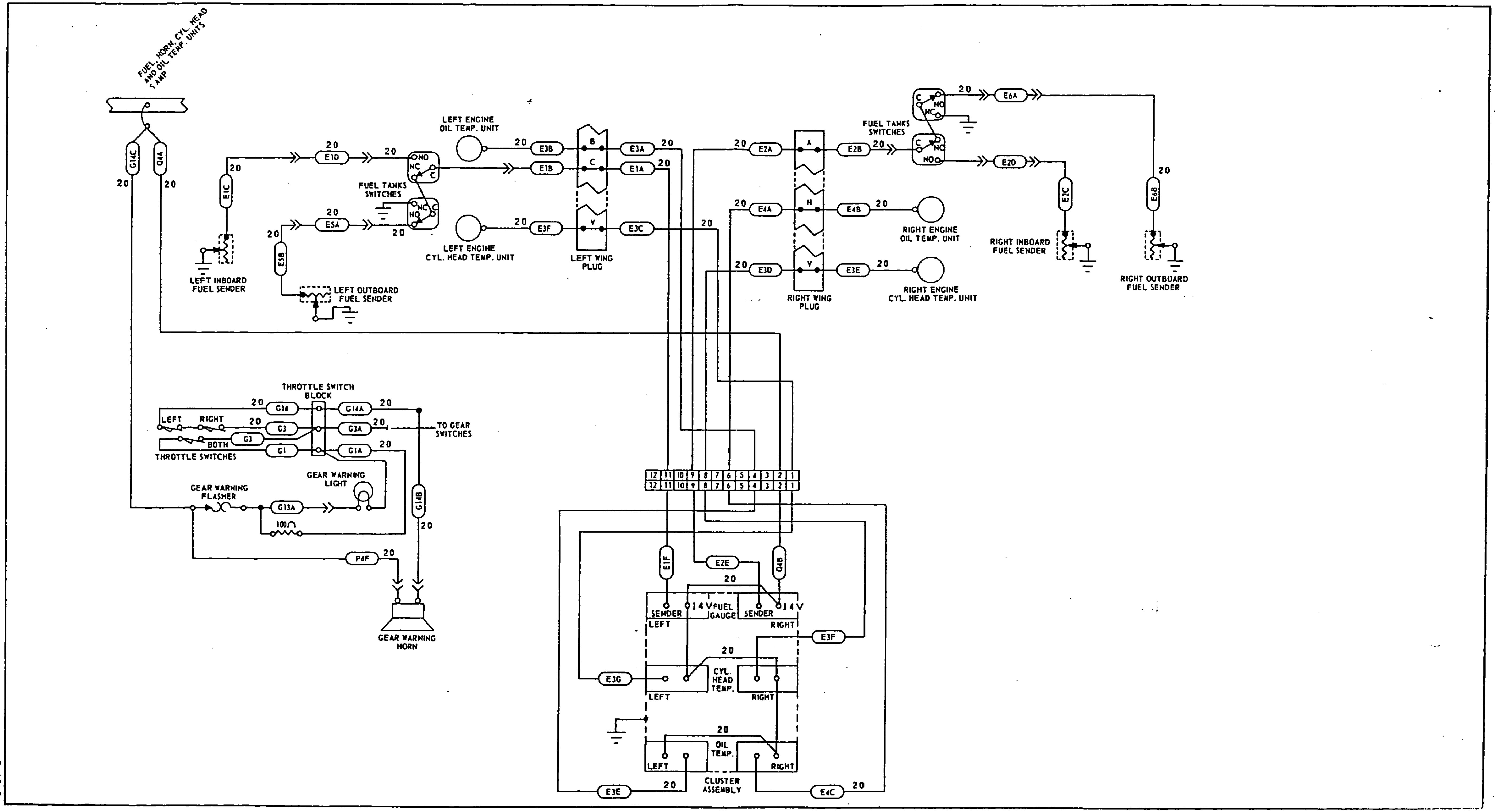

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Figure 11-123. Instrument Cluster Wiring Schematic, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.

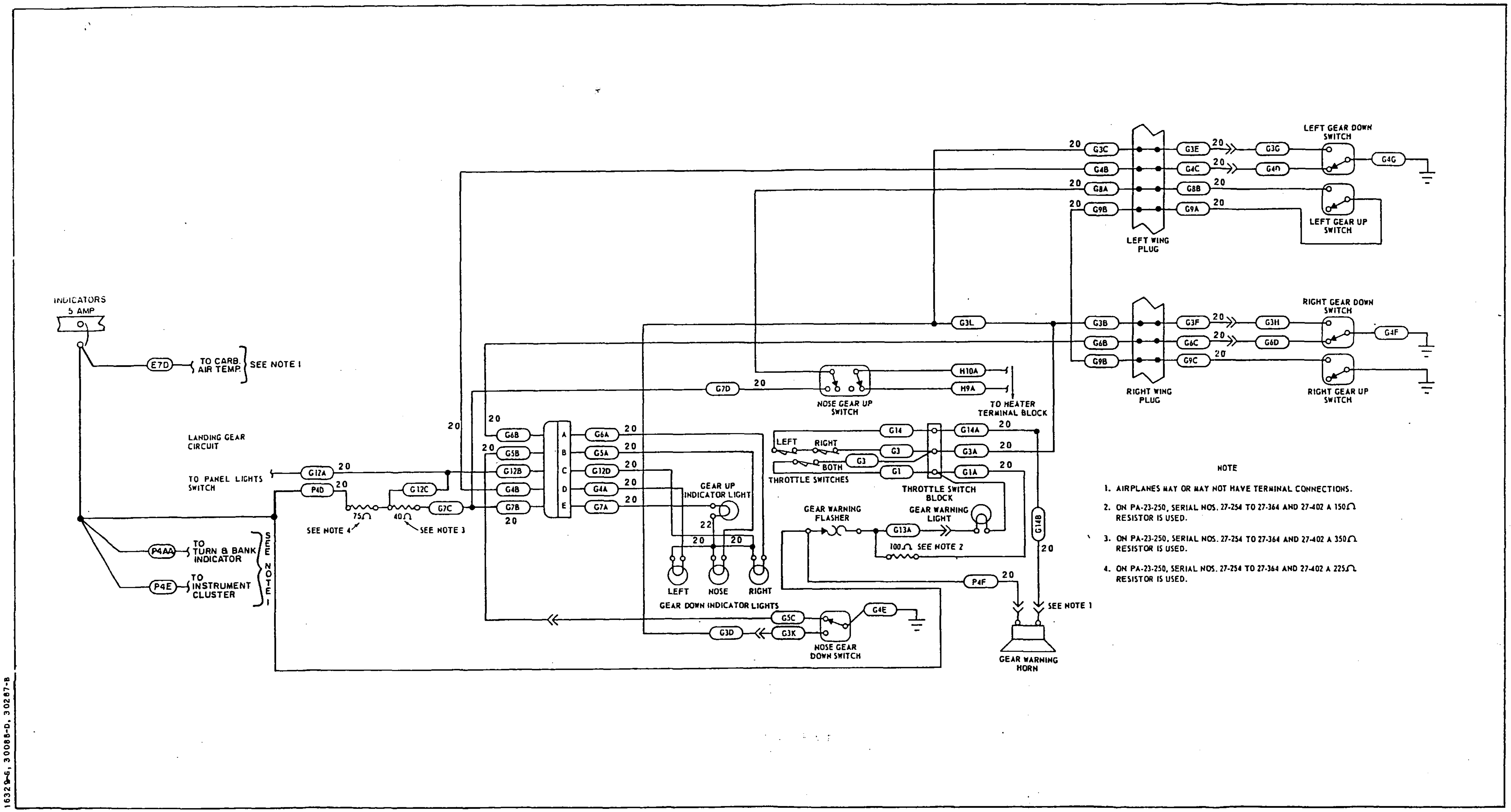

Figure 11-124. Landing Gear and Flap System Schematic, PA-23-250 and PA-23-235

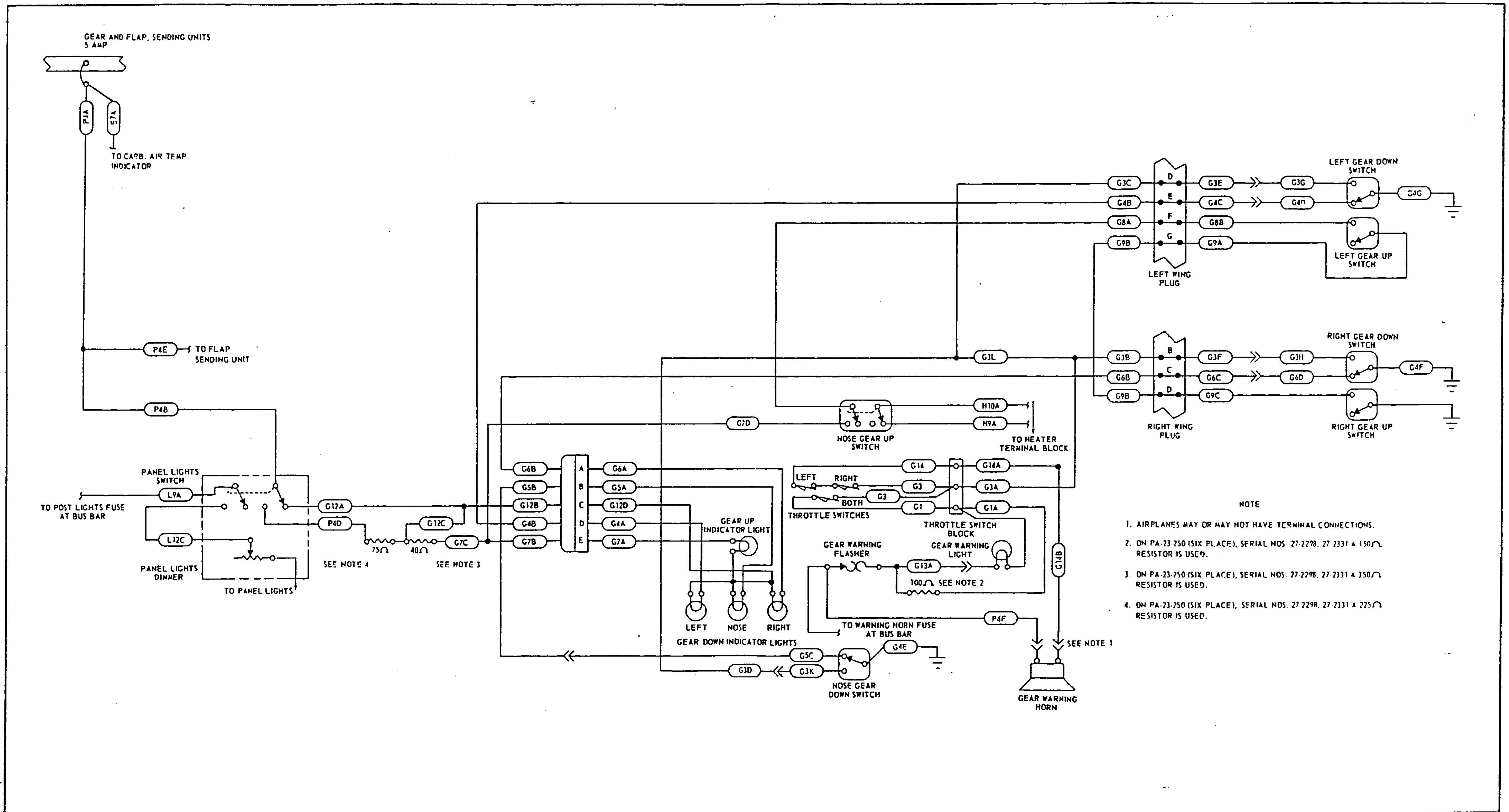

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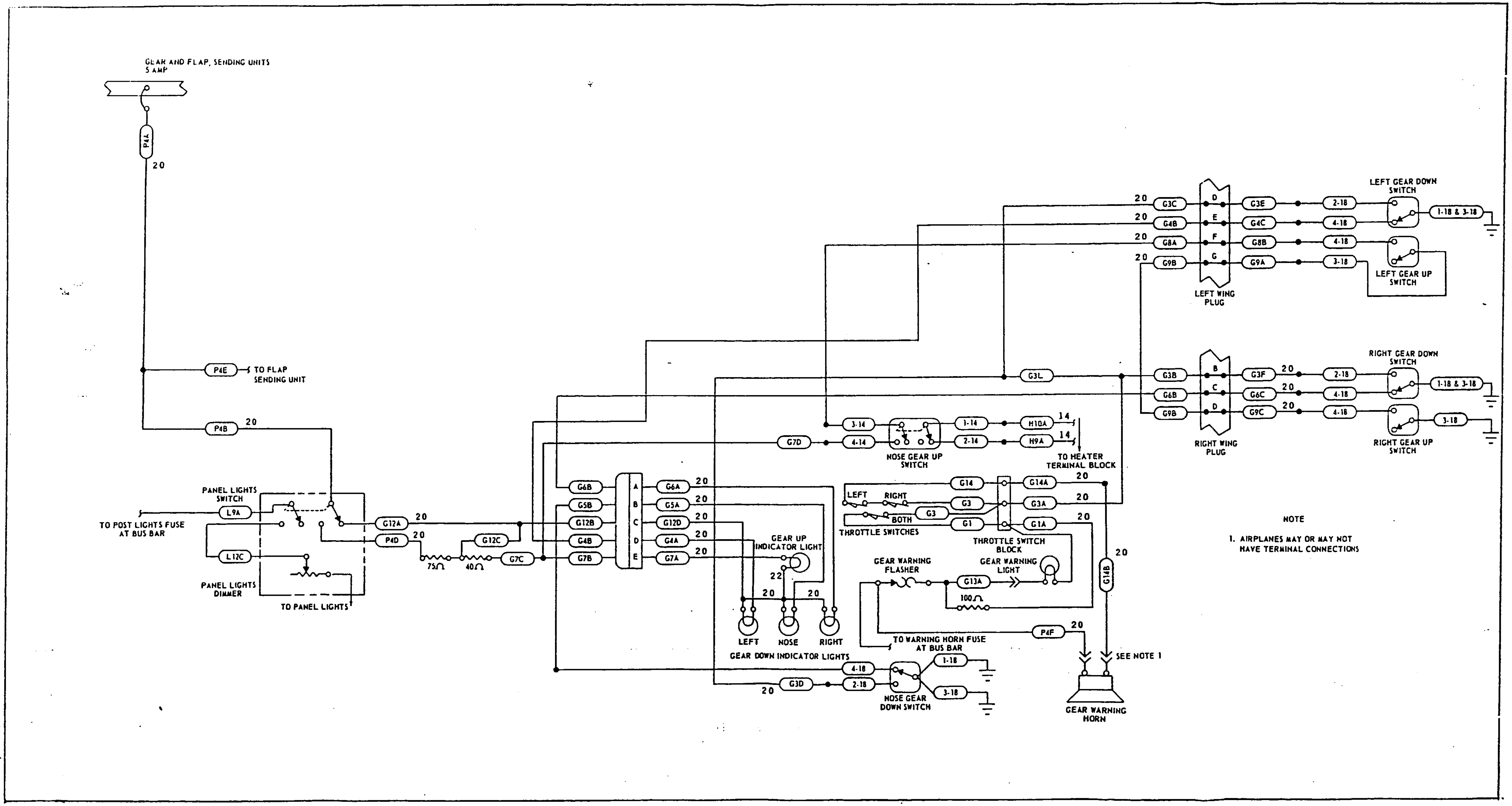
Figure 11-125. Landing Gear and Flap System Schematic (14-volt and 28-volt), PA-23-250 (six place), Serial Nos. 27-2000 to 27-2504 incl.



31347-D, 32132-H

Figure 11-126. Landing Gear and Flap System Schematic, PA-23-250 (six place), Serial Nos. 27-2505 to 27-3836 incl. and 27-2838 to 27-3943 incl.

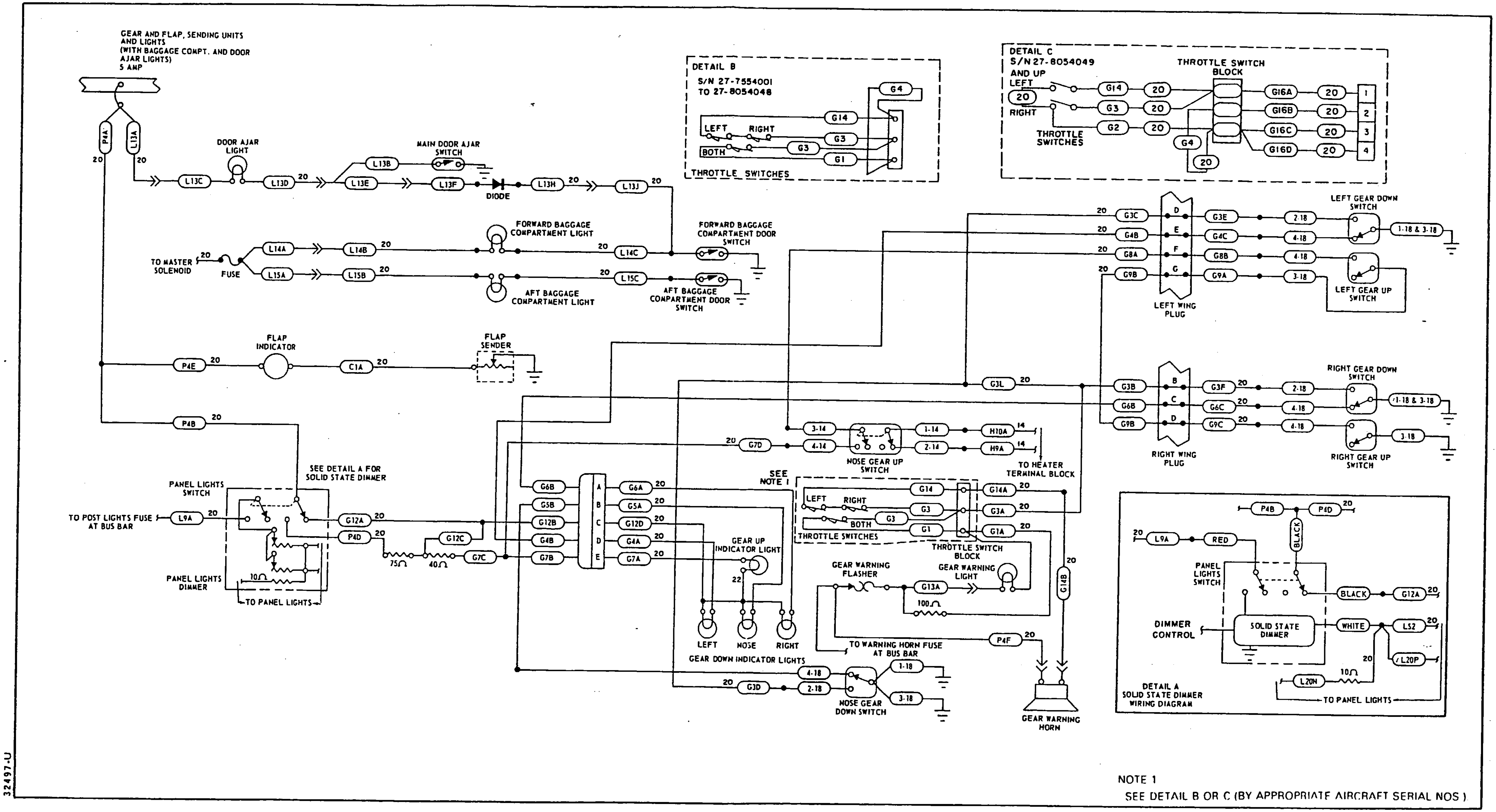


Figure 11-127. Landing Gear and Flap System Schematic, PA-23-250 (six place), Serial Nos. 27-3837, 27-3944 to 27-7554172 incl.

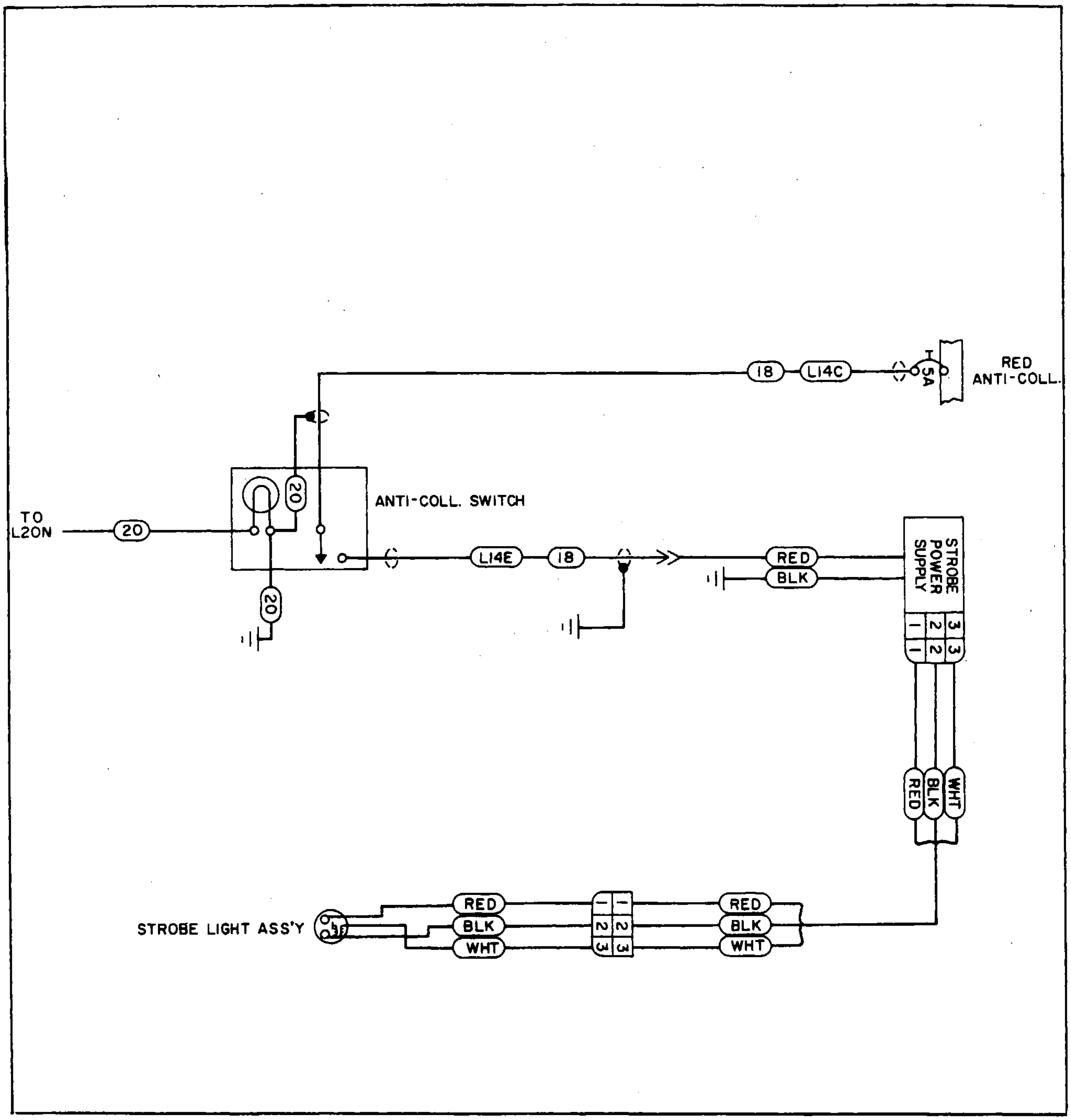


Figure 11-128. Red Anti-Collision Strobe Light (Optional)

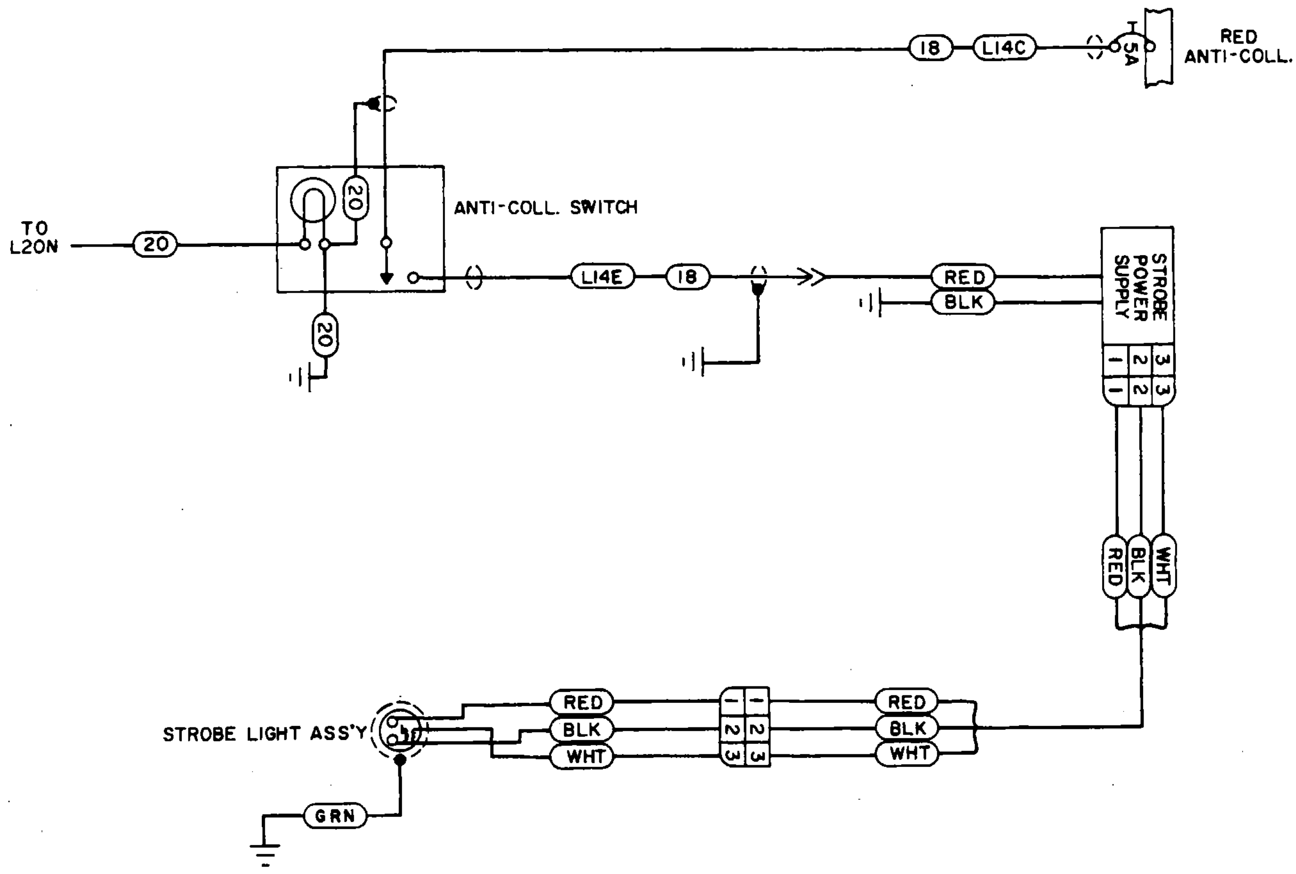
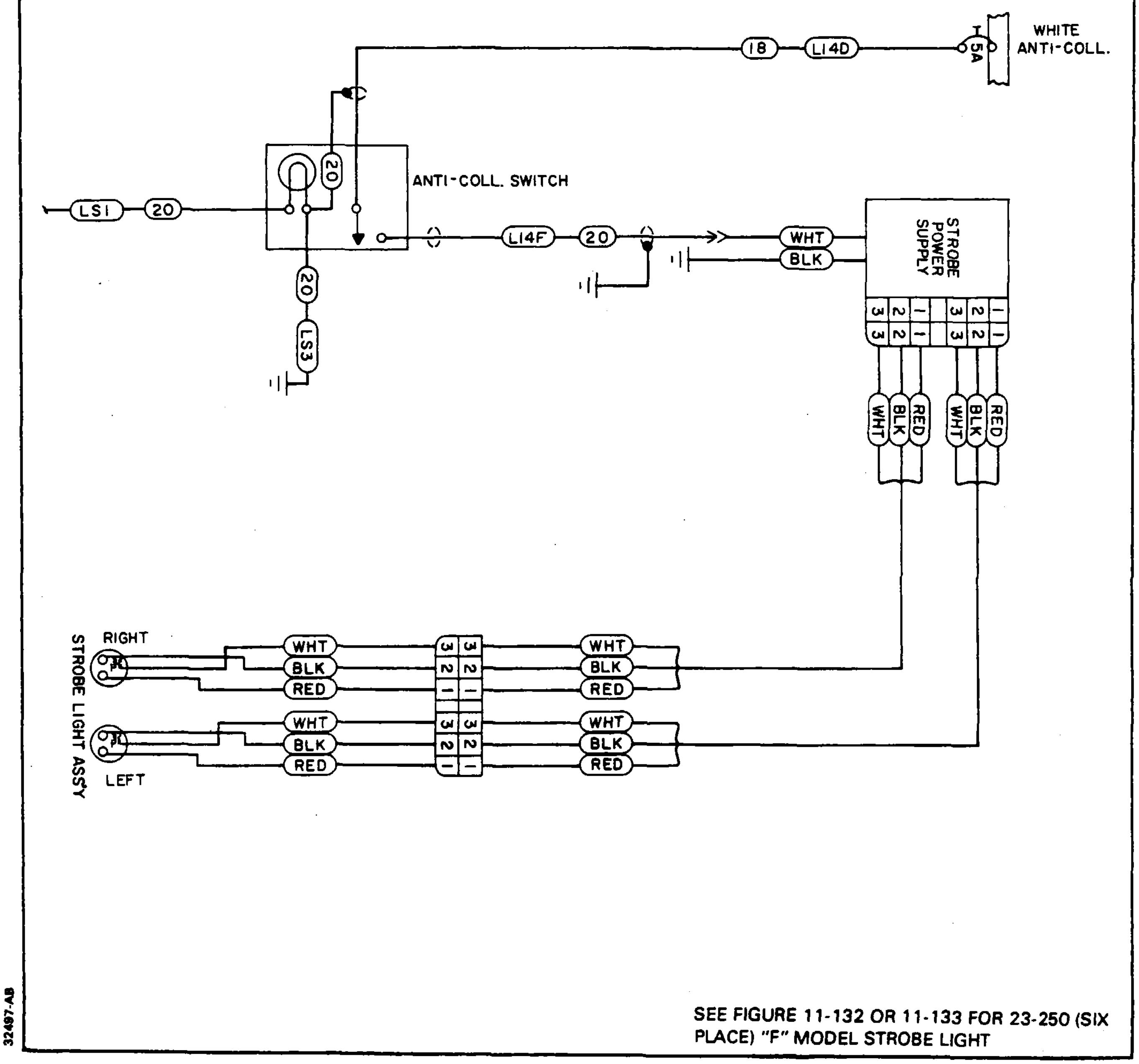


Figure 11-129. Red Anti-Collision Strobe Light (Optional)



SEE FIGURE 11-132 OR 11-133 FOR 23-250 (SIX PLACE) "F" MODEL STROBE LIGHT

Figure 11-130. White Anti-Collision Strobe Light

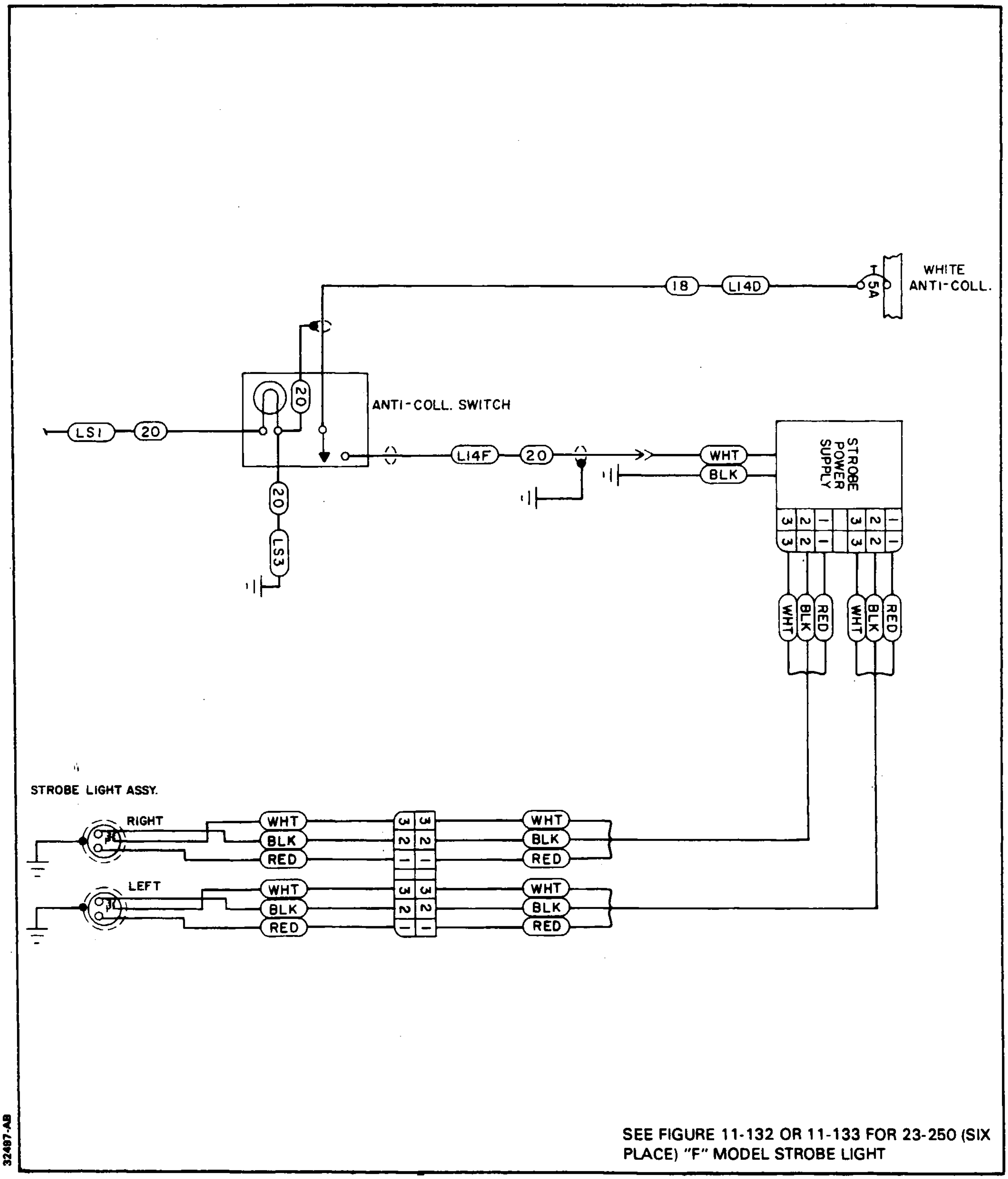


Figure 11-131. White Anti-Collision Strobe Light

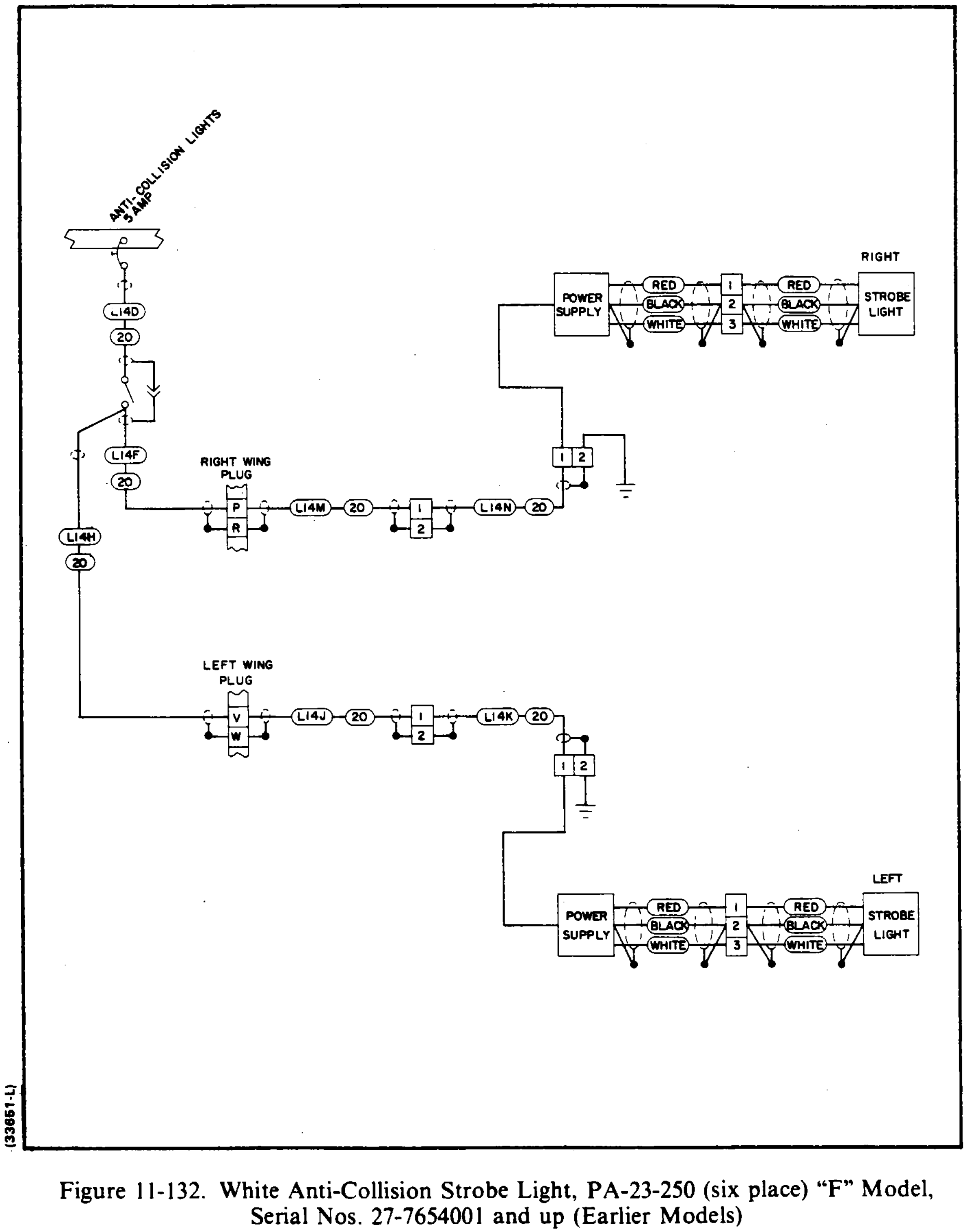


Figure 11-132. White Anti-Collision Strobe Light, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

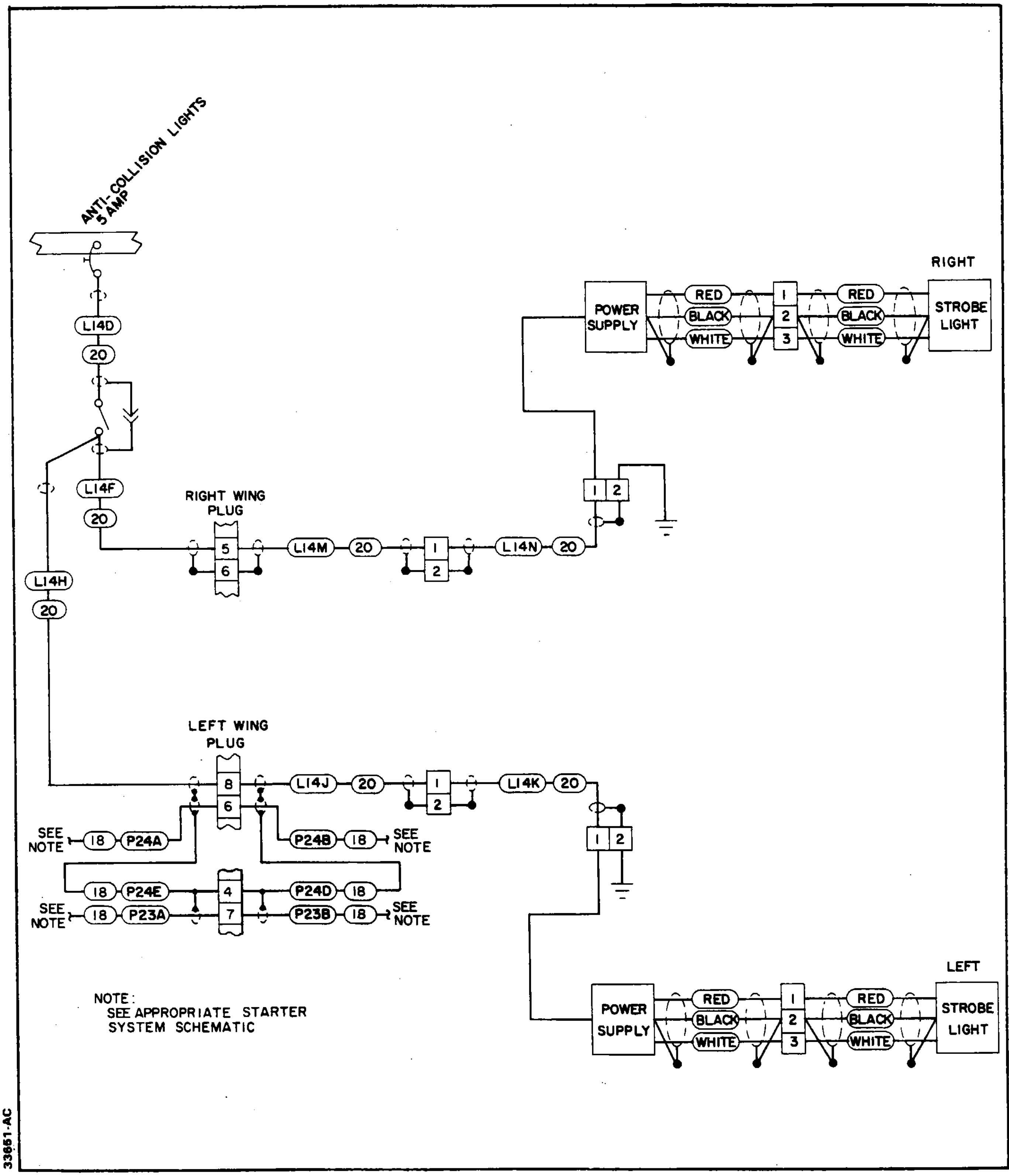


Figure 11-133. White Anti-Collision Strobe Light, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)

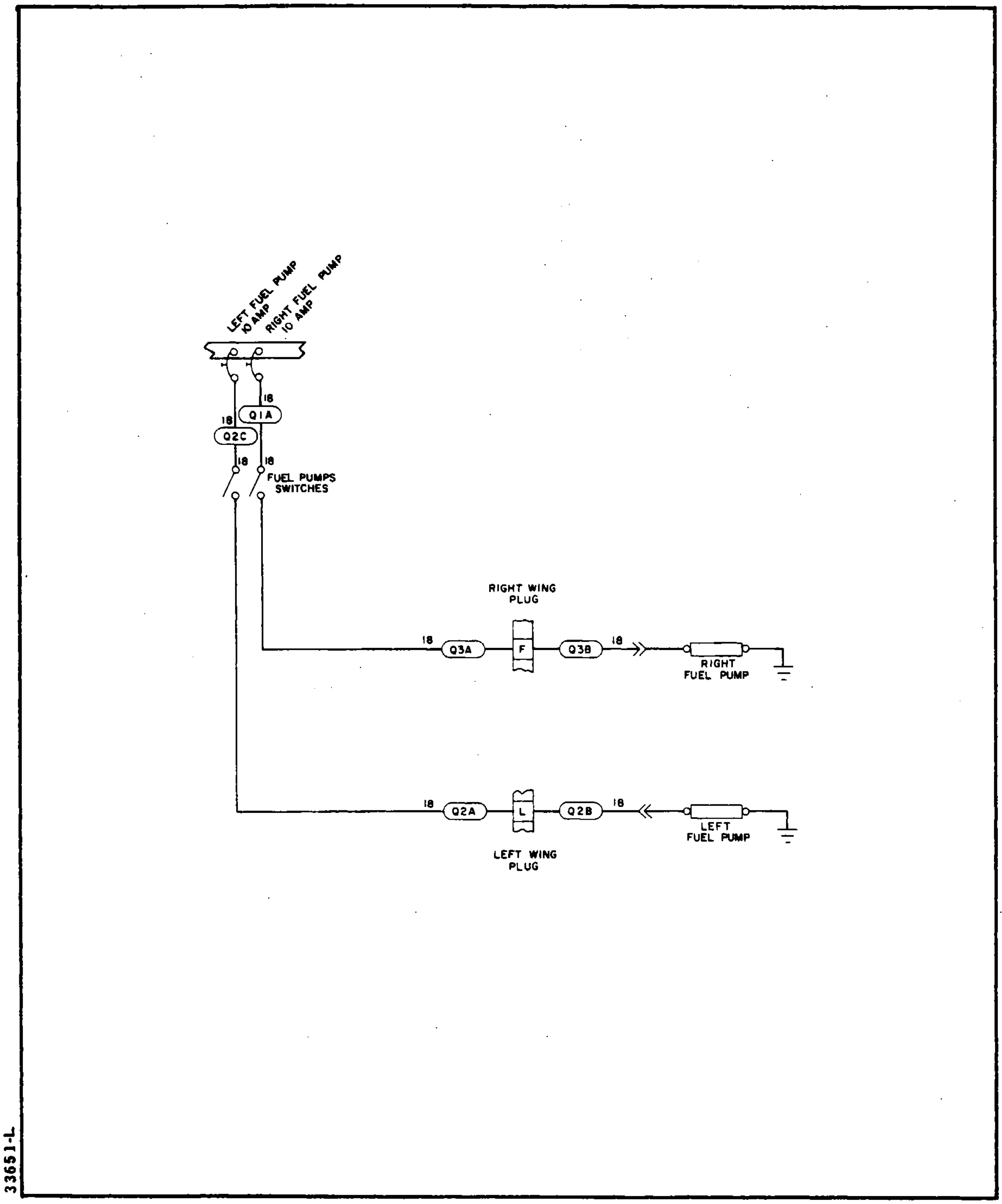


Figure 11-134. Fuel Pumps Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

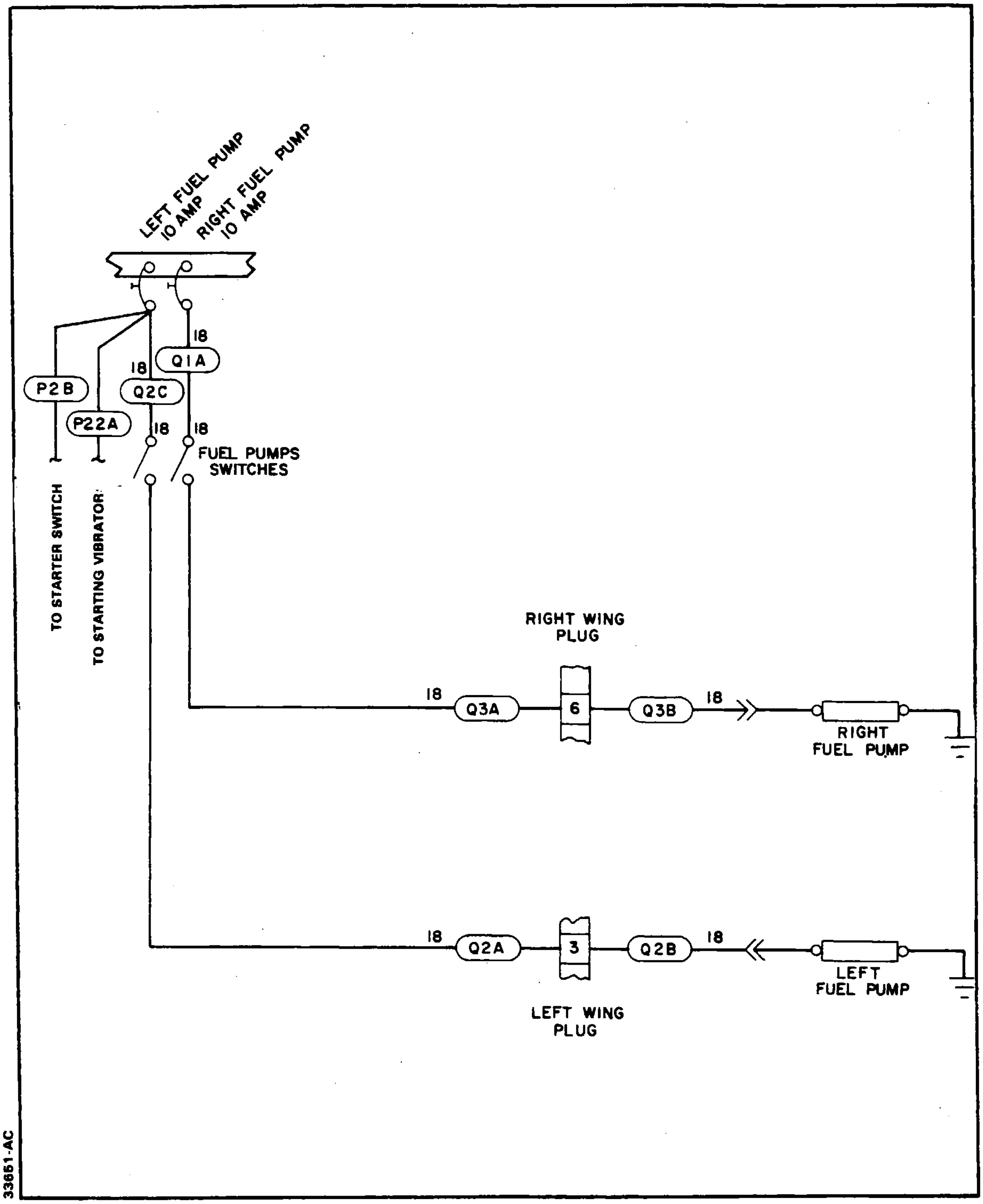


Figure 11-135. Fuel Pumps Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)

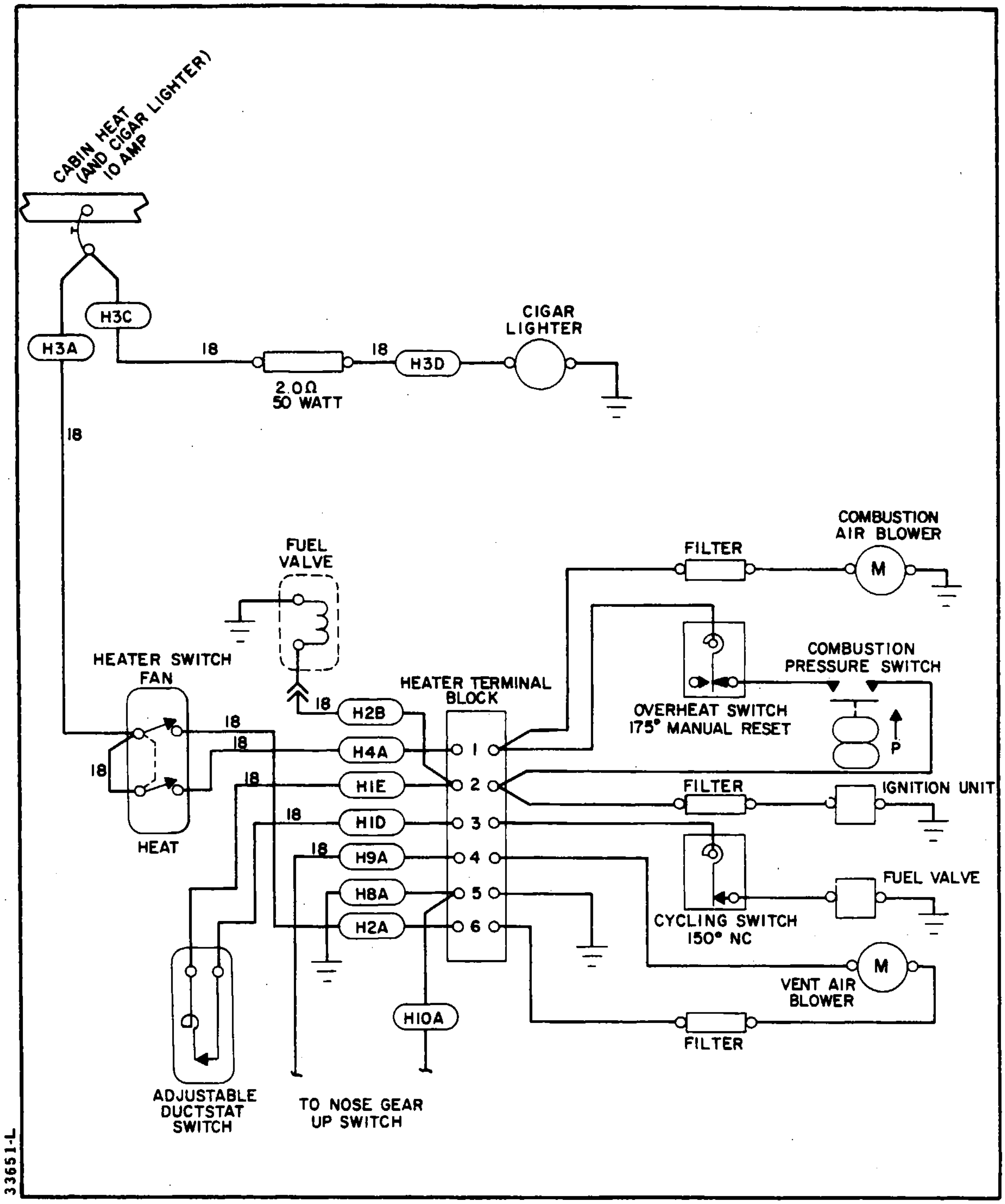


Figure 11-136. Heater and Cigar Lighter Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

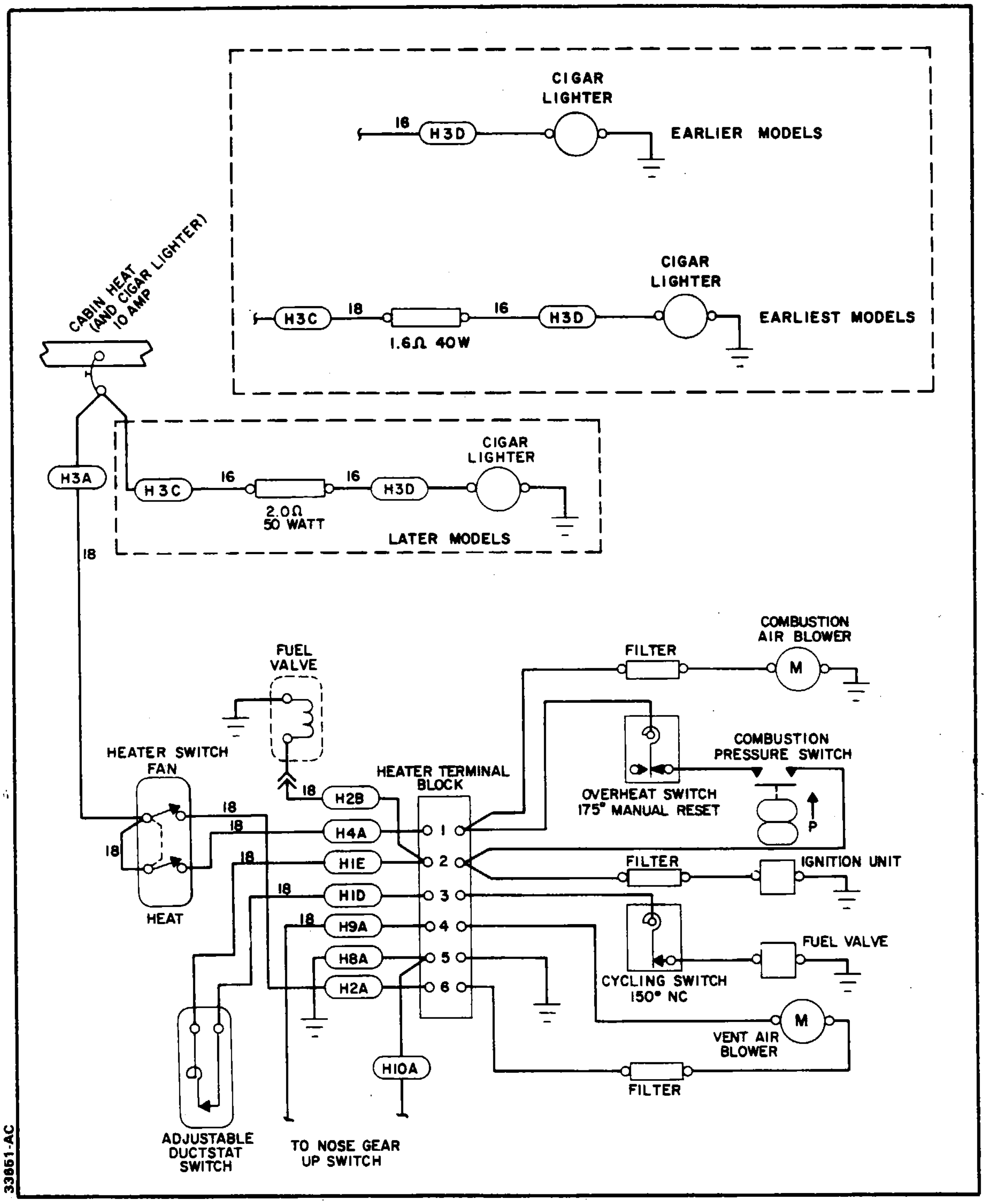


Figure 11-137. Heater and Cigar Lighter Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

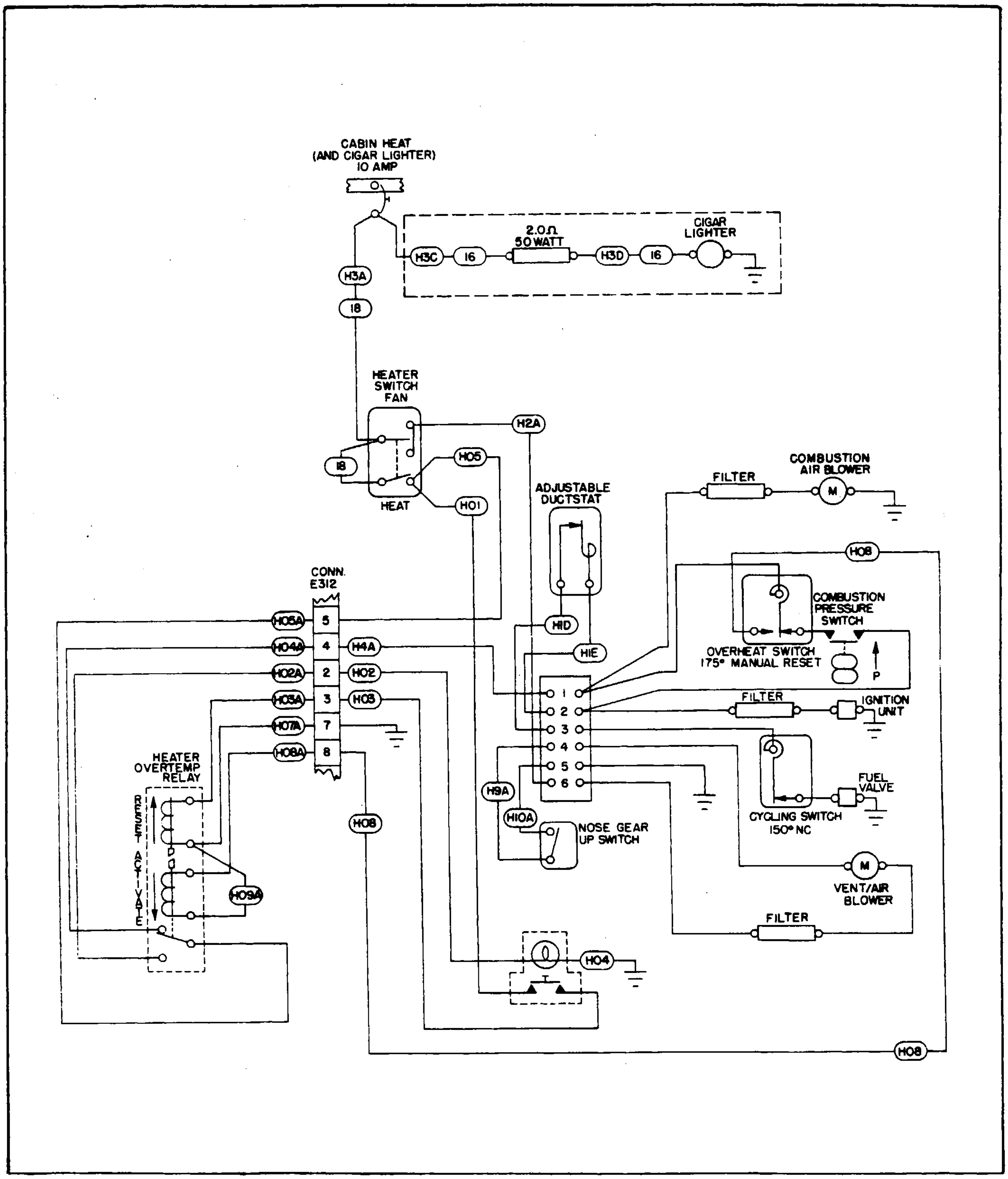


Figure 11-138. Heater with Reset and Cigar Lighter, PA-23-250 (six place) "F" Model, Serial Nos. 27-8154001 and up

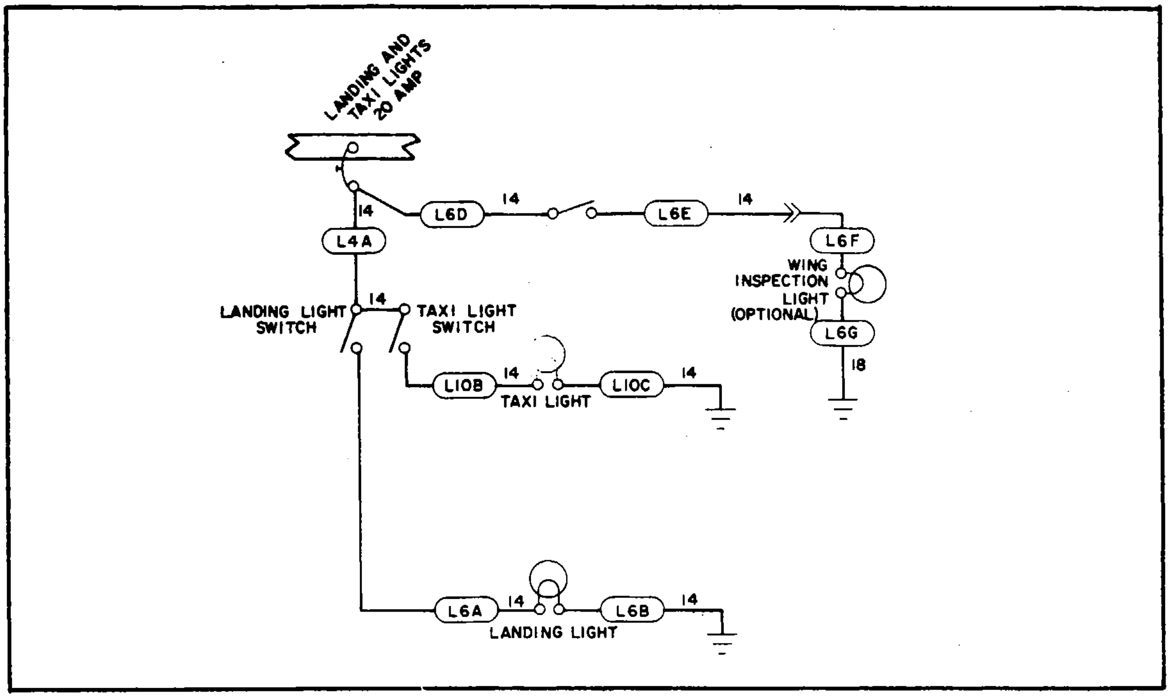


Figure 11-139. Landing and Taxi Lights, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

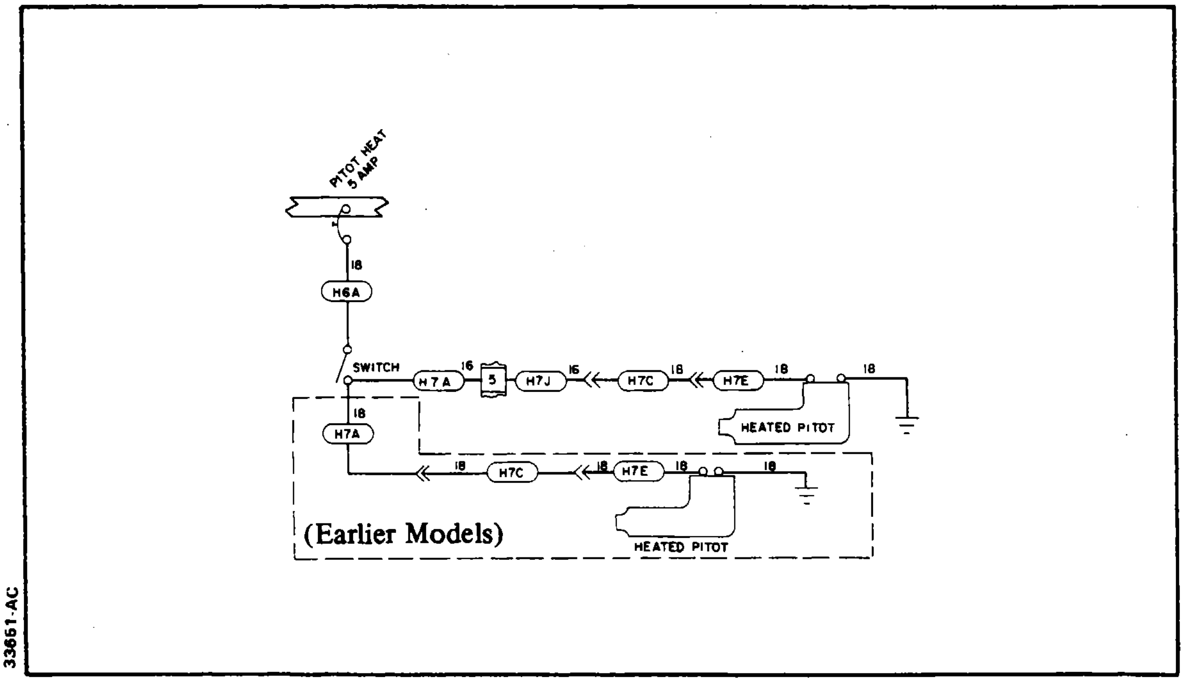


Figure 11-140. Pitot Heat Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

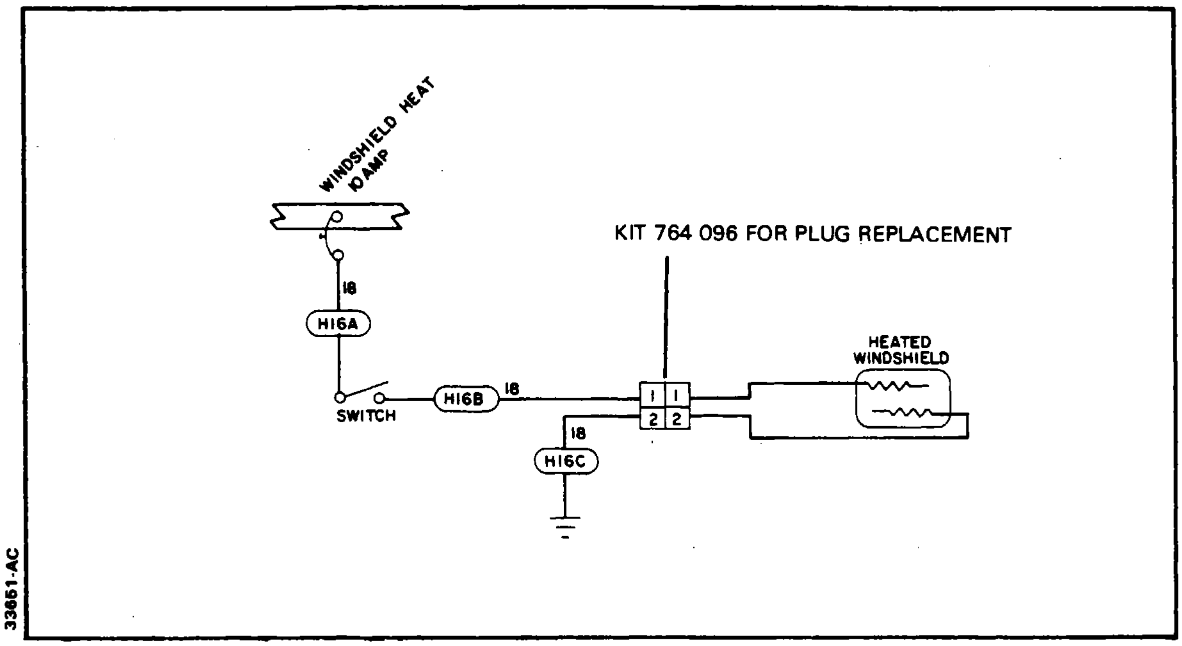


Figure 11-141. Heated Windshield Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

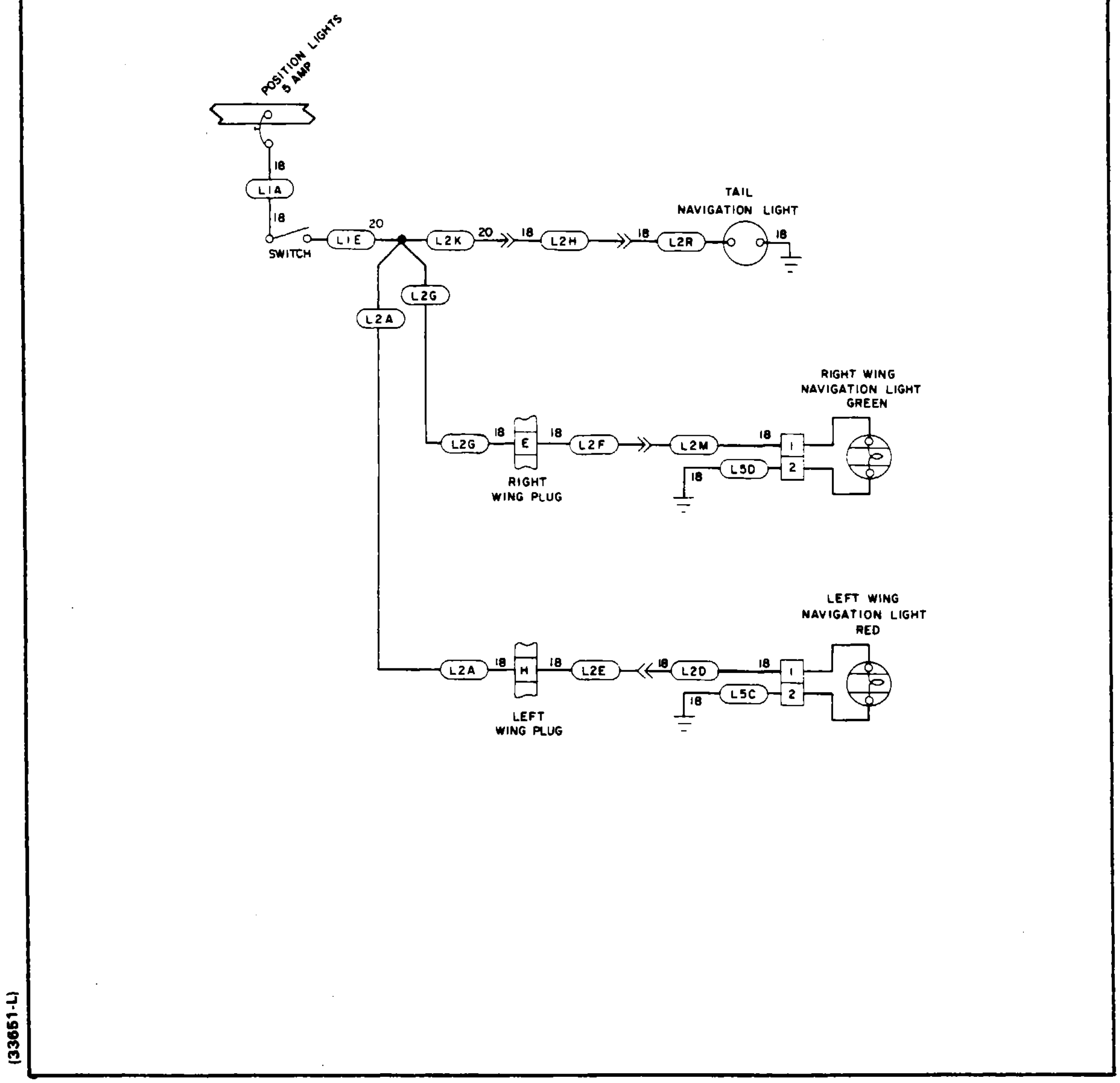


Figure 11-142. Position Lights Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

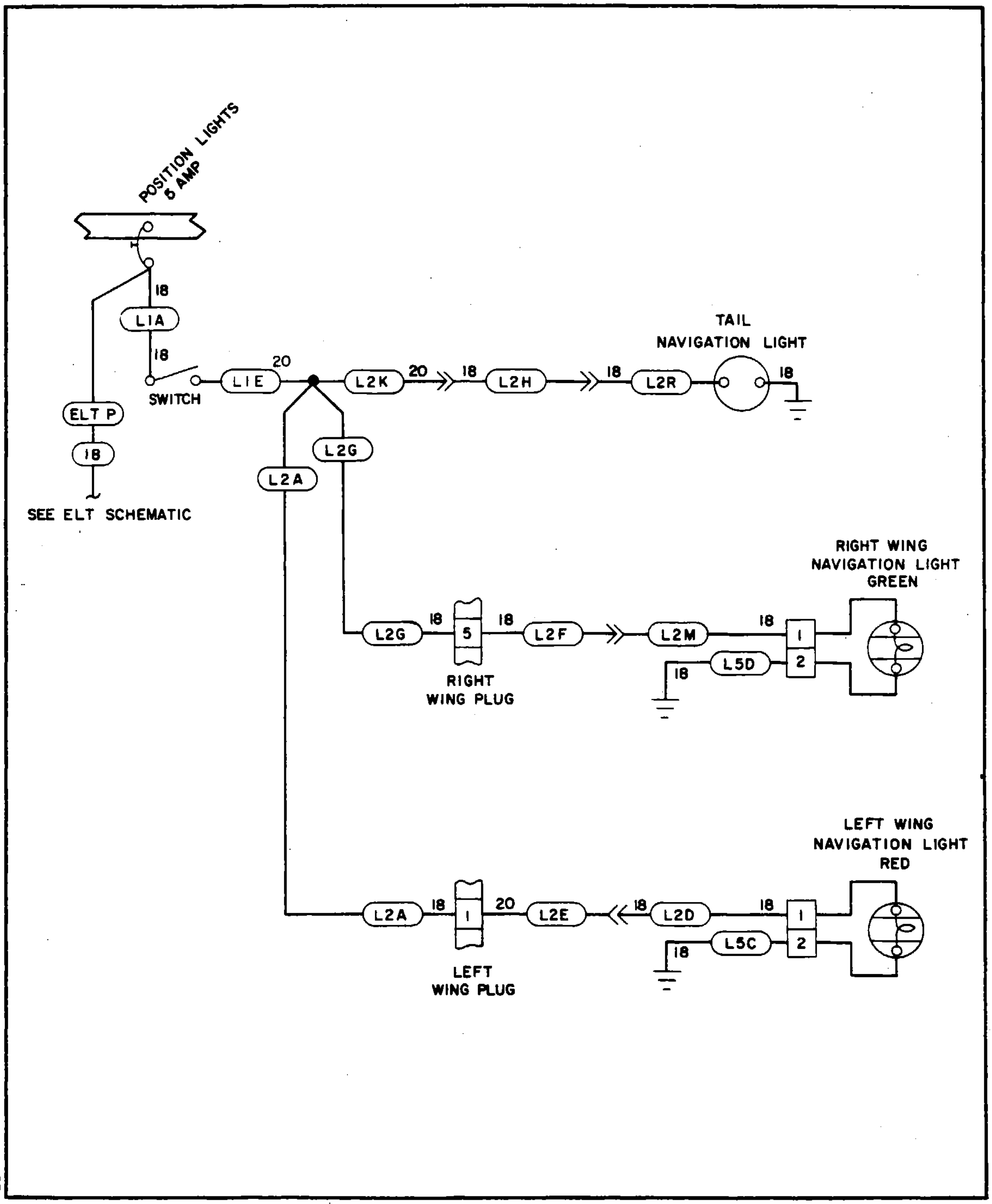


Figure 11-143. Position Lights Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)

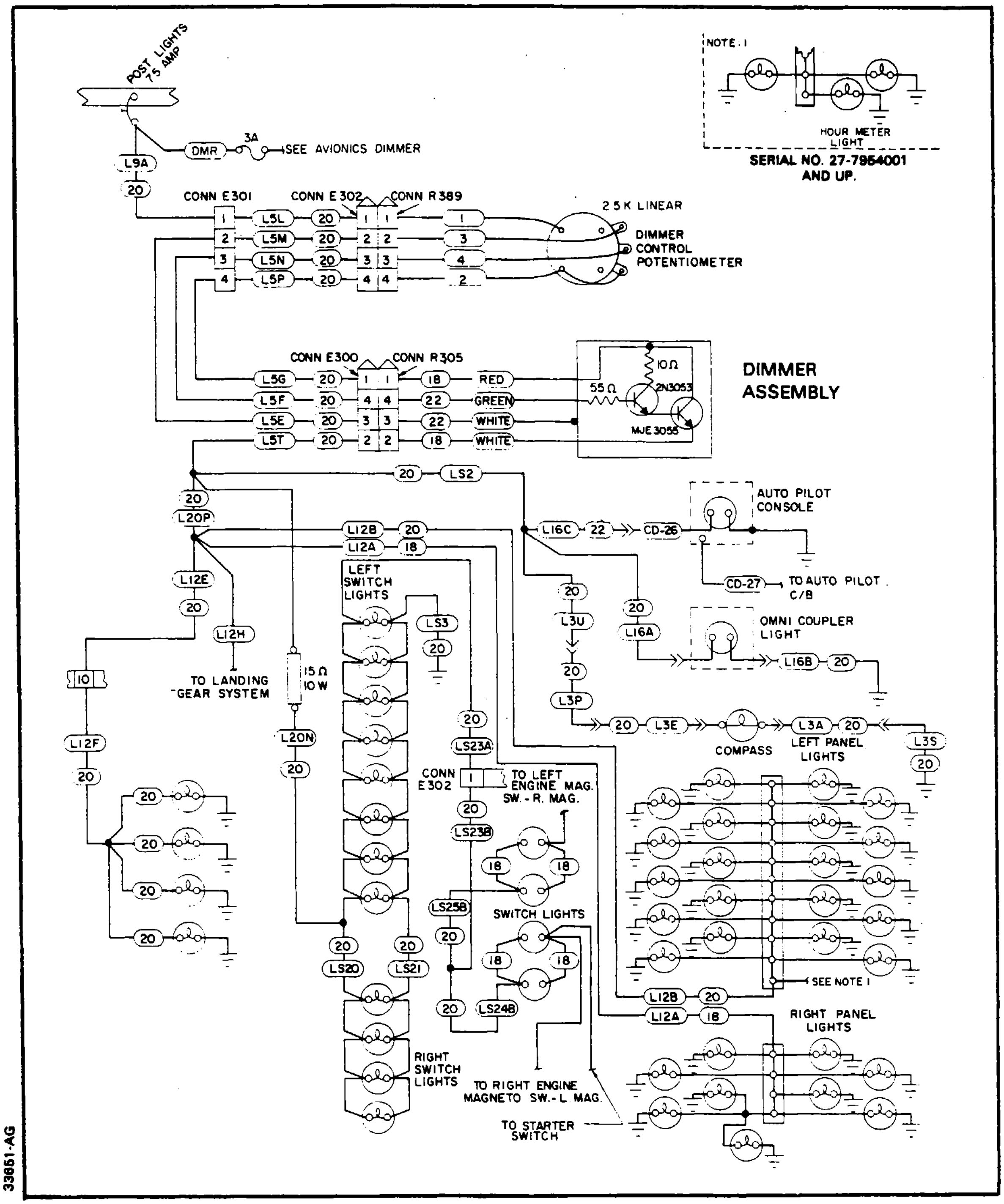


Figure 11-144. Post Lights Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

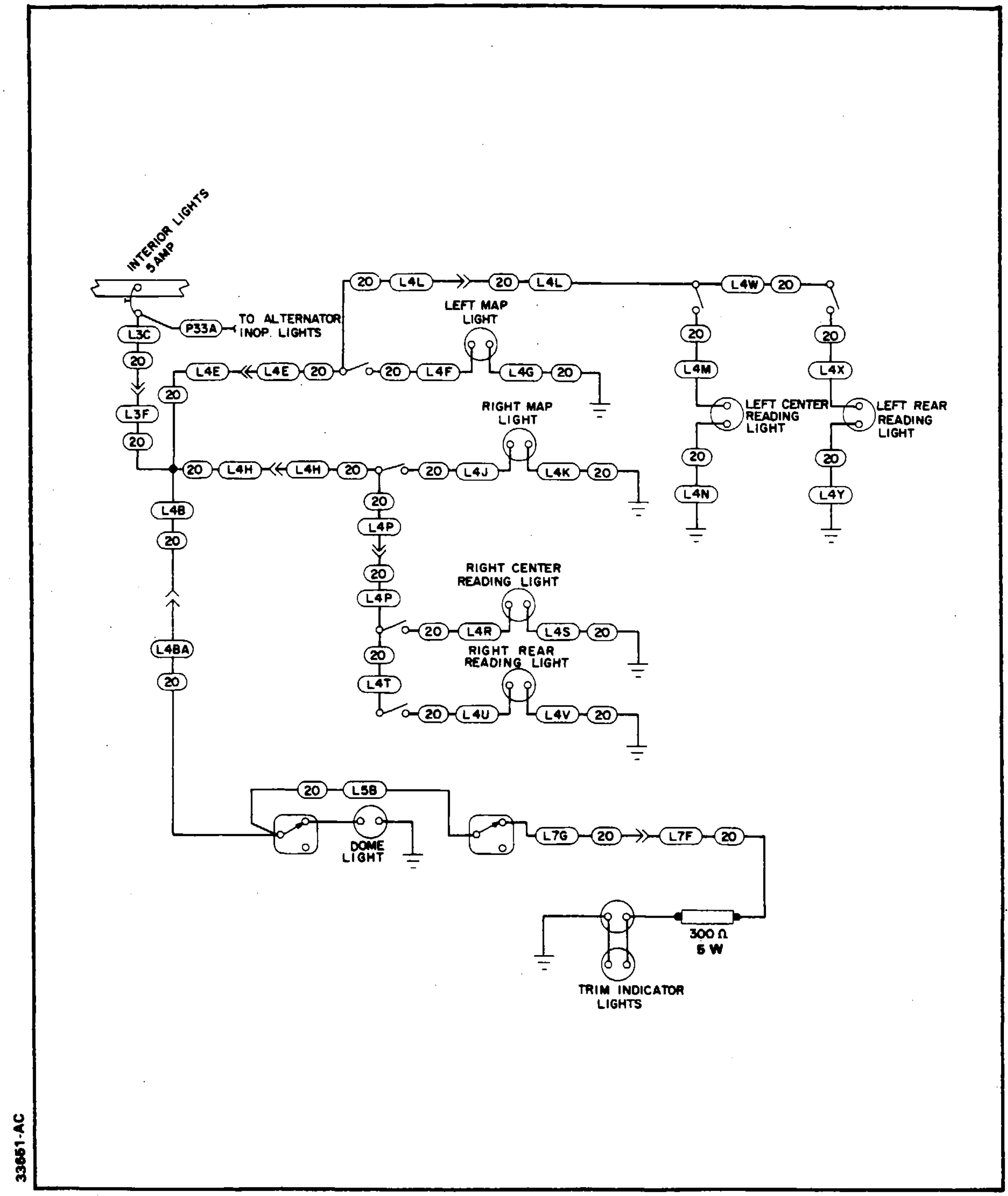


Figure 11-145. Interior Lights Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 to 27-7954121 incl.

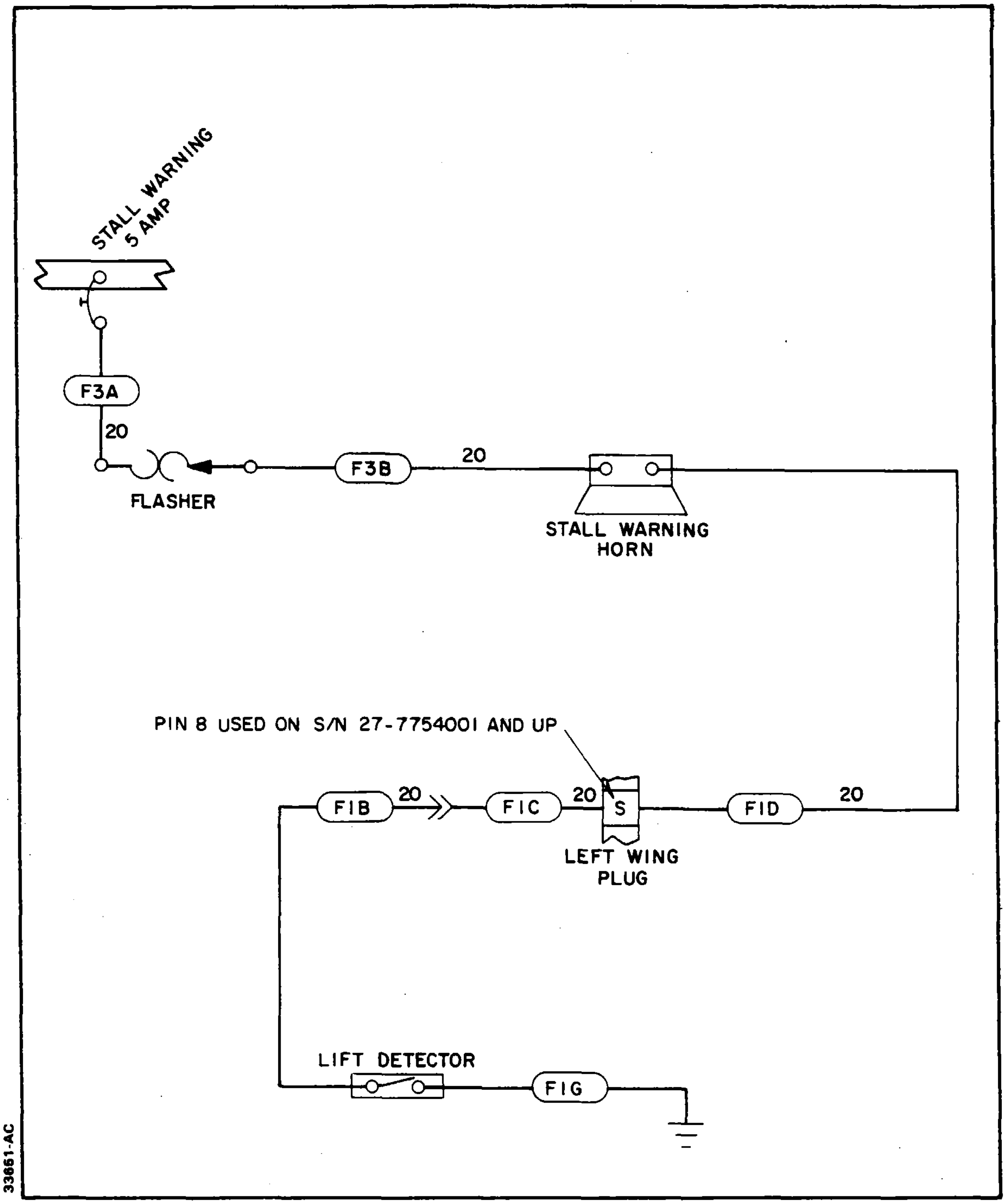


Figure 11-146. Stall Warning Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

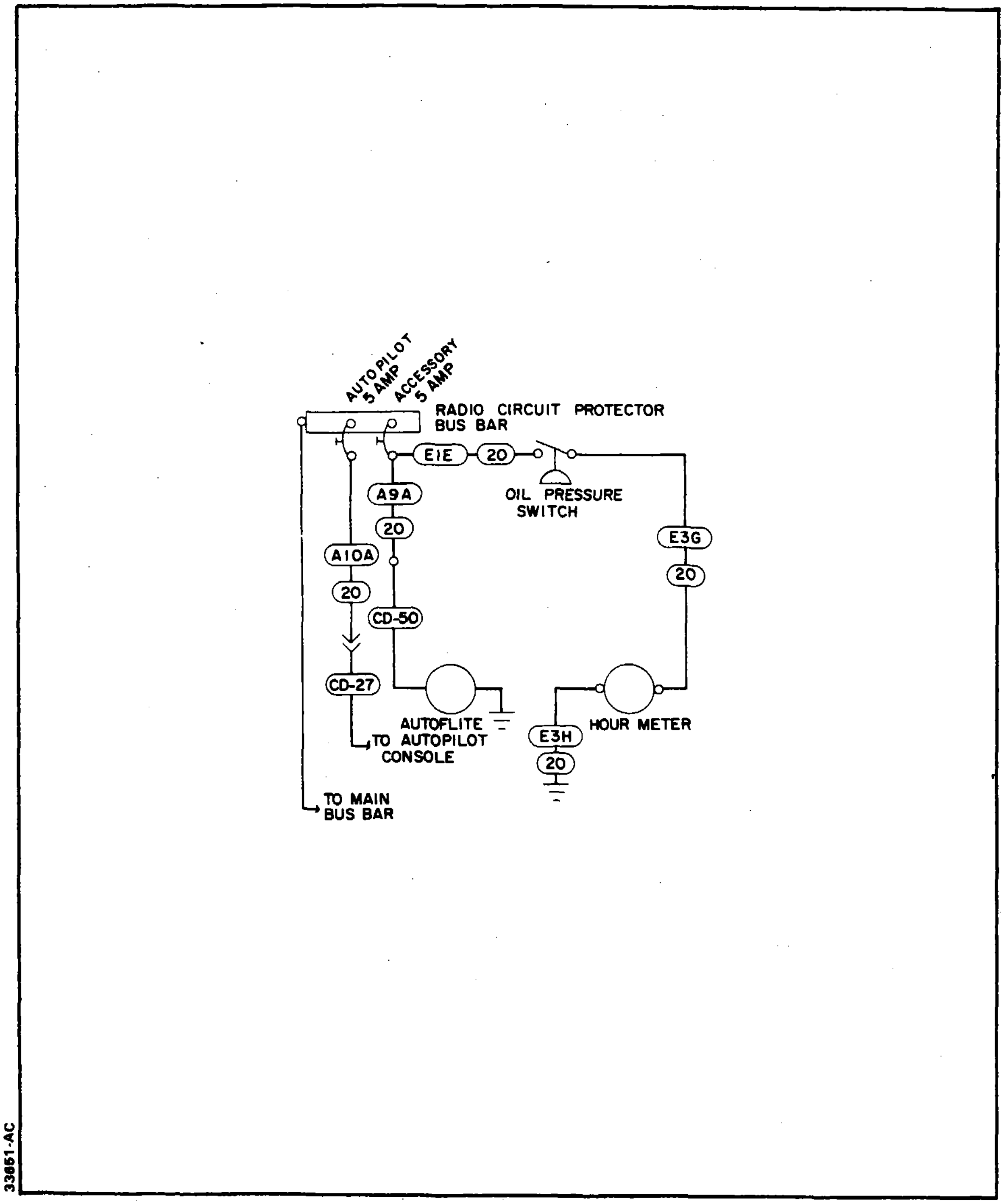


Figure 11-147. Accessory and AutoPilot Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up

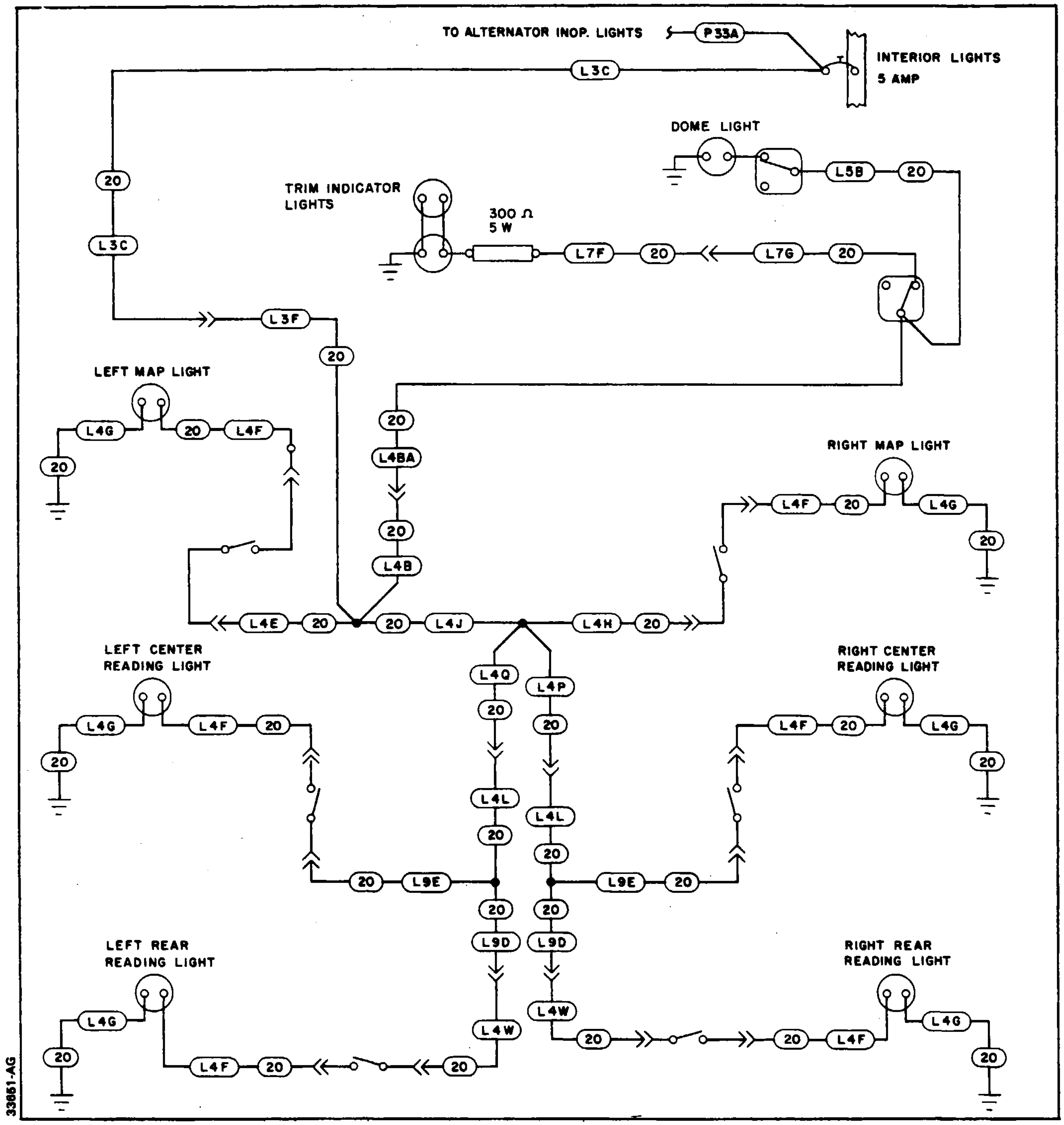
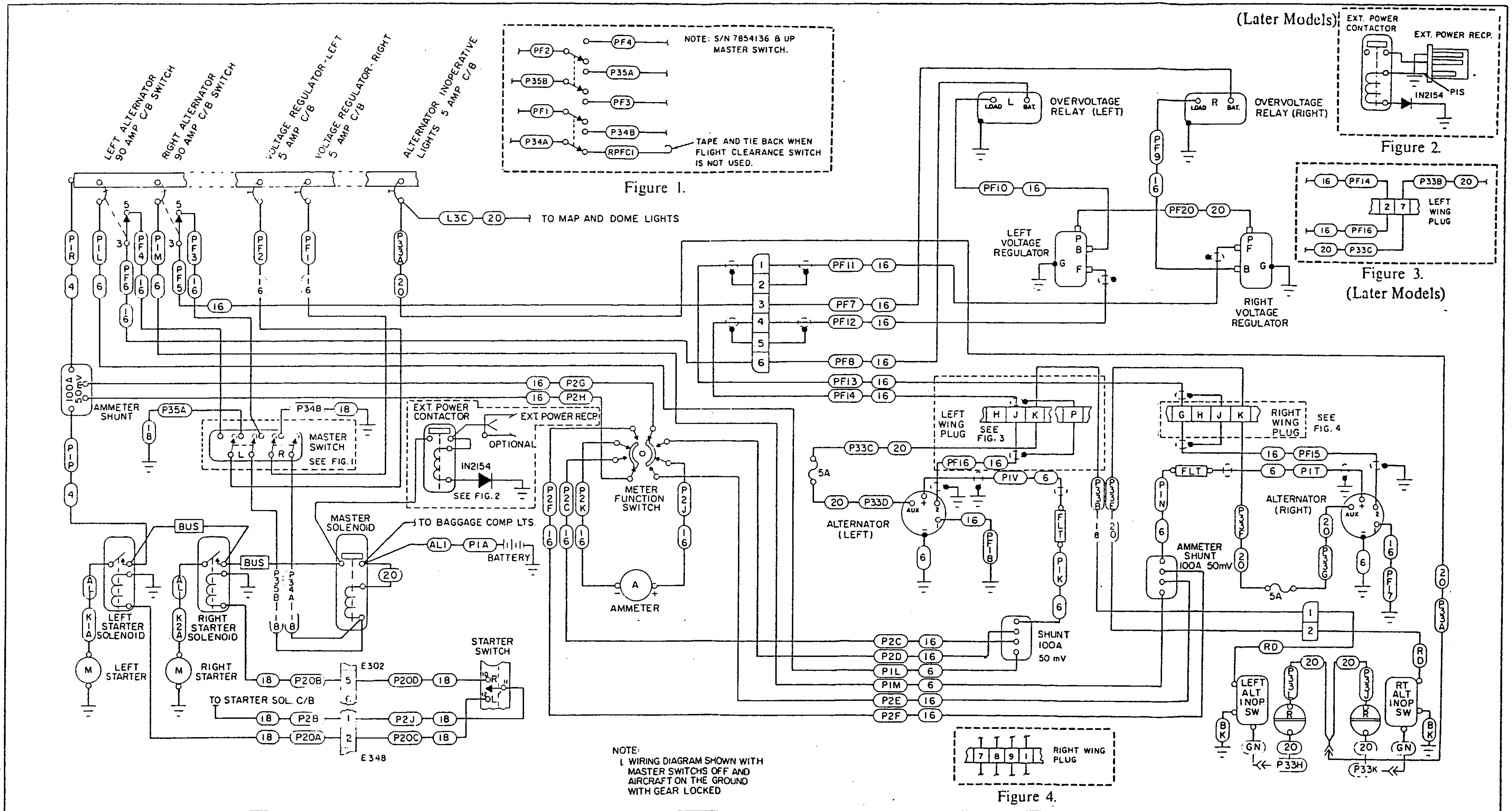


Figure 11-148. Interior Lights Schematic, PA-23-250 (six place)
Serial Nos. 27-8054001 and up



(33651-L)

Figure 11-149. Alternator Paralleling System (Prestolite), PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

INTENTIONALLY
LEFT
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INTENTIONALLY
LEFT
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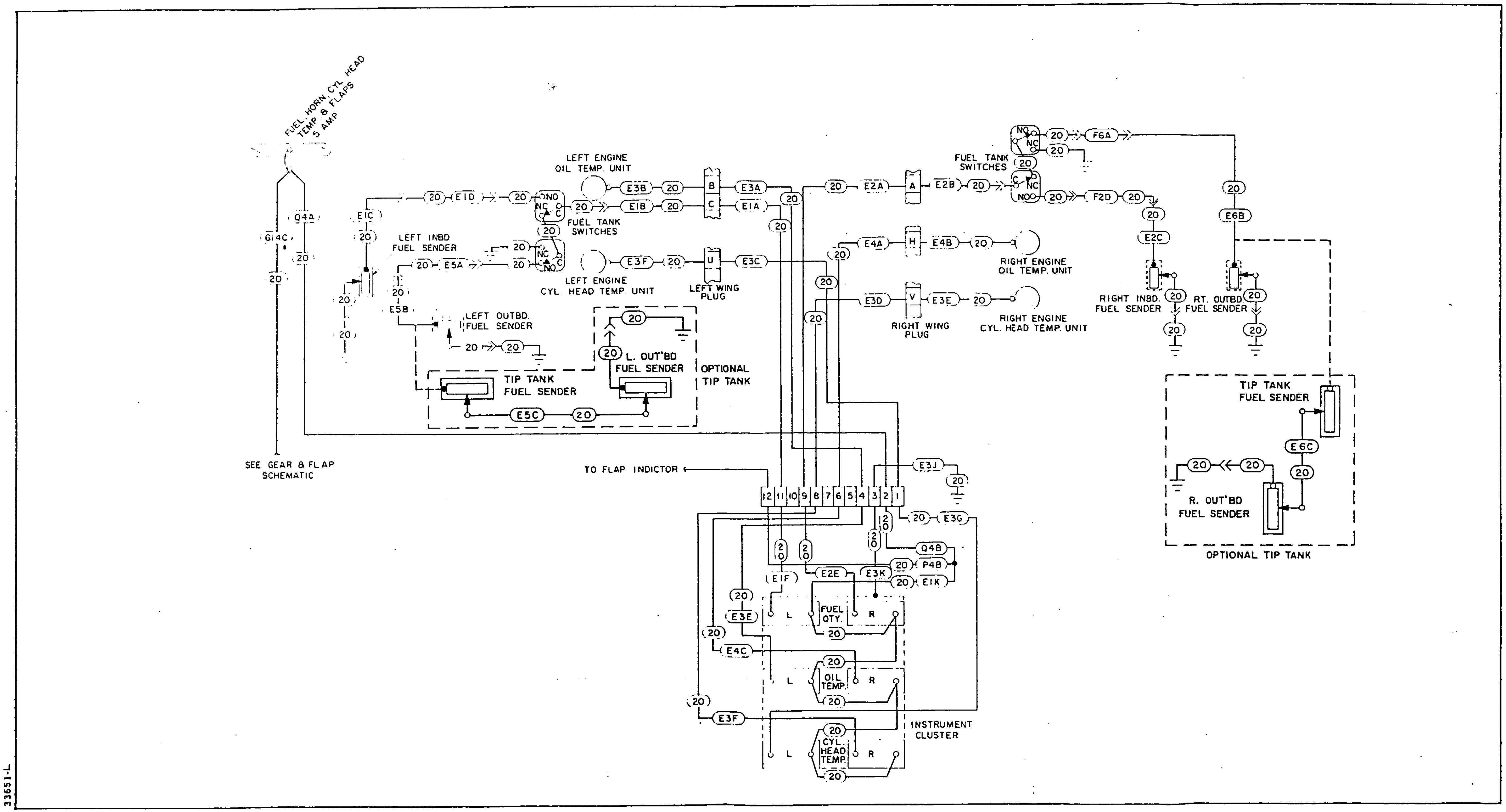

Figure 11-150. Instrument Cluster Wiring Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

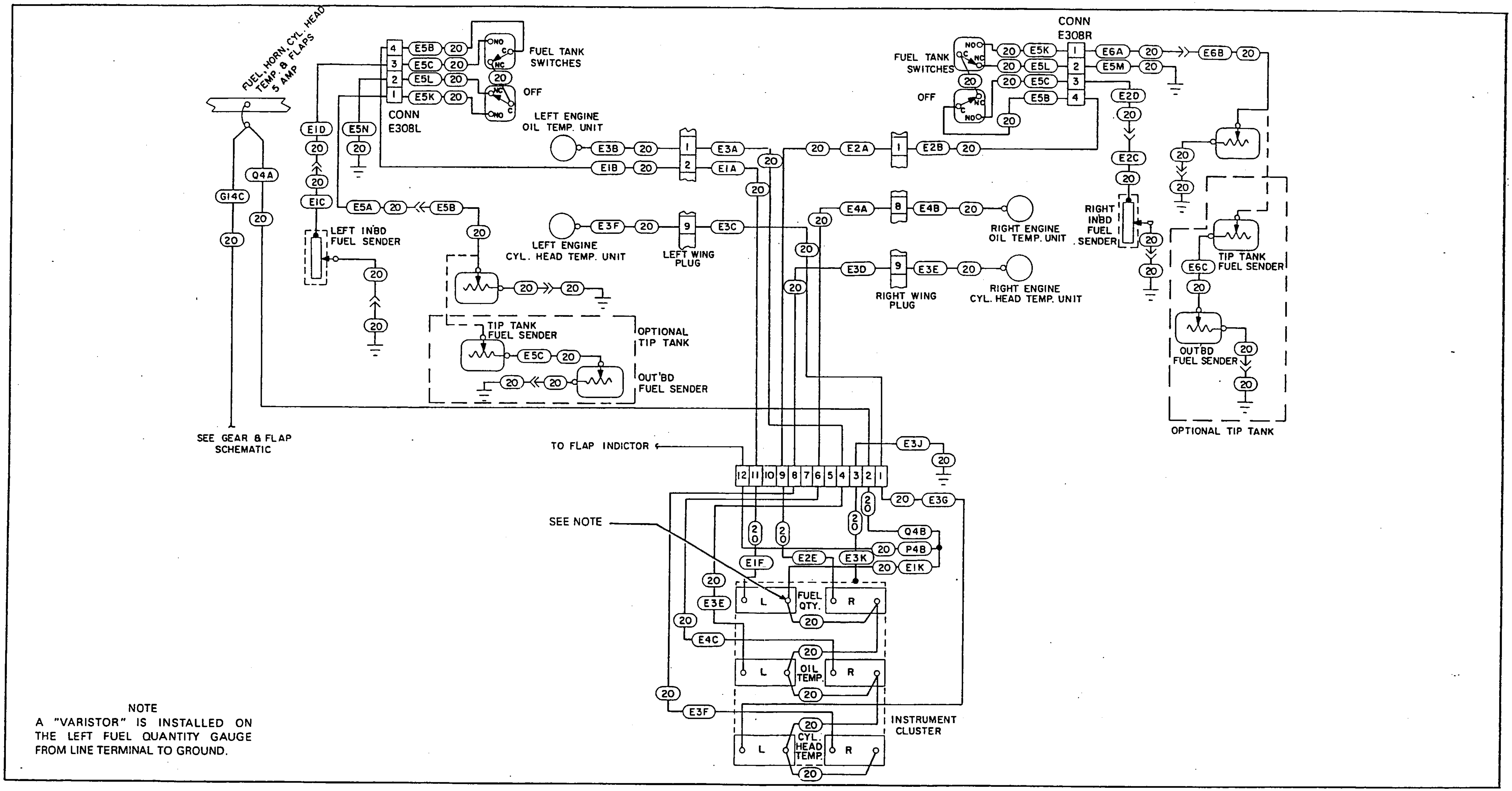

Figure 11-151. Instrument Cluster Wiring Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)

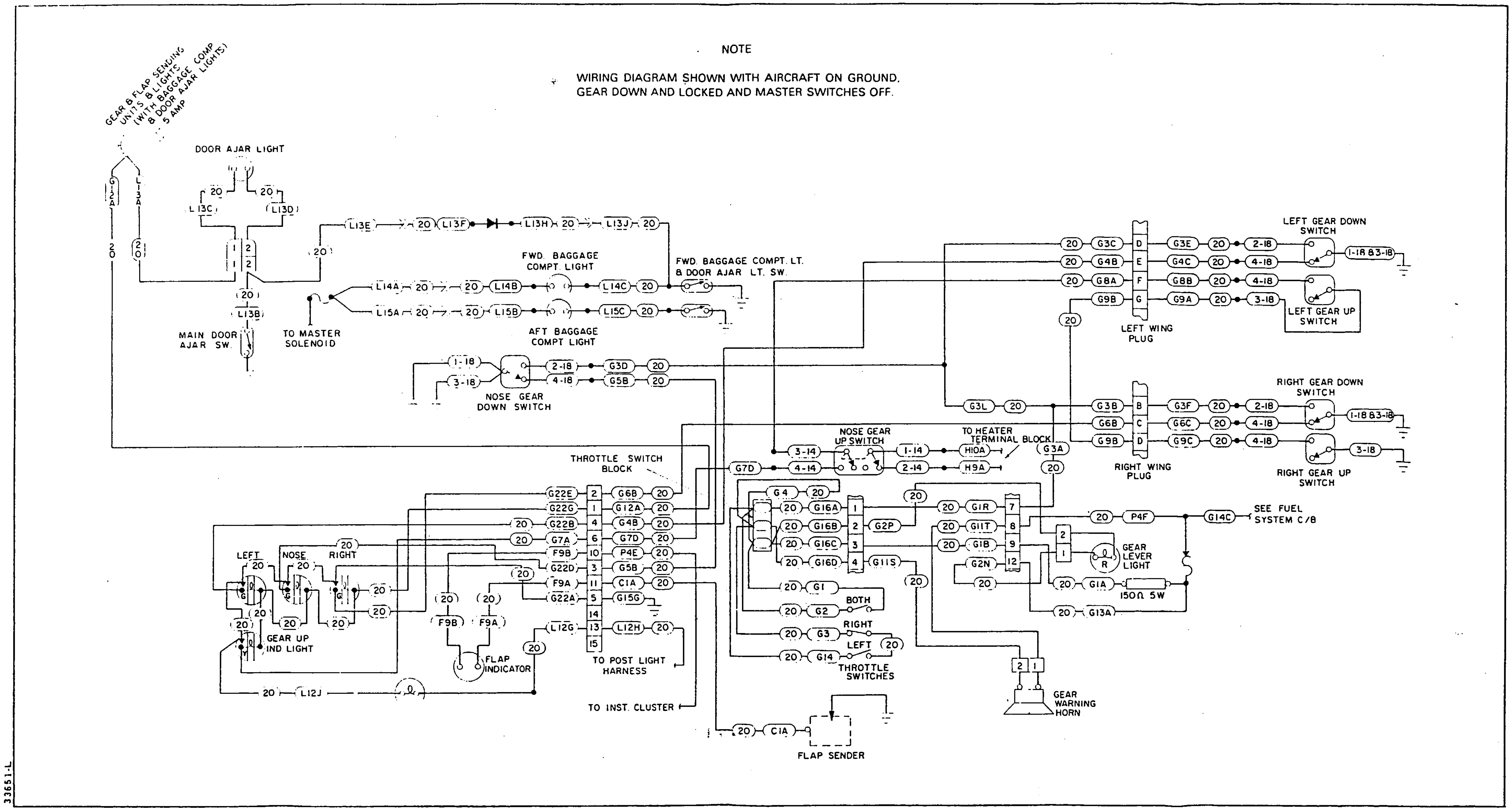

Figure 11-152. Landing Gear and Flap System Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Earlier Models)

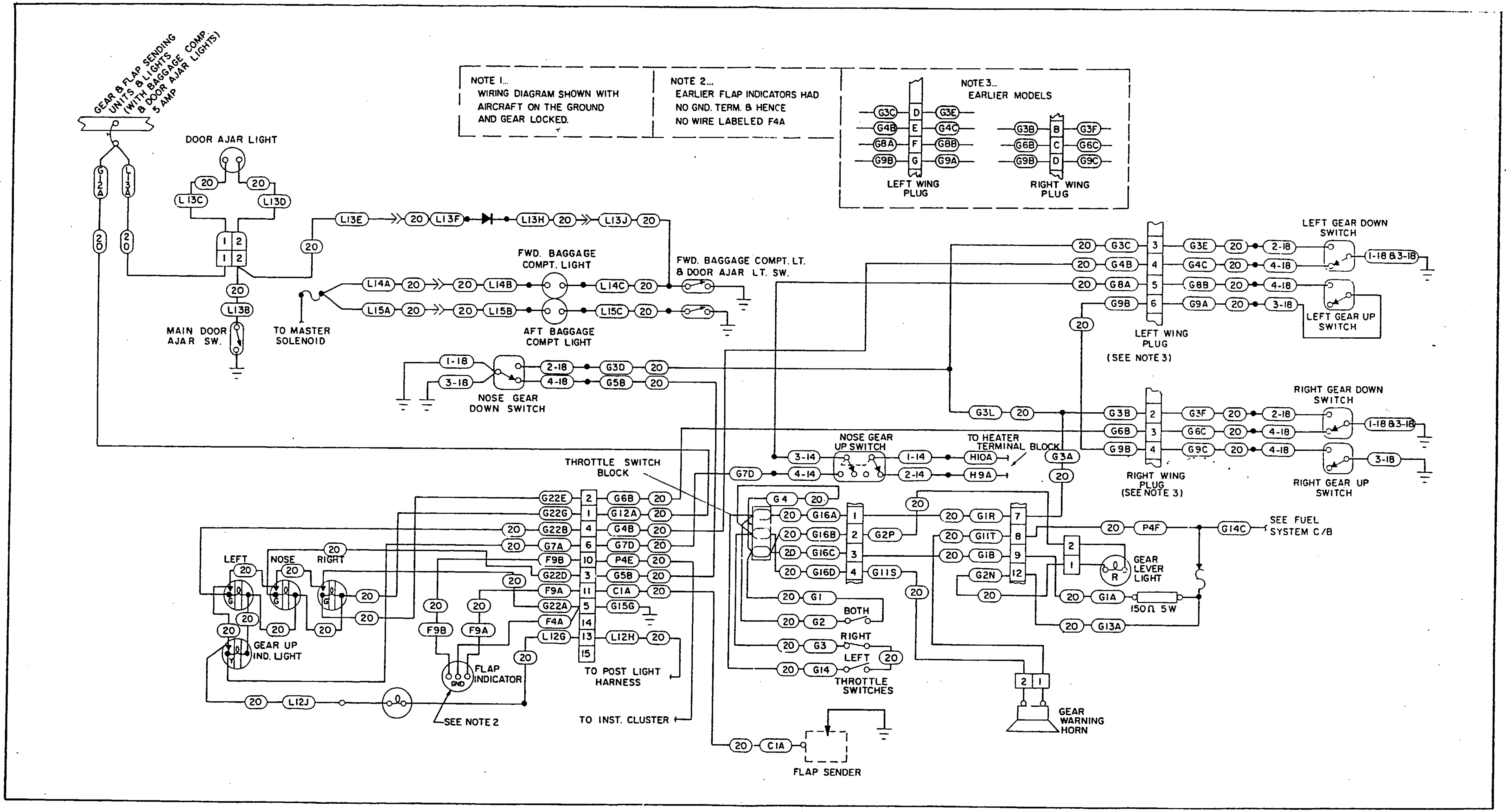

Figure 11-153. Landing Gear and Flap System Schematic, PA-23-250 (six place) "F" Model, Serial Nos. 27-7654001 and up (Later Models)