CHAPTER 5

ELECTRICAL POWER SYSTEMS

TABLE OF CONTENTS

ILLUSTRATIONS

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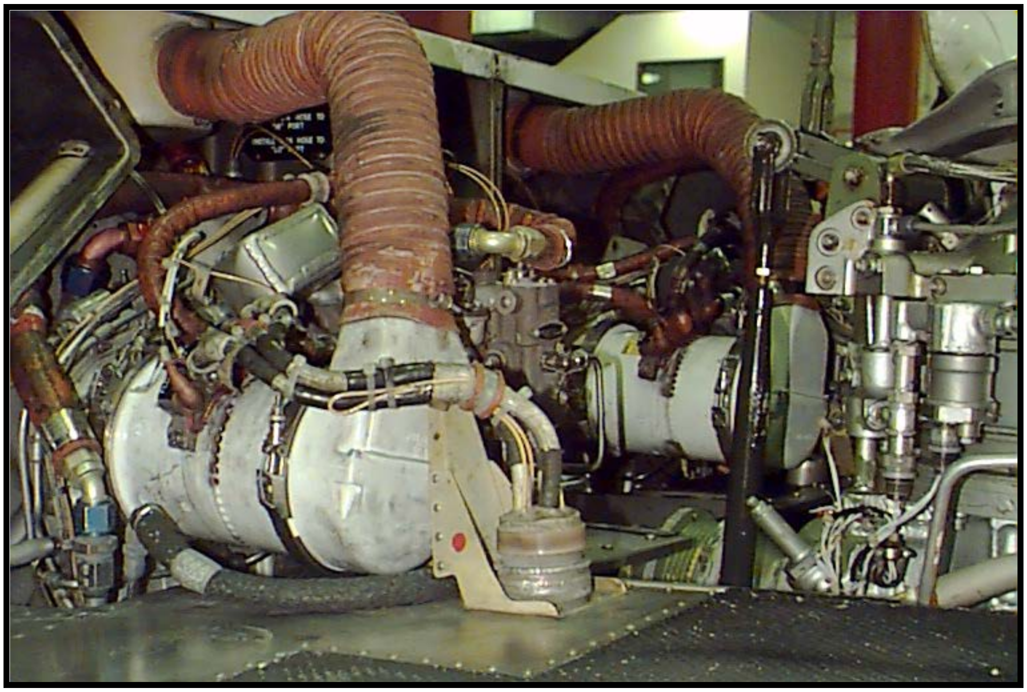
CHAPTER 5

ELECTRICAL POWER SYSTEMS



INTRODUCTION

There are two basic versions of the Bell 212 electrical system, those with serial numbers 30504 through 30553 and those 30554 and subsequent. Campbell aircraft are typically 30554 and subsequent. Focus will therefore concentrate on aircraft 30554 and subsequent.

GENERAL

The helicopter electrical power supply systems provide DC (5, 24 and 28 VDC) and AC (26 and 115 VAC) power for operation of all electrical equipment.

During ground operations, external DC power and internal AC power can be used to supply electrical power.

The electrical systems are controlled by switches, relays, and sensors. Power distribution is accomplished through electrical buses, circuit breakers, and single-wire conductors to each system. The airframe serves as a ground.

Electrical system indications include dual voltmeters for both AC and DC systems, an ammeter to indicate each generator's electrical load, and warning and caution lights to alert the pilot of malfunctions.

DC POWER

GENERAL

28 volts DC is the primary electrical power for the helicopter. DC power is provided by either the 24 volt Ni-Cad battery or by an external power source, when the engines are not operating.

During powerplant operation, 28 volts DC power is furnished by two 200 ampere starter-generator units, one mounted on the accessory gearbox of each power section. In the Bell 212 the generator load is red lined at 150 Amps except during the start.

One Battery bus, two main buses, No.1 and No.2, two essential buses, No.1 and No.2, and two non-essential buses are normally powered by both generators in parallel operation. There is no way to disconnect the one non-essential buss from the other in effect making one buss out of the two.

In the event of a generator failure, the operable generator will power both 28 volts DC essential buses, but the non-essential buses will not be powered unless the pilot selects the non-essential bus switch to the manual position.

External power, either from a battery cart or a ground power unit, may be used for starting, ground operation, or maintenance purposes.

DISTRIBUTION

DC power distribution is provided by a battery bus, No. 1 and No. 2 main DC buses, No. 1 and No. 2 essential buses, and permanently interconnected No. 1 and No. 2 non-essential buses. Figures 5-1 and 5-4 illustrate DC electrical power distribution.

CIRCUIT PROTECTION

Circuit breakers, attached to each bus, provide protection for individual circuits and systems. Isolation diodes provide reverse current protection and separation of the two identical DC electrical systems.

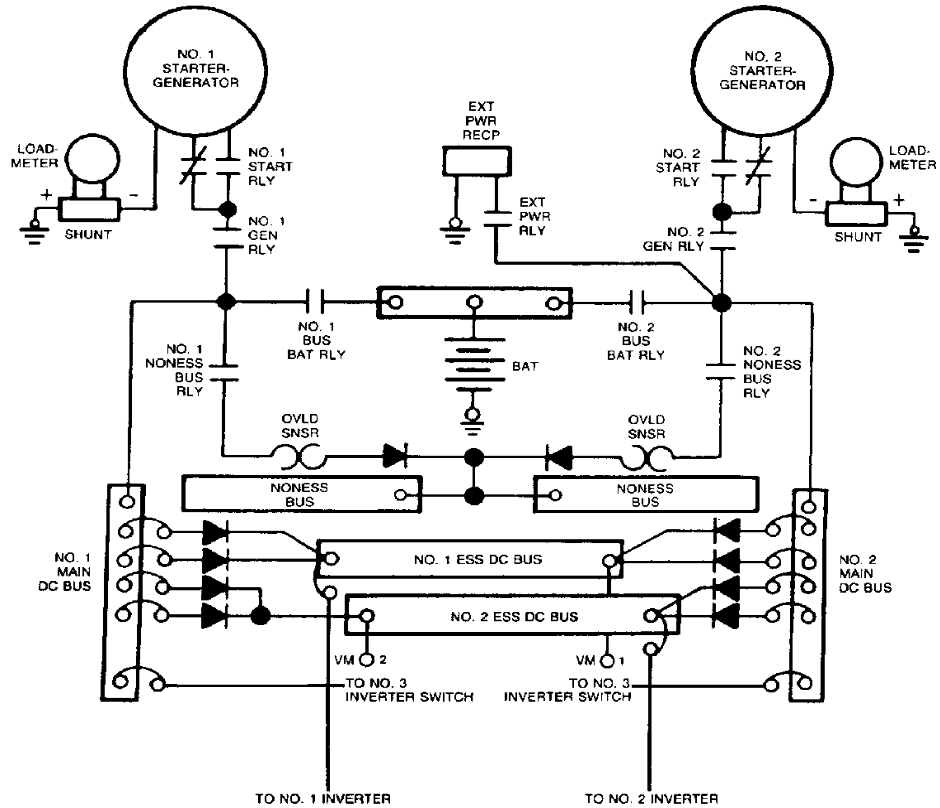


Figure 5-1 DC Electrical Power Distribution (SN 30554 and subsequent)

SYSTEM CONTROLS

DC electrical system controls (Figure 5-2), located on the overhead console, include No. 1 and No. 2 battery bus switches, No. 1 and No. 2 generator switches, and a non-essential bus switch. Sensors, relays, ground fault detectors, DC control units, and circuit breakers at various locations on the airframe also provide control and protection of the DC electrical system.

AC POWER

GENERAL

Power for the 212 AC power system is provided by three 250 volt-ampere, solid state, 400 hertz, 115 VAC and 26 VAC, single phase inverters. These inverters are identical and are interchangeable. The system is automatic in operation, and will provide switching of the AC load from the failed inverter to the No.3 inverter. On early model 212's there are only two inverters; each serving a backup for the other with bus No.2 being the primary.

The inverters are not field adjustable, but may be checked for output within a tolerance of 115 VAC $\pm$ 3 V and 400 Hz $\pm$ 20 Hz.

DISTRIBUTION AND CIRCUIT PROTECTION

AC power is distributed by AC buses No. 1 (115-volt), No. 1 (26-volt), No. 2 (115-volt), No. 2 (26-volt), a non-essential 115-volt bus which is powered by the No. 3 inverter, and by circuit breakers which provide individual circuit protection. Figure 5-4 shows AC electrical power distribution.

SYSTEM CONTROLS

The AC system controls consist of the No. 1, No. 2, and No. 3 inverter switches (Figure 5-2).

In the event of a No. 1 or No. 2 inverter failure, the failed inverter's AC buses are automatically supplied by the No. 3 inverter. If both No.1 and No.2 Inverters fail, the No. 3 inverter will power only the No. 2 AC buses. This is an automatic function.

In the Bell IFR 212 only, a loss of power to the No.1 26 volt AC bus will result in a loss of:

- Co-pilots ADI
- Both Pilot and Co-pilot HSI's
- No.1 & No.2 VOR Needle on both HSI's
- No.1 & No.2 ADF Needles on both HSI's

The Navigation Functions of the No.1 26volt AC bus can be recovered by selecting the NAV AC switch to BUS No. 2. This will result in recovery of:

- Both Pilot and Co-pilot HSI's
- No.1 & No.2 VOR Needle on both HSI's

The Co-pilots ADI and both ADF needles will not be recovered.

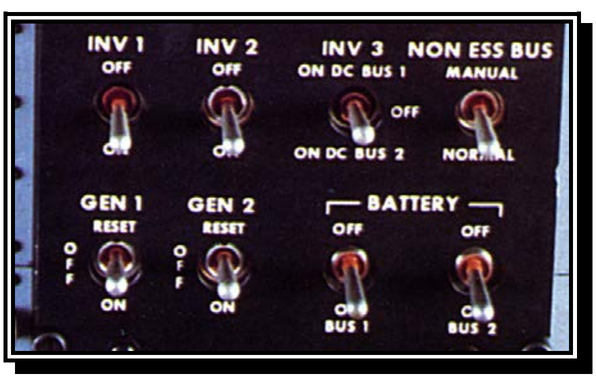


Figure 5-2 DC Electrical System Controls

COCKPIT CONTROLS AND INDICATIONS

The overhead electrical console (Figure 5-3) provides primary control of the DC and AC electrical systems as well as lighting, utility, and optional systems. Three instrument panel gauges are provided to show DC and AC voltages and the load on each generator. Caution panel lights are provided to advise the pilot of electrical system malfunctions.

OVERHEAD ELECTRICAL CONSOLE

Figure 5-3 Overhead Console (Aft)

The overhead electrical console provides the pilot access to electrical system controls, circuit breakers, and various airframe system controls.

The circuit breaker portion of the overhead console is separated in the middle to correspond with the two separate AC and DC electrical systems. The left half of the circuit-breaker panel (marked "BUS No 1") contains the circuit breakers for the No. 1 generator, No. 1 main DC bus, No. 1

essential DC bus, No. 1 non-essential DC bus, No. 1 engine, No. 1 airframe systems, and co-pilot items. The right half of the circuit-breaker panel (marked "BUS No. 2") contains the circuit breakers for all the No. 2 DC buses, systems, and pilot items.

The No. 1 and No. 2 AC buses and No.1 and No. 2 AC items are similarly split. A few exceptions such as AC power for the pilot's and co-pilot's HSI and AC power for the AFCS do occur.

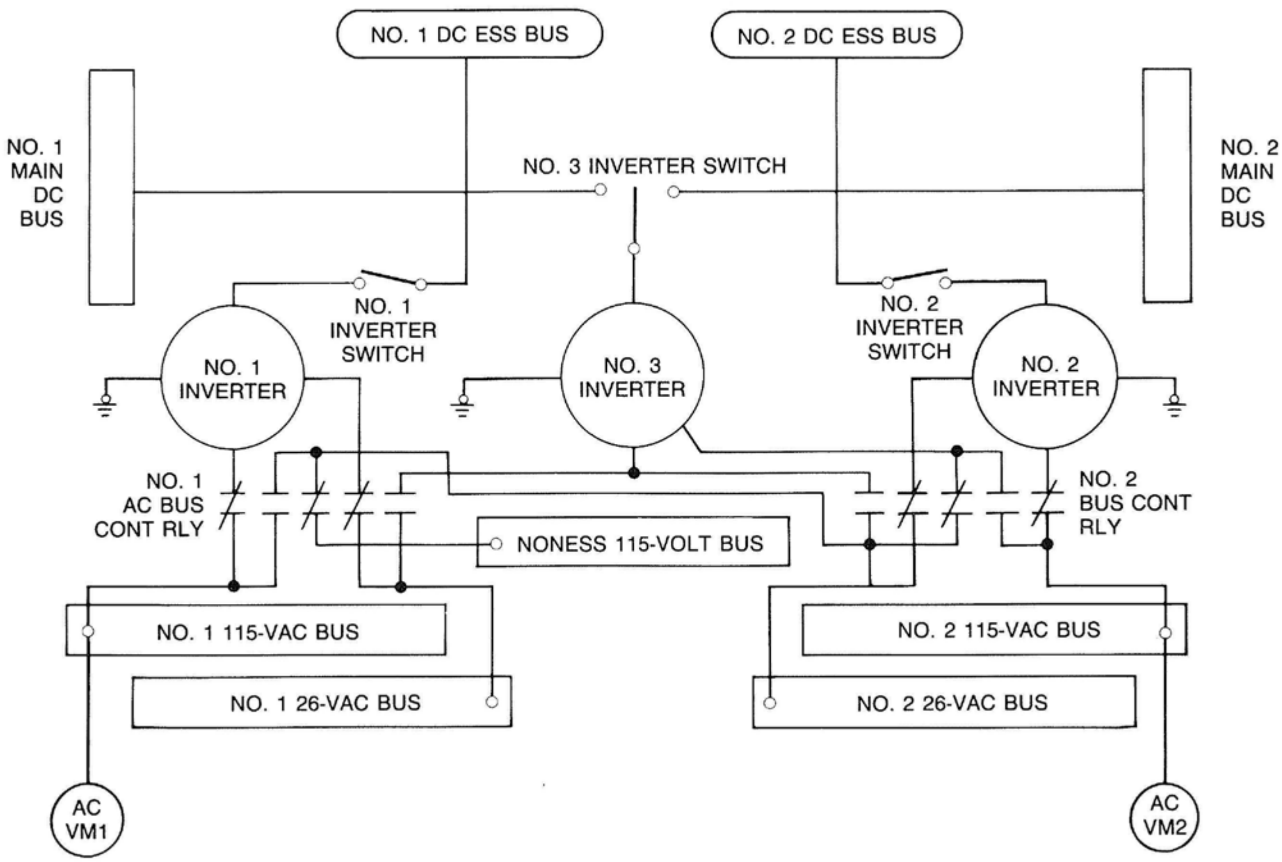


Figure 5-4 AC Electrical Power Distribution

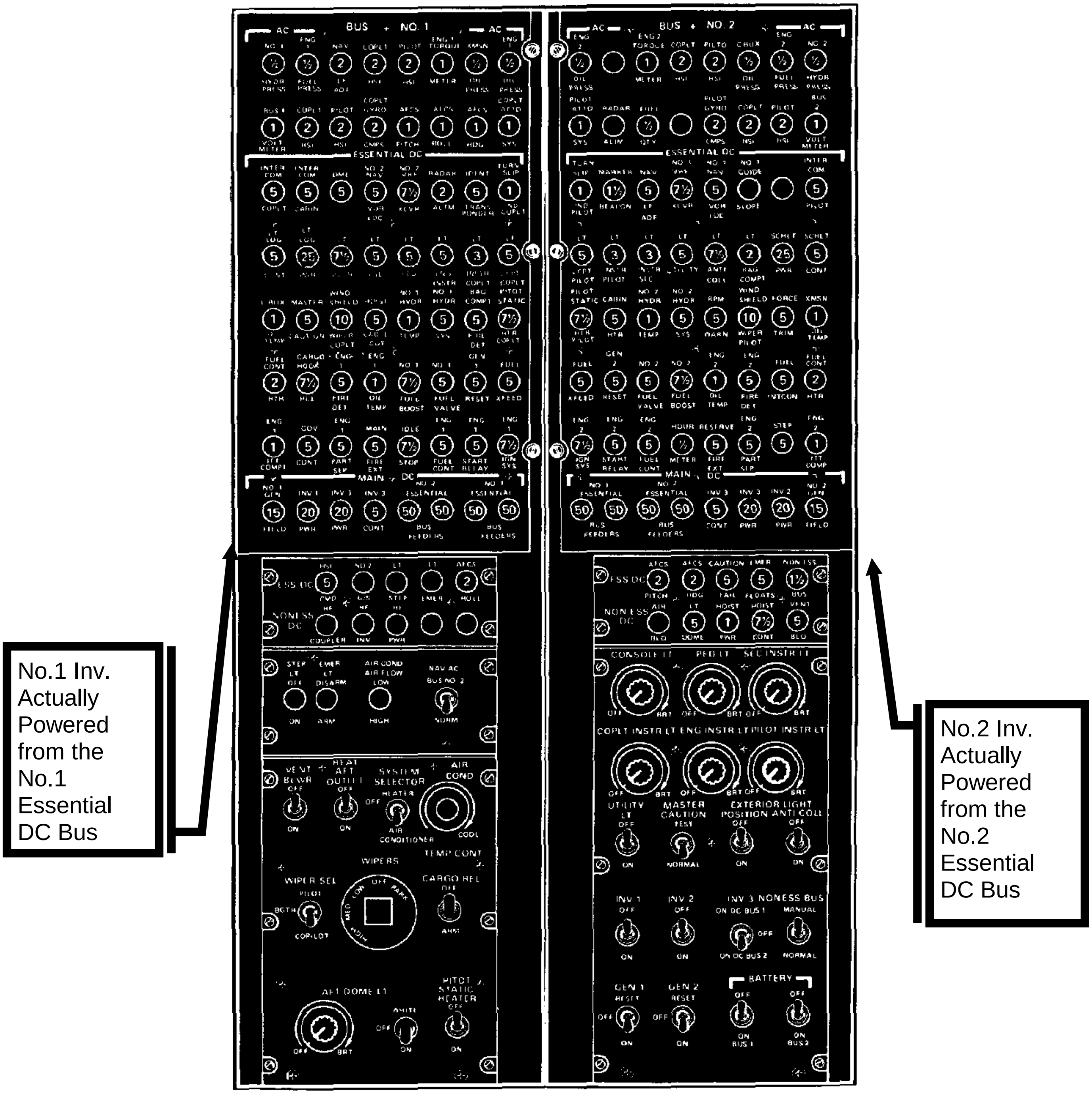


Figure 5-5 Overhead Console

SYSTEM CONTROLS

Electrical system controls include BATTERY BUS No. 1 and No. 2 switches, the GEN No. 1 and No. 2 switches, the NON ESS BUS switch, the INV No. 1 and No. 2 switches and the INV No. 3 switch.

GAUGES

Two dual voltmeters on the engine instrument panel provide voltage indications for the AC and DC electrical systems. A dual ammeter, located to the left of the voltmeters, indicates the amperage load on each generator. Figure 5-6 shows the electrical system indications.

Figure 5-6 DC Voltmeters

DC Voltmeters

The right side of each voltmeter, identified as the No. 1 voltmeter (left gauge) and the No. 2 voltmeter (right gauge), indicates voltage on the No. 1 essential DC bus and No. 2 essential DC bus, respectively. Normally, both DC voltmeters indicate identical voltage. The only exception is in the event of an essential bus failure, when the respective voltmeter indicates 0 volts. The loss of a single generator will show no loss of DC volts.

AC Voltmeters

The left side of each voltmeter indicates the voltage on the No. 1, 115-VAC bus and No. 2 115 VAC bus, respectively. Both AC voltmeters should indicate identical voltage except in the event of a No. 1 or No. 2 AC bus failure. Voltage is not displayed for the two 26-VAC buses nor is the voltage of the non-essential 115-VAC bus displayed. No AC voltage limitations are indicated on the face of the AC voltmeters.

Generator Ammeters

The dual ammeter, or load-meter, indicates amperage load on each generator. The left half ammeter shows the load on the No. 1 generator while the right half indicates the load on the No. 2 generator. The ammeters normally indicate within 20 amps of each other. Generator limitations are indicated on the face of the ammeters.

During a generator-assisted engine start (max deflection 300+ amps) and during initial recharging of the battery, an extremely high (above the red line (150 amps)) generator load is indicated, which is normal.

DC ELECTRICAL SYSTEM

BATTERY

General

The single 24-volt, 34 amp-hour, nickel cadmium battery (Figure 5-8) is located on a shelf in the nose of the helicopter. The battery is connected directly to the battery bus and associated electrical components mounted underneath the avionics shelf.

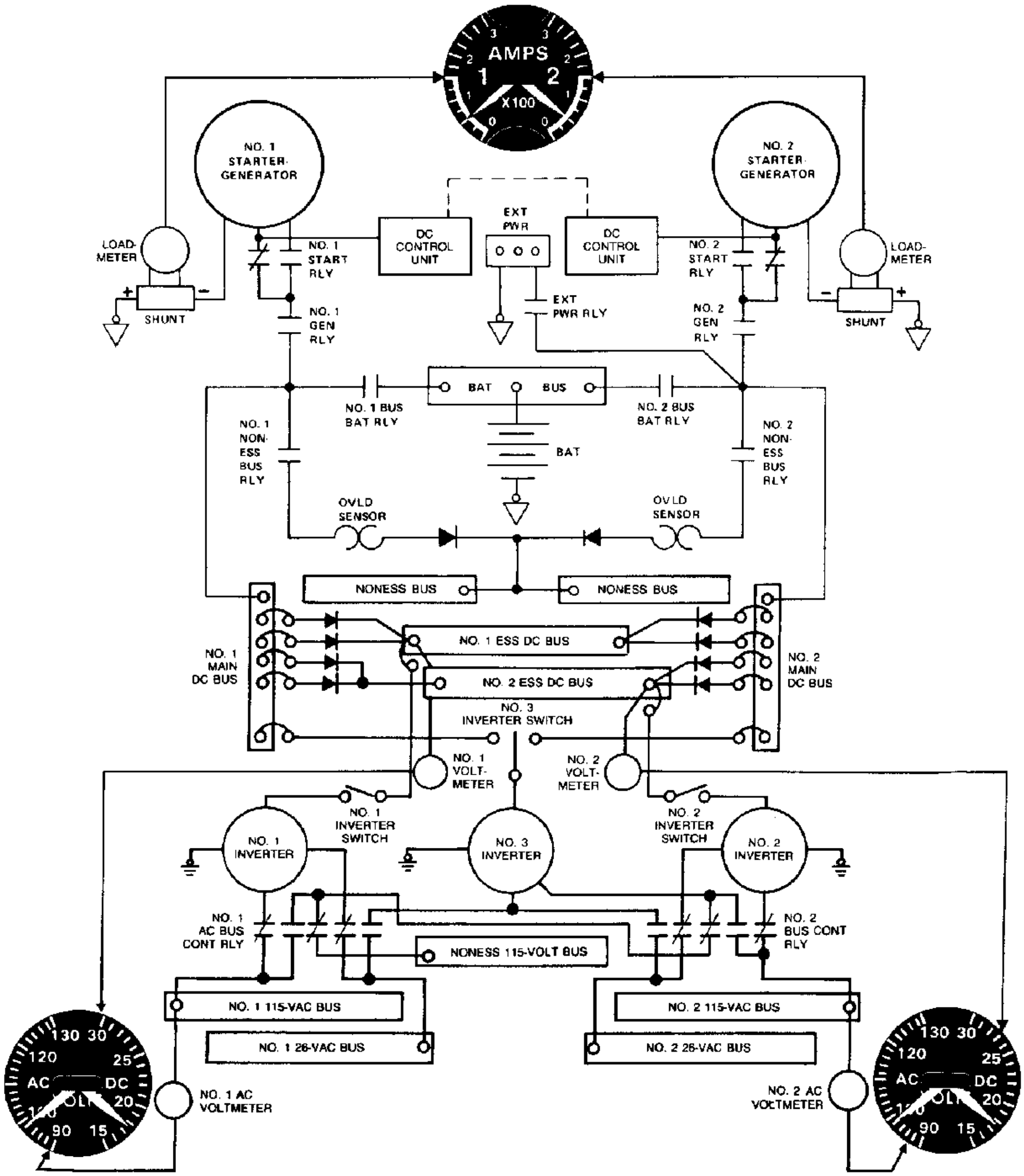


Figure 5-7 Electrical System Indications

Battery use is limited to engine starting and as an emergency backup source of electrical power in the event of dual generator failure. As a backup DC power source in flight, the battery can sustain essential DC loads for approximately 25 minutes. Should battery voltage fall below 20 volts, some form of external power should be used for starting.

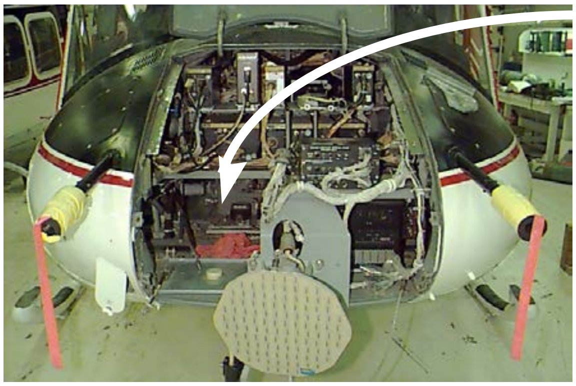


Figure 5-8 Battery Installation

Battery Operation

Battery power is applied to the airframe by connecting the battery bus to the No. 1 and No. 2 main DC buses by means of the No. 1 and No. 2 battery bus relays which are actuated by the BATTERY BUS No.1 and BUS No. 2 switches (Figure 5-9b). The BATTERY BUS switches are connected directly to the battery bus and are protected by the No. 1 and No. 2 BUS BAT circuit breakers located on the hour meter panel.

Figure 5-9 Bus Circuit Breakers

Any time both battery bus relays are in the same position, either closed (BATTERY BUS switches ON) or open (BATTERY BUS switches OFF), the BATTERY caution panel light illuminates. The BATTERY BUS switches are magnetically held in the ON position as long as their respective battery bus relay remains closed.

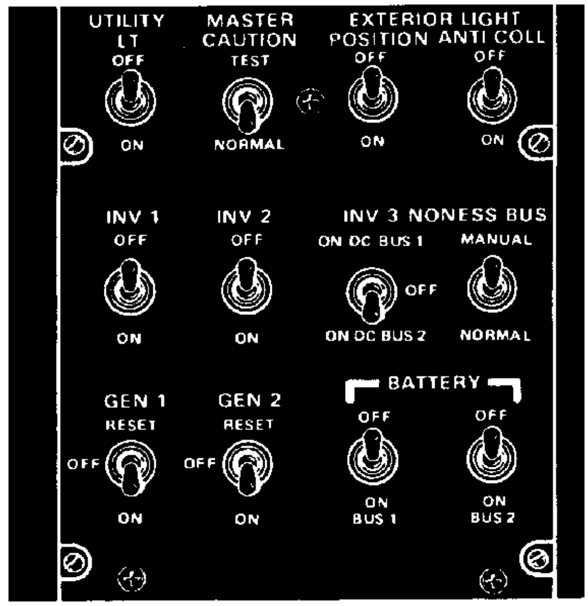


Figure 5-9b Electrical Controls

With both BATTERY BUS switches in the ON position, both battery bus relays close, directing battery power from the battery bus to the No. 1 and No. 2 main DC buses and on to the essential bus. In this condition the non-essential buses are not powered unless the non-essential bus is switched to "MANUAL" (Figure 5-9b). Battery voltage is displayed on both DC voltmeters. Figure 5-10 illustrates battery power.

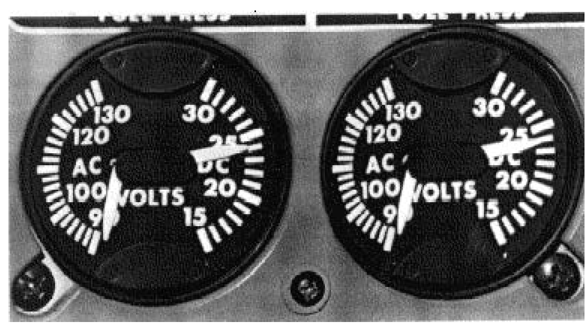


Figure 5-10 Voltmeter

Battery Temperature Warning Light (on some models)

After engine starting the battery's charge may be very low. The charge may also be low if internal deterioration has occurred.

In either case recharging the battery with a full 28VDC at high amperage from a generator may cause overheating of the battery, which can lead to more serious problems. A BATTERY TEMP caution panel warning light is provided to advise the pilot of battery overheating.

A thermoswitch set in the open position is mounted with spring tension against the bottom of the battery case. If the case temperature reaches 130° Fahrenheit, the switch closes and illuminates the BATTERY TEMP warning light. Actual internal battery temperature is approximately 15° higher than case temperature. The warning light circuit uses 28-VDC power and is protected by the MASTER CAUTION circuit breaker.

Illumination of the BATTERY TEMP warning light requires the pilot to disconnect the battery from the DC electrical system by placing both BATTERY BUS switches to OFF. This condition may require a landing. The pilot should consult the approved *Flight Manual* for specific procedures.

NON-ESSENTIAL BUSES

In the event the battery does not have sufficient charge to handle all of the helicopter's DC electrical loads during starting, the non-essential buses should not be powered when the battery bus switches are first turned on. Normally the bus will not receive power until both generators are on line.

If the pilot needs the non-essential bus to be powered, for lighting, radios, etc., the non-essential buses may be activated with the NON-ESS BUS MANUAL-NORMAL switch on the overhead console. Moving the switch to the MANUAL position closes relays connected to the No. 1 and No. 2 main DC buses and powers the No. 1 and No. 2 non-essential buses (No.1 and No.2 non-essential buses are permanently interconnected..

Once both generators are operating on line, the non-essential buses (Figure 5-11) are automatically powered. If one or both generators fail, a generator is turned off, or if an engine fails, the non-essential buses automatically deactivate to reduce the load on the remaining generator or battery. The non-essential buses can be reactivated any time by using the NON-ESS BUS switch.

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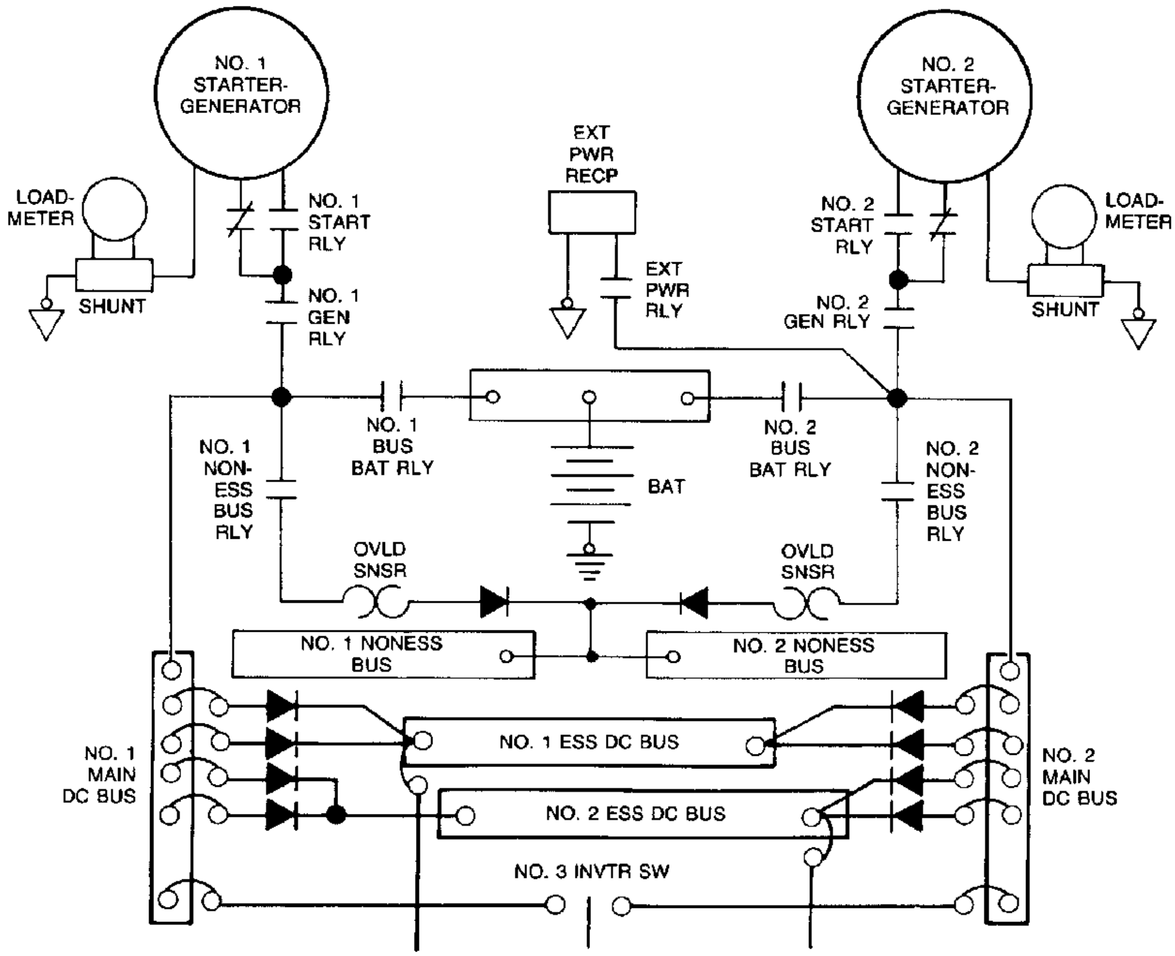

Figure 5-11 Non-essential Buses

EXTERNAL POWER

External power, from either a battery cart or a ground power unit, may be applied to the helicopter if the generators are not operating on line. Although external power is limited to 1,000 amps maximum at 28 VDC, at least 600 to 800 amps are required for a normal engine start.

The external power connection (Figure 5-12) to the helicopter is located on the nose just to the right and slightly below the battery compartment door. When not in use, the standard external power receptacle is covered by a small door. When the door is opened, a microswitch closes and illuminates the EXTERNAL POWER caution panel lightInsertion of the external power plug into the receptacle activates the external power relay, which closes and directs external power to the No. 2 main DC bus. Both BATTERY BUS switches should be ON to close the battery bus relays, thereby directing external power to the battery for recharging and to the No. 1 starter generator for engine starting. Figure 5-13 illustrates the external power circuit.

Once the engines have been started using external power, the external power plug should be removed and the external power door closed.

The pilot should visually check that the plug has been removed and that the EXTERNAL POWER caution light has extinguished, indicating that the external power door has been closed and secured. Generators should be turned on only after external power has been removed from the airframe to ensure proper on-line operation.

The use of quick-start high-voltage battery packs as external power sources should be avoided to preclude possible battery damage. If high voltage (32 to 33 VDC) units must be used, the BATTERY BUS switches should be in the OFF position to preclude battery overcharging and possible damage.

Figure 5-12 External Power Connector

Only the No. 2 engine can be started with both BATTERY BUS switches OFF. (It takes battery power to close the battery bus relays and therefore there must be some voltage in the battery to close the relays when the switches are turned on). With the No. 2 engine started, the high voltage unit should be disconnected, the No. 2 generator turned on, both BATTERY BUS switches turned on, and then the No. 1 engine started with a generator-assisted start.

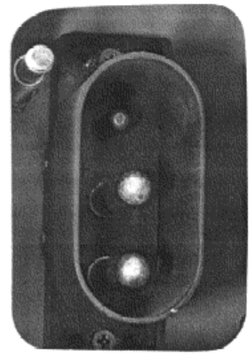

Figure 5-12b External Power Connector

BATTERY BUS BYPASS SYSTEM (Some Models)

GENERAL

Under normal circumstances, with a fully charged battery, both engines can be started from either battery power or an external power source. Both start methods require battery power to close the battery bus relays allowing either battery power or external power to reach both engines for starting. Approximately 13 VDC is required to close and hold the battery bus relays closed.

If the battery is so weak that it cannot close or keep the battery bus relays closed, external power can be applied and the No. 2 engine started from that source. However, the No. 1 engine cannot be started using external power unless there is a path for DC power to get from the No. 2 bus to the No. 1 bus. The external power path normally used is from the No. 2 main bus through the No. 2 battery bus relay to the battery bus and then through the No. 1 battery bus relay to the No. 1 main bus and the No. 1 starter. Since 13 VDC is required to close the battery bus relays, when there isn't sufficient voltage, there is no way to start the No. 1 engine short of replacing the battery with a new or recharged one, a normally unacceptable delay.

Some Bell 212's incorporate a momentary switch that allows the No. 2 battery bus relay to be closed using external power rather than battery power. A second person is required to activate this switch, commonly called the "2S11" switch, due to its location in the pilot's chin window area.

ENGINE STARTING

Each engine is equipped with a starter-generator mounted at the top of the N1 accessory section and geared directly to the N1 compressor. The starter-generator either drives as a starter, or is driven by the N1 compressor as a generator and operates any time the N1 compressor turns. Figure 5-14 illustrates engine starting.

Engine starting is accomplished by energizing the starter windings of the starter-generator with DC electrical power, normally supplied from the battery. With both BATTERY BUS switches in ON, the starter switch must be depressed and moved to the selected engine start position. This opens the generator relay and positions the start relay for the selected engine to route DC electrical power from the respective Main DC Bus to the starter windings. The starter limitations are 30 seconds on, 60 seconds off, 30 seconds on, 5 minutes off, 30 seconds on, and 15 minutes off.

Low battery voltage may not provide sufficient power to activate the starter and hold the starter relay closed. Should this condition occur, external power must be used. Once the engine is started, the starter switch should be positioned to OFF at 55% N1 rpm. This action opens the start relay and closes the generator relay, connecting the generator windings to the Main DC bus. If the starter switch is not positioned to the OFF position the generator relay remains open and the generator will not come on line when the generator switch is turned on. Starters are powered from the Main DC buses and the diodes between the Essential buses and the Main Buses prevent reverse current. The No.1 Main Bus can only get power through the No.1 Battery Bus connection. This is very important for Engine restart.

The engine should be accelerated to 85% N2 rpm (best-second engine engagement speed), and the N1 rpm checked for a minimum of 71% N1 rpm. The 71% N1 rpm ensures proper generator output voltage and that there will be no engine "drag-down" when the generator is turned on.

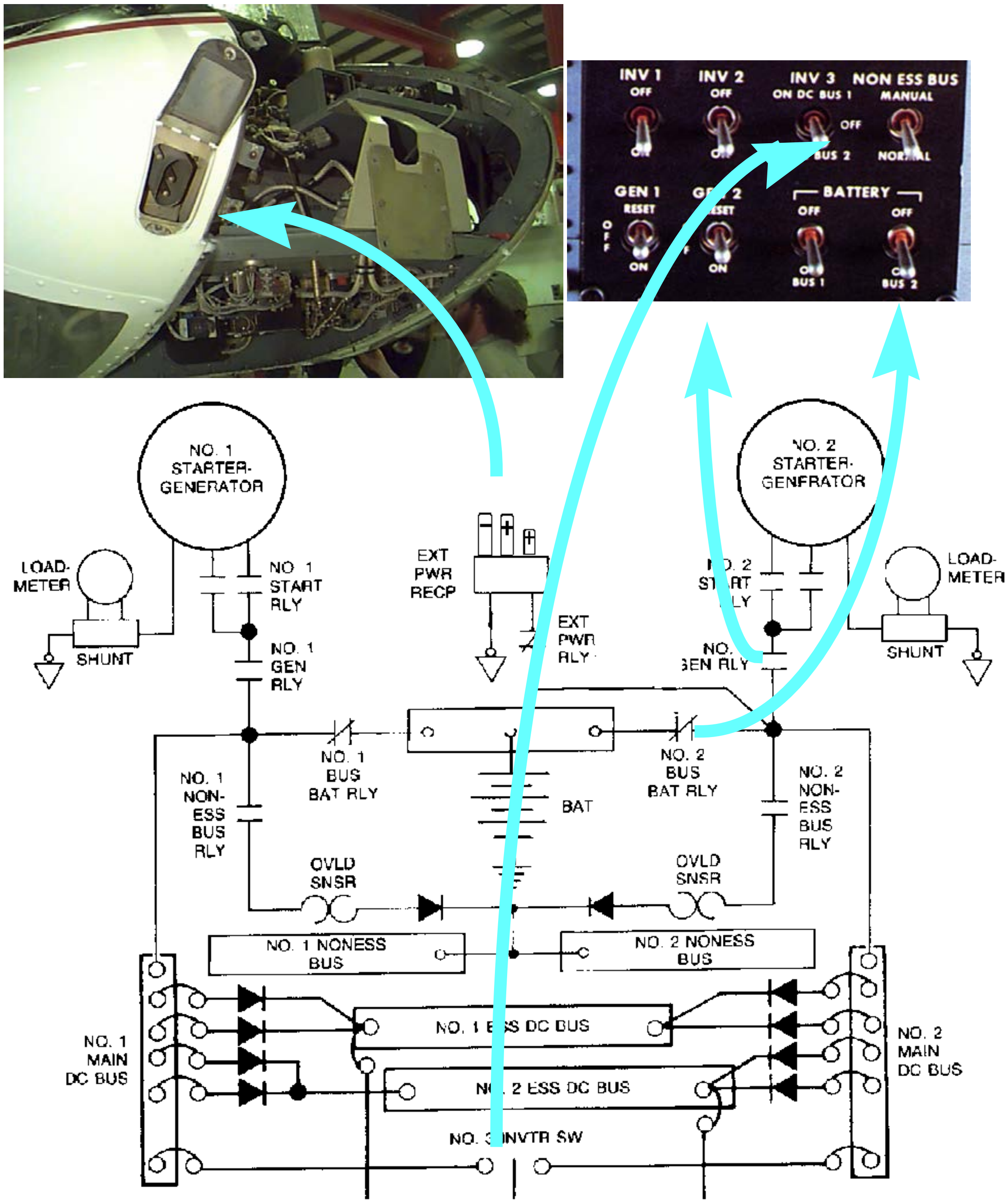

Figure 5-13 External Power Schematic

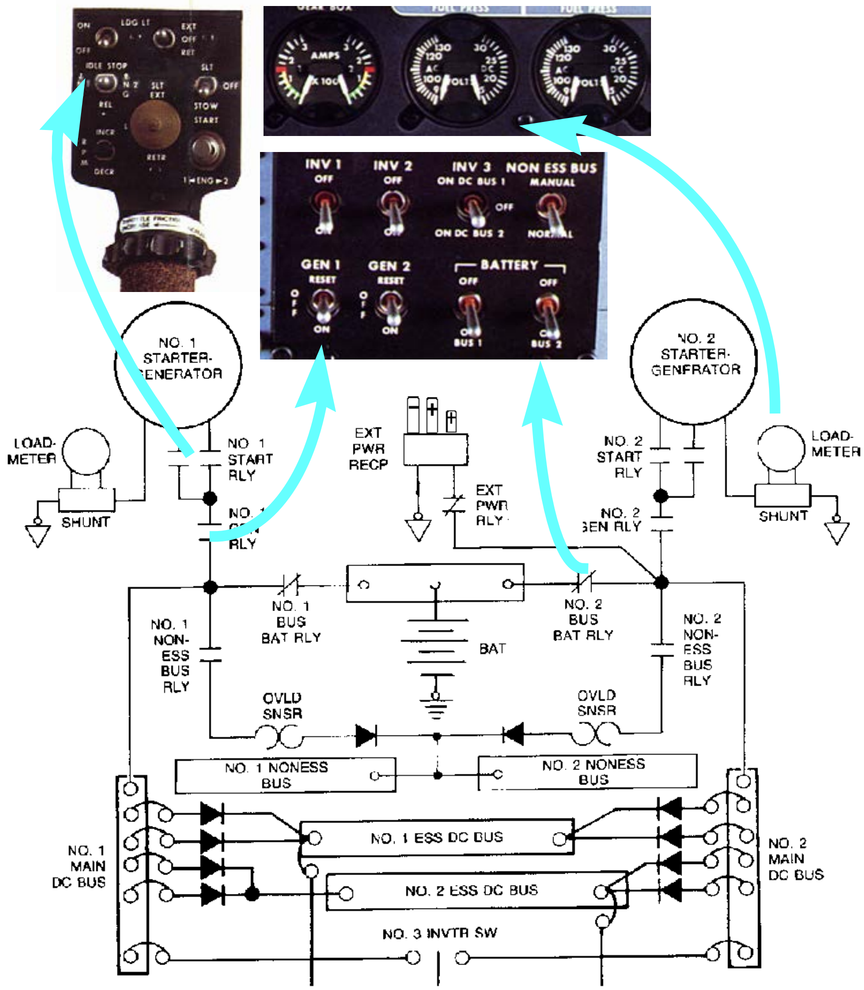

Figure 5-14 Engine Starting

SINGLE-GENERATOR OPERATION

NOTE: The generators should not be turned on with external power connected to the helicopter.

With the engine at 71% N1 rpm or higher and the appropriate generator switch turned on, the generator relay closes and directs the generator output to the associated main DC bus, the battery bus, and the remainder of the electrical system. Three cockpit indications of the proper generator's output are provided: (1) the DC GENERATOR caution panel light extinguishes, (2) both DC voltmeters indicate generator output voltage, and (3) the generator's ammeter indicates a very high load due to battery recharging. Figure 5-16 shows generator operation.

The on-line generator's ammeter remains high for approximately 10 to 15 seconds and then starts to decrease as the battery's charge increases. The ammeter should be allowed to decrease to 150 amps or below prior to starting the second engine.

GENERATOR-ASSISTED START

The second engine is started with a combination of battery and generator power. Starting procedures for the second engine are identical to those for the first engine start with the exception of checking for a proper second engine engagement.

DUAL-GENERATOR OPERATION

With the second engine operating at a minimum of 71% N1 or higher and the associated generator switch turned on, the generator relay closes and directs the generator's output to the other main DC bus and on to the remainder of the electrical system. If the Generator fails to come on line check to see that the Engine Starter switch is in the OFF position. If it is still in the start position, the second generator will not come on line.

With both generators on line, the No. 1 battery bus relay is automatically opened to separate the two electrical systems, and the non-essential buses are automatically powered. Figure 5-16 illustrates dual-generator operation. (The No.1 Battery switch automatically goes to OFF)

Indications of proper dual-generator operation after 2nd engine start include: (1) the second DC GENERATOR caution panel light extinguishes, (2) the BATTERY caution panel light extinguishes, (3) both DC voltmeters indicate parallel generator voltage, (4) the No. 2 generator's ammeter initially indicates a very high load due to battery recharging, and (5) the non-essential buses are powered.

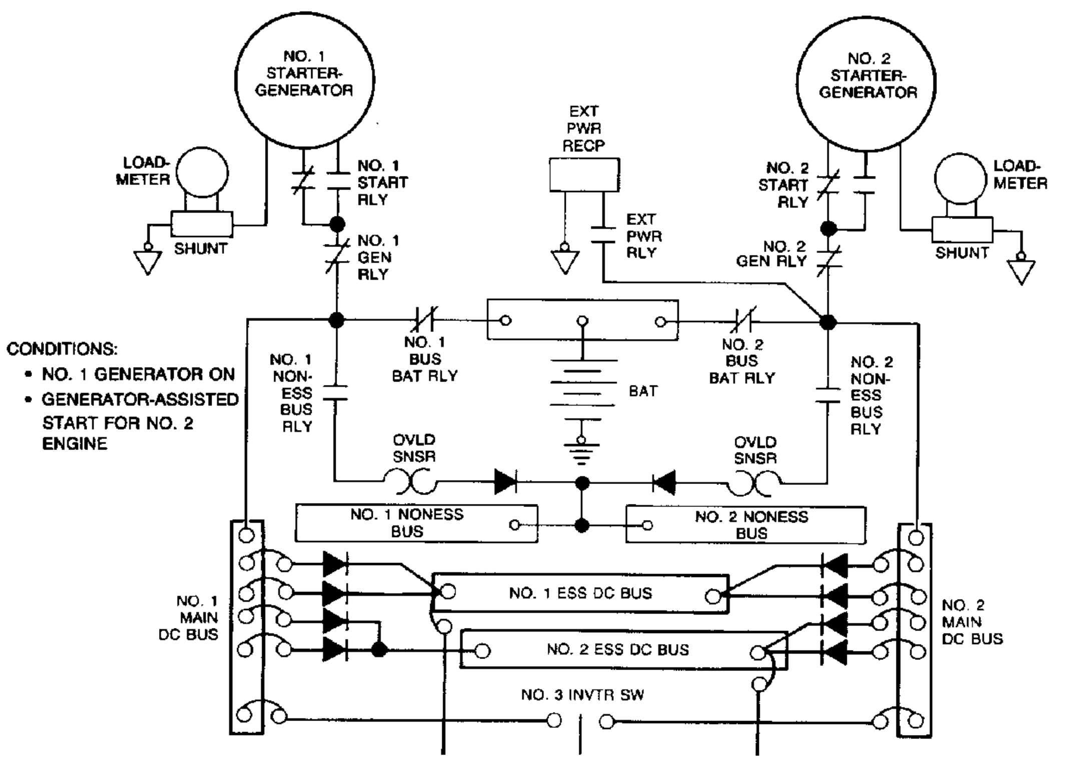

Figure 5-15 Generator Assisted Start

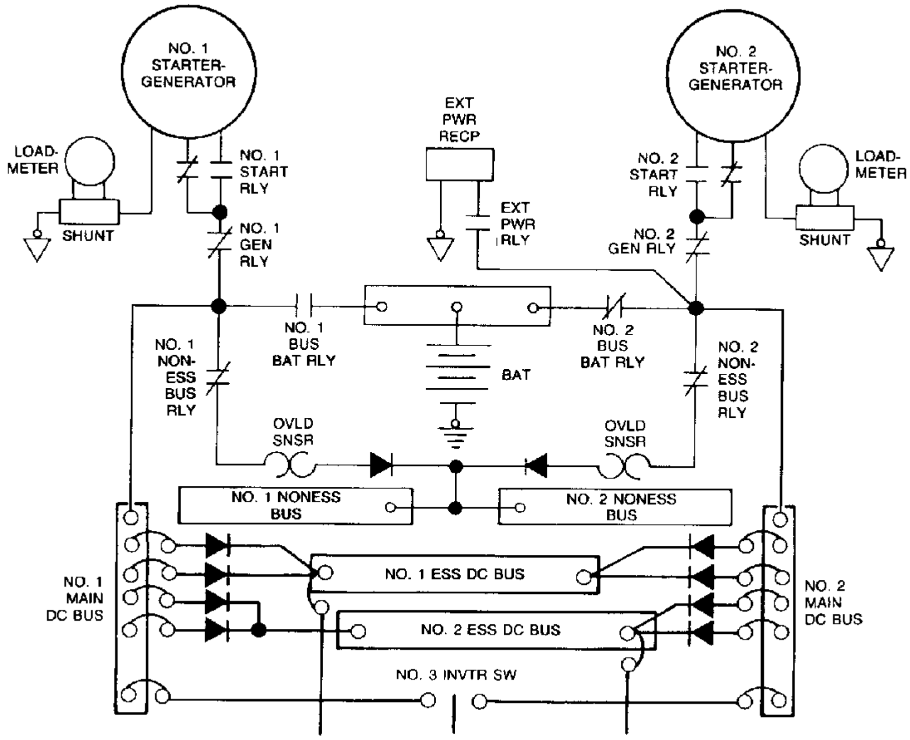

Figure 5-16 Dual-Generator Operation

The normal operating mode of the separate DC electrical systems is achieved with both generators operating on line. In this condition all DC buses are powered, the battery is continually being charged to maintain peak potential, DC electrical loads are being shared by both generators, and back-up as well as load-shedding capabilities are available.

DC CONTROL UNITS

General

During normal, dual-generator operation, each generator's output is controlled by a DC control unit. The DC control units have numerous functions, and work together to control, switch, and interconnect the two separate electrical systems. Figure 5-17 shows the DC control units.

Voltage Regulation

Each generator's DC control unit is adjusted by maintenance to ensure that its generator's output is within 1/10 of a volt of the other and within a range of 27 to 28 VDC, depending upon OAT. Because the generators' output voltages are within such close tolerance, both generators can provide power to the electrical buses with both sharing the load (load sharing) and both providing output (paralleling). The generator ammeters should read within 20 amps of each other.

Under voltage Protection

Any drop in a generator's output voltage that exceeds 1/10 volt is detected and results in the generator with the low voltage being dropped off line. Cockpit indications are the same as generator failure.

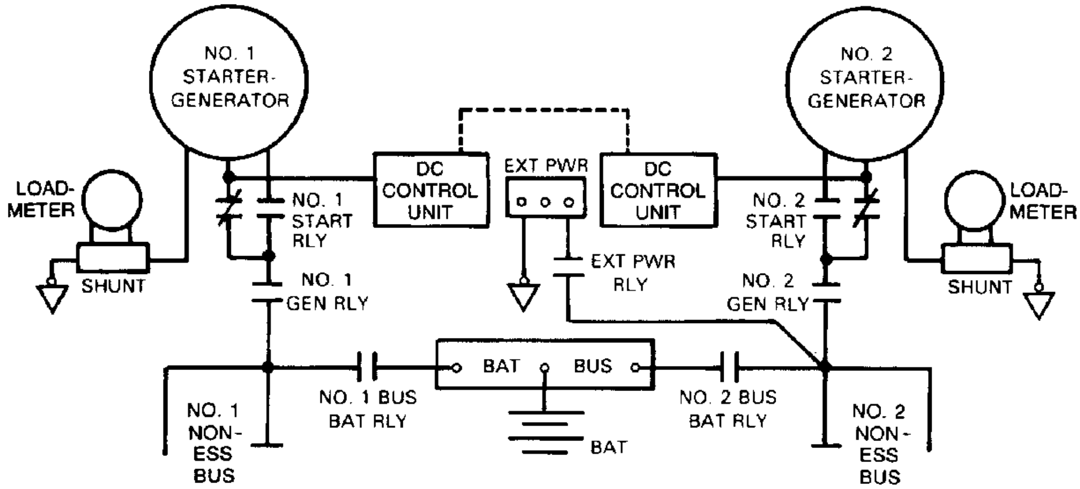

Figure 5-17 DC Control Units

Over voltage Protection

A generator over voltage in excess of 1/10 volt is detected and also results in the generator with the lower voltage being dropped off line. The generator with the lower voltage is always dropped to ensure that in the event of a generator loss, the remaining generator, even with high voltage, remains on line. If a generator's voltage exceeds 33 $\pm$ 1 volts, that generator is dropped off line regardless of other factors.

Reverse-Current Protection

Any time DC electrical system voltage exceeds that of a generator the DC control units will open that generator's relay and drops it off line to prevent a reverse-current situation. This condition most often occurs with external power applied or during engine shutdown when battery voltage exceeds generator output voltage.

Ground Fault Detection

Induction transformers, located at each generator output, on the battery bus and at the buses in the overhead console, sense the amperage of the wires passing through them and send signals to the DC control units. These signals are compared to ensure that the electrical system loads are approximately balanced with the amperage output of the DC generators. If a short circuit or other load imbalance occurs, the DC control unit switches the appropriate generator off line.

Line Contacting

The DC control units exercise extensive control over the generators. One of their functions is that of activating the generator relays to connect or disconnect the generators to or from the electrical system. This switching is called line contacting.

Main DC Circuit Breakers

Eight Circuit breakers are located on each of the Main DC Bus portions of the Overhead Panel.

Each Main DC Bus Panel has two 50 amp “Feeder” C/B’s for the No.1 Essential Bus, two 50 amp “Feeder” C/B’s for the No.2 Essential Bus, one Gen. Field C/B (for the respective generator), and a No.3 Inverter Power C/B (20 amp).

The No.1 and No.2 inverter Power and No. 3 inverter Control C/B's are also found on the Main DC Buses, although these Inverters are powered through their respective Essential Buses. The No.3 Inverter is powered from a Main DC bus, as selected by the No.3 Inverter Switch (ON DC BUS 1 or ON DC BUS 2). (Figure 5-9b)

DC GENERATOR MALFUNCTIONS

General

The DC generators are very reliable and historically free from problems. However, the following caution lights are provided to alert the pilot of any malfunctions that might occur.

DC GENERATOR

Caution Panel Light

Any time a generator fails, is switched off, is tripped off line, or is otherwise taken off line, the DC GENERATOR caution panel light illuminates by the opening of the generator relay. The most common causes for the generator being tripped off line are starter switch left in the start position, under voltage, over voltage of the other generator, engine failure or shutdown, and action by a DC control unit.

If the DC GENERATOR caution light illuminates, the pilot should check that the respective GEN FIELD and GEN RESET circuit breakers are in and then move the generator switch from ON, through OFF, to RESET, and then back to ON. If the generator does not come back on line, it should be switched off. The pilot should also switch the BATTERY BUS 1 and/or BUS 2 switches to the proper position to ensure battery recharging and, if desired, position the NON-ESS BUS switch to MANUAL to reactivate the non-essential buses and facilitate charging of the battery.

GEN OVHT Caution Panel Light

The GEN OVHT (generator overheat) caution panel light is activated by a thermal switch located in the path of the cooling air exiting each generator. The light illuminates if the cooling air reaches a temperature of 155°C. If the air cools down, the light extinguishes.

Generator overheating may be caused by either an excessive electrical load on a generator for an extended period of time or by internal mechanical failure of a generator. If the cause is an excessive electrical load, an indication should be shown on the generator's ammeter. If an excessive electrical load is not indicated, the pilot may assume the overheating is caused by an internal generator problem.

If a GEN OVHT caution panel light illuminates, the pilot should switch off the overheated generator and monitor the caution light. If an excessive electrical load caused the overheating, and the generator is switched off removing the load, the GEN OVHT light should extinguish within a short time. If the overheating was caused by a mechanical malfunction, the GEN OVHT light will most likely remain illuminated.

OTHER DC ELECTRICAL SYSTEM MALFUNCTIONS

General

Although extremely rare, there are several DC electrical system malfunctions that may occur. Among these are dual generator failure and essential bus failure.

Dual-Generator Failure

Failure of one generator does not pose significant problems since the remaining generator can easily handle all normal electrical loads, with the exception of certain systems such as heated windshields, the Nightsun searchlight, and air conditioning. However, if loss of the second generator occurs, the battery then becomes the sole remaining source of DC electrical power. The battery can normally support electrical loads for up to 25 minutes.

Essential Bus Failure

If an essential bus comes in contact with the airframe, a ground fault or short circuit results that causes all four of the main DC NO 1 or NO 2 ESSENTIAL BUS FEEDERS circuit breakers to pop and disconnect the affected essential bus from all electrical power. The loss of essential bus electrical power results in numerous electrical system failures: some indicated by caution panel lights, some resulting in erroneous or unusual indications, and still other failures that are not indicated at all or only when the pilot tries to actuate the affected system. Still other systems change their operating mode due to the loss of electrical power. A reading of 0 volts on the respective DC voltmeter is positive indication of an essential bus failure.

If an essential bus has failed due to a ground fault or short, and all four of the Essential Bus Feeder C/B's are "popped", it is not recommended that the C/B's be reset. This may cause an electrical fire on the Essential Bus. If other C/B's on the Essential bus (in addition to the Bus Feeders) are also "popped" this may indicate a ground fault on separate system rather than the Essential Bus. In this case an attempt to reset the Essential Bus Feeder C/B's may be attempted. Do not, however, attempt to hold the Feeder C/B's in the engaged position or reset the other C/B's. This again may cause an electrical fire.

DC BUS MALFUNCTION PROCEDURES

Failure of an Essential DC bus requires maintenance action. The pilot should determine the impact of the bus failure on safety of flight before attempting to reset the C/B's. In a bus failure situation, if an additional system malfunction would cause a safety of flight problem, and after considering all factors such as weather, terrain, etc., the helicopter should be landed as soon as possible.

Listed in Table 5-17 is the essential bus dependent system, the system failure that results due to the loss of electrical power, the cockpit indication, if any, of the system failure, and finally the bus relationship of the failure to either the No. 1 essential bus, the No. 2 essential bus, or either essential bus.

NOTE: If you experience a Failure of the No.1 Essential Bus, the Caution Panel and Warning Light system will also be lost. None of the Caution Lights for No.1 systems will illuminate, i.e. No.1 Boost Pump, No.1 Inverter, No.1 Fuel Valve, etc.

Non-essential Bus Failure

Non-essential bus failure, which may be accompanied by a popped NON-ESS BUS circuit breaker, does not pose any significant problems because all items on the buses are non-critical for flight.

Table 5-17 ESSENTIAL BUS FAILURE LISTING TABLE

SYSTEM	FAILURE	INDICATION	ESSENTIAL BUS
C-box and	C-box oil temp inop	Gauge at 0	1
Transmission	XMSN Oil temp inop	Gauge at 0	2
Electrical	Gen reset inop (No. 1/No. 2)	None	1/2
System	Inverter inop (No. 1/No. 2)	INVERTER light	1/2
Engine	Ignition system inop	None	1/2
Systems	Start Relay inop	None	1/2
	Fuel Control inop	None	1/2
	Governor Control inop	FCU to AUTO if MANUAL	1
	Idle Stop inop	None	1
	ITT Compensator inop	Gauge at 0	1/2
	Engine Oil Temp inop	Gauge at 0	1/2
	Part Sep inop	None	1/2
	Fire Detector inop	None	1/2
	Fire Ext Main inop	None	1
	Fire Ext Reserve inop	None	2
Fuel System	Fuel Valve inop	FUEL VALVE	1/2
	Fuel Crossfeed inop (Only with both Ess bus fail)	None	1/2
	Fuel Boost inop	FUEL BOOST Light	1/2
	Fuel Control Heater inop	None	1/2
	Fuel Interconnect inop	None	2
Hydraulic	Switch inop	None	1/2
System	Temperature gauge inop	Gauge to 0	1/2
Misc and Kits	Windshield Wiper inop	None	1/2
	Hourmeter inop	None	2
	Cabin Heater inop	HEATER AIR LINE	2
	Cargo Hook Release inop	HOOK ARMED light off	1
	Hoist Cable Cut inop	None	1
	Emergency Floats inop	None	2
	Cabin Step inop	None	2
Avionics,	AFCS Pitch, Roll, HDG	AFCS off	1+ 2
AFCS,	Force Trim inop	No force trim	2

and	INTERCOM inop (COPLT/PLT)	Respective ICS inop	1/2
Lighting	INTERCOM Cabin inop	No ICS in cabin	1
	VHF XCVR(No. 2/No. 1)	No xmit or rec	1/2
	VORLOC NAV (No. 2/No. 1)	No reception	1/2
	NAV LF inop	No ADF reception	2
	FM XCVR inop	No xmit or rec	2
	Marker Beacon inop	None	2
	DME inop	No reception	1
	Glide Slope inop	OFF flag	1/2
	IDENT Transponder inop	None	1
	HSI CMD inop	No nav 1 CDI	1
	Radar Altm inop	Off flag	1
	Turn and Slip inop (COPLT/PLT)	None	1/2
	Pitot heat inop (COPLT/PLT)	None	1/2
	Instr lt (COPLT/PLT)	No lights	1/2
	Eng Instr Lights inop	No lights	1
	Pedestal Lights inop	No lights	1
	Console Lights inop	No lights	1
	Sec Instr Lights inop	No lights (except Sperry IFR Kits)	2
	Utility Lights inop	No lights	2
	Cockpit Lights inop (CP/PLT)	No lights	1/2
	Position Lights inop	No lights	1
	AntiCoil Lights inop	No lights	2
	Searchlight inop	None	2
	Searchlight Control inop	None	2
	Landing Light inop	None	1
	Landing Light Control inop	None	1
	Baggage Comp Light inop	None	2
Baggage Smoke	System inop	None	1
Caution and	Caution Panel inop	CAUTION PANEL Light	1
Warning	CAUTION PANEL Light inop	None	2
	RPM Warning inop	None	2

AC ELECTRICAL SYSTEM

GENERAL

The Bell 212 uses 115 and 26 VAC as secondary electrical power to operate avionics, gyro, AFCS, and instrument indicating systems. Redundancy in the AC electrical system is provided by three identical inverters; the No. 3 inverter acts as a spare, and in the event of an inverter failure the AC buses are automatically supplied by the No. 3 inverter. Distribution of AC electrical power is through two 115-VAC buses, two 26-VAC buses, and a non-essential 115-volt bus. On SNs 30504 through 30553, the AC electrical system is provided by two identical inverters, either of which is capable of supporting all AC electrical loads.

All AC circuits are protected by circuit breakers. Automatic control of the AC system is provided by AC sensing relays and AC bus control relays. AC voltage is indicated on the AC half (left side) of the two dual voltmeters and is read from the No. 1 and No. 2 115-VAC buses. Caution panel lights are provided to indicate AC inverter failure.

INVERTERS

Three identical 250-volt/amp solid-state static inverters (Figure 5-18), all able to provide both 115-VAC and 26-VAC electrical current at 400 Hz, are located underneath the battery shelf in the nose of the helicopter and are powered by airframe DC electrical power. Circuitry within the inverter converts the DC power to 115-VAC power at 400 HZ. A transformer tap-off provides 26 VAC. The inverter switches are located on the right-hand overhead panel. The No.1 and No.2 switches are two position, ON-OFF, No.3 inverter switch is a double pole, three position switch; ON (MAIN) DC BUS No.1, OFF and ON (MAIN) DC BUS No.2.

The inverters are activated by positioning the INV 1 and INV 2 switches to ON, and the INV 3 switch to either ON DC BUS 1 or ON DC BUS 2. The switches are located on the overhead console. If the INV 3 switch is placed in the ON DC BUS 2 position then, under normal conditions, it is on the bus that has the closed battery relay.

For SN’s 30504 through 30553, there are two 250-volt/amp solid-state static inverters, each providing both 115-VAC and 26VAC electrical current at 400 Hz, and they are also located underneath the battery shelf and are powered by DC electrical power. The two inverter switches are located on the overhead console.

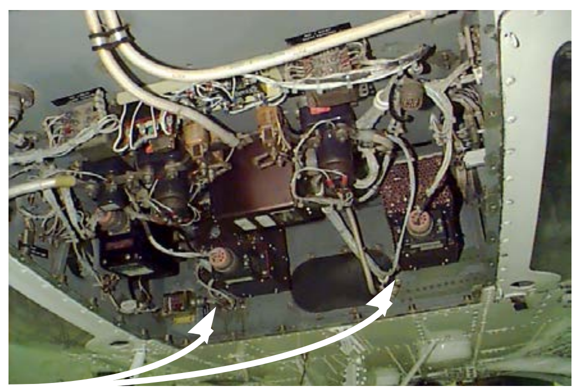

Figure 5-18 Inverters No.1 & No.2

POWER DISTRIBUTION

Two AC buses are provided for both 115-VAC and 26-VAC power distribution for essential AC systems. During normal operation, with all three inverters on and operating, the No. 1, 115-volt bus and the No. 1, 26-volt bus are powered by the No. 1 inverter, while the No. 2, 115-volt bus and the No. 2, 26-volt bus are powered by the No. 2 inverter. Even though the No. 3 inverter powers the non-essential bus, it does not normally have a load since the non-essential bus is a growth or special option bus. If one inverter fails, the No. 3

inverter energizes the respective bus control relay and supplies both the 115 and 26 VAC buses of the failed Inverter. In the event of a failure of both No. 1 and No. 2 inverter, the No. 2 buses have priority and are powered by the No. 3 inverter.

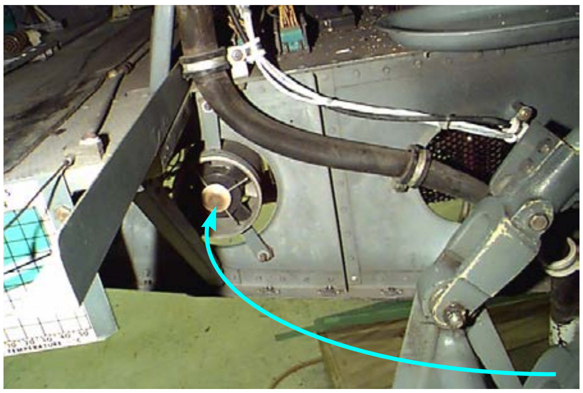

Figure 5-19 Inverter Cooling Fan

In the Bell IFR 212 the 26 VAC power for the Navigation equipment, both HSI's, VOR Needles, and ADF Needles is provided by a single bus, the No.1 26 VAC Bus. Loss of the No.1 and No.3 Inverters requires switching the NAV AC switch from NORMAL to BUS No.2 to recover some of the lost AC Navigation Equipment, VOR and HSi needles.

In the VFR 212 and Sperry 212, No.2 AC Bus (26V) is normally powered by the No.2 inverter and does not require the switch as in the Bell IFR 212.

CIRCUIT PROTECTION

Circuit breakers attached to each AC bus, provide protection for individual circuits and systems. AC bus circuit breakers are located in the aft section of the circuit-breaker portion of the overhead console.

SYSTEM CONTROLS

In addition to the INV 1, INV 2, and INV 3 switches on the overhead console, automatic control of AC bus switching is provided by AC bus sensing relays and AC bus control relays.

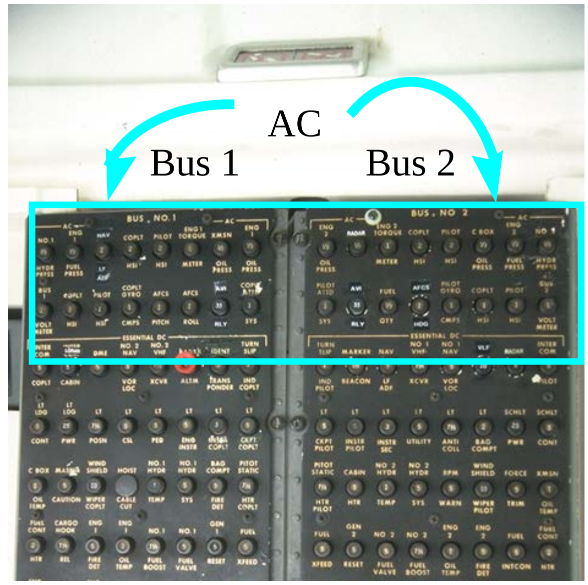

Figure 5-20 AC Circuit Breakers

Sensing Relays

An AC voltage sensing relay is connected to the 115-volt output of all inverters. Three AC sensing relays are located in the lower nose compartment. Their purpose is to sense an inverter failure, which will cause the relay to be de-energized. By changing the relay contacts of either AC sensing relays No.1 or No.2, power will be supplied to energize its associated AC control relay.

The AC sensing relays are also used to operate the INVERTER caution light segment. The only function of No.3 AC sensing relays is to operate its INVERTER fail caution light.

Bus Control Relays

The two AC bus control relays are located in the cabin roof aft of the overhead console they are used to transfer a failed inverter load to an operable inverter, and operate in conjunction with the AC sensing relays**.** In normal operation the bus control relays are positioned to allow the No. 1 and No. 2 inverters to power their respective AC buses independently of each other. With a No. 1 or No. 2 inverter failure, signals from the AC sensing relays energize the AC bus control relays, allowing the No. 3 inverter to power the AC buses of the failed inverter.

OPERATION

The following is the proper procedure for checking the operation of the individual inverters:

1. With DC electrical power applied to the airframe, switch on the No. 1 inverter. Check for 104 to 122 volts on the No. 1 AC voltmeter and 0 volts on the No. 2 AC voltmeter.

2. Turn on the No. 2 inverter and check that the No. 2 AC voltmeter now reads 104 to 122 volts. As each inverter is switched on, ensure that the respective INVERTER caution panel light has gone out.

3. With both engines operating, switch the No. 3 inverter to ON DC BUS 2, and check that the INVERTER 3 caution light extinguishes.

4. Turn the No. 2 inverter off and check the No. 2 AC voltmeter for 104 and 122 volts and that the INVERTER 2 caution light is on. This ensures that the No. 3 inverter has assumed the load.

5. Turn the No. 2 inverter back on.

6. Place the INV 3 switch to OFF, then to ON DC BUS 1, and check if the INVERTER 2 and 3 caution lights are extinguished.

7. Place the INV 1 switch to OFF, and check that the INVERTER 1 caution light is on and the No. 1 AC voltmeter for 104 to 122 volts. This ensures that the No. 3 inverter has assumed the load and that the No. 3 inverter can operate off the No. 1 main DC bus.

8. Return the INV 1 switch to ON, and the INV 3 switch to OFF, (hesitate long enough for INV 1 to pick up it's load again, then to ON DC BUS 2. Any time the No. 1 or No. 2 inverter has been turned off, it is necessary to have the No. 3 inverter switch in the OFF position before the No. 1 or No. 2 inverters can be turned on again.

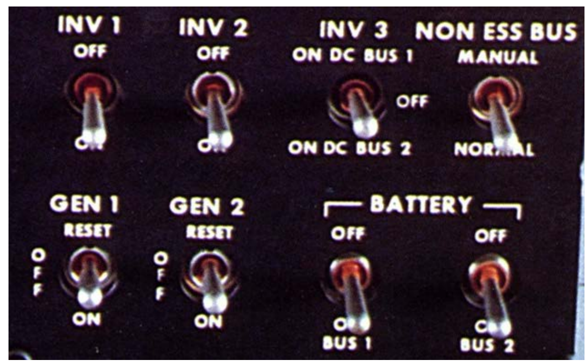

Figure 5-21 Inverter Switches

MALFUNCTIONS

The AC electrical system is very reliable. However, in the event of an inverter malfunction, the AC sensing relays and the AC bus control relays will detect the failure and automatically switch AC electrical loads to the remaining inverter, or the No. 3 inverter, depending upon aircraft serial number. The only cockpit indication of an inverter failure will be an inverter caution panel light. The automatic switching of all AC buses to the appropriate inverter occurs instantly, and the AC voltmeters should indicate no change. This is accomplished by the result of the failed inverter 115 VAC output no longer energizing its sensing relay. This will de-energize the relay changing the position of its relay contacts, completing the CONTROL circuit for the No.3 inverter.

The control circuit will power the respective bus control relay causing it to shift the No.3 inverter to power the AC load which was lost.

If both No.1 and No.2 inverter fail, No.3 inverter will assume the No.2 inverters 115 VAC and 26 VAC load. Power for these buses is routed from the No.3 inverter through the No.1 and No.2 energized bus control relays.

The inverters are not field adjustable, and may be checked only for output using an AC voltmeter and a frequency meter. Tolerance is 115 VAC ± 3 VAC and 400 Hz ± 20 Hz.

In normal operation the INV 3 switch is in the ON DC BUS 2 position. Therefore, a failure of the No. 2 generator, which powers the No. 2 main DC bus, does not require the pilot to switch the INV switch to the ON DC BUS 1 position to restore power to the No. 3 inverter, since the No. 2 battery switch is on and would supply power to the No. 3 inverter. No pilot action is required with the No. 3 inverter for a No. 1 generator failure. Should other AC electrical items or buses fail, check the AC circuit breakers on the overhead console.

NAV AC SWITCH OPERATION

Bell IFR 212 Only

The NAV AC switch (Figure 5-22) gives the pilot the capability of recovering <u>some</u> of the AC radio equipment in the event of a No. 1 and No. 2 inverter failure. If only the No. 3 inverter is operating, the No. 2 AC buses are powered while the No. 1 AC buses are dropped. By placing the NAV AC switch from NORM to BUS NO. 2, the AC radio buses from the No. 1 AC system are tied into the No. 2 system's AC radio buses and are powered by the No. 3 inverter. The homing needles for the VOR Navigation radios will be operating, but the ADF needles will <u>not</u> be recovered.

The Course Deviation Indicator (CDI) and the Glide Slope Indicators located on both Pilots' HSI's are DC powered and will <u>not</u> be lost in the case of an AC power failure.

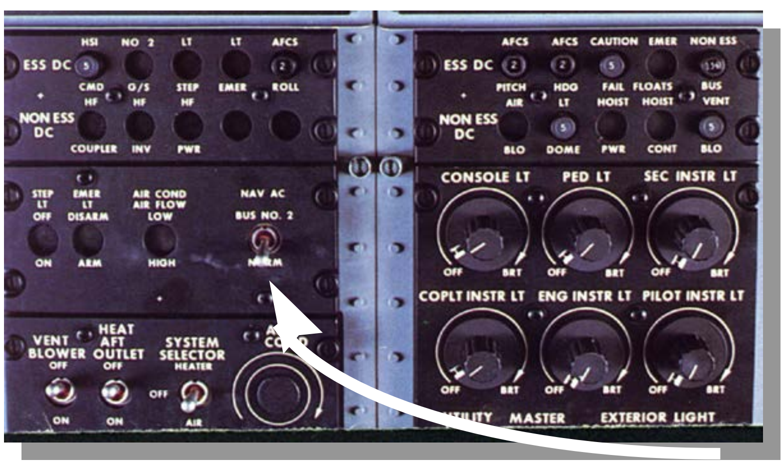

Figure 5-22 NAV AC Switch

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