SECTION III
HYDRAULICS & LANDING GEAR

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SECTION III

HYDRAULICS & LANDING GEAR

HYDRAULIC SYSTEM

The aircraft hydraulic system supplies hydraulic pressure for operation of the aircraft landing gear, brake, flap, spoiler, and thrust reverser systems. Hydraulic fluid is supplied from the hydraulic reservoir through shutoff valves to the engine-driven hydraulic pumps for distribution to the required systems upon demand. The engine-driven, variable-volume hydraulic pumps will normally maintain system pressure between 1500 and 1550 psi (10,343 and 10,687 kPa). A pressure relief valve installed between the high-pressure and return lines will open to relieve pressure in excess of 1700 psi (11,722 kPa). Reservoir pressure is maintained at approximately 20 psi (138 kPa) by bleed air supplied through a pressure regulator. Reservoir pressure in excess of 20 psi (138 kPa) is relieved overboard by a pressure relief valve. A precharged (850 psi [5861 kPa]) hydraulic accumulator is installed to dampen and absorb pressure surges. One high-pressure filter and one return filter prevent hydraulic fluid contamination and incorporate bypass valves which will open in the event a filter becomes clogged. An auxiliary hydraulic pump is installed to provide system pressure in the event of a malfunction or during engine-off ground operations.

Two motor-driven firewall shutoff valves can stop hydraulic fluid flow to the engine-driven hydraulic pumps in the event of an emergency or engine fire. Each shutoff valve is operated by the corresponding ENG FIRE PULL T-handle on the glareshield. (Refer to ENGINE FIRE EXTINGUISHING.) The valves operate on 28 VDC supplied through the 7.5 amp L and R FW SOV circuit breakers on the pilot's and copilot's circuit breaker panels respectively. Loss of power to the shutoff valves causes the valves to remain in their last position. The firewall shutoff valves are operative during EMER BUS mode.

The system is serviced through ground service quick-disconnects located in the tailcone. The service access includes quick-disconnect ports for pressure and return lines, an air valve for accumulator charging, and a direct-reading accumulator pressure gage.

HYD PUMP SWITCH

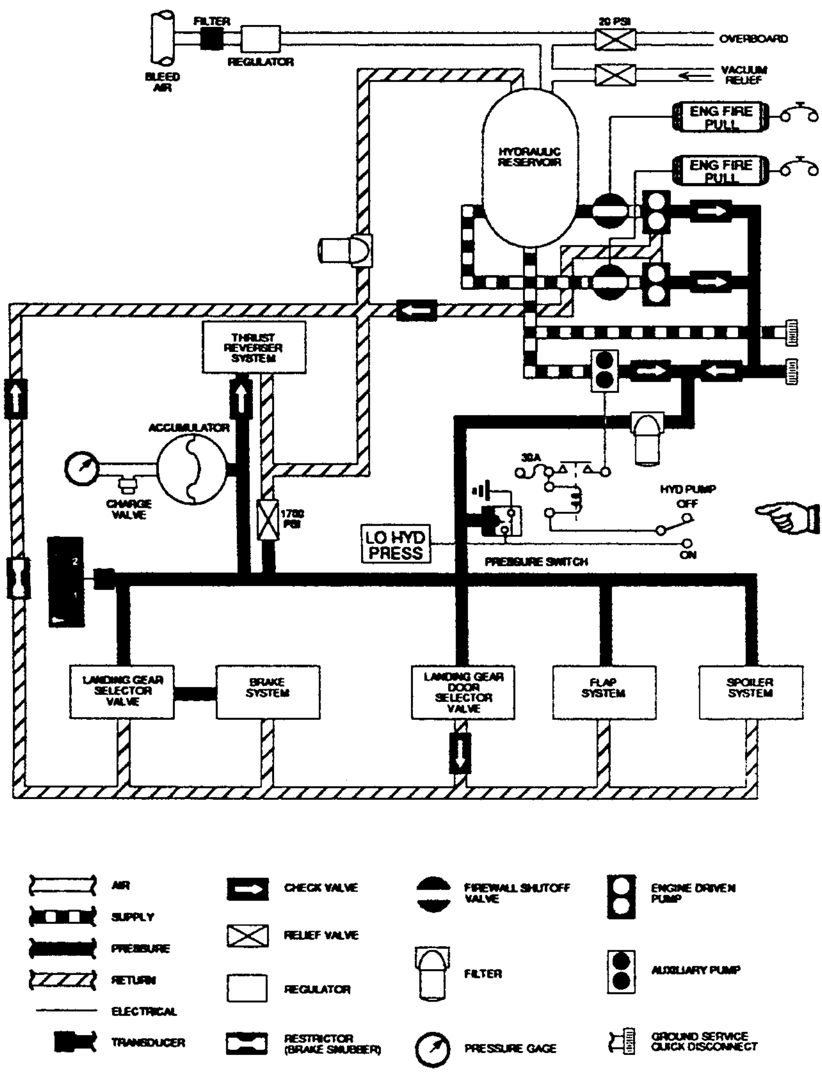
The auxiliary hydraulic pump is controlled by the HYD PUMP switch located on the center switch panel. When the switch is placed in the On (HYD PUMP) position, the auxiliary hydraulic pump is cycled by a pressure sensing switch plumbed into the high-pressure side of the system. The pressure switch will energize the auxiliary hydraulic pump if system pressure drops below approximately 1000 psi (6895 kPa) and then deenergizes the pump when system pressure rises above approximately 1125 psi (7757 kPa). The auxiliary hydraulic pump operates on 28 VDC supplied through a 30-amp current limiter. The auxiliary hydraulic pump is operative during EMER BUS mode.

LO HYD PRESS LIGHT

Illumination of the amber LO HYD PRESS light on the glareshield annunciator panel indicates low hydraulic system pressure. The light is operated by the same pressure switch that controls the auxiliary hydraulic pump operation. The pressure switch will illuminate the light when hydraulic system pressure drops below approximately 1000 psi (6895 kPa) and extinguish the light when hydraulic system pressure rises above approximately 1125 psi (7757 kPa).

HYDRAULIC PRESSURE INDICATOR

The HYD PRESS indicator is a vertical scale instrument incorporated into a combination HYD PRESS/EMERG AIR unit. The unit is located on the center switch panel adjacent to the HYD PUMP switch. The indicator face consists of a vertical scale marked from 0 to 2500 psi in 500 psi increments and a pointer at the left margin of the instrument. The instrument is operated by a pressure transducer plumbed to the high-pressure side of the hydraulic system. The indicator operates on 28 VDC supplied through the 1-amp HYD PRESS IND circuit breaker on the copilot's circuit breaker panel. Refer to Airplane Flight Manual for instrument limit markings.



HYDRAULIC SYSTEM SCHEMATIC
Figure 3-1

EMERGENCY AIR SYSTEM

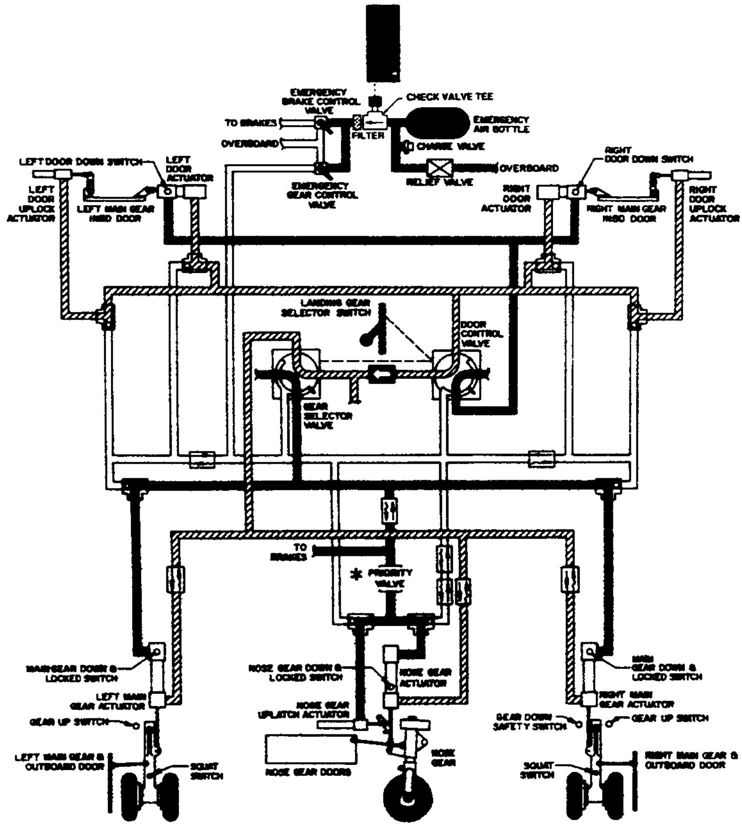
An emergency air bottle (3000 psi [20,685 kPa]) is installed in the nose compartment to provide alternate gear extension and emergency braking in the event of an electrical or hydraulic system failure. The bottle provides air pressure to operate the alternate gear extension blow down system and the emergency brakes. Refer to LANDING GEAR ALTERNATE EXTENSION and EMERGENCY BRAKES for system operation.

EMERGENCY AIR PRESSURE INDICATOR

The EMERG AIR pressure indicator is a vertical scale instrument incorporated into a combination HYD PRESS/EMERG AIR unit. The unit is located on the center switch panel adjacent to the HYD PUMP switch. The indicator face consists of a vertical scale marked from 0 to 4000 psi in 1000 psi increments and a pointer at the right margin of the instrument. The instrument is operated by a pressure transducer plumbed to the emergency air bottle. The indicator operates on 28 VDC supplied through the 1-amp AIR PRESS IND circuit breaker on the copilot's circuit breaker panel. If air bottle is serviced near the high end of yellow segment, pressure may drop during flight as system cools; satisfactory gear extension and braking can still be expected. Refer to Airplane Flight Manual for instrument limit markings.

LANDING GEAR SYSTEM

The landing gear is hydraulically retractable, conventional tricycle gear with air-hydraulic shock strut-type nose and main gear. The main gear has dual wheels and brakes on each strut. Each main gear wheel is equipped with two fusible plugs which will melt and release tire pressure in the event wheel temperature reaches 360°F (182°C) to prevent a wheel explosion. The brake system incorporates four power-boosted disc-type brakes with an integral anti-skid system. The nose gear utilizes a chined tire to prevent splashing into the engine inlets. Nose wheel steering is electrically controlled by the rudder pedals. Hydraulic pressure for gear retraction and extension is transmitted by a system of tubing, hoses, and actuating cylinders, and is electrically controlled by limit switches and solenoid valves. Alternate extension can be accomplished pneumatically in case of hydraulic or electrical system failure. Two doors enclose each main gear after retraction. The inboard doors are hydraulically operated and the outboard doors are mechanically operated by linkage connected to the main gear struts. The nose gear doors operate mechanically with linkage attached to the nose gear shock strut.



* Priority valve removed on aircraft 31-060 & subsequent.

NOTE: THE ABOVE SCHEMATIC DEPICTS THE LANDING GEAR EXTENSION/RETRACTION SYSTEM AT THE END OF THE EXTENSION SEQUENCE (GEAR DOWN AND LOCKED).

LANDING GEAR EXTENSION/RETRACTION SCHEMATIC
Figure 3-2

LANDING GEAR SELECTOR SWITCH

The LANDING GEAR switch, located on the copilot's instrument panel, is a lever-lock type switch and must be pulled aft before selecting the UP or DN position. The switch controls the position of the gear selector valve and the door selector valve through gear and door position switches. Electrical power for the control circuits is 28 VDC supplied through the 2-amp GEAR circuit breaker on the copilot's circuit breaker panel. The landing gear is operative during EMER BUS mode.

Landing gear retraction cycle: When the LANDING GEAR switch is placed in the UP position and the squat switches are in the air mode, the following sequence of events will occur:

1. 28 VDC will be applied to the "open" solenoid of the door selector valve and hydraulic pressure will be applied to both inboard main gear door uplock actuators and door actuators.
2. When the inboard main gear doors open, door open switches will complete a circuit from the LANDING GEAR switch to the "up" solenoid of the gear selector valve. Hydraulic pressure will be applied to the main and nose gear actuators and the gear will retract.
3. When the main gear retract, gear up switches will complete a circuit from the LANDING GEAR switch to the "close" solenoid of the door selector valve. Hydraulic pressure will be applied to the inboard main gear door actuators to raise the gear doors. Additionally, a gear down safety switch will complete a circuit to the "up" solenoid of the gear selector valve to maintain continuous hydraulic pressure in the gear actuators.
4. The inboard main gear doors and nose gear are latched by uplatch actuator spring tension.

Landing gear extension cycle: When the LANDING GEAR switch is placed in the DN position the following sequence of events will occur:

1. 28 VDC will be applied to the "open" solenoid of the door selector valve and hydraulic pressure will be applied to both inboard main gear door uplock actuators and door actuators.
2. When the main gear doors open, door open switches will complete a circuit from the LANDING GEAR switch to the "down" solenoid of the gear selector valve. Hydraulic pressure will be applied to the main and nose gear actuators and the gear will extend.
3. When the main gear are full down, gear down switches will complete a circuit from the LANDING GEAR switch to the "close" solenoid of the door selector valve. Hydraulic pressure will be applied to the inboard main gear door actuators to raise

the gear doors. Additionally, a gear down safety switch will complete a circuit to the "down" solenoid of the gear selector valve to maintain continuous hydraulic pressure in the gear actuators.

4. The inboard main gear doors are latched by uplatch actuator spring tension.

LANDING GEAR POSITION LIGHTS

The landing gear position lights, consisting of a set of three UNSAFE/ DOWN lights arranged in a triangular pattern, are located on the LANDING GEAR control panel to the left of the LANDING GEAR selector switch. The UNSAFE portion of each light is red in color and equipped with dual bulbs. The DOWN portion of each light is green in color and equipped with dual bulbs. The location of each light in the triangular arrangement corresponds to the location of the gear on the aircraft. An UNSAFE (red) indication signifies that the corresponding gear is not in the down and locked position or that the corresponding main gear inboard door is open. A DOWN (green) indication signifies the corresponding gear is down and locked. During the gear retraction sequence, the three UNSAFE lights will illuminate when the sequence is initiated, remain illuminated throughout the retraction cycle, and then extinguish when the nose gear is up and locked and the main gear inboard doors close. During the gear extension sequence, the three UNSAFE lights will illuminate when the sequence is initiated, remain illuminated throughout the extension cycle, and then extinguish when the nose gear is down and locked and the main gear inboard doors close. The lights are operated by the same switches that control the landing gear extension and retraction cycles. The lights are dimmed when the navigation lights are on.

The lights may be tested at any time by depressing the light test switch (under glareshield) or by using the GEAR function of the system test switch. When the system test switch is used, all of the landing gear panel indicator lights will illuminate and the landing gear warning horn will sound.

The landing gear position indicator lights operate on 28 VDC supplied through the 7.5-amp WARN LTS circuit breakers on the pilot's and copilot's circuit breaker panels. The position indicator lights are operative during EMER BUS mode. In the event of a complete DC electrical failure, the landing gear position lights will be powered by the emergency power system when the EMER BAT 1 Switch is in the On position.

LANDING GEAR WARNING SYSTEM

A landing gear warning system is installed to warn the flight crew of potentially unsafe flight conditions with the landing gear retracted. The system consists of the landing gear warning horn, a thrust lever position switch, and flap position switches. The warning system also uses the landing gear position switches and UNSAFE lights. The air data computers provide airspeed/altitude bias for the system. The gear warning horn is operative during EMER BUS mode.

Depending upon the flight condition encountered, one of two distinct warnings will be given as follows:

Warning horn sounds and UNSAFE lights illuminate - This indicates that the landing gear is not locked down, airspeed is below approximately 170 KIAS, altitude is below approximately 14,500 feet, and at least one thrust lever is below the 55% to 65% N_1 position. When the horn sounds under these conditions, the horn can be silenced by depressing the MUTE switch on the LANDING GEAR control panel or depressing the MUTE button in the right thrust lever knob. Whenever the warning horn has been muted, the MUTE button on the LANDING GEAR control panel will illuminate amber. The UNSAFE light indication will continue until either the landing gear is extended or one of the above conditions is corrected.

Warning horn sounds - The warning horn will sound whenever the landing gear is not locked down and the flaps are lowered beyond 25°. When the horn sounds because the flaps are lowered, the horn cannot be silenced by the mute switch. The horn will continue to sound until either the landing gear is extended or the flaps are retracted.

LANDING GEAR ALTERNATE EXTENSION

In the event of a main hydraulic system failure or an electrical system malfunction, the landing gear can be extended pneumatically. Pneumatic gear extension can be accomplished by using the alternate gear blow down system. Air pressure to operate the blow down system is supplied by the emergency air bottle and is controlled by the EMER GEAR lever on the right side of the pedestal. Whenever alternate gear extension is to be selected, the LANDING GEAR selector switch should be placed in the DN position and the GEAR circuit breaker on the copilot's circuit breaker panel should be pulled. This will prevent inadvertent gear retraction in the event electrical or hydraulic power to the system is regained. When the EMER GEAR lever is pushed down, air pressure from the emergency air bottle is admitted to the blow down system through the lever actuated blow down valve. If the air pressure is greater than the landing gear system hydraulic pressure, shuttle valves in the landing gear system will reposition to admit air pressure to the landing gear system inboard main gear door and door uplock actuators, the main gear actuators, the nose gear uplock and gear actuators, the gear control valve, and the door control valve. The gear and door selector valves are positioned to "down" to prevent inadvertent gear retraction. When the landing gear is down and locked, the three green DOWN lights will illuminate. The LEFT and RIGHT red UNSAFE lights will remain illuminated after gear extension due to the inboard main gear doors remaining open. When emergency gear blow down is selected, the EMER GEAR lever must be returned to the "up" position in order to retain air pressure for emergency braking. The EMER GEAR lever is returned to the "up" position by lifting the lever ratchet release (small metal tab available through a small hole immediately forward of the lever) and pulling the lever to the full up (latched) position.

NOSE WHEEL STEERING SYSTEM — ANALOG

Analog nose wheel steering is accomplished by displacement of the rudder pedals and is electronically controlled through a computer-amplifier, nose-gear steering actuator, follow-up sensor, rudder pedal position sensor, and associated aircraft wiring. Wheel rotation speed is sensed by the two inboard and right outboard anti-skid transducers and steering authority is modified as a function of aircraft ground speed. From 0 to 10 knots, 45° of steering authority either side of neutral is available. The steering authority tapers to 8° either side of neutral at 45 knots. Nose wheel steering engage circuits are controlled through the STEER LOCK switch and the Control Wheel Master Switches (MSW). When the squat switch is in the ground mode and the steering circuits are engaged, the rudder pedal position sensor forwards a rudder pedal displacement signal to the computer-amplifier. The computer-amplifier accepts the rudder pedal displacement signal, modifies the signal according to the aircraft ground speed, then forwards a steering signal to the nose wheel actuator, which rotates the nose gear toward the selected position. As the nose gear approaches the selected position, a follow-up signal from the actuator follow-up to the computer-amplifier cancels the rudder pedal displacement signal. The nose wheel steering system is powered by 28 VDC supplied through the 7.5-amp NOSE STEER circuit breaker on the pilot's circuit breaker panel and 115 VAC supplied through the 2-amp NOSE STEER circuit breaker on the pilot's circuit breaker panel.

STEER ON LIGHT

The green STEER ON light on the glareshield annunciator panel will be illuminated whenever nose steering engage circuits have been activated.

STEER LOCK SWITCH

Normally, the STEER LOCK switch on the pedestal trim switch panel is used to lock in steering circuits for taxi operations. Momentarily depressing the STEER LOCK switch will engage the nose wheel steering system. When STEER LOCK has been selected, the nose wheel steering system can be disengaged by depressing then releasing either the pilot's or copilot's Control Wheel Master Switch (MSW).

CONTROL WHEEL MASTER SWITCH — NOSE STEERING FUNCTION

Normally, the Control Wheel Master Switches (MSW), on the outboard horn of the pilot's and copilot's control wheels, are used to control nose wheel steering engagement during the takeoff ground roll. Depressing and holding either Control Wheel Master Switch (MSW) will engage the nose wheel steering system and the system will remain engaged as long as the Control Wheel Master Switch (MSW) is held. When STEER LOCK is engaged, depressing and releasing either Control Wheel Master Switch (MSW) will disengage STEER LOCK.

NOSE WHEEL STEERING SYSTEM — DIGITAL

The digital nose wheel steering system is a steer by wire system that receives pilot commands through dual rudder pedal position and dual rudder pedal force sensors. The computer processes information from the rudder pedal position and force sensors and three anti-skid wheel speed generators and steering authority is modified as a function of aircraft ground speed. For low speed ground operations 45° of steering authority either side of neutral is available. At low speed and large rudder pedal deflection the nose wheel displacement will be large for high maneuverability. Once a rudder pedal has reached its stop, further nose wheel displacement is generated by additional force being applied to that rudder pedal. As ground speed increases, the maximum wheel deflection is reduced to zero. At 90 knots 28 VDC is removed and the system disengages. Above 90 knots the nose wheel is allowed to castor. Nose wheel steering engage circuits are controlled through the momentary-action pedestal-mounted ARM/NOSE STEER switch and the Control Wheel Master Switches (MSW). When the squat switches are in the ground mode, depressing and releasing the ARM/NOSE STEER switch will activate the computer when AC and DC power are available, the nose gear is down and locked, and no faults are detected by the system monitor. When the system is active the STEER ON annunciator on the glareshield and the ARM annunciator on the ARM/NOSE STEER switch will illuminate. At 90 knots, when the system disengages, the glareshield STEER ON annunciator will extinguish. When the nose gear is no longer in the down and locked position, the ARM annunciator on the ARM/NOSE STEER switch will extinguish, however; the computer is still powered and system monitor circuitry remains active. When the nose gear is down and locked for landing the ARM annunciator on the ARM/NOSE STEER switch will illuminate provided no faults have been detected. After touchdown, when ground speed decreases to 90 knots, the STEER ON light on the glareshield will illuminate and steering authority will increase as ground speed decreases. If the system cannot be armed, limited authority steering (18° either side of neutral) is available by depressing and holding either MSW. It should be noted that in some instances, even though a fault has been detected, the system will continue to function normally until shutdown. After that, however, it will not be possible to operate the system with full steering authority until the fault has been corrected. If the system cannot be accessed by either MSW, sufficient control is still available by differential braking.

The nose wheel steering system is powered by 28 VDC supplied through the 20-amp NOSE STEER circuit breaker and 115 VAC supplied through the 2-amp NOSE STEER circuit breaker in the TRIM-FLT CONT group on the pilot's circuit breaker panel.

STEER ON LIGHT

The green STEER ON light on the glareshield annunciator panel illuminates to indicate the nose wheel steering system is capable of responding to rudder pedal inputs.

ARM/NOSE STEER SWITCH

Normally, the ARM/NOSE STEER switch is used to activate nose steering circuits for taxi operations. Momentarily depressing the ARM/NOSE STEER switch will activate the system and the ARM annunciator will illuminate. When nose steering has been activated, the system can be disengaged by depressing then releasing either the pilot's or copilot's Control Wheel Master Switch (MSW) or by depressing the ARM/NOSE STEER switch a second time. The disconnect tone will sound.

CONTROL WHEEL MASTER SWITCH — NOSE STEERING FUNCTION

Depressing and holding either Control Wheel Master Switch (MSW) will engage the nose wheel steering system. While the MSW is held, the nose steering system will operate normally and the STEER ON annunciator will be illuminated. When the MSW is released, the nose wheel steering system will disconnect. The STEER ON annunciator will extinguish. In the event that nose wheel steering will not arm, the MSW can be depressed and held for limited authority steering, under some fault conditions.

WHEEL BRAKE SYSTEM

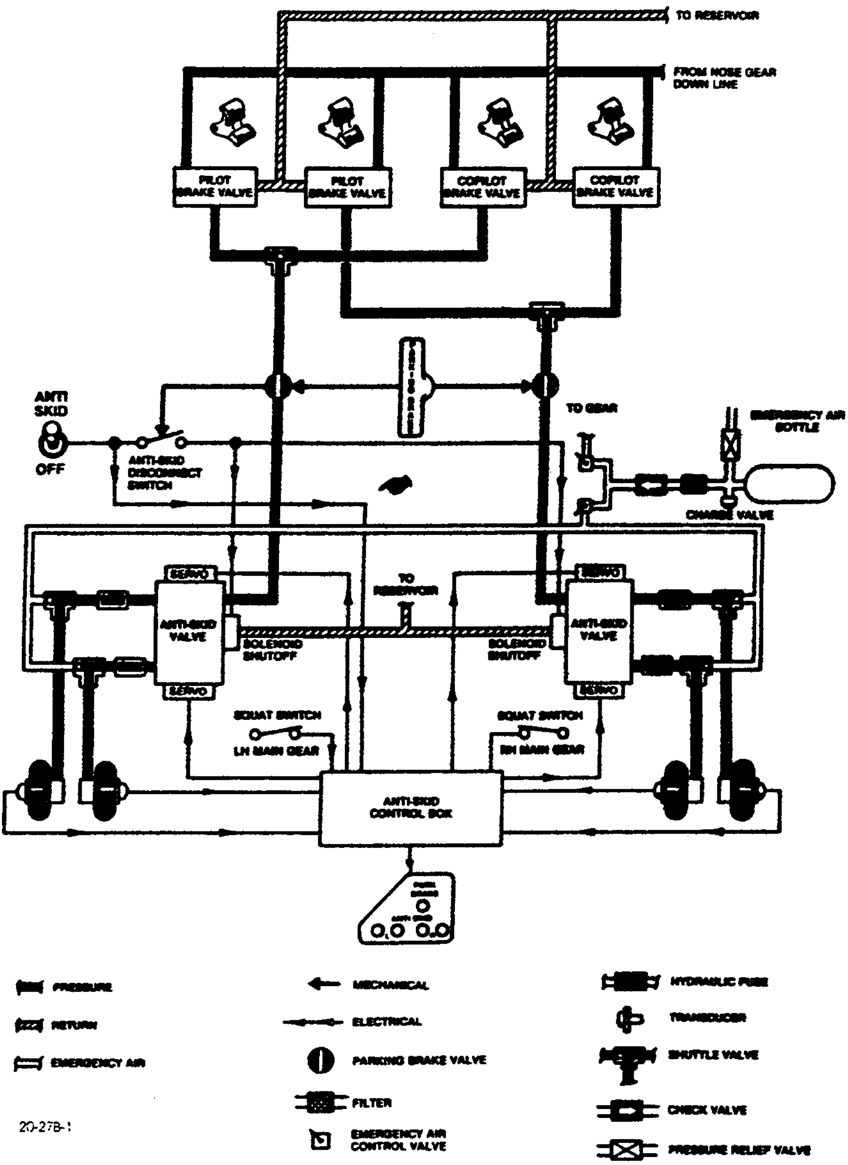
The primary brake system utilizes hydraulic system pressure for power boost. Hydraulic pressure from the nose gear down line is metered to the disc-type wheel brakes by the power brake valves. The valves are controlled by the rudder pedal toe brakes through mechanical linkage. Two shuttle valves in the pressure lines prevent fluid feedback between the pilot's and copilot's pedals. Four additional shuttle valves connect the pneumatic system to the brake system for emergency braking. Hydraulic fuses, located in the main gear wheel wells, will close to prevent pressure loss if fluid flow exceeds normal brake actuation rate. "Snubbing" of the main gear wheels is accomplished during retraction by means of hydraulic back pressure in the brake lines caused by a restrictor in the return line. An integral anti-skid system is installed to effect maximum braking efficiency. When parking, it is advisable to have the wheels chocked prior to releasing brakes.

PARKING BRAKE

The parking brake handle is labeled PARKING BRAKE and is located on the pedestal below the thrust levers. The handle is mechanically connected to the parking brake valve through which all pressure from the primary brake system must pass. The parking brake system is actuated by pressing and holding the toe brakes (hydraulic system pressurized) then pulling the parking brake handle which closes the parking brake valve, thereby locking pressure against the wheel brakes. Returning the parking brake handle to the off (in) position releases the brakes. An amber PARK BRAKE annunciator is installed on the pilot's instrument panel which illuminates (BATTERY Switches On) whenever the parking brake is applied.

EMERGENCY BRAKING

In the event of a main hydraulic system failure, the wheel brakes can be applied pneumatically. Emergency (pneumatic) braking is initiated and controlled through the red EMERG BRAKE handle located on the pedestal to the left of the thrust levers. Emergency braking is initiated by pulling the handle out of the recess and pushing down on the handle. As the EMERG BRAKE handle is pushed down, air pressure from the emergency air bottle is directed to the wheel brake shuttle valves through the lever actuated emergency brake valve. If the emergency air pressure is greater than the hydraulic system pressure, the wheel brake shuttle valves will reposition to admit air pressure to apply the brakes. As the brake handle is released, excess air will be vented overboard and the brakes will release. Because the emergency air lines are plumbed into the hydraulic brake system between the anti-skid control valves and the wheel brakes, anti-skid protection is not available when using emergency brakes. Also, the parking brake will be inoperative when using emergency air pressure.



WHEEL BRAKE SYSTEM SCHEMATIC
Figure 3-3

ANTI-SKID SYSTEM

An anti-skid system is integrated into the hydraulic brake system to provide even braking under all runway surface conditions without skidding the tires. The system consists of the ANTI-SKID control switch, anti-skid control box, two anti-skid control valves, monitoring lights, four wheel-speed transducers (one in each main wheel axle), and associated aircraft wiring. Each anti-skid control valve is a dual unit capable of individually modulating brake pressure for both associated brakes. As the transducers are driven by the main wheels, a frequency proportional to the wheel speed is induced and forwarded to the control box. The control box converts the wheel-speed frequency to an analog signal and compares the analog to a reference representing a near optimum slip ratio between aircraft velocity and wheel velocity to produce the maximum braking coefficient. Should the wheel speed deviate from the optimum slip rate, the control box will signal the affected wheel's control valve to reduce braking pressure on the affected wheel. Braking pressure is reduced by bypassing some of the hydraulic system pressure into a return line by means of a servo controlled valve in the control valve. As the wheel speed increases, normal braking pressure is restored. To ensure full manual control of the hydraulic braking system and to prevent pressure loss when the parking brake is set, a solenoid-operated shutoff valve at each control valve return port is deenergized closed when the ANTI-SKID switch is OFF or the parking brake is set. Electrical power for the anti-skid system control circuits is 28 VDC supplied through the 7.5-amp ANTI-SKID circuit breaker on the copilot's circuit breaker panel.

ANTI-SKID LIGHTS

Four red ANTI-SKID lights on the pilot's instrument panel provide a continuous cockpit indication of anti-skid system control circuit condition. The two lights labeled L represent control circuits for the left main gear brakes and the two lights labeled R represent control circuits for the right main gear brakes. The anti-skid control box continuously monitors the system circuits and will illuminate the applicable light(s) should any of the following conditions arise: loss of input power, open or shorted transducer circuits, open or shorted control valve circuits, and failure of control box circuits. Also, the lights will be illuminated any time the gear is down and locked, power is on the aircraft, and the ANTI-SKID switch is OFF.

ANTI-SKID SWITCH

The ANTI-SKID switch is located on the center switch panel and has two positions: On (ANTI-SKID) and OFF. When the switch is in the On (ANTI-SKID) position, 28 VDC is applied to the anti-skid system control circuits. Normally, the switch remains in the On (ANTI-SKID) position for all operations.