SECTION IV

HYDRAULICS

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Chapter 1

HYDRAULIC SYSTEMS

Introduction

The C-141 hydraulic system consists of separate and functionally independent systems designated as: Systems No. 1, 2, 3, and emergency nose landing gear extension system.

Each system is divided into a hydraulic power system and system components to which pressure is delivered. MIL-H-83282 type fluid is used. Each of the hydraulic systems has a service center where the hydraulic reservoirs are located.

The hydraulic systems' controls and indications are located on the lower left corner of the flight engineer's upper panel and pilot's overhead control panel.

Engine-Driven Pumps. (Figures 4-2 thru 4-4)

Flow capacities for one engine-driven pump, based on 90% volumetric efficiency, are:

Takeoff	23.5 GPM
Cruise	21 GPM
Idle	12.3 GPM

Pump displacement begins to decrease rapidly at 2,800 psi and continues to decrease until a system operating pressure of 3,000 psi is reached. At 3,000 psi, the pump displacement is zero.

The heart of the pump is a revolving cylinder barrel containing nine pistons. By means of a hold-down plate and hydraulically balanced shoes, the pistons are supported on an inclined cam (wobble) plate which causes them to reciprocate as the barrel revolves. Varying the angle of the cam plate changes the displacement of the pump. By regulating the flow, a predetermined pressure can be maintained.

Hydraulic System No. 1

Reservoir

The reservoir is in the No. 1 service center located on the right wall of the cargo compartment at the center wing section. The fluid capacity is 2.4 US gallons and it can be serviced in flight. A sight gage on the side of the reservoir is calibrated full and refill for zero psi and 3,000 psi conditions. The reservoir is nonpressurized and vented to a vent box, and vents through a filter to the cargo compartment. Baffling on the inside prevents direct flow of fluid from the system return to the outlet port on the bottom of the reservoir. This prevents foaming by separating air from fluid and aids in cooling of the fluid.

Electric-Driven Suction Boost Pump (Figure 4-5)

The suction boost pump located below the reservoir consists of a housing, centrifugal impeller and 115-volt, 3-phase AC electric motor. The pump is driven at a constant speed and is controlled by a 28-volt DC switch on the hydraulic systems' control and indicator panel. It is normally turned on before engine start and remains on until after engine shutdown.

The suction boost pump provides a constant flow of fluid from the reservoir to the inlet port of the engine-driven pumps. The pressure range of the suction pump is 80-100 psi. Cooling and lubrication of the boost pump are ensured by a bypass line routed from the pump's outlet port to the reservoir.

Suction Boost Pump Low Pressure Warning Switch

The low pressure 28-volt DC warning switch is connected to the suction line below the suction boost pump. The Yellow PRESS LOW warning light located on the hydraulic systems' control panel will be out when suction line pressure is within operating range, and will come on when pressure drops below approximately 25 psi.

Ground Test Connections

Two ground test connections (suction and pressure) are located in the forward inboard portion of the right gear pod for a hydraulic ground test stand.

Priming Check Valve

The priming check valve downstream of the suction boost pump prevents fluid siphoning when a component is removed. It also prevents gravity flow of fluid back to the reservoir when the system is turned off. This ensures that lubricating fluid will be available at the engine pump for the next start.

Supply Shutoff Valves (Figures 4-8, 4-9)

The motor-operated gate-type shutoff valves in each engine-driven pump supply line controls fluid flow to each individual engine-driven pump.

The valves, mounted in the wing leading edge above No. 3 and No. 4 engine pylons, are controlled by the ENG VALVE switch on the flight engineer's hydraulic control panel and is normally open. It can be closed by three different means: (1) The ENG VALVE switch, (2) Fire emergency handle, or (3) Manually positioning the power-off lever on the side of the valve. This lever is for ground maintenance only; it cannot be reached in flight. Circuit protection and power comes from the Isolated DC bus.

Engine-Driven Pressure Pumps

Two engine-driven, variable-volume, nine-piston, high-pressure pumps are mounted on the accessory gear box drive on engines No. 3 and No. 4. The pumps are connected in parallel and provide hydraulic requirements for system No. 1.

The compensator within the pumps regulates the pressure and volume depending on system requirements. Normal pressure is 3,000 ± 150 psi, with a maximum pressure 3,400 psi for each pump. The pumps are lubricated internally by a case drain return system in the normal mode of operation, and by a run-around system when the pumps are isolated. A one way check valve for the run-around system offsets at 2 - 8 psi.

High Pressure Filters (Figure 4-12)

High pressure filters are installed downstream of the engine-driven pumps on the right side of the engine fan section, to prevent contaminants passing from the pumps into the system.

Should the filter element become obstructed, a pressure drop across the filter will occur. If the pressure drop reaches approximately 70 psid, a red (clogged filter) indicator extends from the top of the filter body, indicating the filter must be removed and cleaned as soon as possible. There is no bypass relief valve in the high pressure filters. An identical type filter is installed in the pressure side of the ground test connection located in the forward inboard side of the right gear pod.

Return Filter

The return line filter, located just aft of the reservoir, filters the fluid before it enters the reservoir. Should the filter element become contaminated, a pressure drop across the filter occurs. If the pressure drop reaches 70 psid, a red (clogged filter) indicator extends from the top of the filter body. Should the element become so dirty that the pressure drop reaches 100 psid, an internal relief or bypass valve will open and allow return fluid to enter the reservoir unfiltered. Any time the indicator is extended, the filter element must be removed, and replaced as soon as possible.

Case Drain Return Filter

The case drain return filter is installed in the case drain return line below the system return filter. This filter is identical to the system return filter, with the exception of the size and flow volume. The red (clogged filter) indicator extends when pressure drop across the filter reaches 28 psid and the by-pass opens at 40 psid.

Pump Pressure Shutoff Valves (Figure 4-9)

The solenoid actuated valves are installed in each pump pressure line in the wing leading edge above No. 3 and No. 4 engine pylons. They are spring-loaded open and electrically closed, and they are controlled by the ENG VALVE switches on the flight engineer's panel and can also be CLOSED by pulling the emergency fire handles. They are normally open. Circuit protection and power comes from the Isolated DC bus.

Engine Pump Low Pressure Warning Switch

The low pressure warning switch is located above each respective engine pod in the wing leading edge, downstream of the pressure shutoff valve. The switch is set at 1,350 psi and operates a yellow PRESS LOW light on the flight engineer's hydraulic control panel. The light remains off as long as pressure is within operating range, and will come ON when pressure drops below 1,350 ± 150 psi.

Isolation Check Valve

A check valve is located in the leading edge of the wing, downstream of the pump low pressure warning switch. Its purpose is to prevent reverse flow through an inoperative pump and prevent the pressure switch on one engine from being actuated when the engine is not operating.

Pressure Transmitter

The pressure transmitter is a bourdon-tube type located in the service center. It operates a 26-volt AC pressure gage on the flight engineer's hydraulic control panel. The pressure gage is calibrated in increments of 250 psi from 0 to 4,000 psi. There is also a direct reading pressure gage located in the service center in the cargo compartment.

System Relief Valve

The relief valve is located in the service center to protect the system from excessive pressure in the event the engine-driven pumps fail to compensate. One port of the valve is connected to system pressure and one to return. Should pressure reach 3,560 psi, the valve will open and pump output will flow back to the reservoir. Once this valve is open, pressure must drop to approximately 3,150 psi before it will reseat.

Hydraulic System No. 1 Pressure Usage

Hydraulic System No. 1 supplies pressure to:

1. Ailerons
2. Elevators
3. Rudder

Hydraulic System No. 2

Reservoir

The reservoir is in the No. 2 service center located on the left wall of the cargo compartment near the center wing section, and can be serviced in flight. The fluid capacity is 4.2 US gallons with landing gear down, and 5.0 US gallons with gear up. When the landing gear is in the UP position, the fluid level will be above the filler neck. A sight gage on the side of the reservoir is calibrated FULL LG UP, FULL LG DN, REFILL LG UP, and REFILL LG DN.

The reservoir is nonpressurized and vented to a vent box and vents through a filter to the cargo compartment. It also has a dual check valve to prevent overflow of fluid in the event the reservoir overfills during ground checkout when No. 2 and No. 3 hydraulic systems are interconnected. The check valve also permits fast escape of air through the vent when the landing gear is in travel to the UP position. The reservoir has baffling on the inside to prevent direct flow of fluid from the system return to the outlet port. This prevents foaming by separating the air from the fluid and aids in cooling of the fluid.

Electric-Driven Suction Boost Pump (Figure 4-5)

The suction boost pump is located below the reservoir. It consists of a housing, centrifugal impeller and 115-volt 3-phase AC electric motor. The pump is driven at a constant speed and controlled by a 28-volt DC switch on the hydraulic systems' control panel. It is normally turned on before engine start and remains on until after engine shutdown.

The suction boost pump provides a constant flow of fluid from the reservoir to the inlet port of the engine-driven pressure pumps. The supply pressure range of the suction pump is 80-100 psi. Cooling and lubrication of the boost pump are ensured by a bypass line routed from the pump's outlet port to the reservoir.

Hydraulic-Driven Suction Boost Pump (Figures 4-5 thru 4-7)

The hydraulic motor-driven suction boost pump is mounted to the bottom of the reservoir. The motor consists of a nine-piston assembly which drives a vane-type suction boost pump. There is no ON-OFF control switch for the motor; it will operate anytime the No. 2 system is pressurized. It assists the electric-driven suction boost pump during peak loads and takes over if the electric-driven suction boost pump fails. There is no individual indicator light on the hydraulic systems' control panel for the hydraulic-driven suction boost pump. It uses the same low pressure warning system as the electric-driven suction boost pump.

When the pressure from the engine-driven pressure pump reaches approximately 500 psi, the hydraulic motor section of the pump begins to turn the boost section, and flow starts toward the inlet side of the engine-driven pump. As flow decreases, pressure increases until the pressure is approximately 80-100 psi. As system demand causes a flow, the pressure is decreased and the cycle starts again.

Ground Test Connections

Two ground test connections (suction and pressure) are located on the fuselage skin inside the left gear pod for a hydraulic ground test stand.

Hydraulic System No.2 Pressure Usage

Hydraulic System No. 2 supplies pressure to:

1. Ailerons
2. Elevators
3. Rudder
4. Pitch trim
5. Landing gear
6. Nose wheel steering
7. Normal brakes
8. Emergency generator
9. Wing flaps
10. Wing spoilers & spoiler cable servo
11. Air refueling slipway door
12. Air refueling receptacle latches

Priming Check Valve

The priming check valve downstream of the suction boost pump prevents fluid siphoning when a component is removed. It also prevents gravity flow of fluid back to the reservoir when the system is turned off. This ensures that lubricating fluid will be available at the engine pump for the next start.

Suction Boost Pump Low Pressure Warning Switch

The low pressure 28-volt DC warning switch is connected to the suction line below the suction boost pump. The yellow PRESS LOW warning light located on the flight engineer's hydraulic systems control panel will be out when suction line pressure is within operating range, and will come ON when pressure drops below 25 psi.

Supply Shutoff Valves

The motor-operated gate-type shutoff valves in each engine-driven pump supply line control fluid flow to each individual engine-driven pump.

The valves, mounted in the wing leading edge above No. 1 & No. 2 engine pylon, are controlled by the ENG VALVES switch on the flight engineer's hydraulic control panel and are normally open. The valves can be closed by three different means: (1) The control switch, (2) fire emergency handle, or (3) manually positioning the power-off lever on the side of the valve. This lever is for ground maintenance only; it cannot be reached in flight. Circuit protection and power come from the Isolated DC bus.

Engine-Driven Pressure Pumps

Two engine-driven, variable-volume, nine-piston high-pressure pumps are mounted on the accessory gear box drive of engines No. 1 and No. 2. The pumps are connected in parallel and provide hydraulic requirements for system No. 2.

The compensator within the pumps regulates pressure and volume depending on system requirements. Normal pressure is 3,000 ± 150 psi, with maximum pressure 3,400 psi for each pump.

Pump lubrication for number 2 system is identical to number 1 system.

Pump Pressure Shutoff Valves

This is a solenoid actuated valve, installed in each pump pressure line in the wing leading edge above No. 1 and No. 2 engine pylons. It is spring-loaded open and electrically closed, and is controlled by the ENG VALVES switch on the hydraulic systems' indicator panel, and can also be CLOSED by pulling the emergency fire handles. Circuit protection and power come from the Isolated DC bus.

Engine Pump Low Pressure Warning Switch

The low pressure warning switch is located above each respective engine pylon in the wing leading edge, downstream of the pressure shutoff valve. The switch is set at 1,350 psi and operates a pump PRESS LOW yellow light on the hydraulic systems' control and indicator panel. The light remains off as long as pressure is within operating range, and will come ON when pressure drops below operating range.

Isolation Check Valves

A check valve is located in the leading edge of the wing, downstream of the pump low pressure warning switch. Its purpose is to prevent reverse flow to an inoperative pump and prevent the pressure switch on one engine from being actuated when the engine is not operating.

Pressure Transmitter

The pressure transmitter is a bourdon-tube type located in the service center. It operates a 26-volt AC pressure gage on the hydraulic systems' control and indicator panel. The pressure gage is calibrated in increments of 250 psi from

0 to 4,000 psi. There is a direct-reading pressure gage located in the service center in the cargo compartment.

System Relief Valve

The relief valve is located in the service center to protect the system from excessive pressure in the event the engine-driven pumps fail to compensate. One port of the valve is connected to system pressure and one to return. Should pressure reach 3,560 psi, the valve is open and pump output will flow back to the reservoir. Once this valve is open, pressure must drop to approximately 3,150 psi before it will reseat.

High Pressure Filters

High pressure filters are installed downstream of the engine-driven pumps on the right side of the engine fan section, to prevent contaminants from passing from the pumps into the system.

Should the filter element become obstructed, a pressure drop across the filter will occur. If the pressure drop reaches approximately 70 psid, a red (clogged filter) indicator extends from the top of the filter body, indicating the filter must be removed and replaced as soon as possible. There is no bypass relief valve provided in the high pressure filters.

Return Filters

The return line filter, located forward of the system reservoir, filters the fluid before it enters the reservoir. Should the filter element become contaminated, a pressure drop across the filter occurs. If the pressure drop reaches 70 psid, a red (clogged filter) indicator extends from the top of the filter body. Should the element become so dirty that the pressure drop reaches 100 psid, an internal relief or bypass valve will open and allow return fluid to enter the reservoir unfiltered. Anytime the indicator is extended, the filter element must be removed and replaced as soon as possible.

Case Drain Return Filter

The case drain return filter is located just forward of the reservoir. This filter is identical to the system return filters with the exception of the size and flow volume. The red (clogged filter) indicator extends when pressure drop across the filter reaches 28 psid and the bypass opens at 40 psid.

Hydraulic System No.3

Reservoir

The reservoir is in the No. 3 service center forward of system No. 2 reservoir, on the left wall of the cargo compartment. The fluid capacity is 4.8 US gallons and it can be serviced in flight. A sight gage on the side of the reservoir is calibrated 0-PSI FULL, 0-PSI REFILL, 3,000-PSI FULL, 3,000-PSI REFILL. Service instructions are placarded on the reservoir.

The reservoir is nonpressurized and vented to a vent box shared with Hyd Sys No. 2 and vents through a filter to the cargo compartment. Bafflings on the inside prevents direct flow of fluid from the system return to the outlet port, the same as No. 1 and No. 2 systems' reservoirs.

<u>Electric Motor-Driven Pumps</u> (Figure 4-10)

Two electrically-driven, high-pressure, variable-volume pumps, including the impeller-type suction boost pumps in the same housing, connected in parallel, are located in the left wheel well. A constant flow of fluid through the case drain return provides lubrication and cooling. Normal pressure is 3,000 ± 150 psi at 6,000 rpm, and maximum pressure is 3,400 psi for each pump. Flow capacities for one pump is 2,300 psi at 8 GPM, 2,950 psi at 6 GPM.

<u>Controls</u>

A control switch for each pump is located on the hydraulic systems' control and indicator panel, and has ON-OFF-RAMP CONTROL positions. When the No. 1 switch is placed ON, the pump will start instantly. (There is a two-second time delay incorporated in the No. 2 pump circuit.)

The hydraulic control panel is decaled "Wait five seconds before starting second pump" to prevent overloading the electrical system. The RAMP CONTROL position of each switch transfers control of related pump to the ramp control panel located in the aft end of the cargo compartment, left hand side.

In addition to the normal controls, system No. 3 pumps turn on automatically when any of the following is accomplished:

1. When spoiler control handle is moved out of the CLOSED position.

2. Spoilers move from closed position.

3. An aileron is in TAB OPERABLE (both switches).

4. Either elevator control switch is placed to EMER position.

When the normal pump control switches are in the OFF position and the pumps are energized by any one or all of the automatic methods, the pumps will stop when the last of the automatic systems is returned to the normal position. The two-second time delay of No. 2 pump is effective when pumps are actuated automatically.

Two 80-cubic-inch hydraulic fuses are located in the No. 3 service center, downstream of each electric motor-driven pump, and prevent motor overloading during initial pump starting. The fuses are spring-loaded open and vented to return, which allows the motors to come up on speed. The fuses are set to close off by fluid volume. When they close, system pressure will build up. (Figure 4-11)

Isolation Check Valves

An isolation check valve located in the service center, downstream of each pump, prevents reverse flow, thus isolating pressure from an inoperative pump.

Pump Low Pressure Warning Switch

The low-pressure warning switch is located aft of the No. 3 reservoir on the left wall of the cargo compartment. The switch is set at 1,350 psi and operates a PRESSURE ON light (green) on the brake pressure and anti-skid control and indicator panel, which is located on the pilots' center instrument panel. The light will stay ON above 1,350 psi.

High Pressure Filter

A high-pressure filter located aft of No. 3 reservoir prevents contaminants passing from the pumps into the system. Should the filter element become obstructed, a pressure drop across the filter will occur. If the pressure drop reaches approximately 70 psid, a red (clogged filter) indicator extends from the top of the filter body, indicating the filter must be removed and replaced as soon as possible. There is no bypass relief valve provided in the high-pressure filter.

Return Filter

The return-line filter located forward of the system reservoir filters return fluid before it enters the reservoir. Should the filter element become contaminated, a pressure drop across the filter will occur. If the pressure drop reaches 28 psid, a red (clogged filter) indicator extends from the top of the filter body. Should the element become so dirty that the pressure drop reaches 40 psid, an internal relief or bypass valve will open and allow return fluid to enter the reservoir unfiltered. Any time the indicator is extended, the filter element must be removed and replaced as soon as possible.

Case Drain Return Filter

The case drain return filter is located just forward of the reservoir. This filter is identical to the system return filters with the exception of the size and flow volume. The red (clogged filter) indicator extends when pressure drop across the filter reaches 28 psid and the bypass opens at 40 psid.

Pressure Transmitter

The pressure transmitter is a bourdon-tube type located in the service center. It operates a 26-volt AC pressure gage on the hydraulic systems' control and indicator panel. The pressure gage is calibrated in increments of 250 psi from 0 to 4,000 psi. There is a direct reading pressure gage located in the service center in the cargo compartment.

Main Accumulators (Figure 4-12)

Two 400-cubic-inch, piston-type accumulators are installed in the No. 3 service center, and are normally charged to approximately 3,000 psi by No. 3 system. A direct reading pressure gage is installed on each accumulator.

These accumulators aid No. 3 pumps during peak loads. They can be used to start the APU. In addition, the accumulators can be used to furnish emergency brake pressure, when normal brake pressure is not available. Accumulator pressure is used for the emergency brake system, when electrical power is off (approximately 10 applications).

Accumulator Control Valve

The accumulator control valve (bypass valve) is electrically energized open when pumps are turned on either manual or automatic, and deenergized closed when pumps are shut off.

Hand Pump

A double-action type hand pump, located on the left wall of the cargo compartment immediately below the system No. 3 reservoir, provides a means of pressurizing the accumulators, emergency brakes, ramp, and doors when the high pressure pumps are inoperable. Approximately 460 strokes of the hand pump are required to pressurize the accumulators to 3,000 psi. A check valve is installed between the pump outlet port and the system pressure line to prevent pressure build-up against the pump during normal operation. A direct-reading pressure gage is located near the No. 3 reservoir to indicate hand pump pressure.

System Relief Valve

The relief valve is located in the service center to protect the system from excessive pressure in the event the electric motor-driven pumps fail to regulate. One port of the valve is connected to the system pressure and one to return. Should pressure reach 3,560 psi, the valve will open and pump output will flow back to the reservoir. Once this valve is open, pressure must drop to approximately 3,150 psi before it will reseat.

Hydraulic System No. 3 Pressure Usage

Hydraulic System No. 3 supplies pressure to:

1. Wing flaps
2. Wing spoilers & spoiler cable servo
3. Aileron tab lockout
4. Elevator emergency power
5. Ramp and doors
6. Emergency brakes
7. APU starter

Ground Interconnect Valves

Two interconnect valves are located between system No. 2 and No. 3 reservoirs. Both valves are controlled by one manually operated control handle. Moving the control handle to the INTERCONNECT position will position one valve to connect the No. 3 system pressure to the No. 2 system manifold, and the remaining valve will connect the No. 2 and No. 3 system reservoirs through an interconnect tube. With the control handle in the INTERCONNECT position, the No. 3 system electrical motor-driven pumps can be used to provide power for all subsystems normally operating on No. 2 system power.

The fluid level in the No. 2 and No. 3 system reservoir will remain constant because of the reservoir interconnect tubing. An isolation check valve prevents the flow of fluid through the pressure line from system No. 2 to system No. 3. This system is for GROUND CHECK ONLY, and the control handle must be in the CLOSED position before flight.

APU-Starter

The APU starter is driven by a hydraulic motor powered by pressure from the accumulators. Controls for the APU are located on the upper left corner of the flight engineer's panel. An APU ACCUM SEL switch allows the selection of No. 1, No. 2, or BOTH accumulators, as desired.

Each accumulator will last approximately 10 seconds when used to start the APU.

An additional surge accumulator is installed in the APU starter inlet line. This accumulator acts as a shock absorber, absorbing the initial starting pressure, and prevents excessive gearbox torque from being transmitted to the clutch. The Accumulator Control Valve and the two starter selector valves are located in the No. 3 service center. Each valve incorporates a manual override.

The APU, located in the left forward gear pod, supplies air for engine starting, air for environmental systems, and mechanically drives an AC generator during ground operation only.

Chapter 2

PRIMARY FLIGHT CONTROLS

The aircraft is controlled by hydraulically powered aileron, rudder, and elevator systems. Aerodynamic lateral control is available through a cable-controlled aileron tab, if normal hydraulic pressure is lost. Electrically operated trim systems are provided for trimming the aircraft about the roll, yaw and pitch axis. A manually operated, hydraulically powered trim system and an electrically operated, hydraulically powered trim system are also provided for the pitch axis.

The primary flight control power control assembly has anticavitation valves to prevent cavitation of the actuators when they are operating with hydraulic power off, while the shutoff and bypass valve is in the normal position (POWER ON).

Wind Gust Limitations

The aircraft was designed to withstand 70-knot gusts from any direction, the tail-on gust being the most severe. Check valves are installed in the pressure lines of the power control assembly to retard reverse flow due to ground gusts when systems are depowered with shutoff and bypass valve in the norm (OPEN) position. Above 70 knots, control damage may occur if the aircraft is not headed into the wind, since design limits can be exceeded. The aircraft should be evacuated to a safe weather area if winds in excess of 70 knots are expected; however, if that is impossible, the aircraft will be moored in accordance with maintenance T.O.'s. If the aircraft has been subjected to wind velocities exceeding 70 knots, thoroughly check the control surfaces and points of attachment before the next flight.

The use of engines to maneuver the aircraft during high wind is not recommended and should be avoided except under extreme circumstances. Foreign object damage (FOD) to the engines is highly probable.

Jammed Flight Controls

The aileron or elevator control interconnects between the cable tension regulators have one shear rivet, and the artificial feel springs have one shear rivet. The rudder artificial feel spring also has one shear rivet. All of these shear rivets are designed to shear at a pilot force above the maximum control operation forces and below forces that the control systems were structurally designed to withstand. (Refer to Sec. 3 in dash 1, for Jammed Flight Controls.)

NOTE

> Partial control can be obtained using the freed system. Since the controls are also tied together at their respective input quadrants, completely free operation will not be obtained.

Aileron Control System (Figure 4-13)

Each aileron is normally actuated by a dual-power control assembly which is controlled by the pilots' control wheels and is powered by the No. 1 and No. 2 hydraulic systems. The travel limits of the ailerons are 25 degrees up and 15 degrees down from the faired positions. The ailerons are hydraulically powered down to the trail position to provide additional lift for the wings. Components of the aileron control system are: the pilot's and copilot's control wheels, cable systems and linkages, tension regulators, an input quadrant, an autopilot servomotor, power control assemblies, aileron servotab lockout actuators, control switches, and warning lights on the pilots' overhead panel and on the annunciator panel.

Dual-Power Control Assembly

The power control assemblies hydraulically actuate the ailerons in response to input control movements from either pilot's control wheel, the autopilot servomotor, or the aileron electric trim actuator. In each power control assembly, one of the dual actuators is powered by the No. 1 hydraulic system, and the other actuator is powered by the No. 2 hydraulic system. During normal operation, each actuator provides one half of the force required to operate the attached aileron; however, either actuator is capable of providing the entire operating force if the hydraulic system to the other actuator fails.

The left and right aileron power control assemblies move simultaneously but in opposite directions. If one aileron becomes inoperable, the SYS 1 and SYS 2 control switches for that aileron can be placed in the tab operable position.

This isolates hydraulic pressure from the power control assembly actuating cylinders of the inoperable aileron; the operable aileron will continue to function normally.

A load limiting relief valve is installed in each actuating cylinder. With hydraulic power ON, the valve opens and allows fluid to bypass from the retract side to the extend side of the actuating cylinder, if the aileron surface load is great enough to cause a pressure difference of 2,900 psi between the two sides of the actuator. The relief valve for the extend side of the actuator is installed in the manifold, the valve opens at 2,700 psid.

A controlled leakage arrangement at each hydraulic system section of the servo valve permits approximately one gallon per minute flow of fluid through the valve when the valve is in the neutral position and the hydraulic systems are pressurized. This provides a continuous supply of warm fluid to the actuators, located in an unheated area of the aircraft. This prevents sluggish operation of the power control assembly. A power control assembly is mounted on the aft side of the rear beam in each wing, forward of the aileron.

Pilot's and Copilot's Control Wheels (Figure 4-13)

The U-shaped control wheels which control operation of the ailerons and servotabs are individually connected by concealed cables to a separate tension regulator input quadrant beneath the flight deck. The pilot's and copilot's input quadrants are interconnected by a pushrod and cranks on the quadrants. This interconnection causes the control wheels and dual control cable systems to operate in unison. It allows operation of both control cable systems with either of the control wheels, and also permits the pilots to combine their efforts during manual operation of the ailerons. Ninety degrees of aileron control wheel rotation is required to obtain full surface deflections.

Aileron Power Control Switches

Four three-position (NORMAL - OFF - TAB OPERABLE), lever-lock type aileron switches, on the pilots' forward overhead panel, control the motor-operated shutoff and bypass valves of the power control assemblies and select tab operation.

The NORMAL position of each switch causes the related system No. 1 or No. 2 shutoff and bypass valve of the corresponding power control assembly to open and port fluid to the servo flow control valve.

The OFF position closes the valve, discontinuing the supply of hydraulic pressure to the servo flow control valve. The OFF position also opens the shutoff valve bypass to connect the two ends of the actuator to each other and to the return line. This action permits the actuating piston to move freely with aileron surface movement.

The TAB OPERABLE position of each switch performs the same function as the OFF position, as far as the power control assemblies are concerned. When TAB OPERABLE is selected with either the two left or the two right aileron power control switches, the corresponding aileron tab becomes operable. Placing either the two left, the two right, or all four power control switches to TAB OPERABLE, energizes the pumps of hydraulic system No. 3. This energizes the corresponding solenoid operated tab lock valve, opening the valve to port system No. 3 pressure to the related tab lockout actuator. Actuator movement changes tab input linkage, giving mechanical advantage, with the result that control wheel movement can be transmitted to the tab.

Aileron System Power Off Lights

Two 28-volt DC POWER OFF lights for the left aileron power control assembly and two for the right aileron power control assembly are located on the pilots' overhead panel, above the aileron power control switches. The lights illuminate if the respective system pressure drops to approximately 1,500 psi, within the related power control assembly. A pressure switch downstream of each aileron system shutoff valve controls the associated light.

Aileron System 1 Power and Aileron System 2 Power Lights

An AILERON SYS 1 PWR and an AILERON SYS 2 PWR light on the annunciator panel illuminate if the respective hydraulic system pressure drops to approximately 1,500 psi within at least one of the power control assemblies. The POWER OFF lights on the pilots' overhead panel indicate which control assembly has suffered a loss of hydraulic pressure. The AILERON SYS 1 PWR and AILERON SYS 2 PWR light will remain illuminated for as long as the system pressure within either power control assembly is below 1,500 psi. Subsequent power failure of the system in the remaining power control assembly will be visually evidenced only by the related POWER OFF light. The AILERON SYS 1 PWR and AILERON SYS 2 PWR lights are controlled by the pressure switches which control the related POWER OFF lights.

Aileron Tab Operable Lights

Two 28-volt DC lights, a R AIL TAB OPER and a L AIL TAB OPER light, are provided on the annunciator panel to give positive indication when the corresponding aileron tab linkage is in the operable configuration. A limit switch, actuated by movement of the related tab linkage lockout actuator, controls the associated light.

Normal System Operation (Figure 4-19)

During normal operation, the LEFT and RIGHT AILERON SYS 1 and SYS 2 control switches on the pilots' overhead panel are in the NORMAL positions. The position of the ailerons is controlled by the pilot's or copilot's control wheel or by pilot or copilot inputs to the aileron trim system. Movement of the control wheels is transmitted aft by dual cable and linkage systems to a common input quadrant assembly mounted on the aft side of the center wing rear beam. The input quadrant assembly can also receive input motions from an aileron electric trim actuator and an autopilot servomotor. A spring cartridge attached to the input quadrant "feeds back" an artificial "feel" resisting force to the control wheels to simulate the "feel" of the aerodynamic loads that resist the movement of the ailerons. Without this "feel," the pilots have no way to gage the amount of control surface loading during normal powered operation. In addition to providing "feel," the spring acts as a centering device by returning the aileron system to neutral trim when the controls are released. During normal flight operation, the aileron servotabs are locked so they move and remain faired with the ailerons.

Operation With One Hydraulic System

If either the No. 1 or No. 2 hydraulic system is inoperable, the LEFT and RIGHT AILERON SYS control switches for the inoperable hydraulic system are placed in the TAB OPERABLE positions to actuate the shutoff and bypass valves in the power control assemblies. The ailerons can then be controlled in the same manner used for normal operation with the system that is still functioning.

In the event both hydraulic systems are lost, the affected aileron will float up to an aerodynamically neutral position.

Aileron Tab Lockout Actuator (Figures 4-15 thru 4-18)

When the LEFT and RIGHT AILERON SYS 1 and 2 control switches on the pilots' overhead panel are in the NORMAL positions, the servotabs remain faired with the ailerons during normal operation of the ailerons. When the No. 1 and No. 2 hydraulic systems are depressurized and the power control assemblies are inoperable, the LEFT and RIGHT AILERON SYS 1 and 2 control switches are placed in the

TAB OPERABLE positions. This will start the No. 3 hydraulic system pumps and also open a solenoid valve in each wing to admit No. 3 hydraulic system pressure to the aileron tab lockout actuators. In tab operable mode, 120° of aileron control wheel rotation produces full tab deflections.

Aileron Trim System (Figures 4-14, 4-15)

The aileron trim system allows the pilot to correct for a wing low or wing high condition. The trim system consists of an actuator assembly, mounted on the center wing rear beam, and is mechanically connected to the input quadrant assembly. A position indicator is located in the pilots' center instrument panel. The aileron trim range is 9.5 degrees up and 8 degrees down.

Aileron Trim Control Switches

Two aileron trim switches on the control pedestal trim the aircraft about the roll axis. The switches are three-position (LOWER LEFT WING - LOWER RIGHT WING - OFF) toggle switches. The spring-loaded center "OFF" position is unmarked. The switches must be operated simultaneously to provide both power and ground to the 115-volt AC trim actuator. Holding the switches in either position energizes the actuator jackscrew. This mechanically positions the aileron quadrant which, in turn, mechanically positions the servo flow control valves of the power control assemblies to actuate the aileron surfaces hydraulically.

Aileron Trim Position Indicator

A 28-volt DC aileron trim position indicator is on the pilots' center instrument panel. The dial of the indicator is calibrated in graduations of 1 degree from 0 to 6 (with an unmarked calibration representing 7) degress for lower left wing and lower right wing. The aileron trim position transmitter is located on the end of the actuator assembly.

Rudder Control System (Figures 4-20 thru 4-22)

The rudder system uses pushrods, levers, and a dual cable system to transmit rudder pedal motion to a quadrant in the fuselage tail cone area. Dual pushrods transmit quadrant motion to levers mounted on the rudder yoke assembly and linkage to a servo flow control valve of a dual hydraulic power control assembly.

Linkage motion positions the servo flow control valve to actuate the rudder surface, hydraulically. Feedback linkage automatically repositions the servo flow control valve to neutral, stopping movement of the rudder surface when movement of the rudder pedals stops. Pressure from hydraulic systems No. 1 and No. 2 is normally supplied to the power control assembly. The travel limit of the rudder is 35 degrees either side of neutral.

The rudder pedals are supported by positionable arms which allow four inches forward and five inches aft adjustment. Two handcranks, one located below the pilot's instrument panel and one below the copilot's instrument panel, make this adjustment.

Rudder Power Control Switches

Two NORMAL - POWER OFF switches on the pilots' overhead panel control the supply of fluid to the power control assembly. In the event either hydraulic power system is shut off or fails, a portion of normal rudder surface deflection is lost at high airspeeds.

Rudder System Power Off Lights

Two POWER OFF lights, one for hydraulic system No. 1 and one for hydraulic system No. 2, are located above the rudder hydraulic systems' control switches on the pilots' forward overhead panel. The lights illuminate if the respective system pressure drops to approximately 1,500 psi within the power control assembly. A pressure switch, installed downstream of the rudder system shutoff valve, controls the associated POWER OFF light.

Rudder System 1 Power and Rudder System 2 Power Lights

A RUDDER SYS 1 PWR light and a RUDDER SYS 2 PWR light are installed on the annunciator panel. The lights work in conjunction with the respective system POWER OFF light on the pilots' overhead panel to indicate visually low-pressure conditions in the pressure inlet lines of the power control assembly. The lights illuminate if the respective system inlet pressure drops to approximately 1,500 psi. The lights are controlled by the pressure switches which control the POWER OFF lights.

Rudder System High Pressure Lights

Two HI PRESS lights, one for each half of the dual-power control assembly, on the pilots' forward overhead panel, advise that high pressure is available at the related rudder actuator. The lights are controlled by the load limiting relief pressure switch associated with rudder power system No. 1 or No. 2. The lights are normally illuminated when aircraft airspeed is below 160 (± 10) knots CAS.

Normal System Operation (Figure 4-23)

The rudder is operated by hydraulic systems No. 1 and No. 2 which supply pressure to the power control assembly. Load limiting relief valves within each half of the power control assembly relieve normal (3,000 psi) hydraulic pressure to 2,450 psi. This is the maximum rudder system operating pressure at airspeeds below 160 (± 10) knots CAS. At aircraft airspeeds above 160 (± 10) knots CAS, control pressure to the relief valves is released through the action of the CADC controlled, solenoid-operated pilot valves to further relieve rudder system operating pressure to 900 psi, maximum. Loss of main DC power deenergizes the pilot valve solenoids, which are normally energized above 160 (± 10) knots CAS.

A bypass feature of the motor-operated shutoff valve ports return fluid directly from one side to the other side of the piston of the actuator when the valve is in the shutoff position. This permits the piston to move freely with rudder surface movement. Prior to the time the shutoff valve is closed during a hydraulic system failure, an anti-cavitation check valve within each half of the power control assembly prevents cavitation of the actuator and permits free movement of the actuating piston.

A controlled leakage arrangement at each hydraulic system section of the servo valve permits approximately one gallon per minute flow of fluid through the valve when the valve is in the neutral position and the hydraulic systems are pressurized. The system incorporates an artificial feel mechanism. The mechanism operates the same as the aileron.

Rudder High-Pressure Override Switch

This switch, located on the pilots' overhead panel, permits selection of rudder system high-pressure, if required, when operating below 160 knots CAS.

Rudder System Overpressure Light

A RUDDER OVERPRESS light illuminated on the annunciator panel advises of an overpressure condition within the power control assembly. Under normal conditions the light illuminates only when aircraft airspeed is above 160 (± 10) knots CAS and high rudder system pressure is being supplied to at least one of the rudder actuators. The light is controlled by the joint action of either of the load limiting relief pressure switches and a CADC controlled 28-volt DC rudder pressure limiting relay incorporated in the system.

Rudder Trim System (Figures 4-21, 4-22)

The rudder trim system allows the pilot to correct for minor directional deviations. The system consists of an actuator assembly mounted to the aft fuselage structure, mechanically connected to the input quadrant assembly, and a position indicator located on the pilots' center instrument panel. The range of rudder trim is 6 degrees to either side of neutral; the rate is 1 degree per second.

Rudder Trim Position Indicator

The trim position indicating system consists of a DC synchro-type transmitter inside the trim actuator and a synchro-receiver indicator located on the pilots' center instrument panel. The dial of the indicator is calibrated in graduations of one degree from zero to seven degrees for nose left and nose right.

Rudder Trim Control Switches

Two rudder trim control switches, on the control pedestal, are three-position (NOSE LEFT - NOSE RIGHT - OFF) toggle switches, spring-loaded to the center unmarked OFF position. The switches must be operated simultaneously to provide both power and ground to the 115-volt AC trim actuator. Holding the switches in either position energizes the trim actuator, extending or retracting the actuator jackscrew to mechanically position the rudder quadrant. This, in turn, mechanically positions the servo flow control valve of the power control assembly to hydraulically actuate the rudder surface.

Elevator Control System (Figures 4-24 thru 4-26)

The elevators are hydraulically actuated by a power control assembly mounted between the elevator torque shafts in the bullet. During normal operation, the actuators powered by the No. 1 and No. 2 hydraulic systems move the elevators. If either of the hydraulic systems becomes inoperable, the elevators could be controlled with the remaining system; however, the No. 3 hydraulic system and the emergency actuator can be used, with the system still operating, to provide dual hydraulic system control. If both the No. 1 and No. 2 hydraulic systems become inoperable, the elevators can be controlled with the No. 3 hydraulic system and the emergency actuator.

Elevator Control Column

During normal system operation, full control column travel, forward and aft of neutral, produces full elevator travel of 15 degrees down and 25 degrees up. A mechanical stop prevents movement of the control columns beyond the distances mentioned. The control columns are equipped with bob-weights which work in conjunction with the feel spring to provide control column feel for increased "Gs." A single pushrod and dual cable system for each control column transmits column motions to a quadrant assembly installed in the empennage.

Elevator Hydraulic Power Control Switches

Two three-position (NORM - OFF - EMER), lever-lock type switches on the pilots' forward overhead panel control the motor-operated shut-off and bypass valves on the power control assembly. The NORM position of these switches causes the related system No. 1 or system No. 2 shutoff and bypass valve to open and port fluid to the servo flow control valve. The OFF position closes the shutoff valve, discontinuing the supply of hydraulic pressure to the servo flow control valve. The OFF position also opens the shutoff valve bypass to connect the two ends of the actuator to each other and to the return line, permitting the actuating piston to move freely with elevator surface movement. The EMER position performs the same function as the OFF position as far as hydraulic systems No. 1 and No. 2 are concerned. It also causes the emergency system (hydraulic system No. 3) shutoff and bypass valve to open and port fluid to the emergency system servo flow control valve. The emergency system shutoff and bypass valve is energized closed when both switches are in any position other than emergency.

Elevator System Power Off Lights

Two POWER OFF lights, one for elevator hydraulic system No. 1 and one for elevator hydraulic system No. 2, are above the elevator system hydraulic power control switches on the pilots' forward overhead panel. The lights illuminate if the respective system pressure drops to approximately 1,500 psi within the power control assembly.

Elevator System 1 Power and Elevator System 2 Power Lights

An ELEV SYS 1 PWR light and an ELEV SYS 2 PWR light are on the annunciator panel. The lights illuminate if the respective system pressure drops to approximately 1,500 psi within the power control assembly. The lights are controlled by the pressure switches which control the associated POWER OFF lights on the pilots' forward overhead panel.

Elevator Emergency Power On Lights

An EMER PWR ON light is provided on the pilots' forward overhead panel to give a positive indication of the adequacy (above 1,500 PSI) of the elevator emergency system pressure, when using the emergency actuator. A dual function pressure switch controls the lights.

Elevator Emergency Power Light

An ELEV EMER PWR light is on the annunciator panel. The light illuminates if the pressure within the emergency actuator drops to approximately 1,500 psi while the emergency elevator system is being used. A dual function pressure switch controls the light.

Normal Operation (Figure 4-28)

During normal operation, the ELEVATOR SYS 1 and SYS 2 control switches, on the pilots' overhead panel, are in the NORM positions to connect the 28-volt isolated DC bus to the No. 1 and No. 2 hydraulic system shutoff and bypass valve motors on the elevator power control assembly. The motors drive the valves to the open positions. Also, during normal operation, the ELEVATOR ARTIFICIAL FEEL switch is in the NORM position so the artificial feel servo mechanism adjusts the amount of "feel" in the system in relation to the airspeed detected by the CADC No. 1.

The control column movements are transmitted to a common input quadrant assembly mounted in the vertical stabilizer. The input quadrant assembly can also receive input motions from a cable-connected autopilot servomotor. A spring cartridge, mechanically connected to the input quadrant assembly, "feeds back" a resisting force to the control columns to provide an artificial "feel" of the aerodynamic loads on the elevators. Moreover, the attach point of the artificial feel spring rod to the input quadrant assembly is moved and adjusted by an artificial feel servo mechanism. Without this "feel" force, the pilots have no means of gaging the amount of control surface loading. Pushrod and bellcrank linkages transmit motion from the input quadrant to the power control assembly in the bullet between the torque tube ends of the elevators.

During normal operation, the input movements to the power control assembly displace the servo valves to connect the pressure and return lines of the No. 1 and No. 2 hydraulic systems to the opposite ends of the actuating cylinders. The direction of actuating piston movement is determined by the direction of servo control valve displacement from the neutral position. Extension and retraction of the actuator pistons are transmitted by bellcranks and pushrods to the elevator torque tubes to move the elevators.

The main servo valve has a controlled leakage arrangement which permits approximately one gallon of fluid per minute to flow through the valve when the valve is at the valve neutral position. This provides a continuous supply of warm fluid to the actuators, located in the unheated empennage, to prevent sluggish operation of the power control assembly after periods of inactivity. A piston and orifice arrangement at one end of the main servo valve provides a hydraulic snubbing and damping action to protect the valves and the system from too rapid actuation.

Pressure relief valves within the power control assembly prevent air loads on the elevators from developing excessive pressure in the actuators and excessive load on tail sections.

Partial Emergency and Emergency Operation (Figure 4-29)

The elevators can be controlled with any of the three hydraulic systems energizing the power control assembly; however, usually two hydraulic systems are used in unison, to provide uninterrupted control of the elevators, if one of the operating systems should fail.

If one of these systems becomes inoperable, the corresponding ELEVATOR SYS control switch on the pilots' overhead panel is placed in the EMER position. This causes the inoperable hydraulic system shutoff and bypass valve to close, the No. 3 hydraulic system shutoff and bypass valve to open, and the No. 3 hydraulic system pumps relay to close to start the No. 3 system pumps. Thus, the emergency actuator, powered by hydraulic system No. 3, becomes operable to aid whichever system is still operating.

In case hydraulic system No. 1 or No. 2 pressure is lost to the power control assembly, place the related elevator power control switch in the EMER position. The aircraft can be safely flown as long as at least one of the elevator hydraulic power systems is functioning normally.

Elevator Artificial Feel System (Figures 4-26, 4-27)

The artificial feel system includes a Q (FEEL) spring which has an adjustable attachment point on the elevator quadrant assembly, and a motor-operated Q system actuator, also mounted on the quadrant assembly. Signals from CADC No. 1 energize the motor of the Q system actuator, sliding the point of Q-spring attachment on the quadrant to increase or decrease the feel produced by the spring in accordance with increases and decreases in aircraft airspeed. Limit switches deenergize the Q system actuator motor when the Q spring reaches the minimum Q or maximum Q position.

Minimum Q and maximum Q positions represent approximately 220 KCAS and 380 KCAS respectively.

The signals from No. 1 CADC are modified by a pitch rate adapter which obtains power from the 26-volt AC bus through a PITCH RATE ADAPT EXC circuit breaker on the emergency circuit breaker panel.

A signal comparator, which receives signals from a potentiometer in the Q system actuator and signals from CADC No. 2, compares the actual versus the desired operation of the Q system actuator. If a discrepancy exists, the comparator deenergizes the actuator, causing the Q spring to be held in the position it was in at the time the discrepancy was detected. A light on the annunciator panel illuminates when the Q system has been deactivated by the signal comparator. A switch on the pilots' forward overhead panel moves the feel spring to the LO-Q position, if desired, when the light illuminates.

Elevator Artificial Feel Selector Switch

A three-position (LO-Q - NORM - RESET), lever-lock type elevator artificial feel selector switch is located on the pilots' forward overhead panel. It can be used to obtain the LO-Q feel value of the artificial feel spring, in the event of Q system malfunction. Placing the switch to LO-Q results in the quadrant attachment point of the Q spring being driven to the LO-Q position. LO-Q position is approximately 220 KCAS. The NORM position allows the motor of the Q system actuator to be controlled by signals from the CADC in accordance with the changes in aircraft airspeed. The RESET position is effective only when the aircraft is on the ground, by actuation of touchdown relays.

Elevator Feel Malfunction Light

An ELEV FEEL MALFUNC light on the annunciator panel indicates a malfunctioned artificial feel system. Illumination of the light indicates that a discrepancy between CADC input and follow-up signals has deenergized the Q system actuator and the Q spring is being held in the last position required by the CADC prior to system malfunction. The light is controlled by a signal comparator incorporated in the system.

Chapter 3

SECONDARY FLIGHT CONTROLS

Pitch Trim System (Figure 4-30)

The horizontal stabilizer is the pitch trim control surface. Pitch trim is accomplished by moving the stabilizer to change the angle of attack. The pitch trim supplements elevator control but is completely independent of elevator control movement.

Maximum trim limits are 4 degrees, aircraft nose down; 8 degrees, aircraft nose up with flaps retracted. Maximum trim limits are 9.6 degrees, aircraft nose up, when flaps are out of up position. A mechanical stop is installed at the 4.5° and 10.0° position. The system has two modes of operation, and three modes of control.

The pitch trim system uses a jackscrew and nut arrangement as its two modes of operation. The jackscrew is driven by an ELECTRIC MOTOR and produces slow changes in pitch trim. The nut is driven by a HYDRAULIC MOTOR, powered by hydraulic system No. 2, and causes trim changes about five times as fast as the electric mode.

Position Indicator and Transmitter

The position indicator is located on the pilots' center instrument panel, and is calibrated in degrees of stabilizer travel for aircraft nose up and nose down. The position transmitter is mounted on the limit switch bracket assembly and is mechanically linked to the limit switch cam by a positioning arm and linkage rod.

Controls

There are three pitch trim control modes: electro-hydraulic, hydraulic and electric. There are electric switches on the outboard grip of each aileron control wheel for electro-hydraulic control, a lever on each side of the control console for hydraulic control, and one set of electrical switches on the control pedestal for electrical pitch trim control.

Electro-Hydraulic Pitch Trim Switches

Two electro-hydraulic pitch trim switches, located on the outboard grips of the aileron control wheels, operate a control solenoid, routing hydraulic pressure to drive the nut on the jackscrew. The switches are recessed to provide a guard against inadvertent operation of the switches.

These dual switches must be operated simulteneously to provide both power and ground for one solenoid of an electro-hydraulic pitch trim control valve. This deenergizes the solenoid-operated shutoff valve and ports hydraulic pressure to the appropriate side of the pitch trim hydraulic motor by positioning the modulating valve. The circuitry is designed so that opposing signals from pilot and copilot cancel each other. (Figure 4-33)

To initiate electro-hydraulic actuation of pitch trim, the dual switches are pushed up with the thumb for nose-down trim and pulled down for nose-up trim. The switches are spring-loaded to a center (OFF) position.

Pitch trim rate, when the system is actuated by these switches, is 0.4 degrees per second. Switch operation automatically disengages the autopilot, if it is operating when the trim change is made, requiring the autopilot to be reset. Nose-up trim is interrupted if a stall signal is present in the stall prevention system.

Hydraulic Pitch Trim Lever (Figures 4-31, 4-32)

A hydraulic pitch trim lever is located on each side of the control console just below and outboard of each set of throttle levers. A flow control valve operated by a mechanical cable system from these control levers determines trim direction and provides a maximum trim rate of 0.4 degrees per second. Hydraulic power is available only when the electrical switches, incorporated on the trim levers, are depressed.

Depressing the lever switch, or a main DC power failure, deenergizes the solenoid-operated shutoff valve and ports hydraulic pressure to the flow control valve, permitting hydraulic operation of the system by the levers. When the autopilot pitch axis is engaged, movement of the hydraulic pitch trim lever will disengage the autopilot, requiring the autopilot to be reset.

Electrical Pitch Trim Switches

Two electrical pitch trim switches are located on the lower center portion of the control pedestal. The dual switches must be operated simultaneously to provide both power and ground to up or down clutches in the trim power unit.

For electrical actuation of pitch trim, both switches are moved up for nose-down trim or down for nose-up trim. This is accomplished by engaging one of the two counter-rotation clutches to drive the jackscrew. The switches are spring-loaded to a center (OFF) position.

Pitch trim rate, when the system is acutated by these switches, is 0.08 degrees per second. If the autopilot pitch axis is engaged, the switches are inoperative, and the autopilot must be disengaged to operate the electrical pitch trim system.

Electrical Pitch Trim Disconnect Buttons

A TRIM DISC button on the inboard grip of each aileron control wheel provides disconnect, through relays, of electrical and electro-hydraulic pitch trim in the event of a runway trim condition.

Pressing the button disconnects pwoer from the electrical pitch trim motor and the magnetic clutches, and disconnects power from the electro-hydraulic pitch trim control valve.

Hydraulic pitch trim will still be available through use of the hydraulic pitch trim levers.

Electrical and Electro-Hydraulic Pitch Trim Reset Switch

A TRIM RESET switch will restore power to either the electrical or the electro-hydraulic pitch trim system after the TRIM DISC button has been depressed. The switch has three positions: ELEC, ELEC HYD, and an unmarked, spring-loaded center OFF position.

The switch is held momentarily in the ELEC position to restore electric pitch trim after a disconnect of electric pitch trim. This is accomplished by reenergizing the electric pitch trim motor and clutches. The switch is held momentarily in the ELEC HYD position to restore electro-hydraulic pitch trim after a disconnect of the electro-hydraulic pitch trim. This signal reenergizes the pitch trim control valve.

If the pitch trim system has been disconnected through use of the TRIM DISC button, resetting of only one mode will not restore operation of the other mode. Both modes, ELEC and ELEC HYD, must be reset to restore both modes of operation.

Wing Flap System (Figure 4-34)

Wing flaps are used to change the relatively low-lift wing needed for high speed flight to a high-lift wing needed for slow landing and takeoff speeds. This is accomplished by changing the camber and area of the wing. The flaps are double-slotted Fowler-type and consist of two sections on each wing. They are extended or retracted by jackscrew actuators operating from a torque tube drive which is connected to a gear box driven by two hydraulic motors powered by No. 2 and No.3 systems.

Position Indicator

The wing flap position indicator is a 28 volt DC Selsyn-type located on the pilots' center instrument panel. The indicator is calibrated in percent of travel in increments of ten percent. (100% equals 49 ± 1 degrees.) The transmitter is located on the gearbox output drive. Power for this system comes from the 28 vdc bus.

Wing Flap Lever (Figure 4-34)

The wing flap lever, on the control pedestal, has three detent lock positions, placarded: FLAPS UP, TAKEOFF-APPROACH and LANDING. Additional markings are provided for the 25 percent (of fully extended) and 50 percent positions. Any percentage of fully extended flaps can be selected with the lever. A spring-loaded friction brake locks the lever in position once a selection has been made. The aft edge of the lever knob must be tilted upward to release the brake.

In conjunction with the flap lever, there is a lockout solenoid controlled by the spoiler lever. It adds approximately 50 pounds of force to the flap handle, anytime the spoiler lever is out of the closed position in flight with the flaps lever in the up position.

Flap Drive Gearbox (Figure 4-36)

The flap drive gearbox is located on the aft side of the rear wing beam. Most of the components in the flap system are installed on the gearbox assembly.

Control Selector Valve

The selector valve is a tandem valve which provides a synchronized flow from each hydraulic system to the flap drive motors. The valve has an orifice-type damper to control the rate of pilot input motion, which prevents excessive surges in the system.

Hydraulic Motors (Figure 4-38)

Two identical motors installed on the gearbox drive the flaps up or down in 15 seconds. If only one system is used, the flaps will travel at half speed or take 30 seconds for full travel in either direction. Each motor has a brake which is released by hydraulic pressure and applied by springs.

Manual Shutoff Valve

Mounted on the gearbox is a manually operated shutoff valve which shuts off both system pressures for maintenance, servicing, or to isolate the system in flight. To operate, pull down on handle and rotate 180 degrees to the closed detent position.

Manual Isolation Shutoff Valve

The manual isolation shutoff valve is located to the right of the gearbox in the No. 3 system pressure line and provides a means of ground testing the flaps on No. 2 system through the interconnect valve. It may also be used in flight to isolate the No. 3 hydraulic system.

Flow Control Regulator (10 GPM)

There is one flow control regulator in each return line to prevent overloading of either system and overspeeding of the hydraulic motors.

Limit Switch Assembly (Figure 4-35)

There are three limit switches contained in a single housing driven by the left hand inboard flap panel. The Full Up Switch (0% flaps) controls the spoiler lockout mechanism. The 20 Degree Switch (45% flaps) increases the autopilot gain for nose down trim to prevent ballooning as flaps are extended. The 34° Takeoff and Approach Switch (75% flaps) is one of the items that completes the circuit to the green TAKEOFF light on the pilot's instrument panel.

Asymmetry System (Figure 4-39)

The asymmetry system compares the movement of the flap panels symmetrically (outboard to outboard, etc.), and stops flap movement if either set of panels get out of synchronization 3 degrees or more. After an asymmetry condition and shutoff has occurred, it cannot be reset in flight.

Flap Asymmetry Light

A FLAP ASYM light on the annunciator panel illuminates if the flap asymmetry system has caused the flaps to be locked. The light also illuminates if a malfunction causes at least one of the solenoid-operated, spring-loaded torque tube brakes to engage, or causes the asymmetry shutoff valve to close. Illumination of the light indicates only that the flaps are locked; they may or may not be in an asymmetric condition.

Asymmetry Detectors

There is one asymmetry detector for each flap panel which is driven by a sprocket and chain from the flap panel itself. Each one sends a comparison signal to the computer amplifier which compares the signals and trips the shufoff valve to the flap motors if an asymmetrical condition exists. An asymmetry brake on the outboard end of each torque tube is also applied by the computer amplifier when an asymmetrical condition exists, locking the torque tube. Resetting of the brakes can be accomplished on the ground only. The asymmetry detectors are located at the inboard track of each flap section.

Broken Cable Detector

The broken cable detector is at the input quadrant to the flap drive gearbox on the cable from the flap lever. Should the cable break, the detector would trigger the solenoid-operated shutoff valve, cutting the pressure off from both the No. 2 and No. 3 systems, stopping the flaps and preventing uncontrollable flap operation. In this case, the asymmetry torque tube brakes should not be triggered.

Flap Asymmetry Test Panel and Lights

In the APU compartment is a test panel whereby the asymmetry system can be tested for malfunctions. It is also used when resetting the system after an asymmetry condition has existed.

NOTE: Operation of the TEST switch with the DEFEAT switch in the NORM position will result in tripping of the torque tube brakes and closing of the shutoff valve, and will require manual resetting of the flap asymmetry system.

Flap System Failure

Flap system malfunctions can result from loss of electrical power, loss of hydraulic power or asymmetrical operation.

Loss of electrical power to the flap asymmetry detection system will be indicated by illumination of the FLAP ASYM DET light on the annunciator panel. The flaps will continue to operate after illumination of the FLAP ASYM DET light, but without protection against an asymmetrical condition.

Resetting Wing Flap Asymmetry System

NOTE: Placing the power select switch to OFF prior to shutdown of the APU will prevent tripping the wing flaps asymmetry system. If tripping should occur, it will be necessary to reset the system in accordance with the procedures listed below.

If tripping of the wing flap asymmetry system occurs, reset the system as follows:

1. Close Manual Shutoff Valve.

2. Position the DEFEAT switch (in the APU compartment) to DEFEAT.

3. Manually reset both flap drive asymmetry brakes in the wings.

4. Manually reset the hydraulic shutoff valve at the drive gearbox. Then reset the computer amplifier from the wing flap asymmetry test panel by assuring the TEST switch is in NORM and holding the RESET switch in RESET.

5. The flaps asymmetry detection system is restored to normal by releasing the RESET switch and placing the DEFEAT switch to NORM.

6. Open Manual Shutoff Valve.

IN EMERGENCY, OUTBOARD BRAKES CAN BE OVERPOWERED BY PARTIAL OPENING OF SOLENOID OPERATED SHUTOFF VALVE.

Wing Spoiler System (Figure 4-40)

The spoilers are used to reduce speed, shorten landing ground roll and increase rate of descent.

There are thirty-six spoiler panels on the wings; eighteen upper and eighteen lower. There are five upper and five lower panels on the inboard wing section of each wing, and four upper and four lower panels on the outboard wing section of each wing.

All spoilers are extended at the same rate and at the same time to produce aerodynamic drag and reduce wing lift.

Spoilers are operated by hydraulic systems No. 2 and No. 3 through a dual-power control assembly, located on the rear wing beam where the trailing edge starts to sweep back. Each dual-power control assembly has two actuators connected to push-pull rods for inboard and outboard spoiler operation. Each spoiler panel is individually connected to the pushpull rods by cable and quadrant assemblies.

Control of the spoilers is manual, with an asymmetry system to prevent uneven operation during initial extension. Asymmetry protection is provided for outboard spoilers only.

Spoiler Deployment Limits

Spoiler panel deflections are limited in the extreme open and closed positions by mechanical stops in both ends of the inboard and outboard cylinders. On the ground, the upper panels open to 90 degrees and the lower panels to 86 degrees. In flight, the upper panels open to 27 degrees and the lower panels to 59 degrees.

Spoiler Indicators

One indicator with dual pointers and a flag is installed on the pilots' center instrument panel. The pointers are marked L and R, and the dial face is marked CLOSED and GRD. The flag is marked LOCKED and UNLKD. The pointers are for inboard spoilers ONLY.

A 2-SPOILER INOP and a 3-SPOILER INOP light on the annunciator panel indicate the condition of the system.

Spoiler Control Lever (Figure 4-40)

The spoiler control lever is located on the control pedestal between the flap lever and the pilots' throttles. It is connected to the spoiler cable servo by push rods. The control lever has three detents: CLOSED, FLIGHT LIMIT and GROUND. Spoiler RESET position is forward of and spring-loaded to the CLOSED position.

To prevent inadvertent operation of spoilers while flaps are extended, a lockout solenoid controlled by the flap-up limit switch adds approximately 50 pounds force to the spoiler lever when the flaps are out of the full up position.

Movement of the spoiler control lever out of the CLOSED position automatically starts hydraulic system No. 3 pumps, when hydraulic system No. 3 is not pressurized and the pumps are not operating.

Spoiler Cable Servo (Figures 4-40 thru 4-43)

The spoiler cable servo is located under the control pedestal and is used for smooth operation and to reduce pilot effort for spoiler control. Movement of the spoiler control lever positions the control valves, allowing hydraulic systems No. 2 and No. 3 pressure to drive a single-loop cable run, which positions the selector valves in the dual-power control assemblies for spoiler operation.

Spoiler Dual-Power Control Assemblies (Figures 4-46, 4-47)

The dual-power control assemblies are located on the rear wing beam at the junction of inboard and outboard spoiler panels. Each assembly contains two dual-tandem actuating cylinders, main and auxiliary, which operate inboard and outboard push-pull rods.

In flight, with the landing gear control lever in the GEAR UP position, both hydraulic systems No. 2 and No. 3 drive all spoiler panels open or closed.

With the landing gear control lever in the GEAR DN position, hydraulic system No. 2 pressure drives the inboard spoiler panels, while hydraulic system No. 3 pressure drives the outboard spoiler panels.

In the event either hydraulic system fails, both inboard and outboard spoiler panels will automatically operate from the remaining hydraulic system at a reduced rate of speed.

Blow Down System

Relief valves in the spoiler system prevent structural damage when excessive airloads occur on spoiler surfaces. Blow-down occurs at 250 KCAS or above. Maximum airspeed operation is 350 KCAS or 0.75 Mach.

Spoiler Asymmetry Lights (Figure 4-44)

The 2 SPOILER INOP and 3 SPOILER INOP lights are located on the annunciator panel. The lights illuminate when the solenoid-operated asymmetry pilot valves are deenergized by either the asymmetry detectors, the EMER RETRACT switch, the EMER OFF switch, or a loss of electrical power through the circuit protection.

Illumination of only one light indicates that an electrical malfunction has occurred in the hydraulic system asymmetry control circuit. The spoilers will remain fully operational with one light illuminated.

Both lights illuminated indicate that an asymmetric condition has occurred, and hydraulic pressure has been routed to close the spoilers. Placing the spoiler lever to RESET extinguishes the light if they have illuminated as a result of an asymmetric condition. 2 1/2" of travel on one outboard, and 3/4" on the opposite side.

Emergency Retract, Emergency Off Switch

A three-position EMER RETRACT, NORM, EMER OFF switch on the control pedestal can be used to retract the spoilers if they cannot be retracted with the spoiler lever.

The EMER RETRACT is a spring-loaded momentary position and simulates an asymmetrical condition which deenergizes the solenoid-operated asymmetry pilot valves on the No. 2 and No. 3 hydraulic systems to retract the spoilers. The SPOILER INOP lights will illuminate and all modes of operation will be inoperative until the spoiler lever is moved to the RESET position.

The EMER OFF position is a lever-locked position, and with the spoilers closed, will prevent deployment of the spoilers, either manually or automatically. Hydraulic systems No. 2 and No. 3 are shut off at the spoiler actuators through the inlet shutoff and bypass valves. The 2 SPOILER INOP and 3 SPOILER INOP lights also illuminate. If the spoilers are deployed when the switch is placed in this position, only No. 2 hydraulic system power is shut off at the spoiler actuators. No. 3 hydraulic system remains ON to close the spoilers. When the spoilers close, the No. 3 system is automatically shut off. If the spoilers move from the closed position, No. 3 system is again automatically energized to close them. If the system No. 3 control switches are in the OFF position, the pumps will stop when the spoilers return to the CLOSED AND LOCKED position.

In the NORM position, normal spoiler circuitry is restored, and the spoilers may be operated after resetting.

Asymmetry Test Panel

This panel on the copilot's side console is used to test the circuit and lights without triggering the asymmetry system.

Under Spoiler Speed Light

A spoiler UNDER SPLR SPEED warning light on the annunciator panel will illuminate, and an intermittent warning note will sound on the under spoiler speed audible warning system through the headsets, under the following conditions:

(1) Arming or removing the spoiler lever out of CLOSED position.
(2) A stall signal present in the stall prevention system circuits.

Loss of Electrical Power

Spoilers are inoperative with loss of main DC electrical power.

Chapter 4

LANDING GEAR

Landing Gear Selector Valves (Figures 4-48 thru 4-50)

The three-position four-way selector valves are 28-volt DC solenoid controlled and hydraulically positioned. Manual override buttons provide manual control in the event 28-volt DC power is lost. The door lock, gear downlock, and the MLG selector valves are all located in the No. 2 hydraulic service center. The NLG selector valve is located in the left underdeck area under the autopilot "J" box.

Landing Gear Control Panel

The landing gear control panel is located on the right side of the pilots' center instrument panel. The two-position (UP-DOWN) landing gear control handle is electrically connected to all of the gear solenoid-operated selector valves.

A 28-volt DC, solenoid-operated locking mechanism prevents movement of the landing gear lever from the DOWN position until the main landing gear struts are fully extended after takeoff. The circuits controlled by the landing gear lever receive 28-volt DC power from the Isolated DC Bus through a LANDING GEAR CONT circuit breaker on the flight engineer's No. 3 circuit breaker panel. A manual release, adjacent to the landing gear lever, can be used to release the locking mechanism in case of electrical malfunction.

Landing Gear Warning Lights

Two red warning lights in the landing gear control handle will illuminate when the landing gear control handle is placed to DOWN, and will remain illuminated until all landing gear are down and locked. The light will also illuminate when the landing gear control handle is placed to UP, and will remain illuminated until all landing gear are up and locked. The warning light will illuminate if a throttle is retarded to approximately one inch forward of IDLE START position and all landing gear are not down and locked. The light will also illuminate if one or both MLG door uplocks are not locked, or if there is a bad MLG door uplock micro-switch.

Landing Gear Warning Horn

A warning horn, located in the flight station, will also sound if a throttle is retarded to approximately one inch forward of IDLE START position and all landing gears are not down and locked. Pressing the HORN SILENCE button on the landing gear control panel will cause the horn to silence, but the light in the handle will remain illuminated until the throttle is advanced or all gear are down and locked.

The warning horn will sound if the flap control handle is placed to the LANDING position and all gear are not down and locked. The horn silence button will <u>not</u> silence the horn if it sounds under this condition.

Landing Gear Warning Horn Cut-Out Switch and On/Off Light

A two-position ("NORMAL", "OFF") gear-up warning horn cut-out toggle switch is located on the copilot's paradrop and ADS panel. When the switch is in the "NORMAL" position, the horn will operate in its normal manner. When moved to the "OFF" position, the horn will not sound except when the wing flap lever is moved to the "Landing" position when the landing gear is not down and locked. The ON/OFF light, located just below the switch, illuminates when the toggle switch is moved to the "OFF" position, and the light is out when the toggle switch is in the "NORMAL" position.

Landing Gear Position Indicators

Three 28-volt DC flag-type position indicators, located above the landing gear lever, show the position of each landing gear. A miniature wheel and tire flag indicates gear down and locked, an UP flag indicates gear up and locked, and a black and yellow striped flag indicates the gear is neither up and locked nor down and locked. Limit switches, actuated by movement of the landing gear to the down-and-locked or up-and-locked positions, control the position indicators. Power for operation of the indicator is supplied from the Isolated DC Bus through a LANDING GEAR POS IND circuit breaker on the No. 3 circuit breaker panel.

Warning Light and Horn Test Switch

The warning light and horn test switch is located on the landing gear control panel and is used to test the landing gear warning light and horn system.

Axle (Bogie) Beam Position Indicator

A 28-volt DC flag-type bogie position indicator for each of the main gear bogies is located on the pilots' center instrument panel. A miniature wheel and tire flag indicates the associated bogie is in the position required for landing. (Within 5° perpendicular to the main gear shock strut.) A black and yellow striped flag indicates the bogie is either in transit or is up. Limit switches, actuated by movement of the bogies, control the position indicators. Power for operation of the indicators is supplied from the Isolated DC Bus through a BOGEY POS IND circuit breaker on the flight engineer's No. 3 circuit breaker panel.

Nose Landing Gear (Figure 4-53)

The nose landing gear assembly retracts forward into the nose section. The assembly consists of an air-oil shock strut, an axle, torque arms, a drag link and up-down lock assembly, an actuating cylinder, the wheels and tires. The shock strut cylinder has a trunnion by which the nose gear is mounted to structural pillow blocks on each side of the wheel well. The nose gear is locked in either the up or down position by an up-down lock incorporated in the drag link.

Nose Landing Gear Doors

The nose landing gear doors enclose the nose wheel well when the gear is in the retracted position. The doors open and close by the operation of the nose landing gear through a system of adjustable pushrods and bellcranks. The doors consist of two clam-shell doors covering the forward section and one single door on the aft section. When the gear is in the up position, all doors are closed. Door closure is maintained by preset tension adjustments through the gear door linkage. The clam-shell doors move downward and outboard as the gear extends, and then back to the closed position when the gear is down. The aft door moves down and back under the fuselage, and remains in this position until the gear is retracted. Bumpers on the aft door contact the fuselage to provide additional support for the door.

Nose Landing Gear Up-Down Lock (Figure 4-54)

The nose landing gear up-down lock mechanism is incorporated in the drag link assembly, and the actuating cylinder is mounted on the nose gear shock strut. The cylinder is connected to the mechanism through bellcranks and a pushrod. The gear is locked in either the up or down position by two cranks forced into an over-center position. The cranks are forced into the over-center position by a combination of a spring and hydraulic pressure to the actuating cylinder, and are maintained in the locked position by the spring assembly. Hydraulic pressure to the unlock side of the actuating cylinder unlocks the up-down lock mechanism.

Nose Landing Gear (Ground) Safety Pin

The ground safety pin is inserted in the nose landing gear (NLG) drag brace as a safety precaution when the aircraft is on the ground. This pin will be installed from right to left.

Nose Landing Gear Emergency Extension System (Figure 4-57)

Reservoir

The hydraulic fluid reservoir is located under the flight deck in the right-hand underdeck area. The fluid capacity is 0.9 gallon and can be serviced in flight through the filler neck. A placard is provided for servicing. A sight gage is mounted on the reservoir, and the reservoir is vented to a vent box in the underdeck area. Hydraulic fluid flows by gravity to the hand pump and check valve.

Hand Pump

A double-action type hand pump is located in the right underdeck area. When the handle is not in use, it is secured to the structure near the pump. A direct-reading pressure gage is on the front bulkhead, in the right underdeck area, to indicate hand pump pressure.

The hand pump is operated to build up system pressure, which is limited to approximately 1,200 psi, by a relief valve connected to the pressure line and to the reservoir.

Manual Selector Valve

A manually operated selector valve is located on the front bulkhead, in the right underdeck area below the pressure gage. A two-position valve, it has NORMAL and EMERGENCY positions.

Nose Land Gear Emergency Extension Systems

Nose Land Gear Emergency Extension is used to extend and lock the nose landing gear in the down position, if the No. 2 hydraulic system is inoperative.

Normal Operations (Figures 4-69, 4-70)

Retraction

Movement of the landing gear control handle to the UP detent rotates a cam to actuate a limit switch. The limit switch closes to complete the circuit from the Isolated DC Bus to the up solenoid of the landing gear selector valves. The up solenoid is energized and opens the selector valves to permit hydraulic system No. 2 pressure to be applied simultaneously to the downlock and gear actuating cylinders of the left main and right main landing gears. Hydraulic system No. 2 pressure is also applied simultaneously to the up-down lock and gear-actuating cylinder of the nose landing gear. This permits the actuating cylinder of each MLG to retract and raise the gear. As each main landing gear reaches the full up position, a roller on each landing gear door mechanism torque tube arm strikes the uplock hook. The up-down lock cylinder of the nose landing gear retracts to unlock the over-center locking mechanism and thus permit the actuating cylinder to retract and raise the nose landing gear. The NLG is locked in the raised position by the over-center locking mechanism linkage.

Switches, which are actuated closed by movement of the landing gear to the up-and-locked position, complete circuits to the landing gear position indicators on the landing gear control panel to provide gear-up indications. With the gears up and locked, the hydraulic pressure is off. As the gears move to the up and locked position, sequence switches complete the circuit through a relay to the main landing gear door lock selector valve opening the valve to port hydraulic system No. 2 pressure to the MLG door lock actuating cylinders to engage the door uplock latches. As the door locks are locked, the landing gear warning lights are extinguished and the door lock selector valve is deenergized.

Hydraulic system return pressure is automatically applied to the brakes during gear retraction to stop the rotation of the main wheels. Nose gear wheel spin is stopped during final retraction by contact with friction pads (or spin brakes) installed in the wheel well.

Extension

Movement of the landing gear control handle to the DOWN detent actuates limit switches. One limit switch, which closed to complete the circuit from the Isolated DC Bus to the down solenoid, becomes energized and opens the MLG selector valve to permit hydraulic system No. 2 pressure to be applied simultaneously to the uplock, gear-actuating cylinders of the left and right main landing gears, and to the door uplock actuators.

Hydraulic system No. 2 pressure is also simultaneously applied through the NLG selector valve to the up-down lock and the gear actuating cylinder of the NLG. The uplock cylinders of the main landing gear extend to release the uplock hooks through mechanical linkage, and the up-down lock cylinder of the NLG extends to unlock the over-center linkage. The actuating cylinders of the left main, right main, and nose landing gears then extend to assist gravity in lowering the landing gear. When each main landing gear reaches the fully extended position, limit switches energize the downlock actuator solenoid valve, after the drag braces have reached the full down position. The downlock latch then slides into the recess to lock each main landing gear in the extended position. The nose gear is locked in the extended position by the over-center locking linkage.

Limit switches, which are actuated closed by movement of the landing gear to the down-and-locked position, complete circuits to the landing gear position indicators on the landing gear control panel to provide a landing gear down indication, and to the bogie position indicator panel to indicate bogies in position.

Nose Gear Steering System

Introduction

Hydraulic pressure for the nose gear steering system is supplied by Hydraulic System No. 2 from the nose gear downline. A steering wheel, located on the pilot's side console, provides the control for steering the nose wheels. The nose gear wheels can be steered 60 degrees left or right of center with the steering wheel.

Nose gear steering by movement of the rudder pedals is also incorporated. A maximum of eight degrees steering left or right of center is available. The steering wheel tracks this movement.

Turning the steering wheel mechanically positions a control valve which ports pressurized fluid to the left or right nose gear steering cylinders to actuate the rack-and-pinion type steering mechanism. A cable-type mechanical feedback mechanism automatically repositions the control valve to neutral when the selected degree of turn is achieved.

A centering mechanism automatically holds the control valve in neutral when the nose wheels are not being turned, which allows interflow between the actuating cylinder cavities by way of the return passages, thus allowing the nose gear wheels to rotate in response to castering loads. The interflow or bypass also provides shimmy dampening.

Centering cams within the strut automatically position the nose wheels in the line of flight when the nose landing gear strut is fully extended after takeoff.

Control Wheel Steering (Figures 4-58 thru 4-62)

The nose gear steering system is controlled by a nose gear steering wheel, located on the pilot's side console. A nose wheel position scale, with the placarded directions of "Left" and "Right" arranged to either side of a white center-position index mark, is installed immediately beneath the wheel. Two and three-fifths revolutions of the steering wheel are required to turn the nose wheel from center, through a full 60 degrees left or right of the nose wheel centered position. The steering wheel is disengaged and locked when the gear is not in the down and locked position.

Rudder Pedal Steering

The rudder pedal steering system provides the pilot and copilot with the capability of maintaining steering control of the aircraft during takeoff and landing while retaining aileron control. Rudder pedal steering is 8 degrees either side of center. Rudder pedal steering is available when main gear touchdown switches are activated or forward main wheel spinup of 34-60 kts occurs. The rudder pedal steering system design is such that the steering wheel rotates with pedal movement and the rudder pedals move somewhat with steering wheel rotation unless restrained. The system also provides the capability of full rudder in one direction and full wheel rotation in the other direction steering.

Main Landing Gear System (Figure 4-63)

The landing gear is a fully retractable tricycle-type, consisting of a steerable dual-wheel nose gear and two "four-wheel bogie" main gears. All gears retract forward and up. The doors are actuated by gear movement through mechanical linkage. A door-locking mechanism prevents inadvertent opening of the main landing gear doors in flight. The landing gear system is electrically-controlled and hydraulically-actuated.

Normally the landing gear should retract in approximately 10 seconds and extend in approximately 15 seconds. The maximum airspeed for landing gear operation is 200 KCAS or 0.48 Mach. A maximum airspeed with landing gear extended is 235 KCAS or 0.55 Mach.

Main Landing Gear

Each main landing gear assembly consists of an oleo-pneumatic shock strut, an axle beam and axle assembly, torque arms, wheel and tires, drag braces, drag links and down lock, up lock, leveler rod, axle (bogie) beam positioner system, actuating cylinder, wheel brake assembly, and brake compensating rods.

Main Landing Doors

The main landing gear (MLG) doors are actuated by mechanical linkage and gear movement. Three doors are installed on each main landing gear pod; one upper door on top of each pod above the MLG strut, and two lower doors. All three doors open simultaneously, and the strut extends thru the upper door opening while the landing gear is extended. All doors remain closed when the landing gear is up and locked.

Main Landing Gear Door Uplock (Figure 4-64)

When the aircraft is on the ground, the landing gear doors are open, and the door lock hydraulic actuator is pressurized to the unlocked position. The door lock hydraulic actuator is sequenced to the locked condition when the landing gear goes into the uplock position. The door lock system is designed to hold the MLG doors closed and prevent gapping while the MLG is up and locked in flight. In case of No. 2 hydraulic system failure, each door uplock latch assembly may be manually unlatched by using the red T-handle (Step No. 1) to allow the door to open.

Main Landing Gear Shock Struts

The stroke of the shock strut meets special requirements of C-141 aircraft. To reduce fuselage bending loads (stresses), the main landing gear has been placed as close to the center of gravity as possible. The overhang of the fuselage aft of the main landing gear, together with small ground clearance, limits the tail-down angle during landing or takeoff. To compensate for this, a two-step action of the shock strut is provided. By setting the piston stroke at approximately 28 inches, the wheels are placed sufficiently below the fuselage to permit an approximate 11-degree tail-down angle at impact. During the first 17 inches of shock strut compression, the energy is absorbed at a normal rate by the action of the hydraulic fluid. The shock strut then compresses at a reduced rate, controlled by two fixed orifices in the strut, until the tail clearance is ample.

Leveler Rod Assembly

The leveler rod is a mechanical linkage which positions and holds the MLG axle (bogie) beam parallel to the retracted position. This provides clearance of the main landing gear doors during the last portion of retraction and the first portion of extension.

Axle (Bogie) Beam Positioner (Figure 4-66)

The pneumatic-hydraulic axle beam positioning cylinder maintains the axle beam approximately perpendicular to the longitudinal axis of the shock strut assembly, while the gear is in the extended position for landing. It also provides a degree of snubbing action to prevent oscillations of the axle beam during landing, taxiing and takeoff.

Main Landing Gear Downlock (Figure 4-67)

The main landing gear downlock assembly is a combination of hydraulic action and mechanical linkage. When the landing gear is extended, the downlock latch assembly rides on the forward drag link and, as the drag link becomes straight, the latch rides over the mechnical stop and locks into place. Any aft movement of the latch is resisted by spring action inside the downlock cylinder. This spring action is overcome hydraulically when the gear is to be retracted, which forces the latch away from the stop. If the No. 2 hydraulic system fails, and the main landing gear doesn't lock in the down position, operating a red emergency downlock engage handle (Step No. 3) will mechanically move the associated gear to the downlock position.

Main Landing Gear (Ground) Safety Pin

The MLG ground safety pins are inserted through the drag brace aft of the downlock latch. The ground safety pins must be inserted from the inboard to outboard side of the strut. In the event an unsafe condition is indicated after a landing gear extension, the ground safety pins can be installed in flight through the gear inspection windows.

Main Landing Gear Uplock (Figure 4-68)

The MLG is locked in the up position by an uplock assembly mounted on the fuselage in each wheel well. The uplock hook receives a roller on the torque tube bellcrank forward of the door actuating mechanism. The roller forces the hook down into the locked position. The hook is held in the locked position by three links, a bellcrank and a stop. The links are forced into an over-center position by a stop on one link which rests against the uplock bellcrank. Actuation of the hydraulic uplock actuating cylinder will cause rotation of the bellcrank and pull the links out of the over-center position. A spring attached to the hook then forces the hook out of the locked position.

In case hydraulic system No. 2 fails, the MLG uplock may be released manually by pulling a red T-handle (Step No. 2).

Brake Limitations

The brakes are limited in the amount of work they can perform and still function properly. A measure of the amount of heat absorbed by the brakes is the amount of work performed by the brakes. The amount of work done is the kinetic energy expended, measured in millions of foot-pounds per brake. The amount of heat added to the brakes for each braking effort is cumulative and is determined by the speed of the aircraft and the gross weight of the time the brakes are applied.

*See Section 5 of TO 1C-141B-1 for detailed information and charts.

Chapter 5

BRAKE SYSTEMS

The normal brake system is activated by No. 2 hydraulic system pressure, which is controlled by one side of each of the two dual pilot metering valves, and by the four dual anti-skid control valves. The pilot metering valves are located under the flight station floor. The dual pilot metering valves apply control pressure to the anti-skid valves located on the left and right brake panels in the cargo compartment. Application pressure is then routed to the brake assemblies. Control pressure for brake operation is taken from the nose landing gear down line. Application pressure is taken from the main landing gear down line.

Brake Selector Valves

The brake selector valves, which are solenoid-operated, are deenergized open, and are controlled through the brake selector switch. The valves are wired electrically through the brake selector switch so that, in the NORM position, the normal brake selector valve is deenergized open, and the emergency selector valve is energized closed. In the EMER position, the emergency brake selector valve is deenergized open, and the normal brake selector valve is energized closed. If there is a D.C. power failure, both valves will direct pressure to the pilot brake metering valves.

Pilot Brake Metering Valves (Figure 4-74)

There are two of these metering valves: One valve is for the right wheel brakes, and the other is for the left wheel brakes. One valve of each dual valve assembly is connected to emergency pressure and return. Each dual valve assembly consists of two identical piston and sleeve metering assemblies, which are fitted into the dual-bore housing. Both pistons are actuated at the same time by a bellcrank assembly; however, brake pressure is effective only through one valve, depending on the position of the brake selector valve. The valve is mechanically actuated through linkage from the brake pedals.

Anti-skid Valves

The eight anti-skid valves are solenoid controlled. When the anti-skid system detects a skid or locked wheel condition, the valve is energized and ports brake pressure to return. As soon as the wheel starts to speed up again, the valve is deenergized and braking action is reapplied. Metered fluid from the pilot brake metering valve enters the anti-skid valve. The fluid is directed to the top of the control piston. As pressure builds up on the top of the control piston, the piston is forced downward to overcome the control spring. This movement unseats the metering poppet, which ports hydraulic pressure to the brake.

The amount of poppet opening depends on the pressure from the pilot brake metering valve. When a rapid deceleration is detected by the skid detector and amplified in the anti-skid control box, a signal is sent to the modulating solenoid on the valve. When this solenoid is energized, metered fluid to the control cylinder is blocked and existing pressure within the control cylinder is relieved to return. Braking action to the affected wheel stops and free wheel rotation should occur. If free wheel rotation does not occur, the modulating and dump valves are energized and all control pressure is ported to return. The wheel is then free to turn until the detector signal deenergizes the solenoids. The valves are located on the wheel brake controls just aft of the No. 2 and the No. 1 hydraulic system service center.

Hydraulic Fuses (20 C1)

There are eight hydraulic fuses in the brake system; both normal and emergency systems use these fuses. Without such protection, the failure of a hydraulic line or component downstream from the valve could cause complete loss of fluid in the systems.

Shuttle Valve

The shuttle valve consists of a piston which is free to move from one side of the valve to the other; thus, if hydraulic pressure is greater on the normal brake pressure end, the piston moves to the emergency brake pressure end and seats. This prevents normal pressure from entering the emergency lines. If emergency brake pressure is greater than normal brake pressure, the piston will move to the normal inlet and seat, closing off the normal lines. Pressure then cannot enter the normal brake pressure lines.

Emergency Brake System

In the event the normal brake system fails, the brake selector switch on the brake and anti-skid panel can be moved to EMER to engage the emergency brake system.

Hydraulic pressure for the emergency wheel brake system is supplied by the electrically-driven pumps of hydraulic system No. 3 and is independent of the positions of the landing gear selector valves. The pressurized fluid applied to the brakes is routed through a main metering valve. The main metering valve is installed in the cargo compartment aft of the No. 2 hydraulic system service center. The control pressure for metering the pressure applied to the brakes is routed to the main metering valve through the pilot brake metering valves.

The anti-skid brake control system is inoperative when the emergency brake system is being used.

Two accumulators in hydraulic system No. 3 provide a standby emergency wheel brake system when the electrically-driven pumps of hydraulic system No. 3 are inoperable. Approximately ten brake applications can be made with both accumulators fully charged.

NOTE: In case of DC electrical power failure, the deenergized valves admit both system No. 2 and system No. 3 hydraulic pressures to the brake system. The shuttle valve is positioned by the system supplying the greater pressure.

Parking Brake

The parking brake is set by depressing the brake pedals, and pulling the T-handle on the pilot's instrument panel. The T-handle is connected by a flexible shaft to mechanical linkage. When the pedals are depressed, the brake linkage applies pressure to the dual pilot metering valves and, at the same time, allows the parking brake to lock the pedals in the depressed position. This action keeps hydraulic pressure applied to the brake metering valves. The parking brakes may be set by using No. 2 or No. 3 hyd. system. The parking brakes can be released by depressing the brake pedals.

Anti-skid System

A fail-safe anti-skid brake control system provides maximum braking efficiency and prevents locking of the wheels in the event excess brake pressure is metered by the pilot during any phase of ground operation above 15 knots. The system is energized by a switch on the brake and anti-skid control panel located on the pilots' center instrument panel.

The ON position of the switch is effective only if the brake pressure switch is in the NORM position. When this condition is satisfied, the ON position arms the 28-volt DC anti-skid circuits; and when both main gear struts are depressed, the circuits are completed through the touchdown circuit to provide anti-skid braking. The GND TEST switch position is a momentary position and provides a means of testing the anti-skid system for fail-safe operation. Holding the switch in the GND TEST position while applying brakes will result in the following sequence of events: brakes release, the DET OUT and ANTI-SKID OFF lights come on, and braking action gradually returns.

Brakes Released Light (Figure 4-71)

A green, BRAKES REL light is provided on the brake and anti-skid control panel on the pilots' center instrument panel. Illumination of this light with the landing gear handle in the down position and the anti-skid switch ON, advises the pilots that the anti-skid locked wheel circuit will prevent brakes being applied until wheel spin-up after touchdown. If the light does not illuminate, locked wheel protection is not available at touchdown and there is a possibility of blown tires if the pilot applies any amount of brakes prior to, or immediately after touchdown.

The BRAKES REL light receives power from Main DC Bus No. 1, through the ANTI-SKID circuit breaker. Ground test of the light circuit is made by placing the anti-skid control switch to ON, selecting normal brakes, and placing the annunciator light test switch to TEST, at which time the light should illuminate.

Anti-skid Operation

The anti-skid system is primarily based on controlling the skid in its beginning stage. Braked wheel speed is converted to an AC signal which is proportional to the wheel acceleration and deceleration. The signal is supplied to a wheel spin-up control box on the left side of the cargo compartment. The control box detects, from the AC input signal from the detector, both excessive wheel deceleration and nonrotation. The control signals are transmitted to the anti-skid control metering valve, where brake hydraulic pressure is reduced by metering action until wheel speed is restored. The valve then begins to increase brake hydraulic pressure at a gradual predetermined rate until either skid control action is repeated or the pressure demanded by the pilot is reached.

If the pilot demands sufficient braking action to cause skidding, the skid control system will apply and release the brake pressure, as necessary, to obtain a nearly constant braking action without skidding. The resultant braking action gives maximum stopping action. Locked wheel control provides skid protection for any wheel which may be off the runway.

Anti-skid Fail-Safe

Fail-safe action prevents prolonged brake release in the event of the malfunction of the anti-skid system. Warning lights inform the pilot that the skid control system has malfunctioned or that the system is off. ANTI-SKID OFF lights, one on the pilot's instrument panel and one on the copilot's instrument panel, indicate two or more wheels have lost braking action due to anti-skid malfunction. When this happens, the skid control system turns itself off, and the brakes are under manual control. The pilot may also obtain this condition by turning the ANTI-SKID switch to OFF. The DET OUT lights, located on the pilot's and copilot's instrument panels, indicate that there is a continuous brake release action on one wheel only. Skid control is provided over a speed range covering the maximum landing speed to a minimum taxi speed of approximately 15 knots. Below 15 knots the anti-skid is inoperative.

Skid Detector

The skid detector is a small alternator which supplies an AC signal to the control box. The output of this alternator is low, since only signal voltage is supplied to the control box for amplification. The detector is located in the landing gear axle and fastens to the axle nut. The detector splined shaft (coupling) slips into a splined receptacle on the wheel dust cap. The rotor of the detector, therefore, turns with the wheel. Any acceleration or deceleration of the wheel is transferred directly to the alternator. Any change of rotor speed causes a change in signal to the control box which may, in turn, cause a change in the operation of the anti-skid valve.

Brake System Failure

If the NORM BRAKE PRESSURE indicator shows a loss of system pressure, check that the No. 3 HYD SYSTEM PRESS ON light is illuminated. Place the brake pressure selector switch to the EMER position.

This will supply pressure to the brakes from the No. 3 hydraulic system. Use the brakes cautiously because the anti-skid system is inoperative when pressure is supplied by the No. 3 hydraulic system.

Anti-skid System Failure

If any one skid detector fails, the DET OUT lights will illuminate, and anti-skid protection will be available only on the remaining seven wheels. If two or more skid detectors fail, the ANTI-SKID OFF lights will illuminate, and skid protection will be lost on all wheels. If the ANTI-SKID OFF light illuminates, the anti-skid switch should be placed to the OFF position to prevent possible erratic operation.

Chapter 6

CARGO DOOR AND RAMP SYSTEM

General (Figures 4-75 thru 4-79)

The cargo door and ramp system is used for ground loading and aerial delivery. The system consists of an internal pressure door, ramp, petal doors and operating control. The system is operated by No. 3 hydraulic system. In flight, the system is operated from the pilot's and copilot's paradrop and ADS panels. Ground operation is controlled from the cargo door and ramp control panel after the system is armed from the pilot's control panel and door selection is made at the door and ramp control panel. The pressure door may be individually controlled from the forward crew door interphone and PA panel (inflight only), or the cargo door and ramp control panel.

Pilot's Controls and Indicators

The pilot's controls and indicators are located on the pilot's paradrop and ADS control panel. The petal door opening is 65 degrees. The DOOR ARMING switch is a two-position OFF - ARM toggle lock switch that is set to ARM to energize the system. The ALL DOORS switch is a three-position OPEN - OFF - CLOSE switch that initiates system operation. Four indicator lights on the panel (EXTERNAL CL, INTRANSIT, PRESS OPEN, PETAL OPEN) illuminate to indicate door status.

Copilot's Controls and Indicators

The copilot's controls and indicators are located on the copilot's paradrop and ADS panel. The controls and indicators consist of an ALL DOORS switch and four indicator lights which are identical to those on the pilot's panel. However, the pilot's ALL DOORS switch has priority over the copilot's switch and can override any door movement initiated by the copilot.

Navigator's Indicator

A cargo doors OPEN light on the navigator's ADS and jump light panel illuminates when the cargo doors are open to the position selected on the pilot's control panel.

Cargo Compartment Controls and Indicators

Controls and indicators for the system are located on the forward crew door and interphone panel and on the cargo door and ramp control panel. The PRESS DOOR ONLY switch on the crew door interphone and PA panel is a three-position OPEN - OFF - CLOSE guarded switch. This pressure door switch will control the opening function only, it WILL NOT close the pressure door. Arming of the system will be indicated when the DOORS ARMED indicator on the panel illuminates. The pilot's and copilot's ALL DOORS switches will override any operation initiated by this switch. The INTRANSIT and ALL OPEN lights on the panel illuminate during system operation to indicate door status.

The cargo door and ramp control switches located on the DOOR AND RAMP CONTROL panel are: an ALL DOOR switch, RAMP switch, PETAL DOOR switch, and PRESSURE DOOR switch.

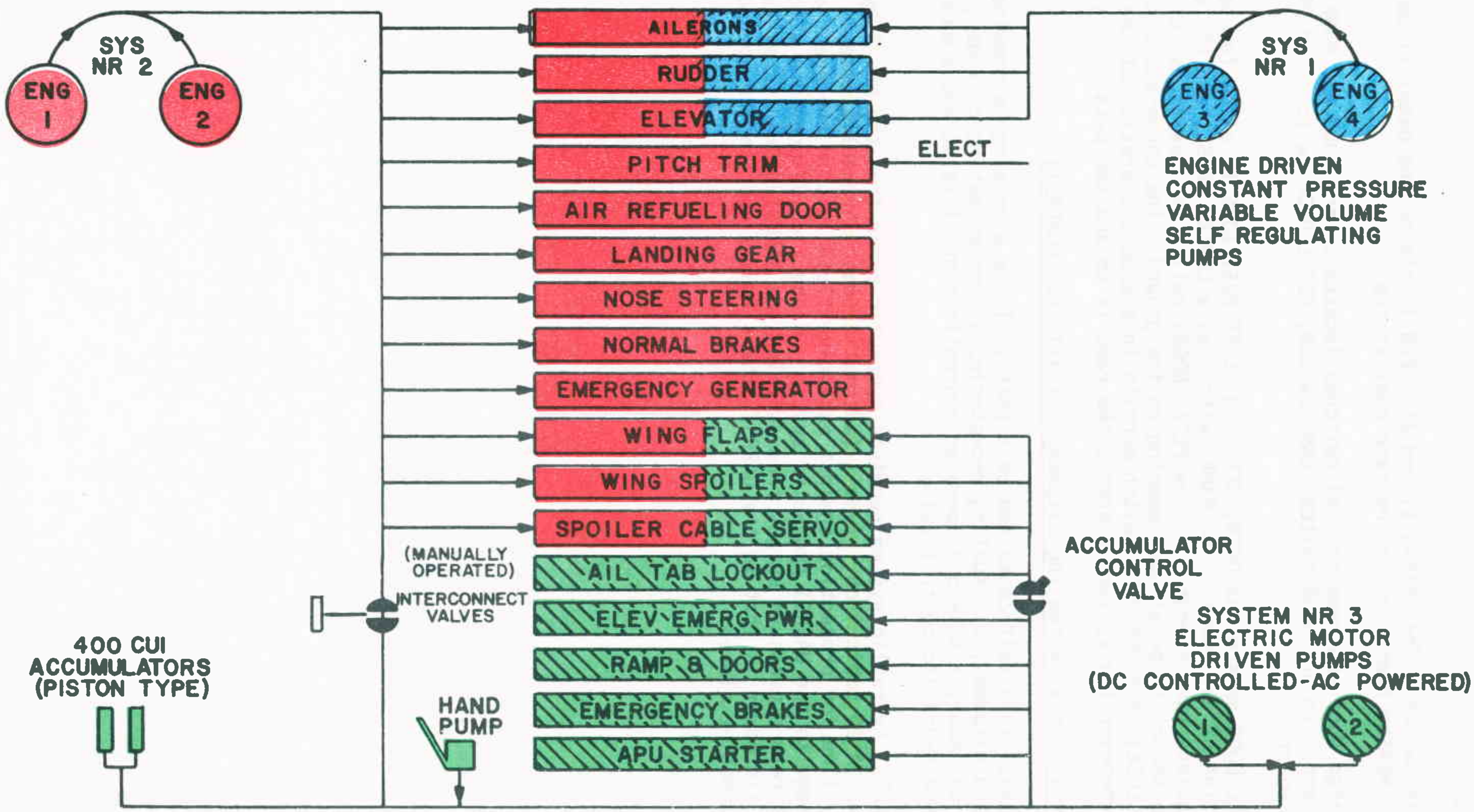
The ALL DOOR switch has OPEN, OFF, and CLOSE POSITIONS to allow for sequential operation of all doors. The RAMP switch has a LOWER, RAISE, and OFF position to regulate ramp operation. The PETAL DOORS switch has positions for selection of the amount of petal door opening on the ground. The three-position (OPEN, OFF, CLOSE) PRESSURE DOOR switch permits independent operation of the pressure door whenever the system is armed, the ramp is up and the petal doors are closed.

Universal Aerial Refueling Slipaway Installation (UARRSI)

The UARRSI is a self-contained unit that includes a housing, a combination door and slipaway, a refueling receptacle, a door actuating cylinder, a boom latch cylinder, a solenoid-operated hydraulic control valve and a manually-operated hydraulic control valve.

The UARRSI hydraulic system receives hydraulic power from the No. 2 hydraulic system. A 20 cubic inch - Type 1 (automatic reset) hydraulic fuse is installed in the supply line for protection against excessive fluid loss in the event of leakage or damage to the UARRSI hydraulic system. A check valve prevents aircraft system return pressure surges from entering the UARRSI hydraulic system. If hydraulic power is lost to the UARRSI, the slipaway door can be opened manually but cannot be closed.

HYDRAULIC SYSTEM DISTRIBUTION



MAR 1980

FOR INSTRUCTIONAL PURPOSES ONLY

Figure 4-1

ENGINE DRIVEN PUMP
(FULL FLOW)

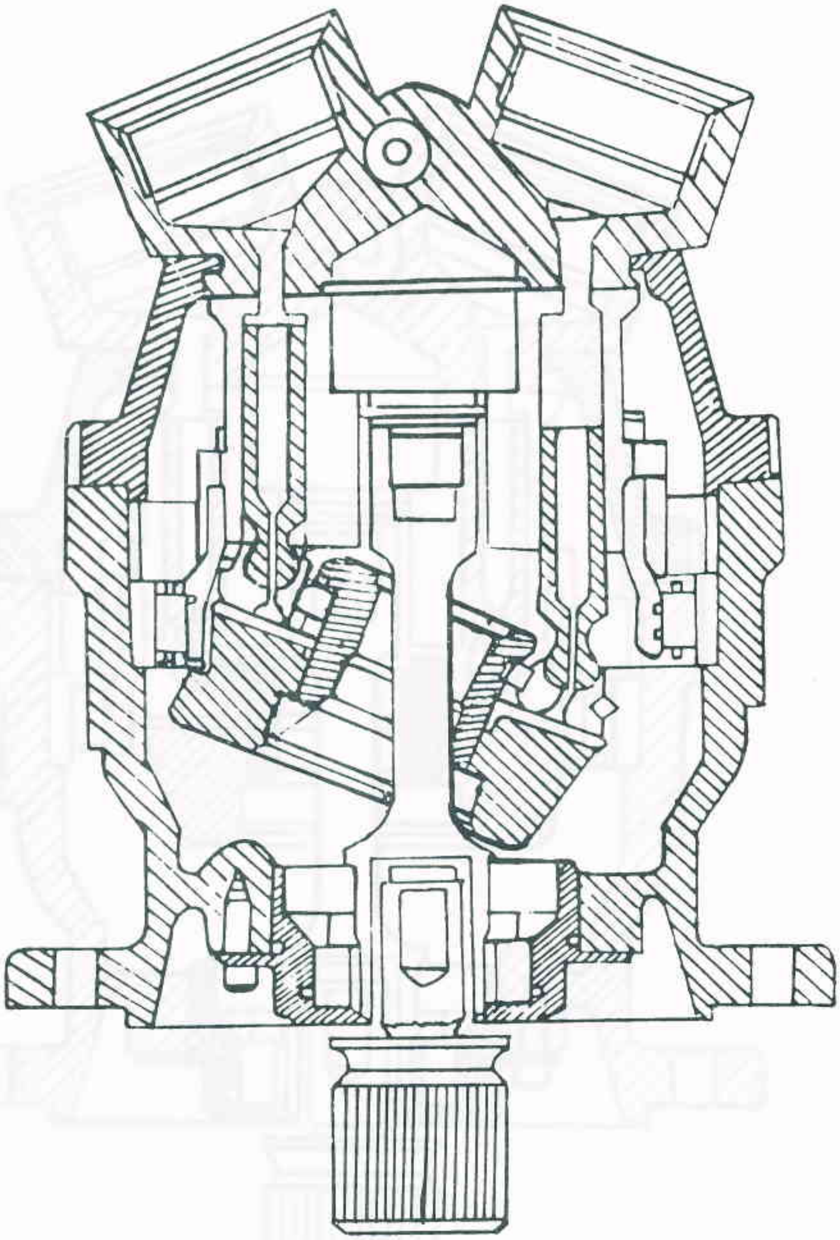


Figure 4-2

ENGINE DRIVEN PUMP
(ZERO FLOW)

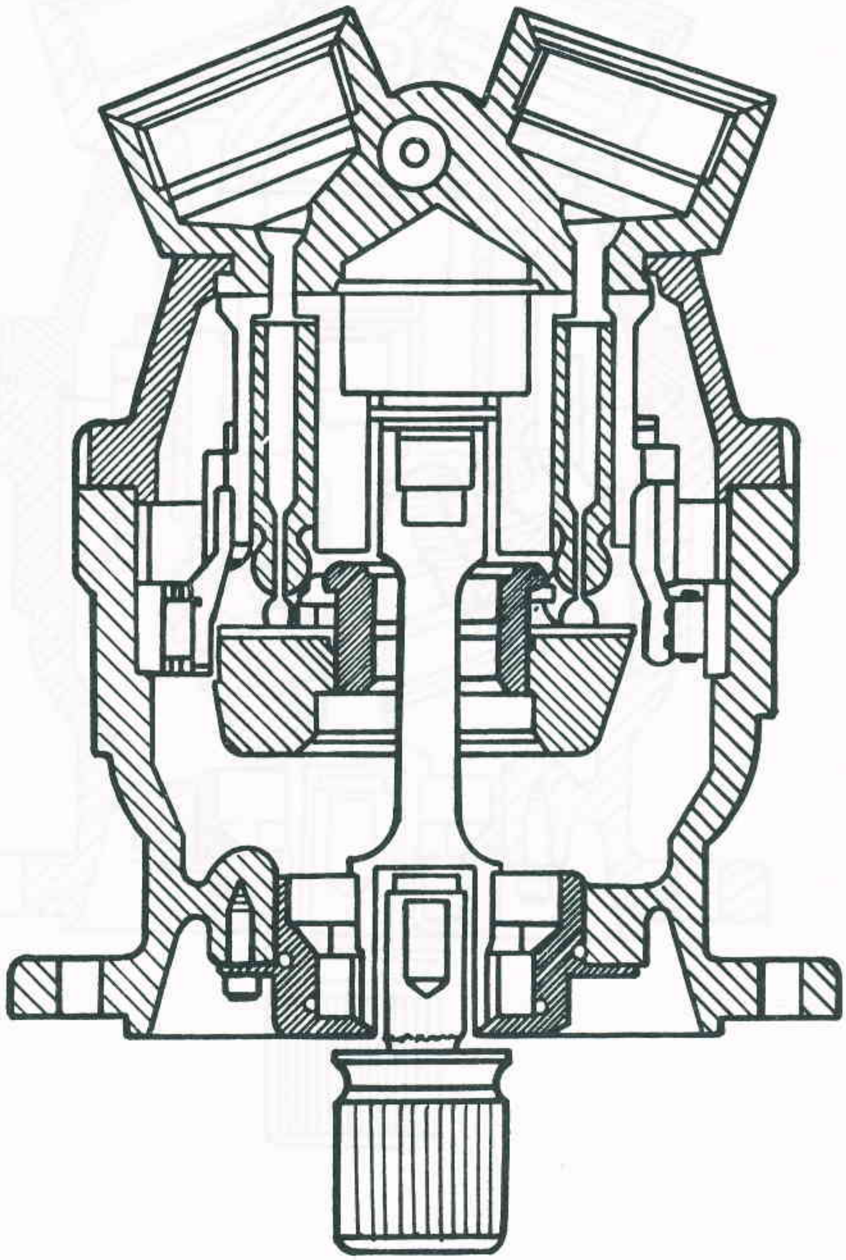
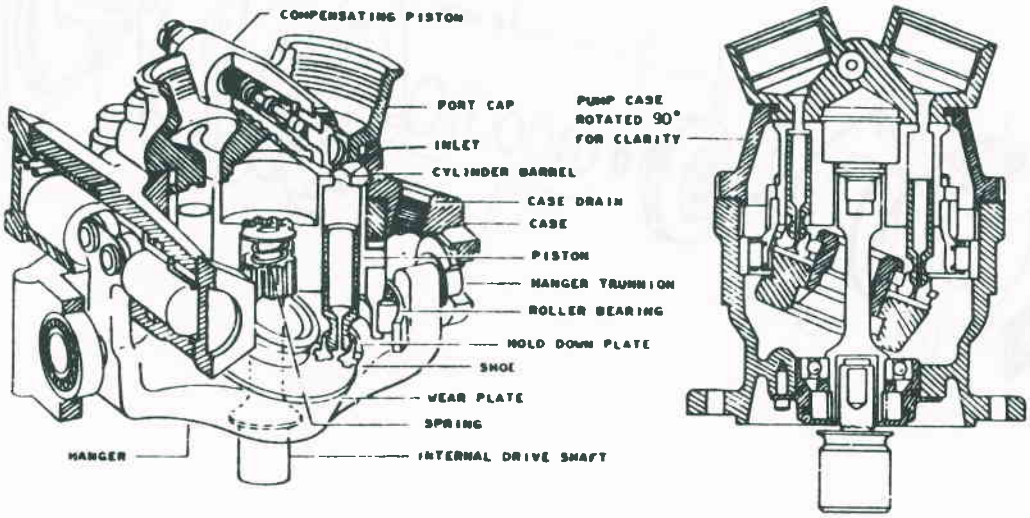
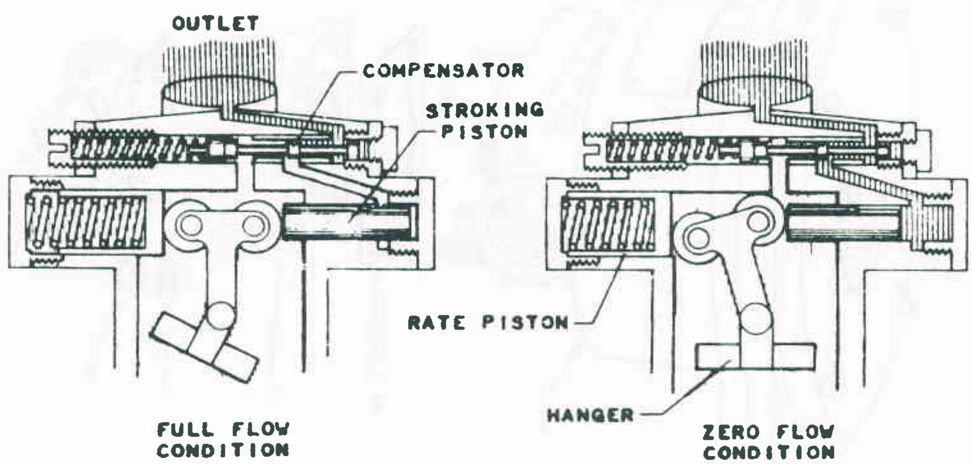


Figure 4-3

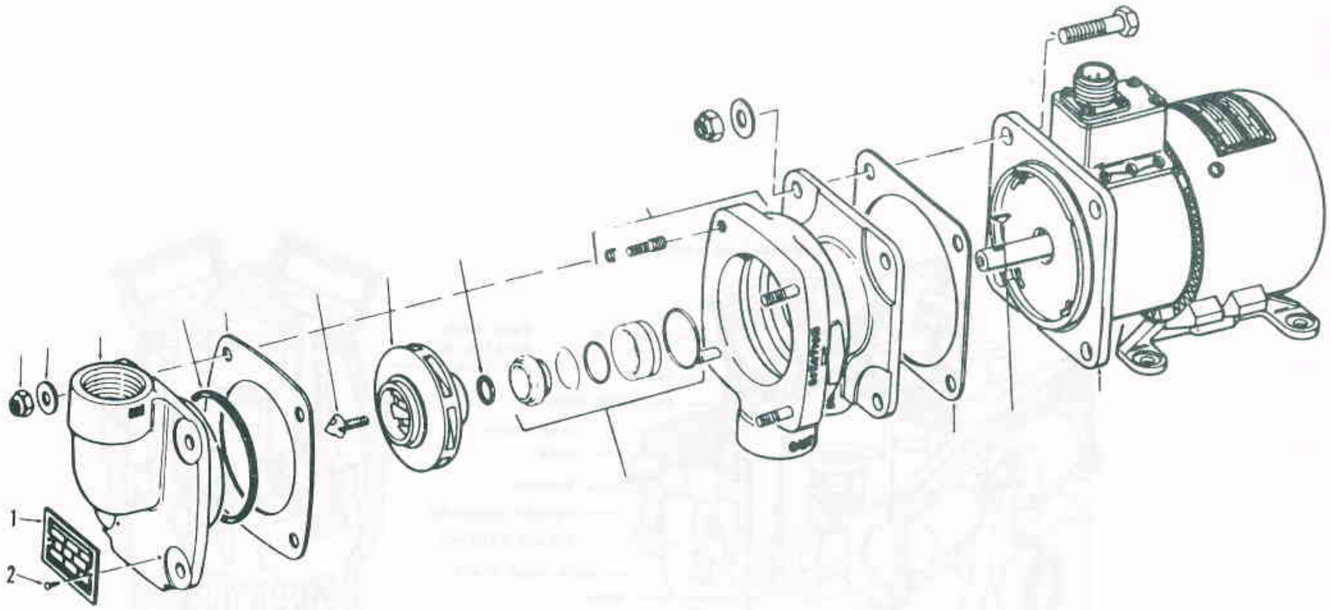


ENGINE DRIVEN PUMP

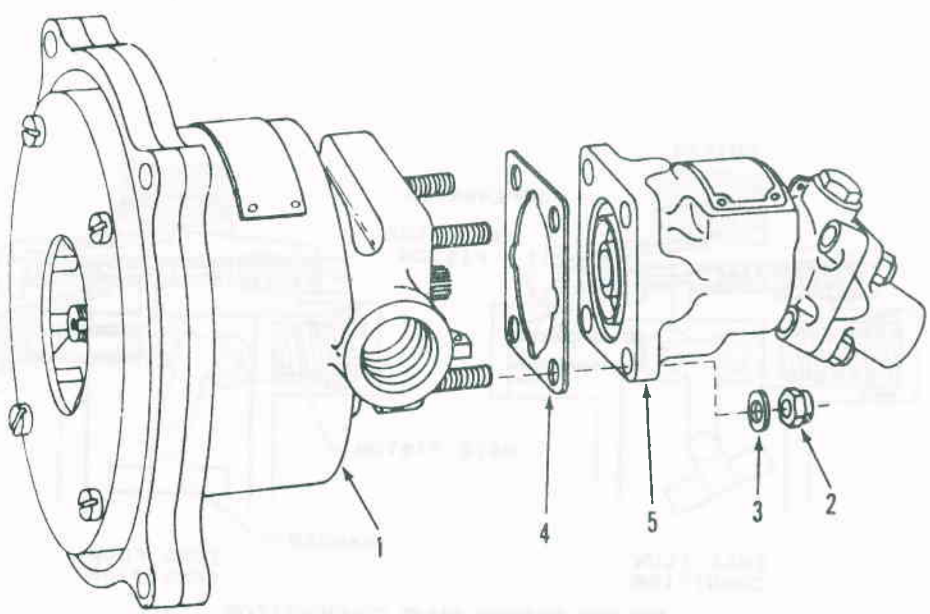


ENGINE DRIVEN PUMP COMPENSATOR

Figure 4-4



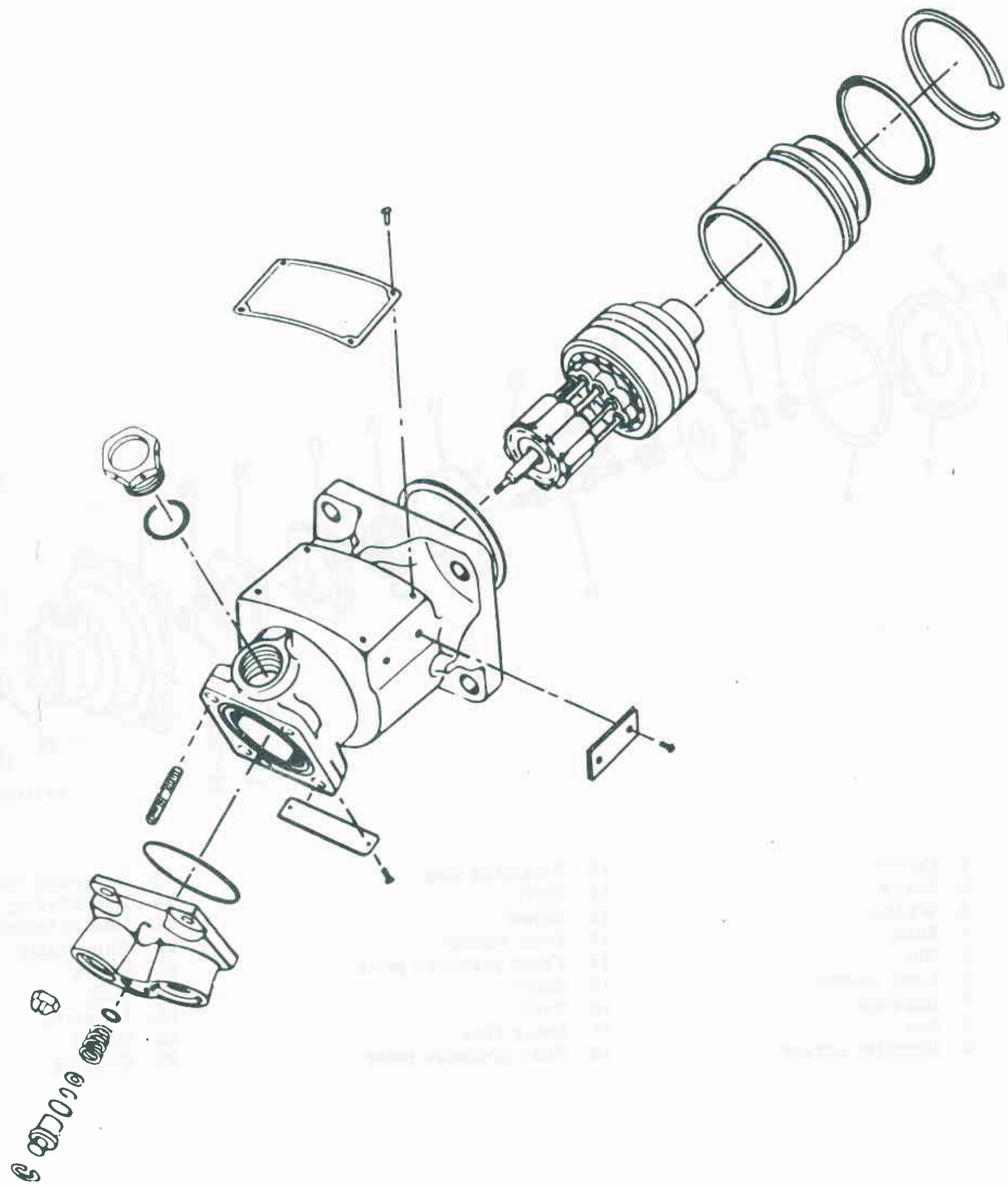
ELECTRIC SUCTION BOOSTER PUMP AND MOTOR



1. Inlet booster pump subassembly
2. Nut
3. Washer
4. Gasket
5. Hydraulic motor assembly

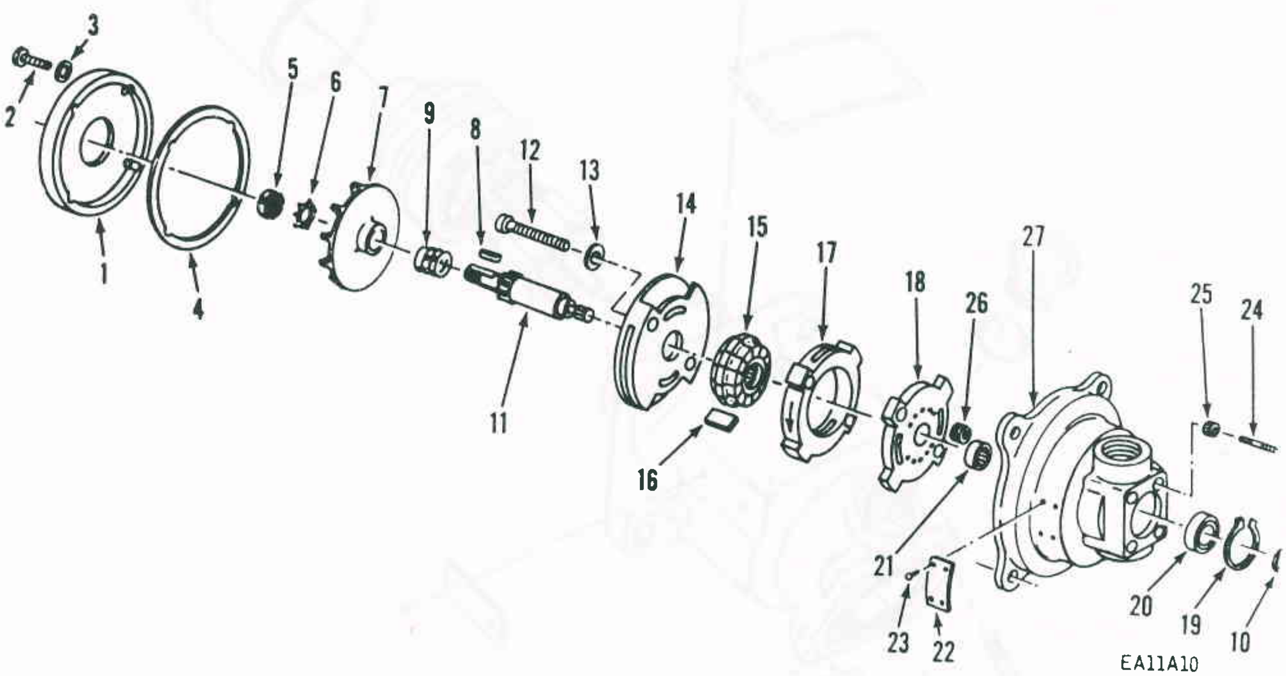
HYDRAULIC SUCTION BOOSTER PUMP AND MOTOR

Figure 4-5



HYDRAULIC SUCTION BOOSTER PUMP MOTOR

Figure 4-6



1. Cover
2. Screw
3. Washer
4. Shim
5. Nut
6. Lock washer
7. Impeller
8. Key
9. Impeller spring
10. Retaining ring
11. Shaft
12. Screw
13. Lock washer
14. Front pressure plate
15. Rotor
16. Vane
17. Rotor ring
18. Rear pressure plate
19. Retaining ring
20. Ball bearing
21. Needle bearing
22. Name plate
23. Screw
24. Stud
25. Lockring
26. Insert
27. Housing

HYDRAULIC SUCTION BOOSTER PUMP

Figure 4-7

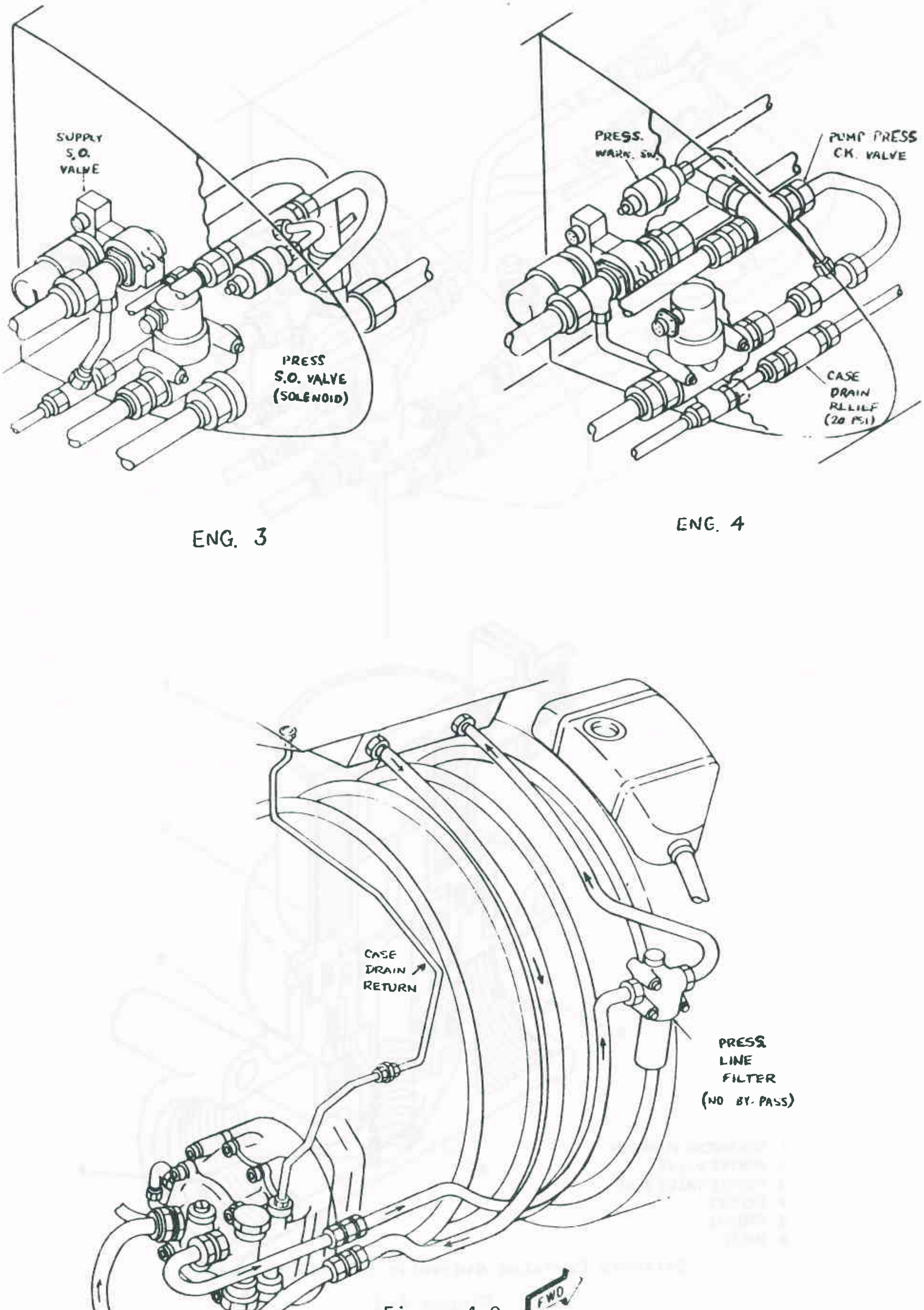
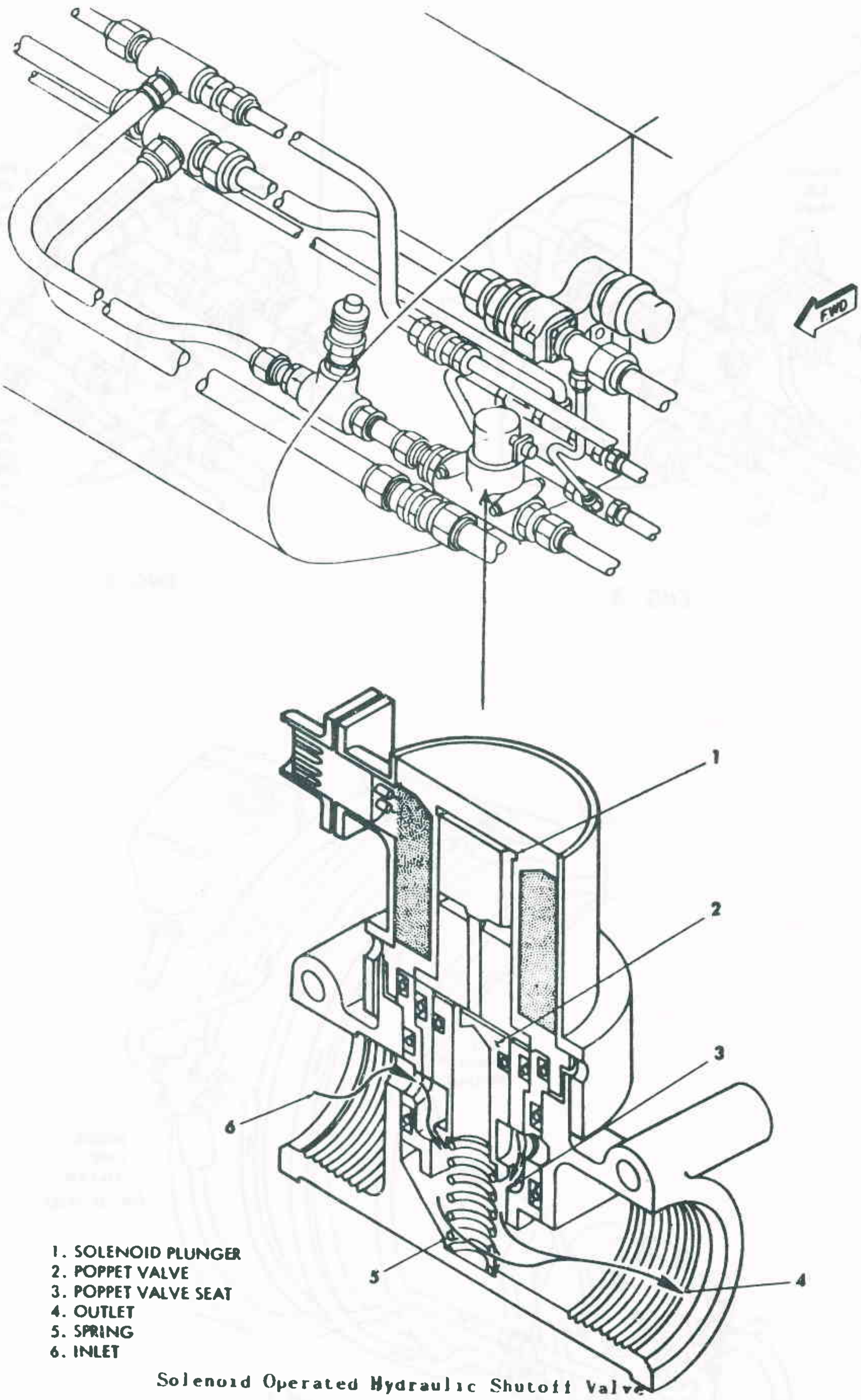

SUPPLY S.O. VALVE
PRESS S.O. VALVE (SOLENOID)
ENG. 3
PRESS. WARN. SW.
PUMP PRESS CK. VALVE
CASE DRAIN RELIEF (20 PSI)
ENG. 4
CASE DRAIN RETURN
PRESS. LINE FILTER (NO BY-PASS)
FWD

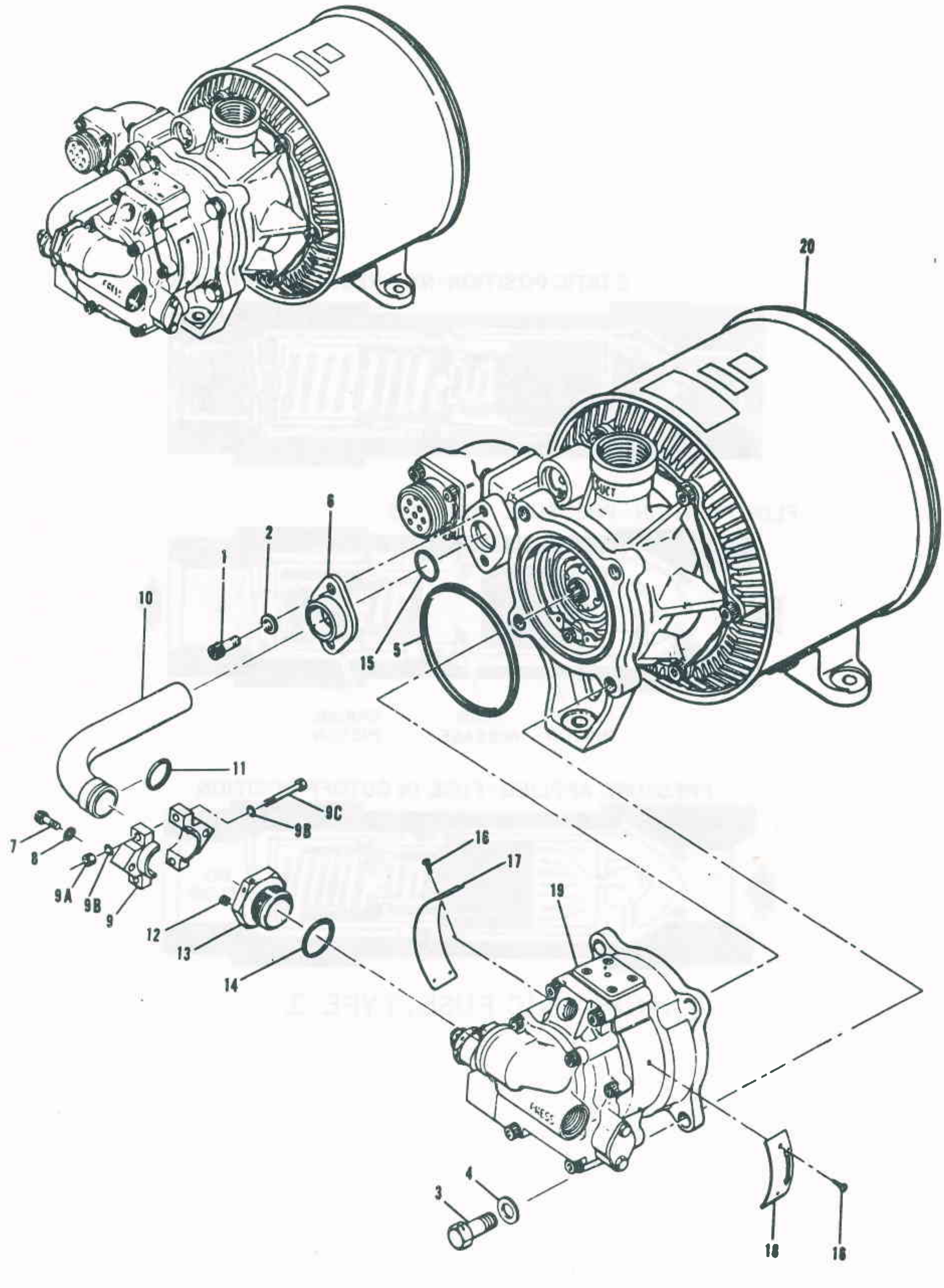
Figure 4-8



1. SOLENOID PLUNGER
2. POPPET VALVE
3. POPPET VALVE SEAT
4. OUTLET
5. SPRING
6. INLET

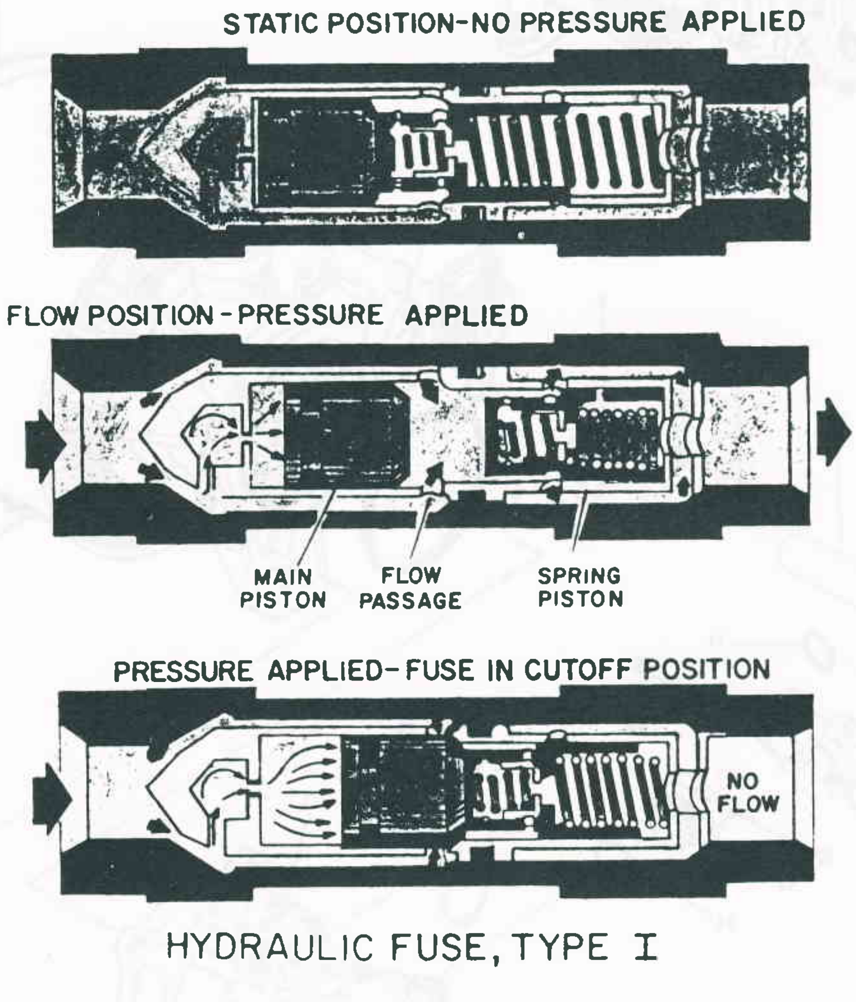
Solenoid Operated Hydraulic Shutoff Valve

Figure 4-9



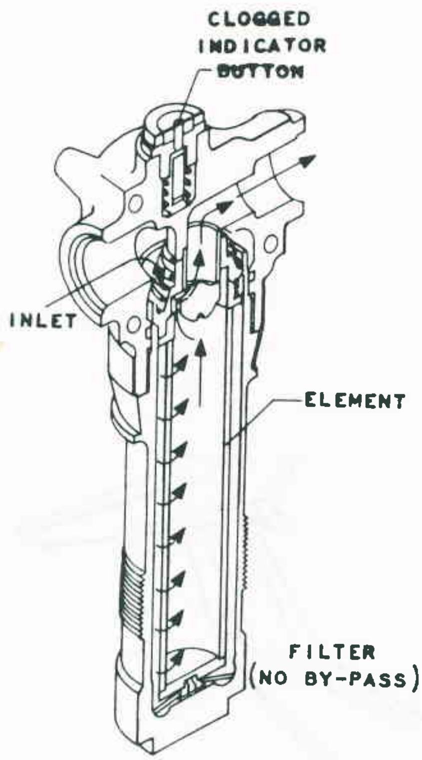
ELECTRIC MOTOR-DRIVEN PUMP NO. 3 SYSTEM

Figure 4-10

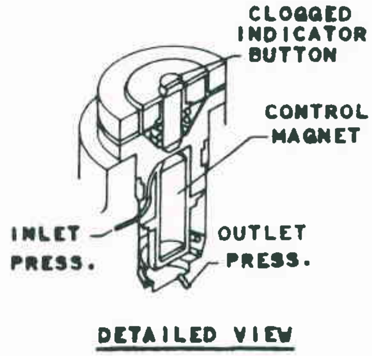


HYDRAULIC FUSE

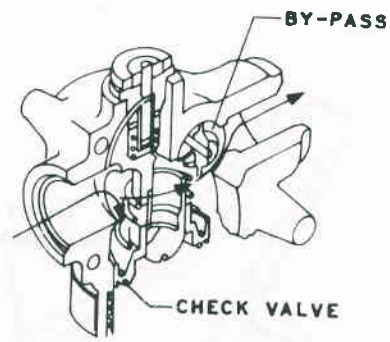
Figure 4-11



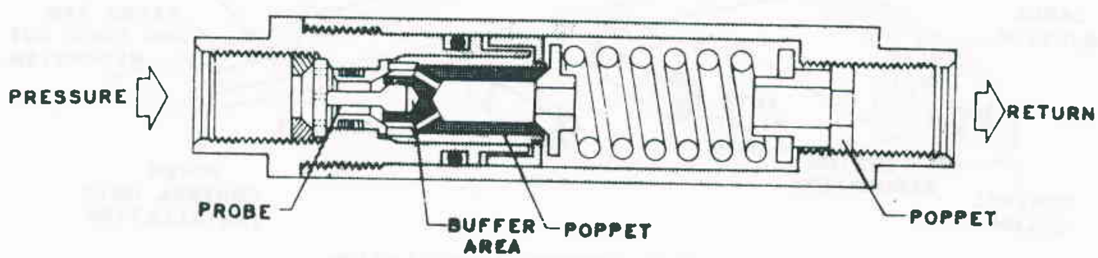
HYDRAULIC OIL FILTER



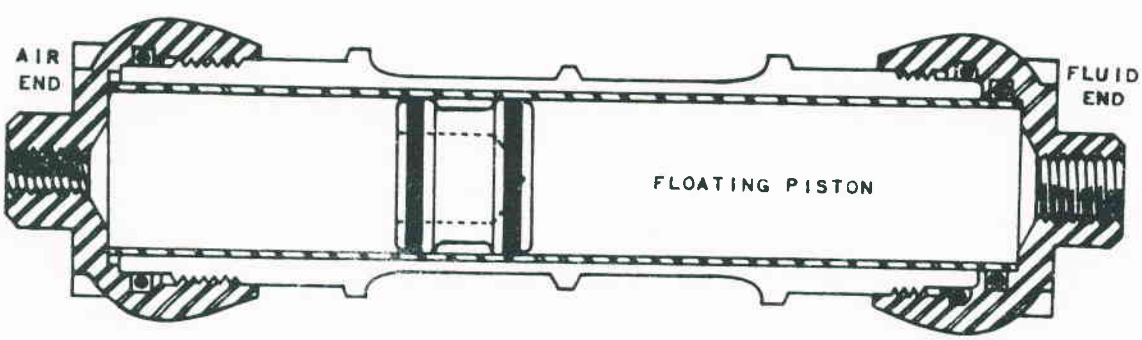
CLOGGED INDICATOR BUTTON



FILTER BY-PASS

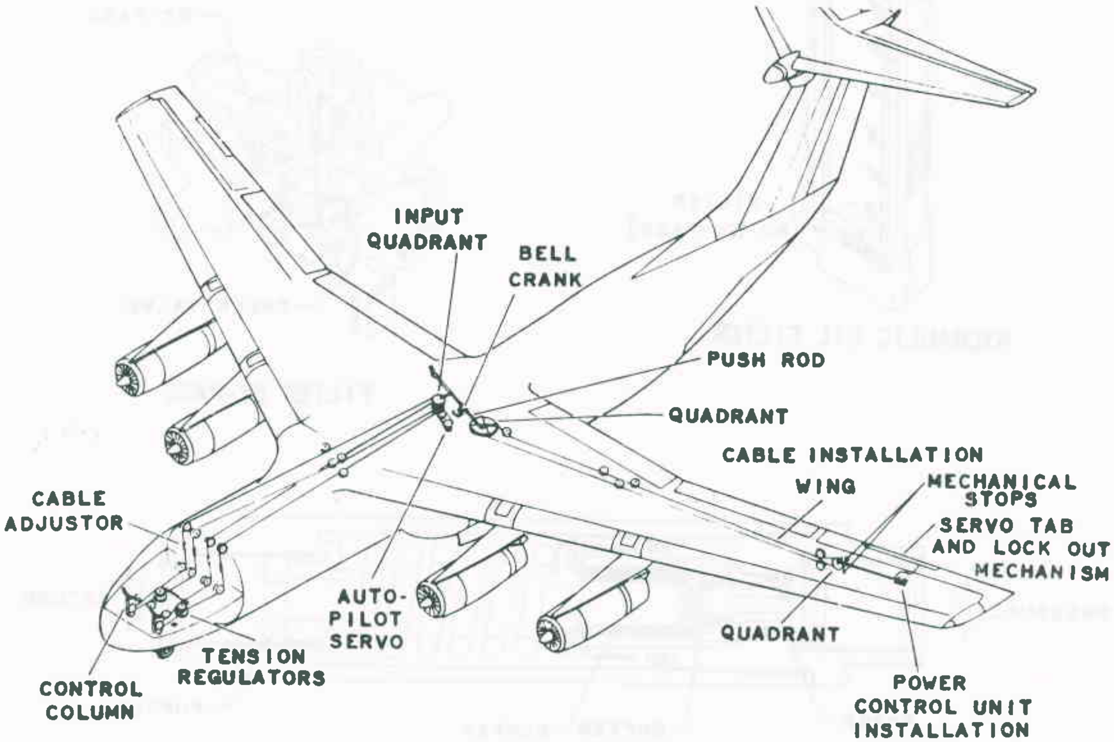


SYSTEM RELIEF VALVE



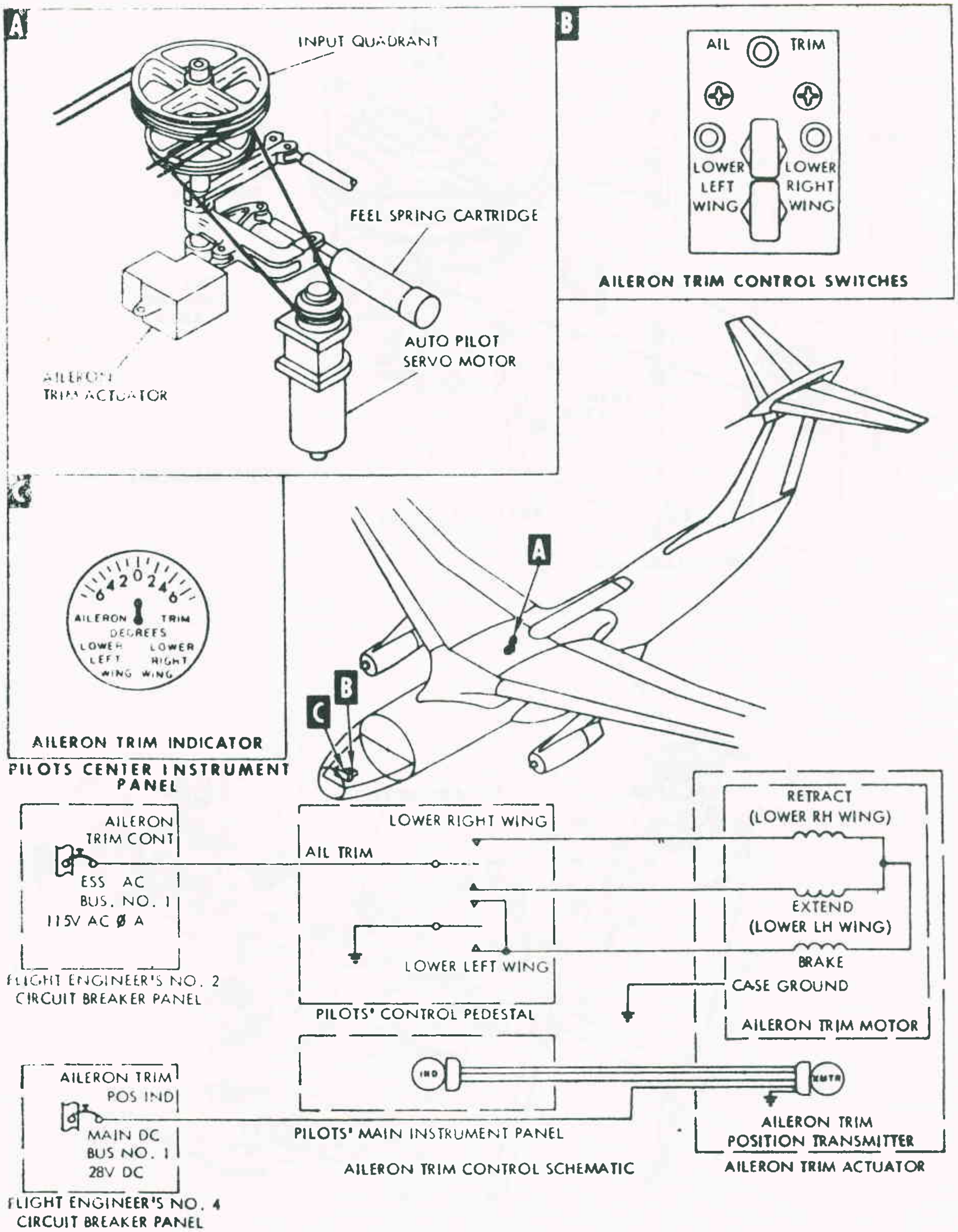
PISTON-TYPE ACCUMULATOR

Figure 4-12



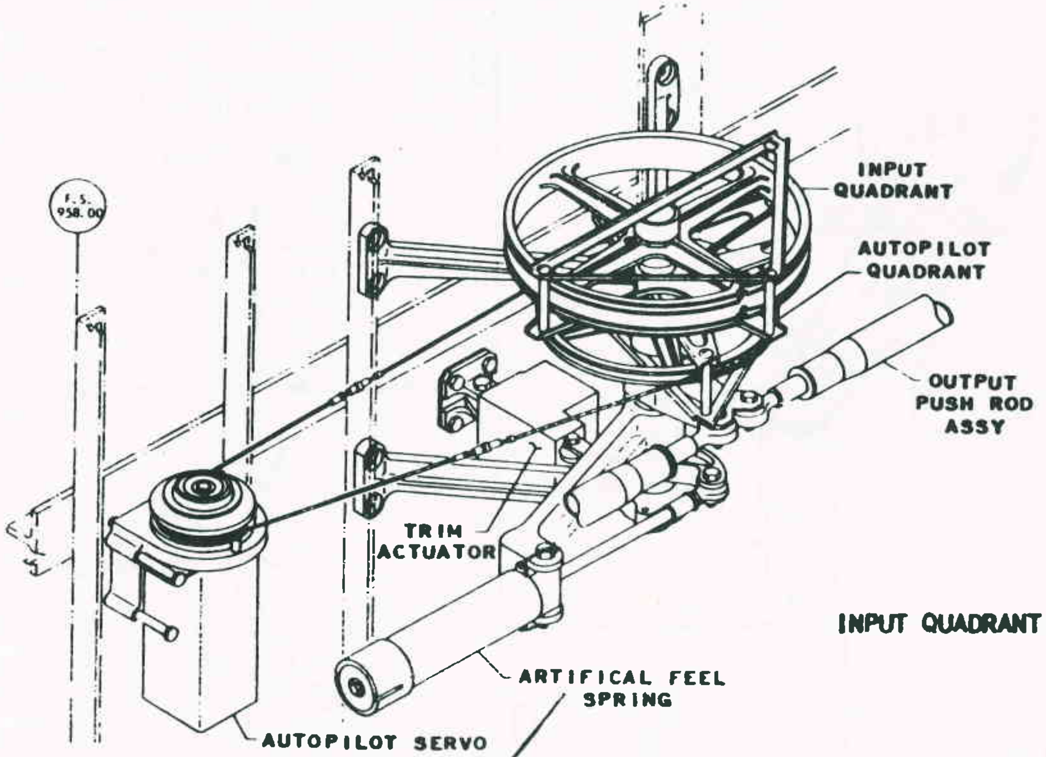
AILERON CONTROL INSTALLATION

Figure 4-13

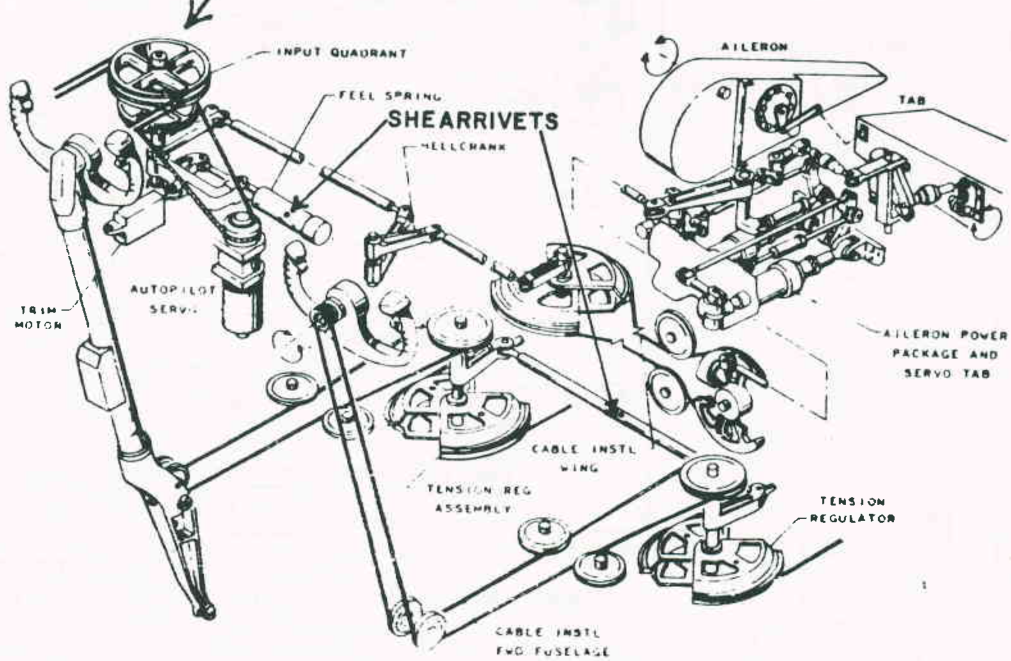


Aileron Trim System

Figure 4-14

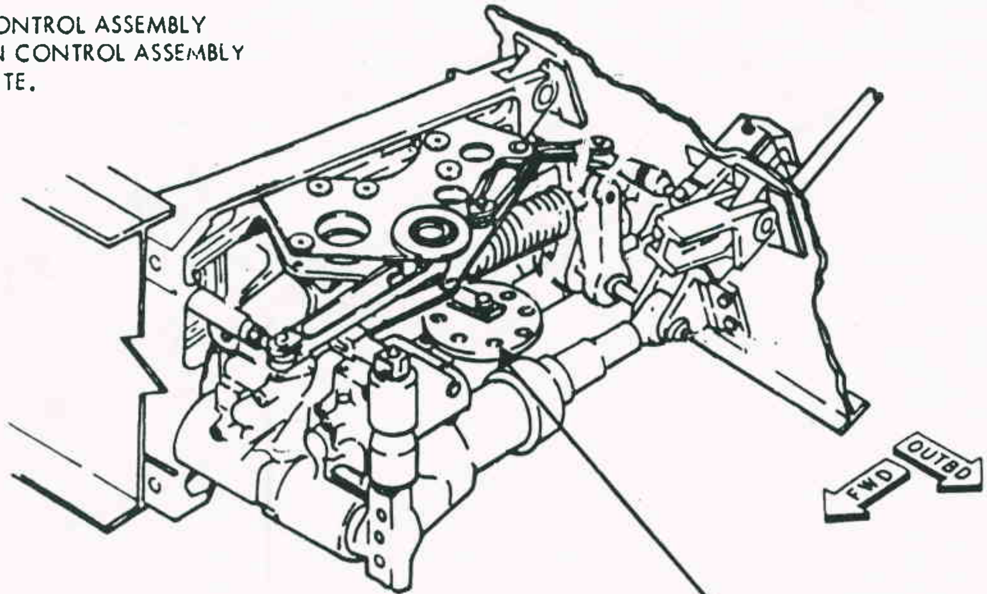


INPUT QUADRANT

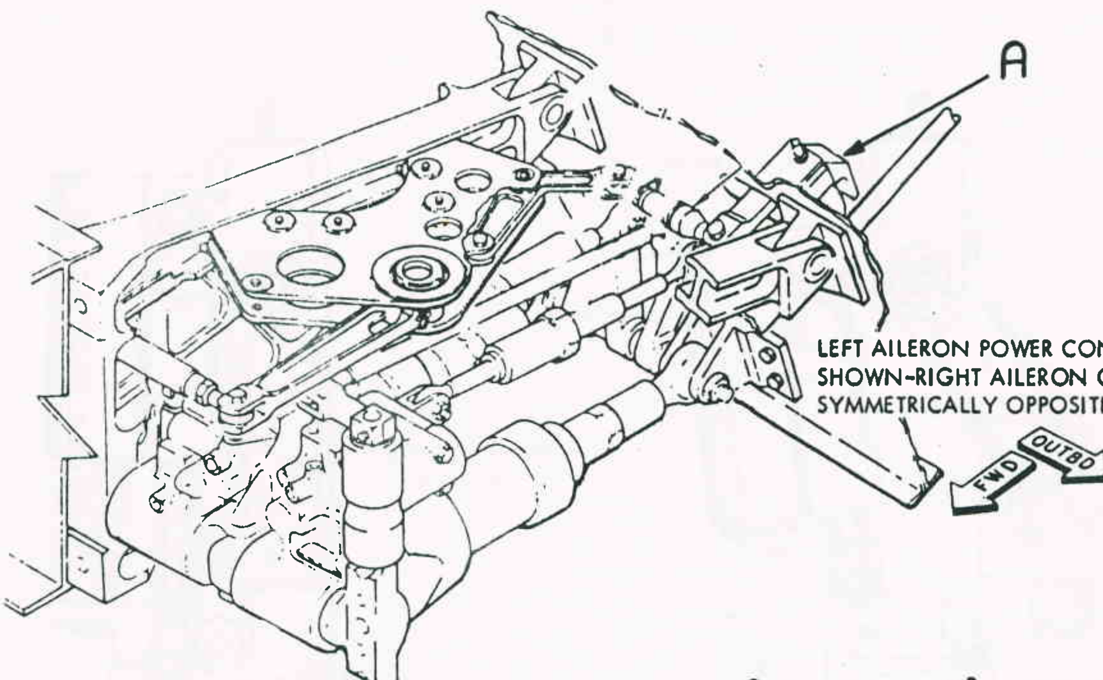


AILERON CONTROL SYSTEM

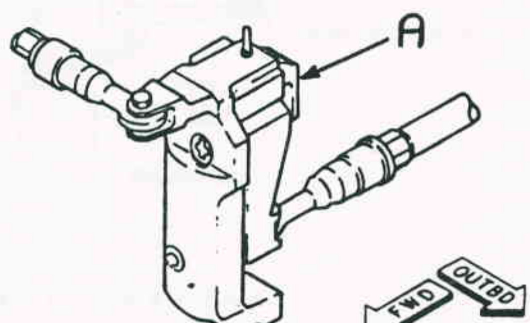
Figure 4-15



⚠1 AILERON POWER CONTROL ASSEMBLIES



⚠2 AILERON POWER CONTROL ASSEMBLIES

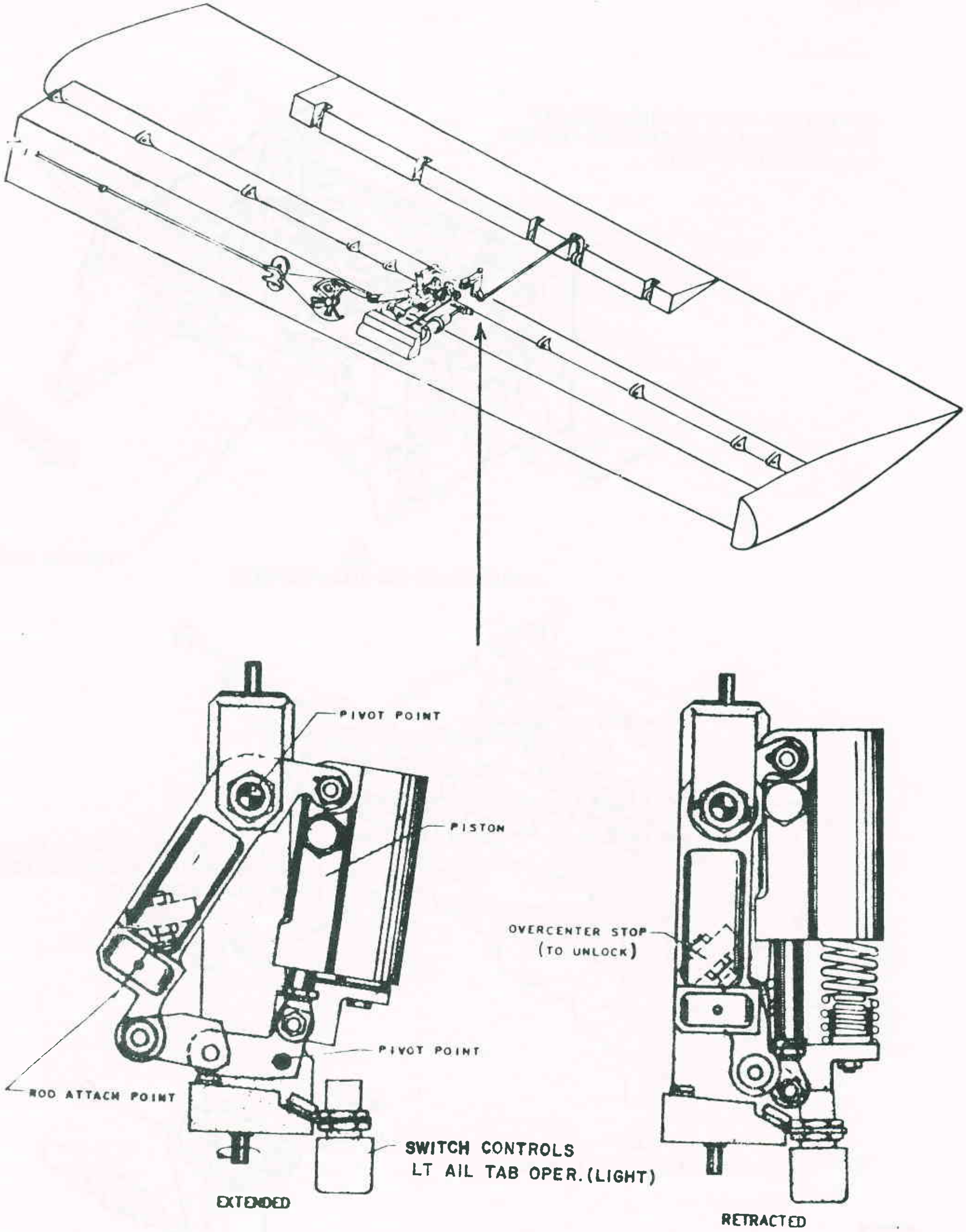


NOTE

⚠1 APPLIES TO AIRPLANES MODIFIED BY T O IC-141-587.

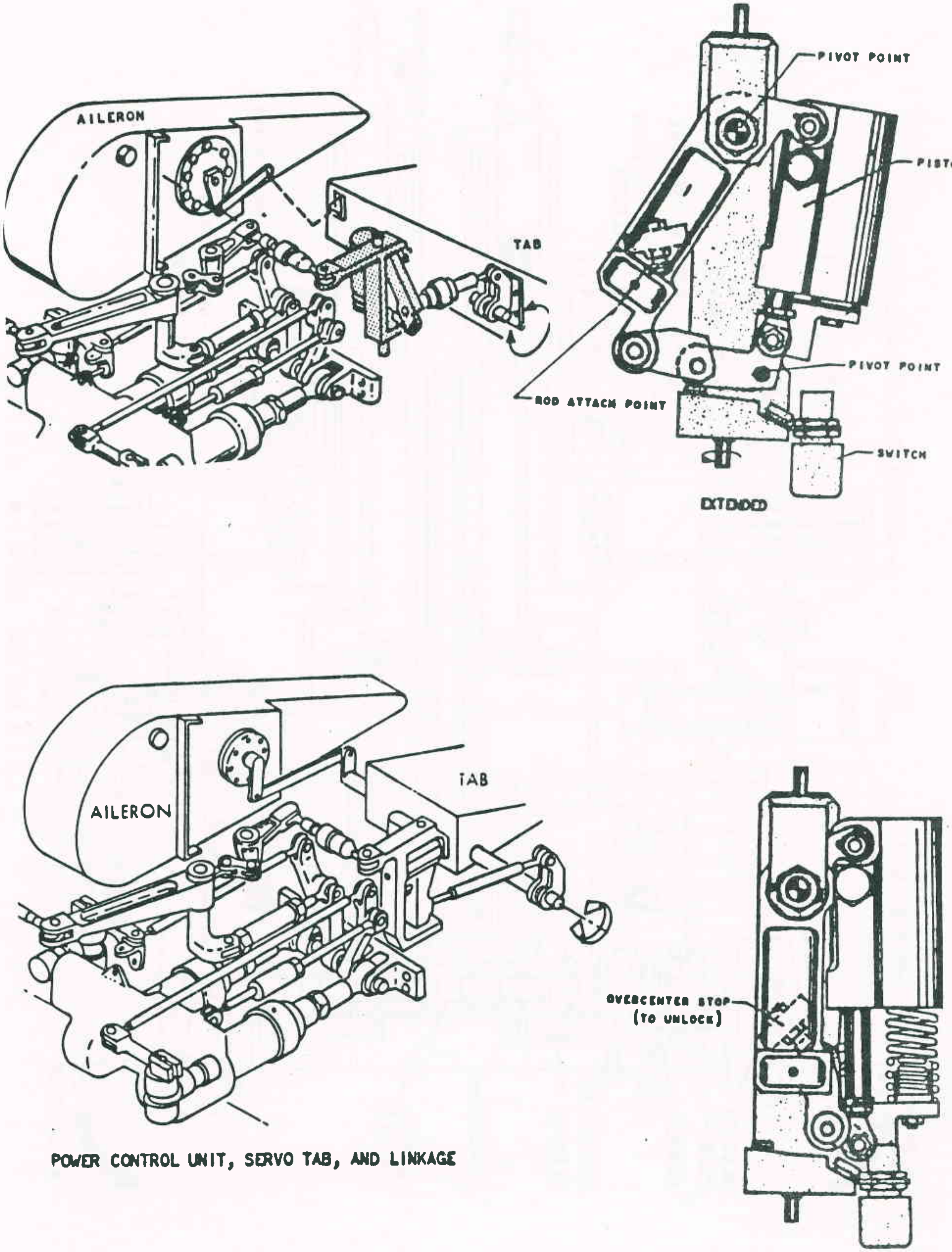
⚠2 APPLIES TO AIRPLANES NOT MODIFIED BY T O IC-141-587.

Figure 4-16



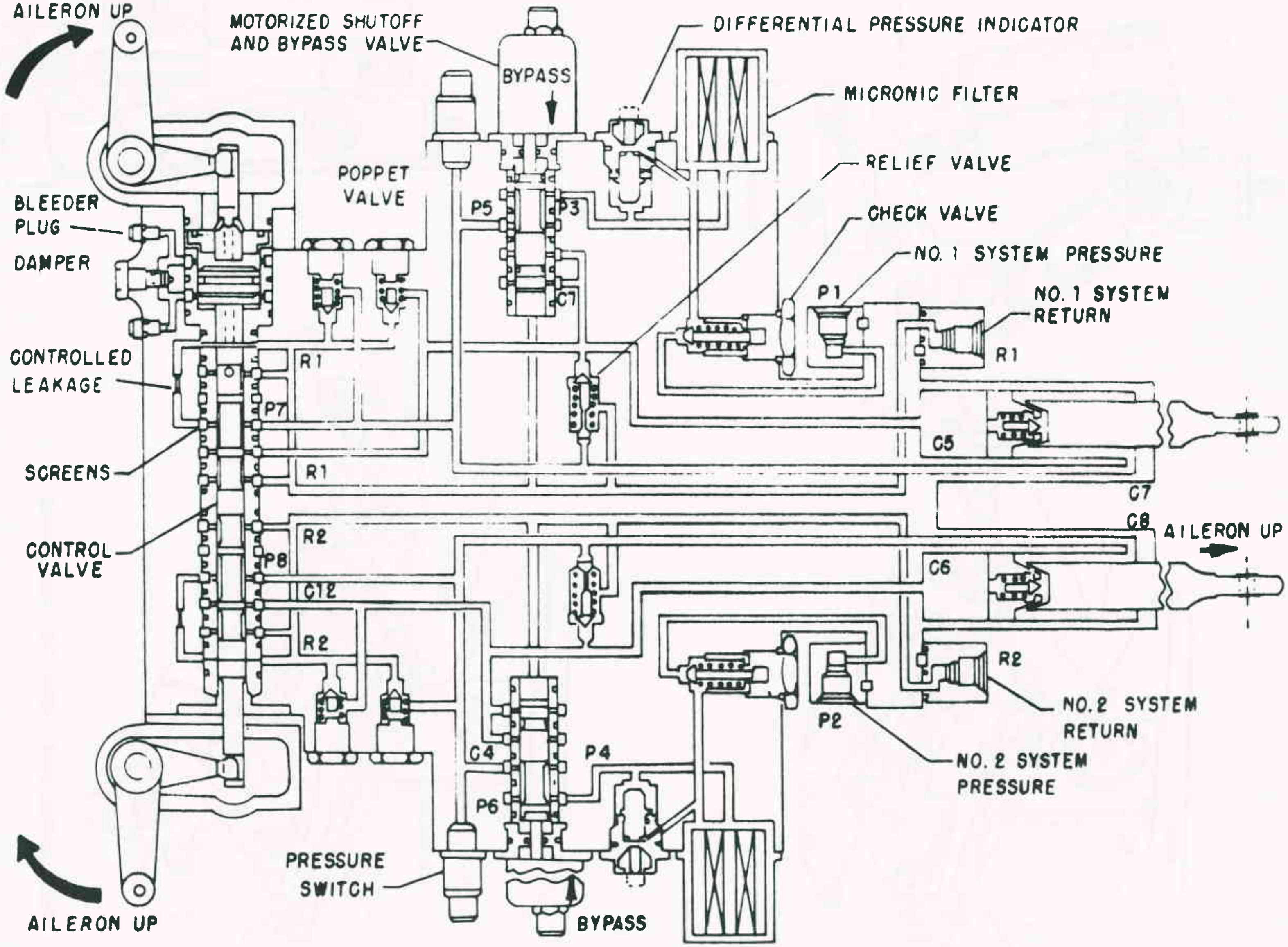
AILERON TAB LOCKOUT LINKAGE

Figure 4-17



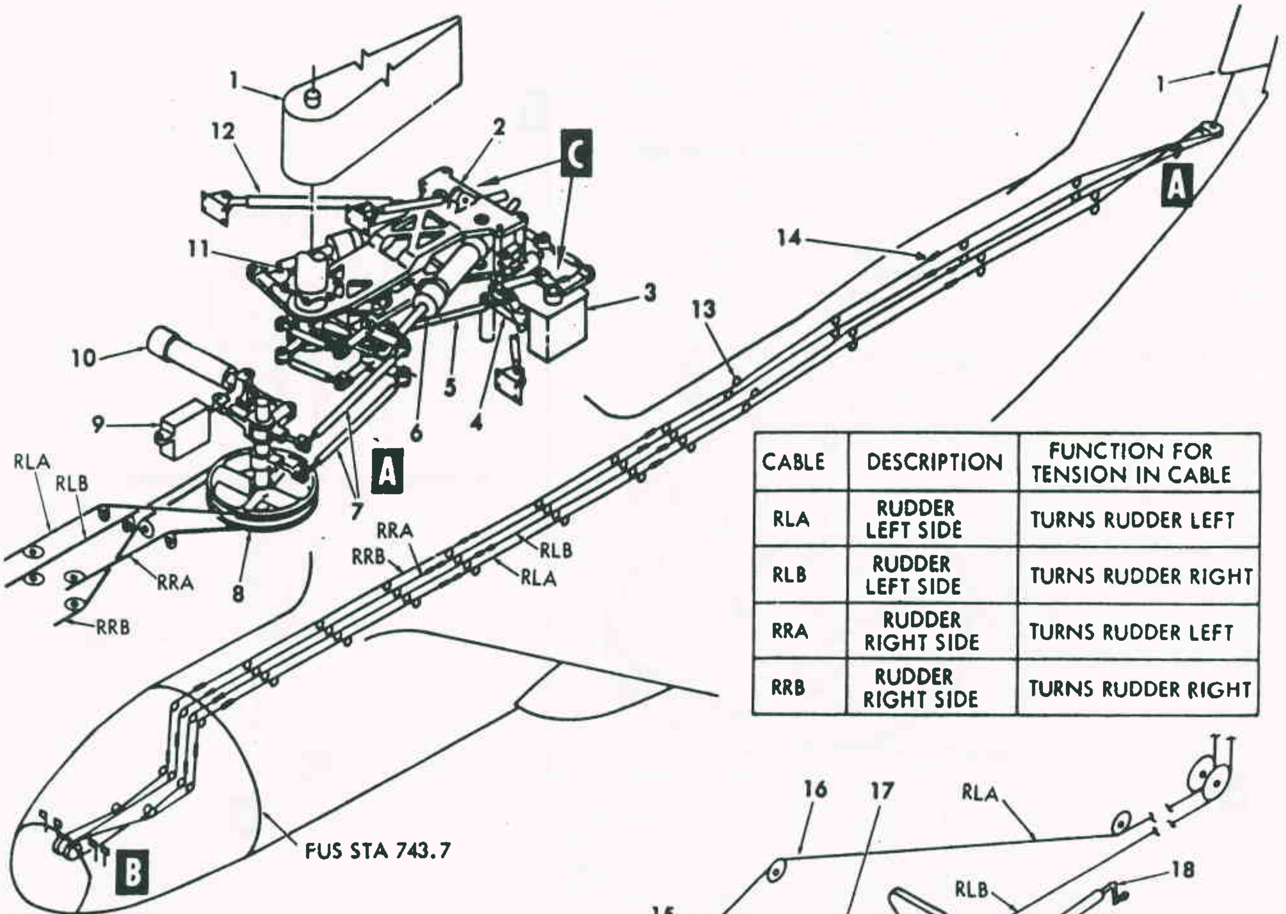
POWER CONTROL UNIT, SERVO TAB, AND LINKAGE

Figure 4-18

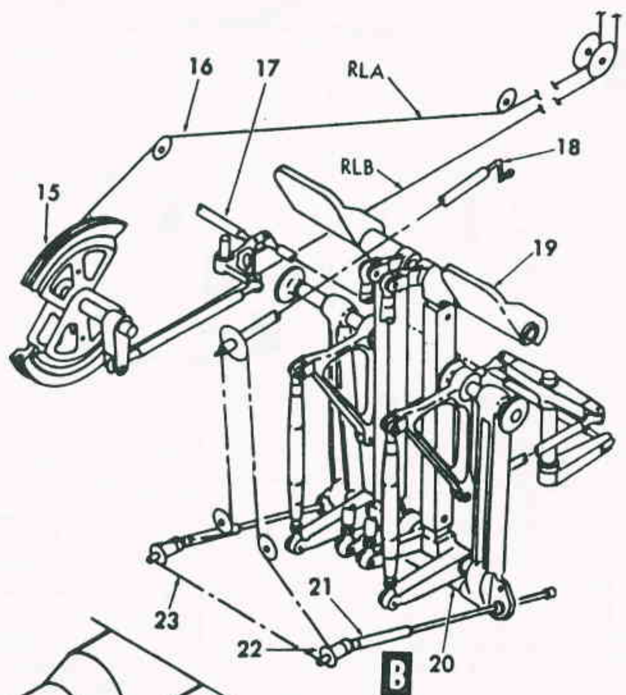


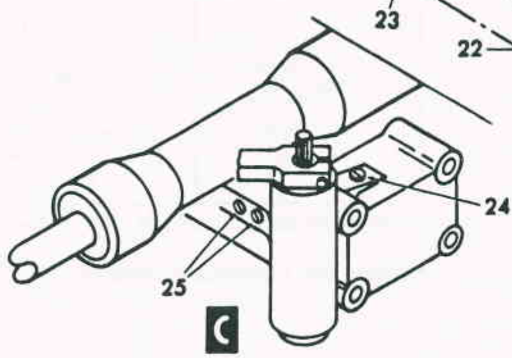
AILERON POWER UNIT

Figure 4-19



CABLE	DESCRIPTION	FUNCTION FOR TENSION IN CABLE
RLA	RUDDER LEFT SIDE	TURNS RUDDER LEFT
RLB	RUDDER LEFT SIDE	TURNS RUDDER RIGHT
RRA	RUDDER RIGHT SIDE	TURNS RUDDER LEFT
RRB	RUDDER RIGHT SIDE	TURNS RUDDER RIGHT

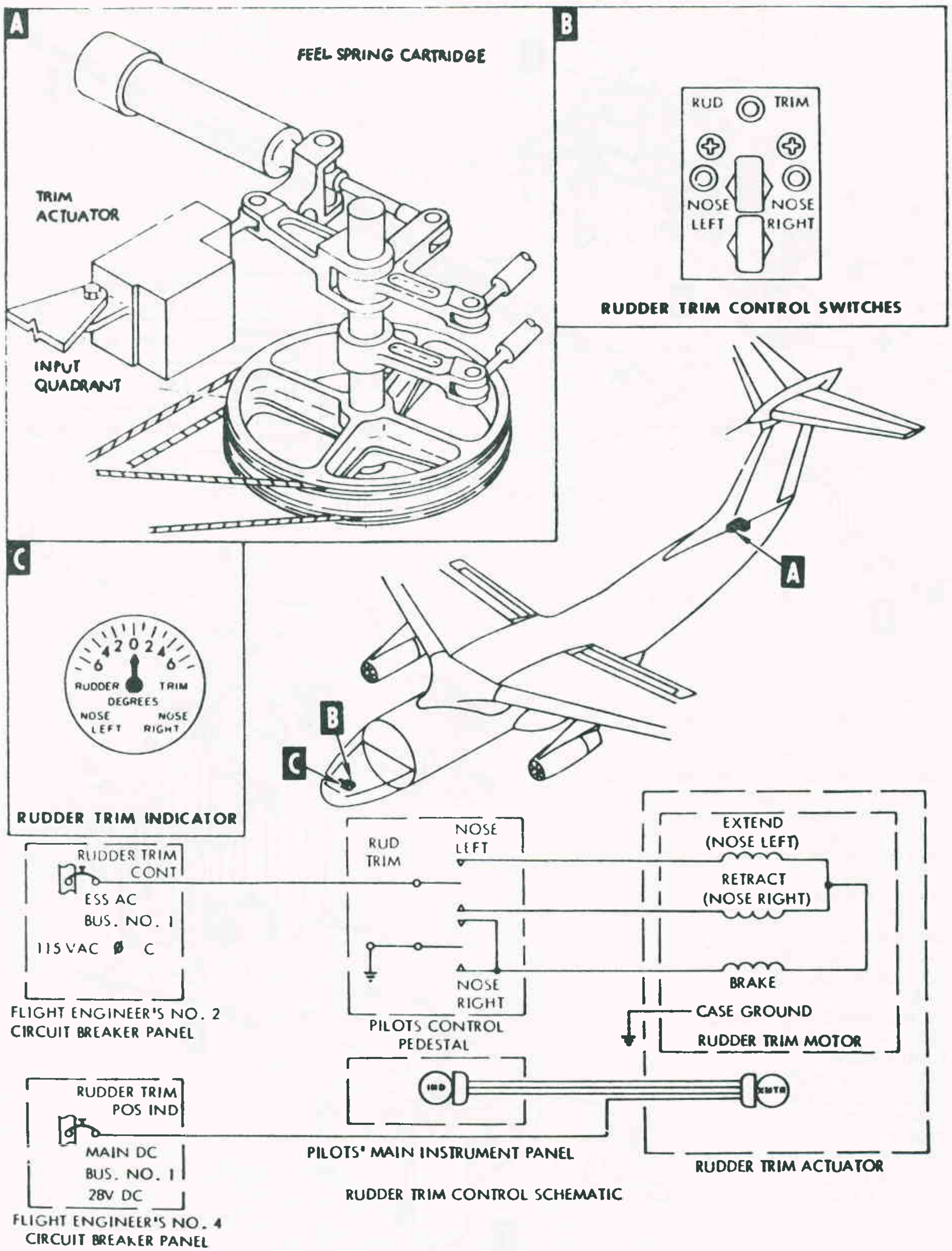




1. RUDDER
2. RUDDER POWER CONTROL ASSEMBLY
3. YAW DAMPER SERVO
4. SERVOVALVE INPUT LEVER
5. SERVOVALVE INPUT AND FEEDBACK LINKAGE
6. ACTUATING CYLINDER
7. INPUT PUSHRODS
8. INPUT QUADRANT
9. TRIM ACTUATOR
10. FEEL SPRING
11. RUDDER TORQUE TUBE
12. SUPPORT BAR
13. GUIDE PULLEYS
14. CABLE CONNECTORS
15. TENSION REGULATOR
16. CABLE
17. INTERCONNECTING PUSHROD
18. PEDAL ADJUSTMENT CRANK
19. RUDDER PEDAL
20. PEDAL PIVOT SHAFT
21. ADJUSTING SCREW
22. CHAIN SPROCKET
23. CHAIN
24. SERVO VALVE END CAP UPPER DRAIN PLUG (2 PLACES)
25. DAMPER BLEED PLUGS

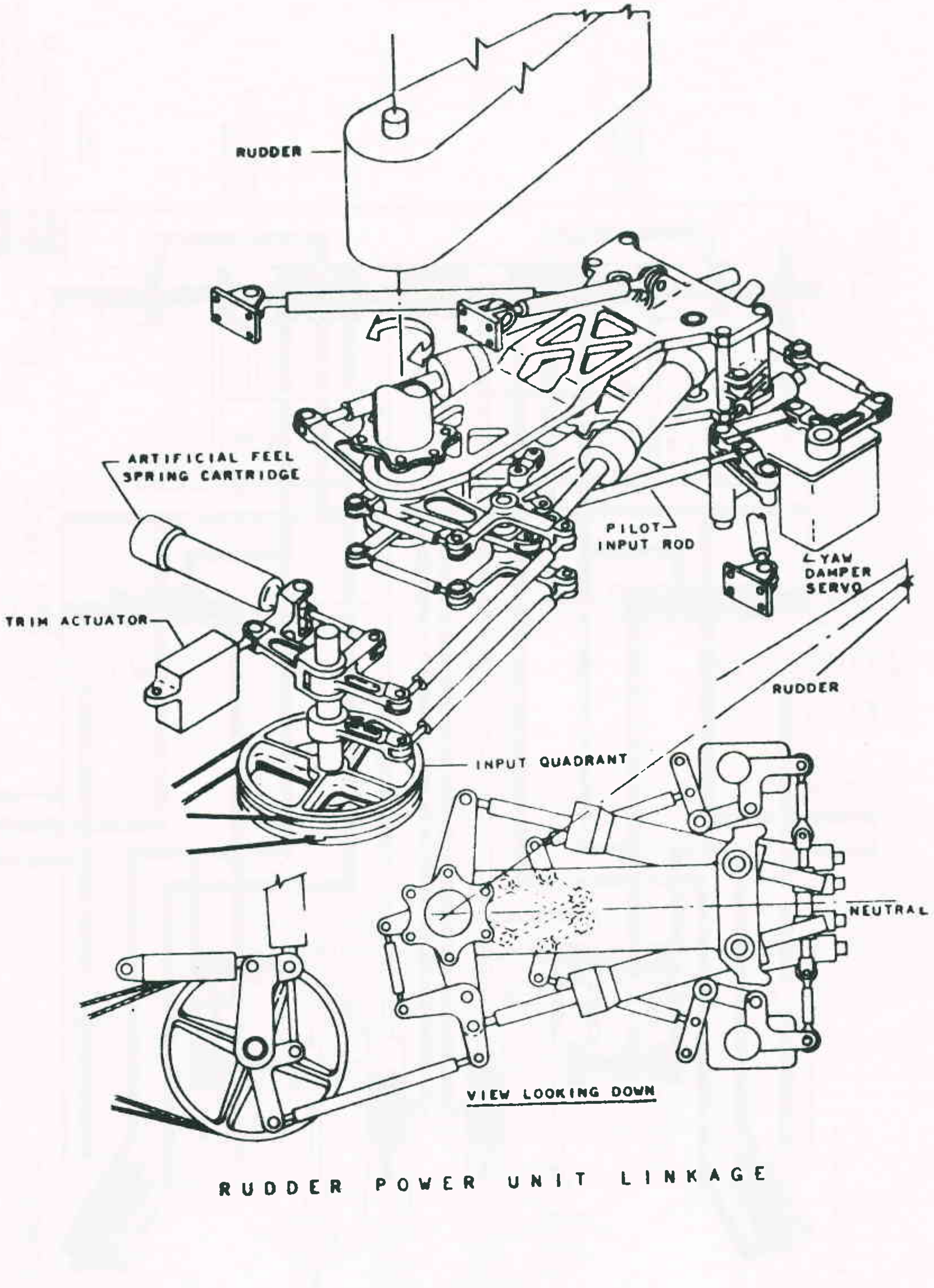
Rudder Control System Component Locations

Figure 4-20



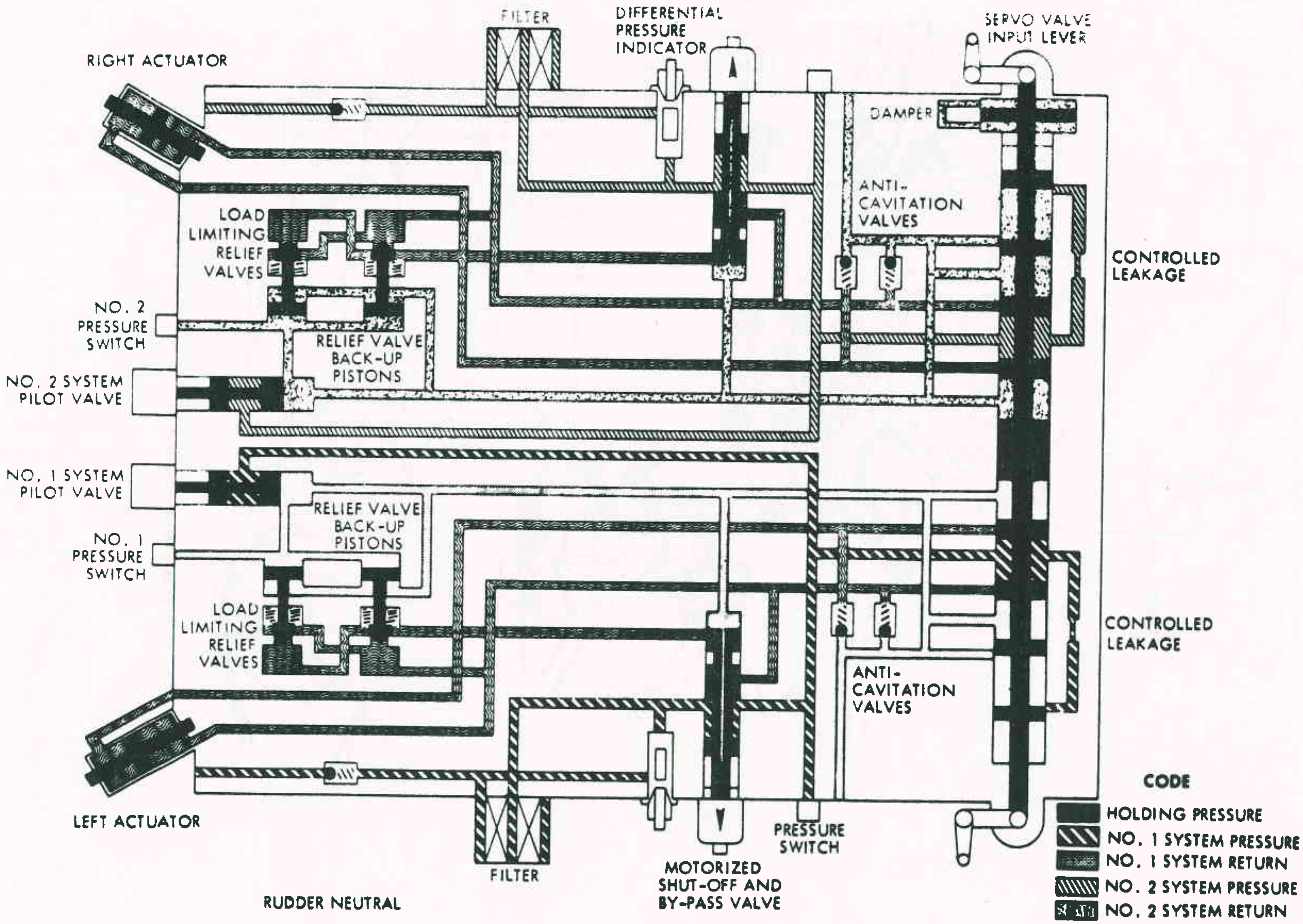
Rudder Trim System

Figure 4-21



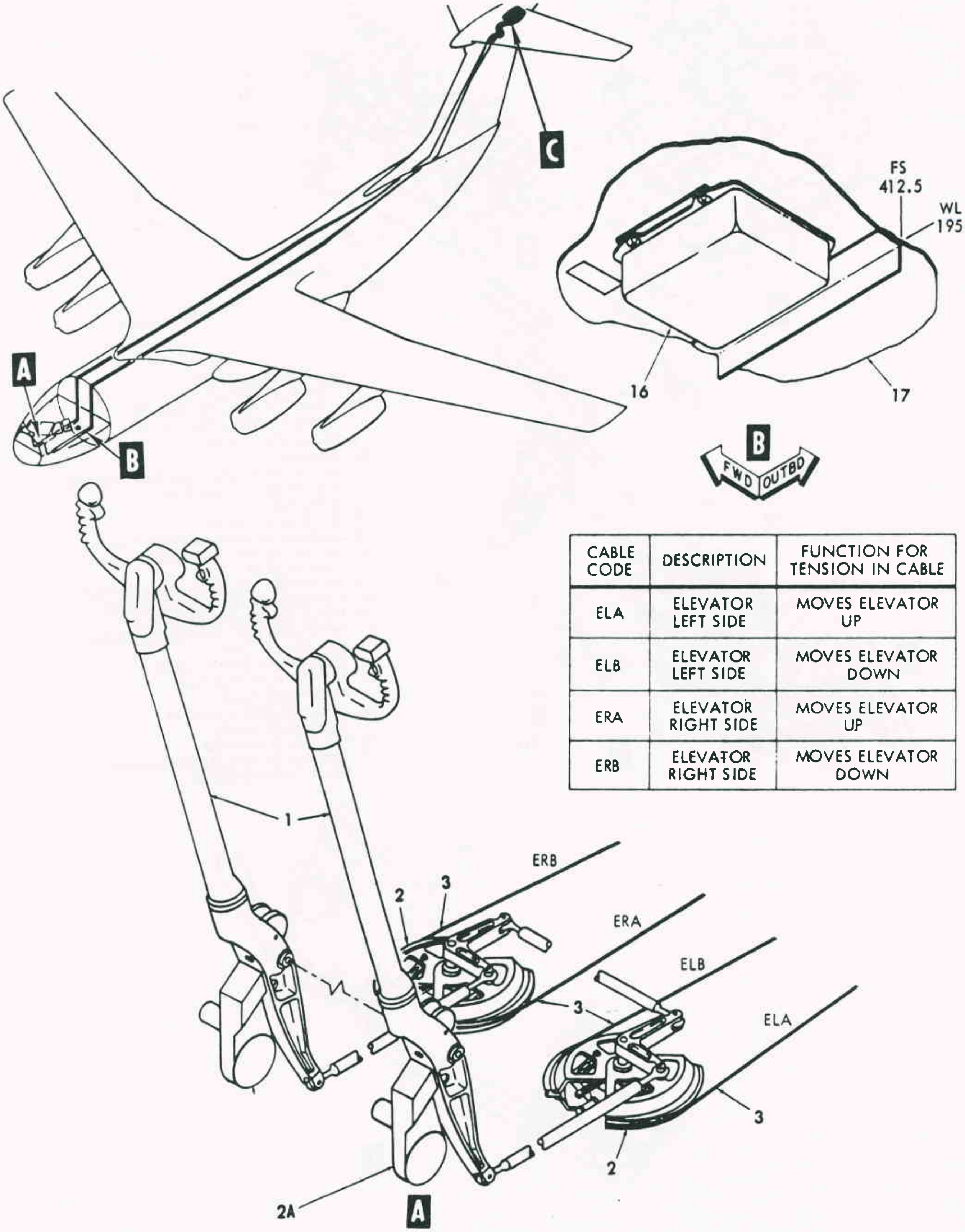
RUDDER POWER UNIT LINKAGE

Figure 4-22



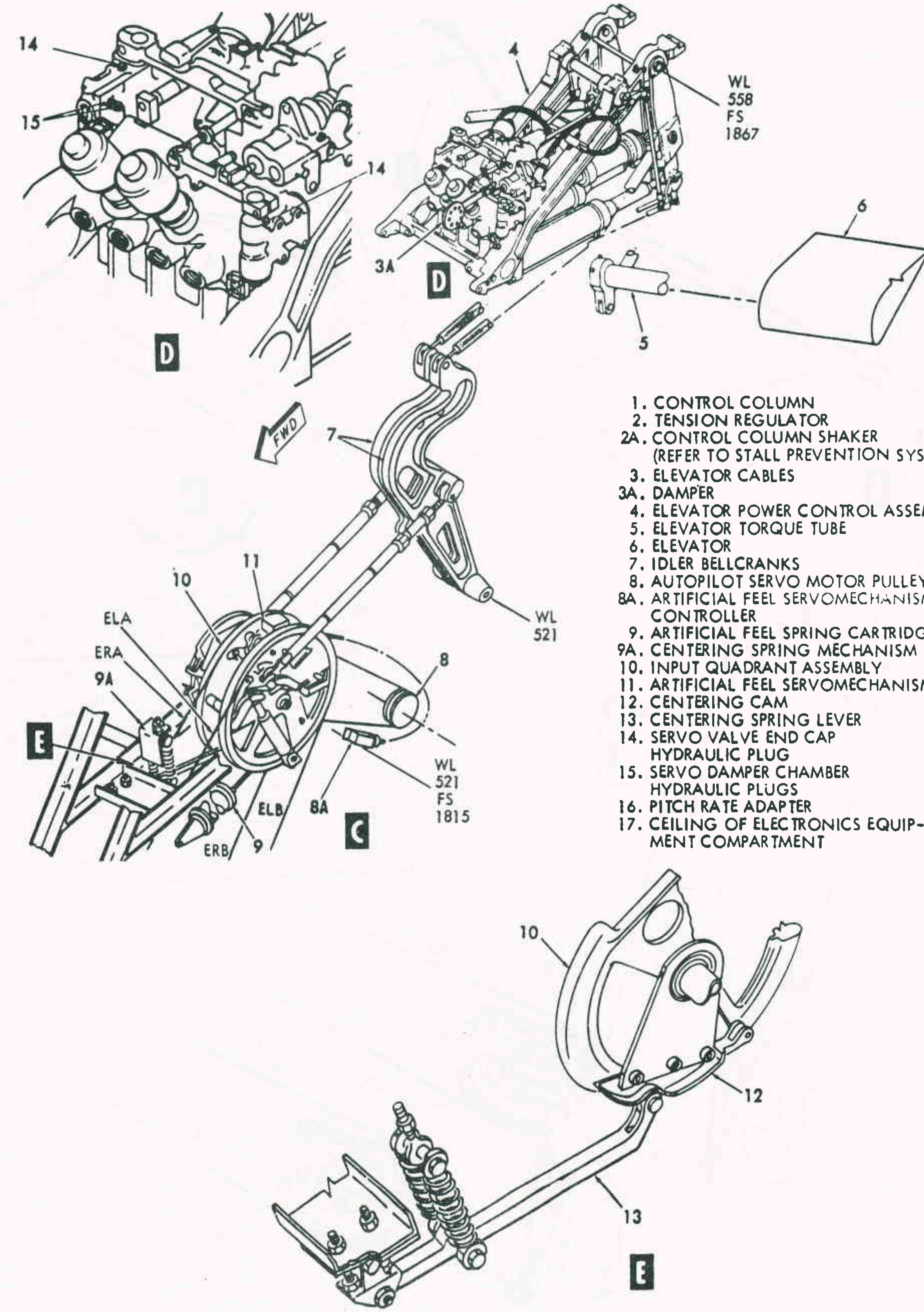
Rudder Power Control Assembly

Figure 4-23



CABLE CODE	DESCRIPTION	FUNCTION FOR TENSION IN CABLE
ELA	ELEVATOR LEFT SIDE	MOVES ELEVATOR UP
ELB	ELEVATOR LEFT SIDE	MOVES ELEVATOR DOWN
ERA	ELEVATOR RIGHT SIDE	MOVES ELEVATOR UP
ERB	ELEVATOR RIGHT SIDE	MOVES ELEVATOR DOWN

Figure 4-24

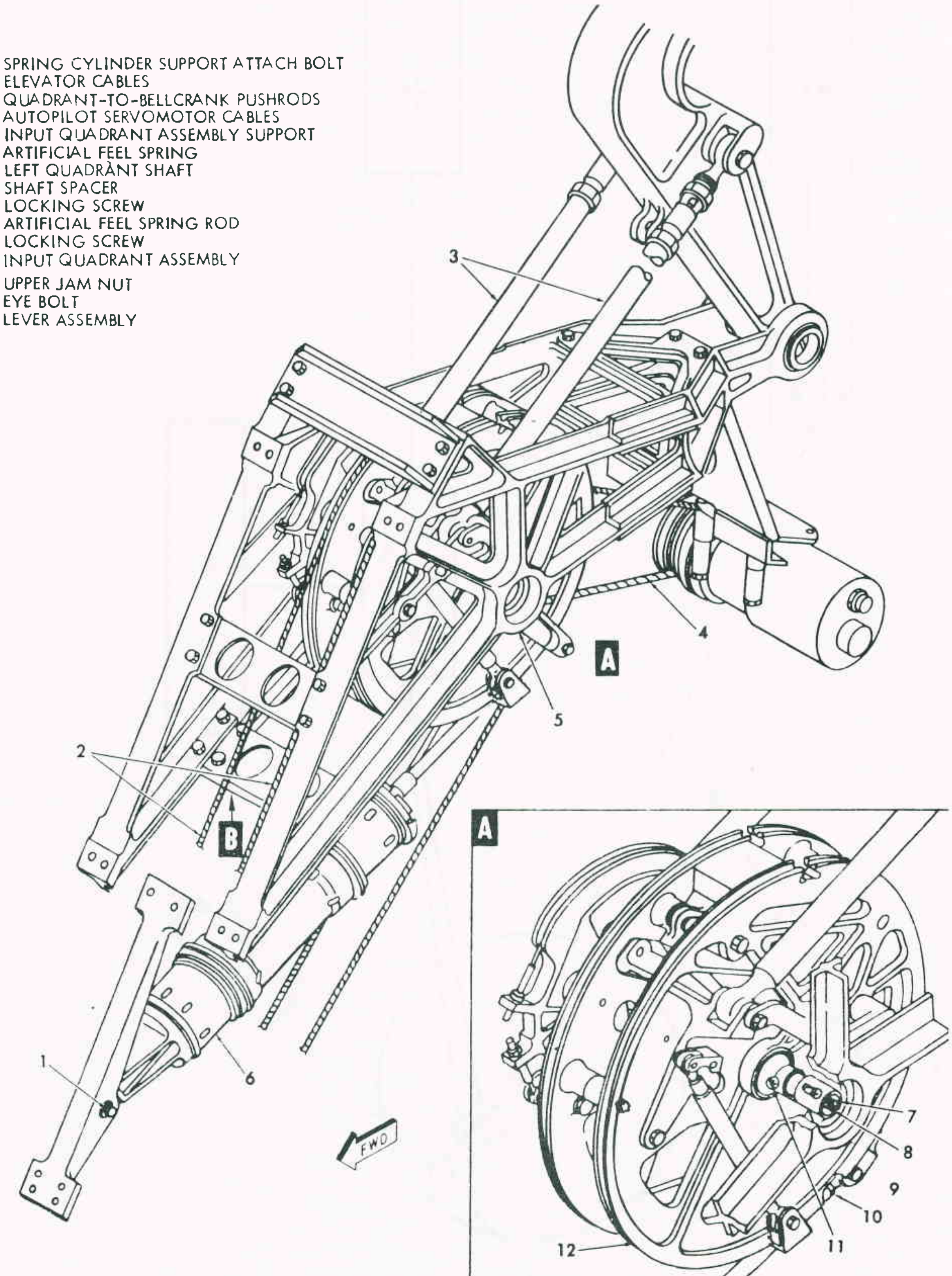


1. CONTROL COLUMN
2. TENSION REGULATOR
2A. CONTROL COLUMN SHAKER (REFER TO STALL PREVENTION SYSTEM).
3. ELEVATOR CABLES
3A. DAMPER
4. ELEVATOR POWER CONTROL ASSEMBLY
5. ELEVATOR TORQUE TUBE
6. ELEVATOR
7. IDLER BELLCRANKS
8. AUTOPILOT SERVO MOTOR PULLEY
8A. ARTIFICIAL FEEL SERVOMECHANISM CONTROLLER
9. ARTIFICIAL FEEL SPRING CARTRIDGE
9A. CENTERING SPRING MECHANISM
10. INPUT QUADRANT ASSEMBLY
11. ARTIFICIAL FEEL SERVOMECHANISM
12. CENTERING CAM
13. CENTERING SPRING LEVER
14. SERVO VALVE END CAP HYDRAULIC PLUG
15. SERVO DAMPER CHAMBER HYDRAULIC PLUGS
16. PITCH RATE ADAPTER
17. CEILING OF ELECTRONICS EQUIPMENT COMPARTMENT

Elevator Control System Component Locations

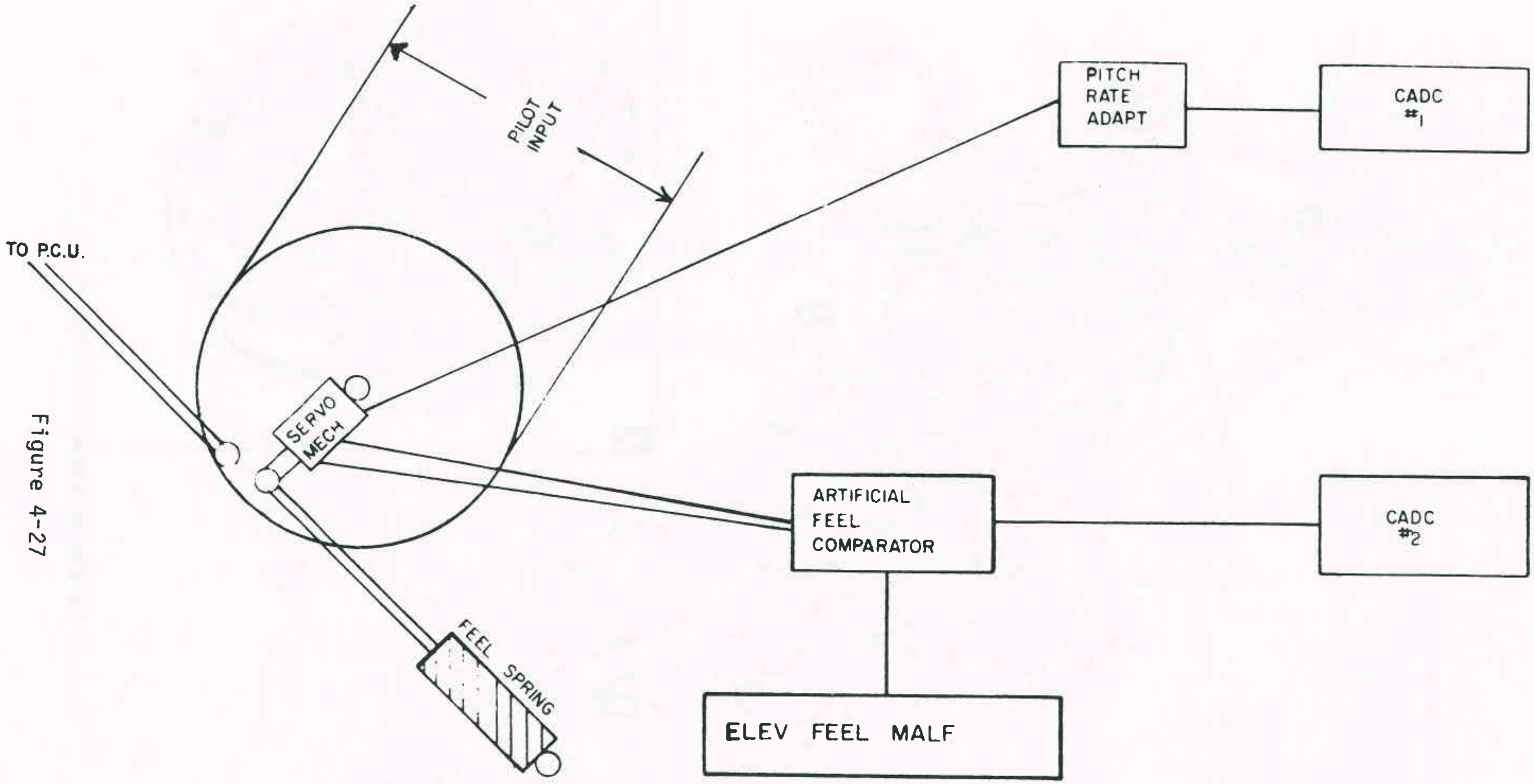
Figure 4-25

1. SPRING CYLINDER SUPPORT ATTACH BOLT
2. ELEVATOR CABLES
3. QUADRANT-TO-BELLCRANK PUSHRODS
4. AUTOPILOT SERVOMOTOR CABLES
5. INPUT QUADRANT ASSEMBLY SUPPORT
6. ARTIFICIAL FEEL SPRING
7. LEFT QUADRANT SHAFT
8. SHAFT SPACER
9. LOCKING SCREW
10. ARTIFICIAL FEEL SPRING ROD
11. LOCKING SCREW
12. INPUT QUADRANT ASSEMBLY
13. UPPER JAM NUT
14. EYE BOLT
15. LEVER ASSEMBLY



Elevator Input Quadrant Assembly

Figure 4-26



ELEVATOR ARTIFICIAL FEEL SYSTEM

Figure 4-27

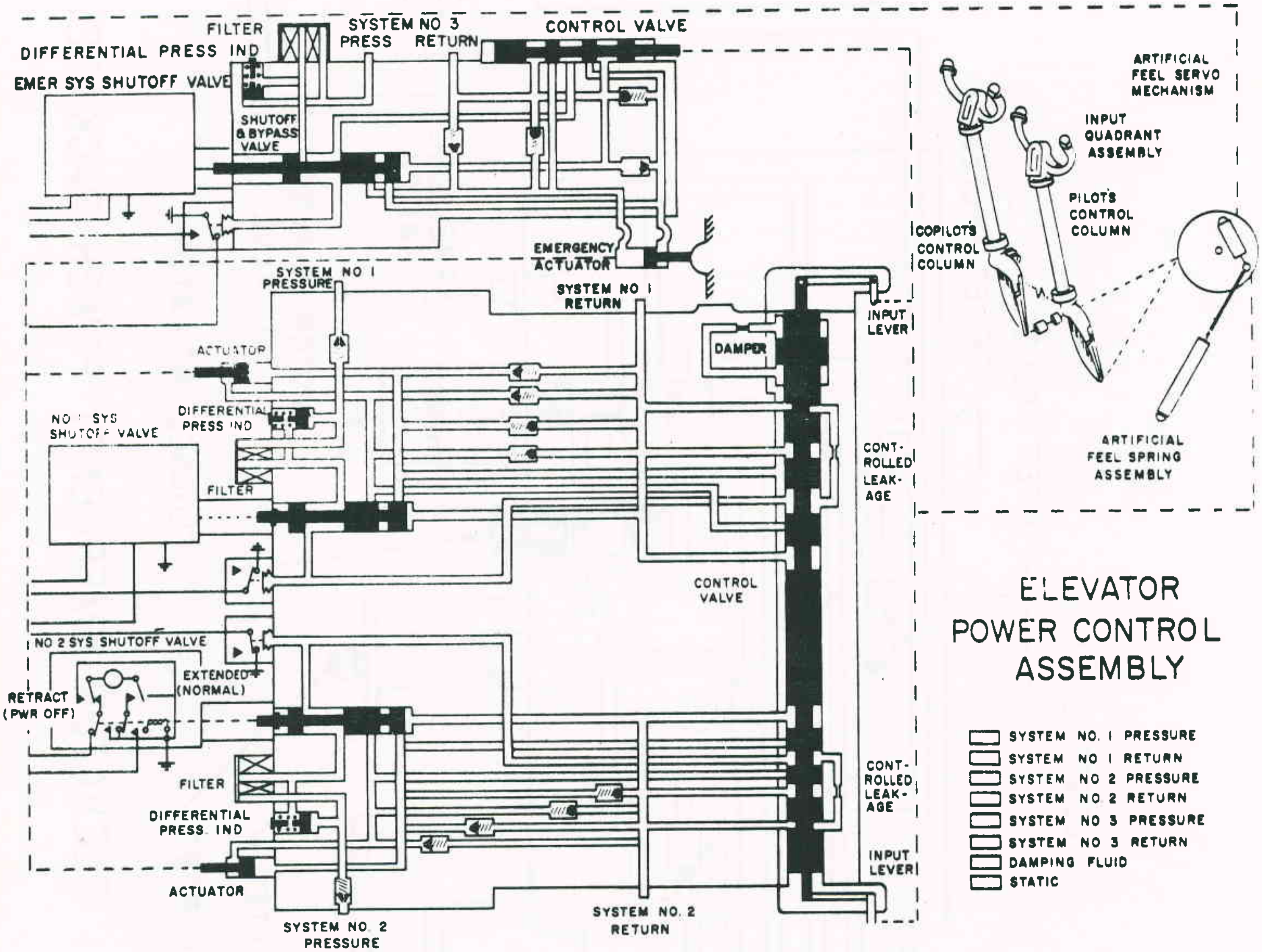
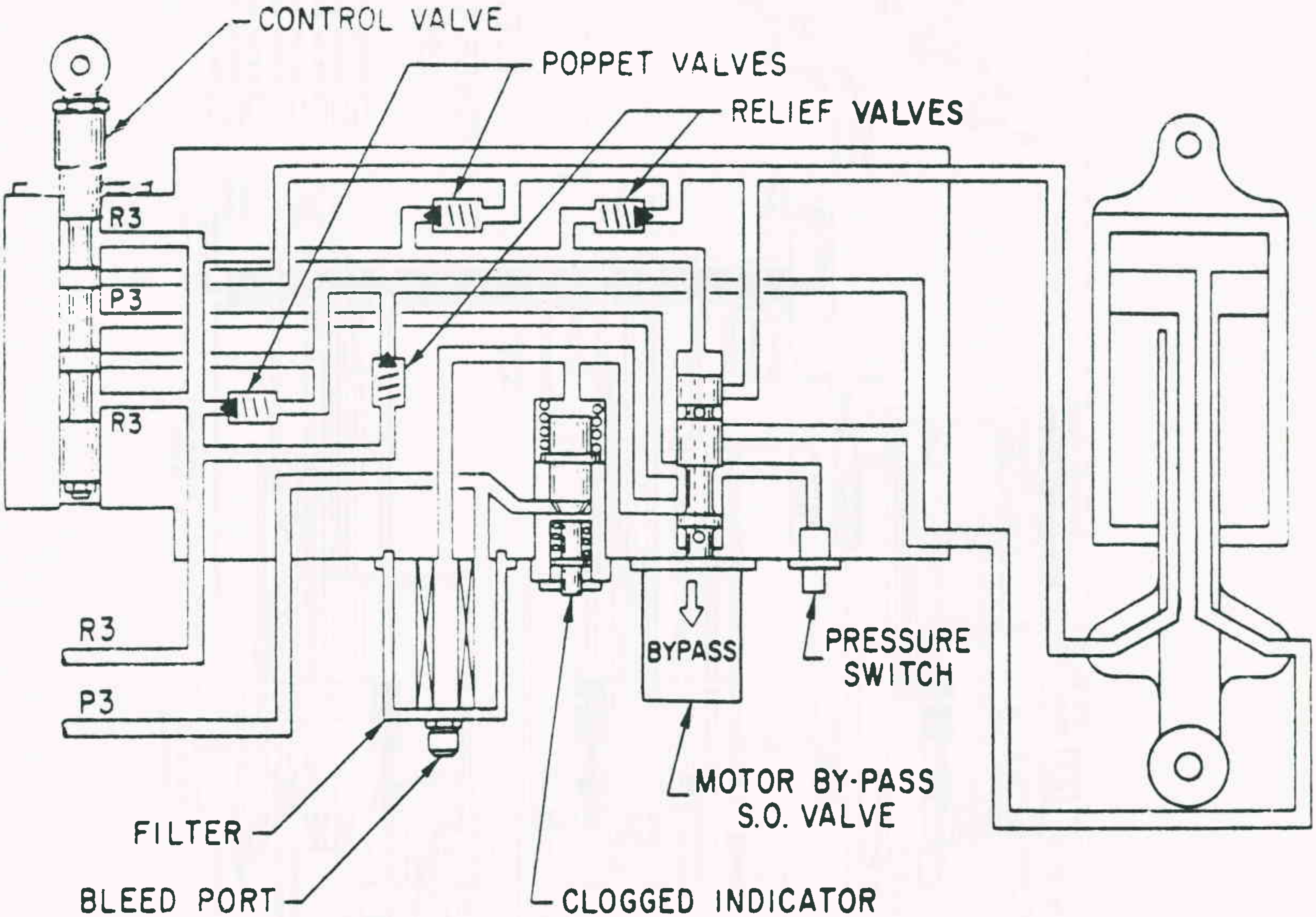
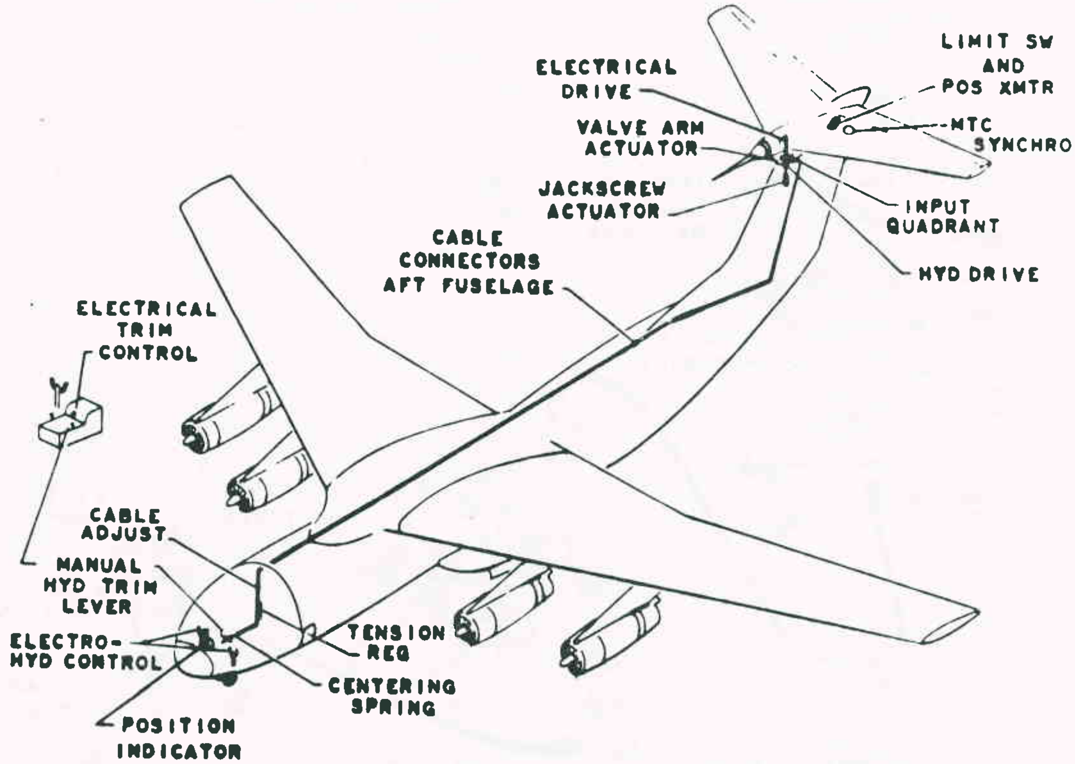

FILTER
DIFFERENTIAL PRESS IND
EMER SYS SHUTOFF VALVE
SYSTEM NO 3
PRESS RETURN
CONTROL VALVE
SHUTOFF & BYPASS VALVE
EMERGENCY ACTUATOR
SYSTEM NO I PRESSURE
SYSTEM NO I RETURN
ACTUATOR
NO I SYS SHUTOFF VALVE
DIFFERENTIAL PRESS IND
FILTER
DAMPER
INPUT LEVER
CONT-ROLLED LEAK-AGE
CONTROL VALVE
NO 2 SYS SHUTOFF VALVE
EXTENDED (NORMAL)
RETRACT (PWR OFF)
FILTER
DIFFERENTIAL PRESS. IND
ACTUATOR
SYSTEM NO. 2 PRESSURE
SYSTEM NO. 2 RETURN
CONT-ROLLED LEAK-AGE
INPUT LEVER
ARTIFICIAL FEEL SERVO MECHANISM
INPUT QUADRANT ASSEMBLY
PILOTS CONTROL COLUMN
COPILOTS CONTROL COLUMN
ARTIFICIAL FEEL SPRING ASSEMBLY
ELEVATOR POWER CONTROL ASSEMBLY
SYSTEM NO. I PRESSURE
SYSTEM NO I RETURN
SYSTEM NO 2 PRESSURE
SYSTEM NO 2 RETURN
SYSTEM NO 3 PRESSURE
SYSTEM NO 3 RETURN
DAMPING FLUID
STATIC

Figure 4-28

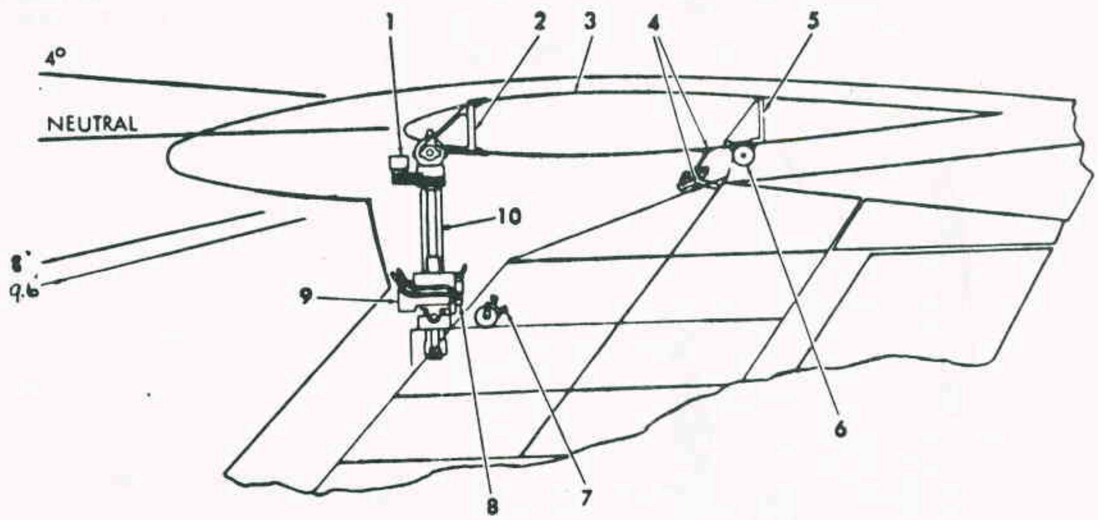


ELEVATOR EMERGENCY POWER PACKAGE

Figure 4-29



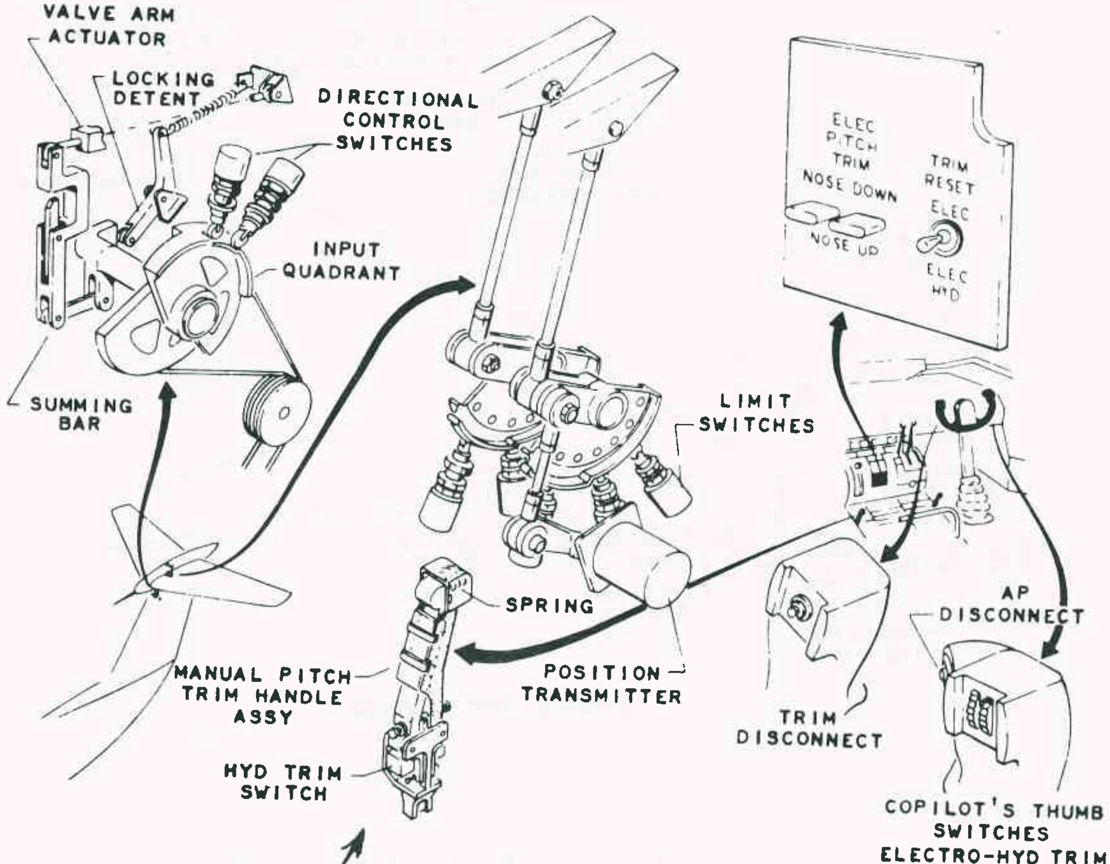
CONTROLS INSTALLATION



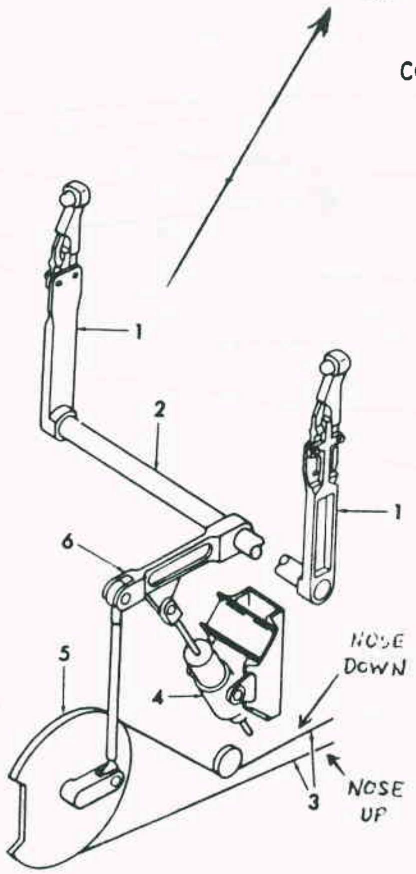
1. ELECTRICAL MOTOR DRIVE ASSEMBLY
2. FWD SPAR
3. HORIZONTAL STABILIZER
4. POSITION TRANSMITTER AND LIMIT SWITCH ACTUATOR
5. AFT SPAR
6. AFT ATTACH FITTING AND PIVOT POINT
7. DIRECTIONAL CONTROL SWITCHES
8. HYDRAULIC FLOW CONTROL VALVE ASSY
9. HYDRAULIC DRIVE ASSEMBLY
10. HORIZONTAL STABILIZER ACTUATOR ASSEMBLY

PITCH TRIM SYSTEM

Figure 4-30



CONTROL SWITCHES



1. HYDRAULIC PITCH TRIM LEVERS
2. TORQUE TUBE
3. CABLES
4. CENTERING SPRING CARTRIDGE
5. FORWARD QUADRANT
6. CENTERING SPRING LEVER

Figure 4-31

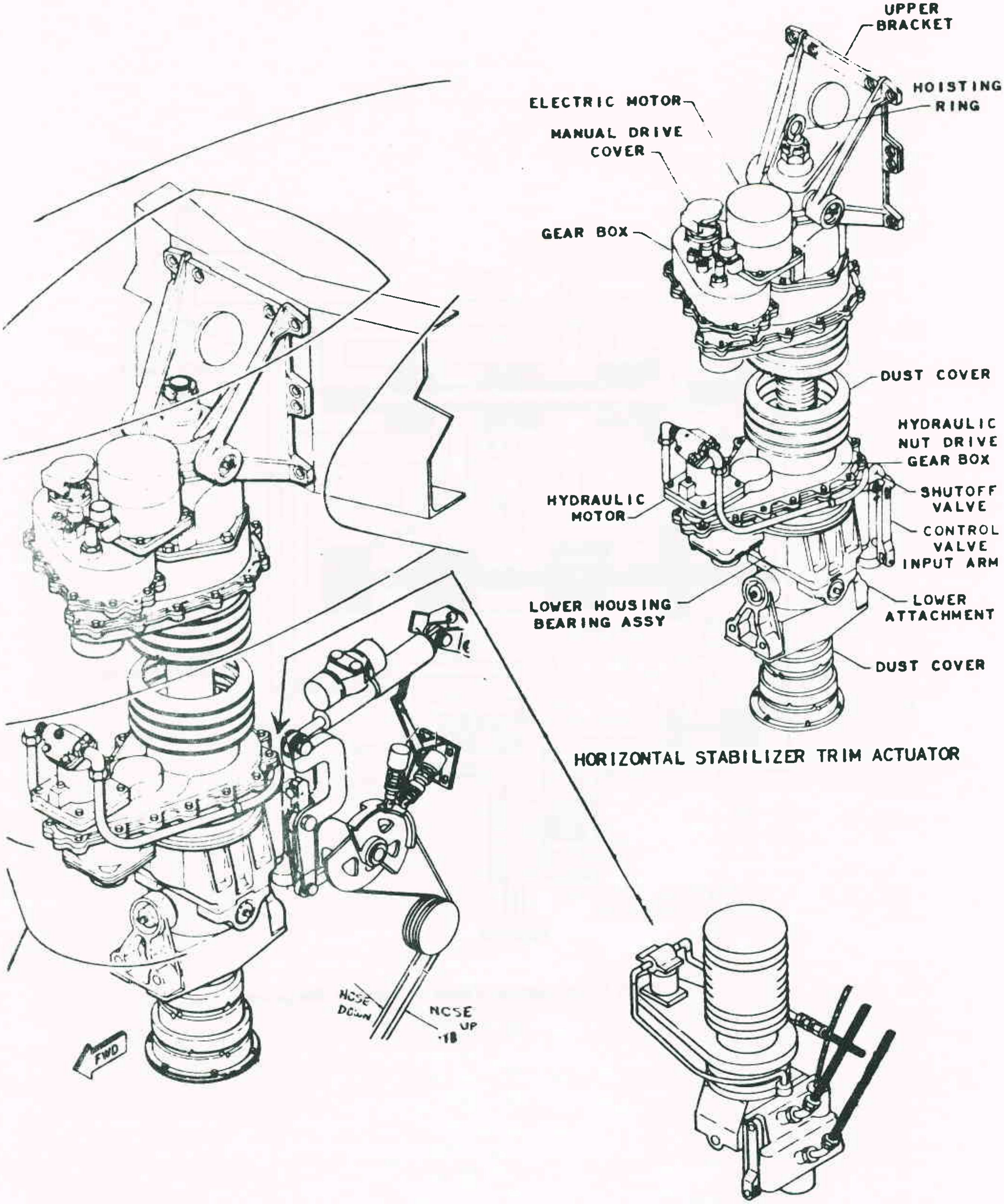
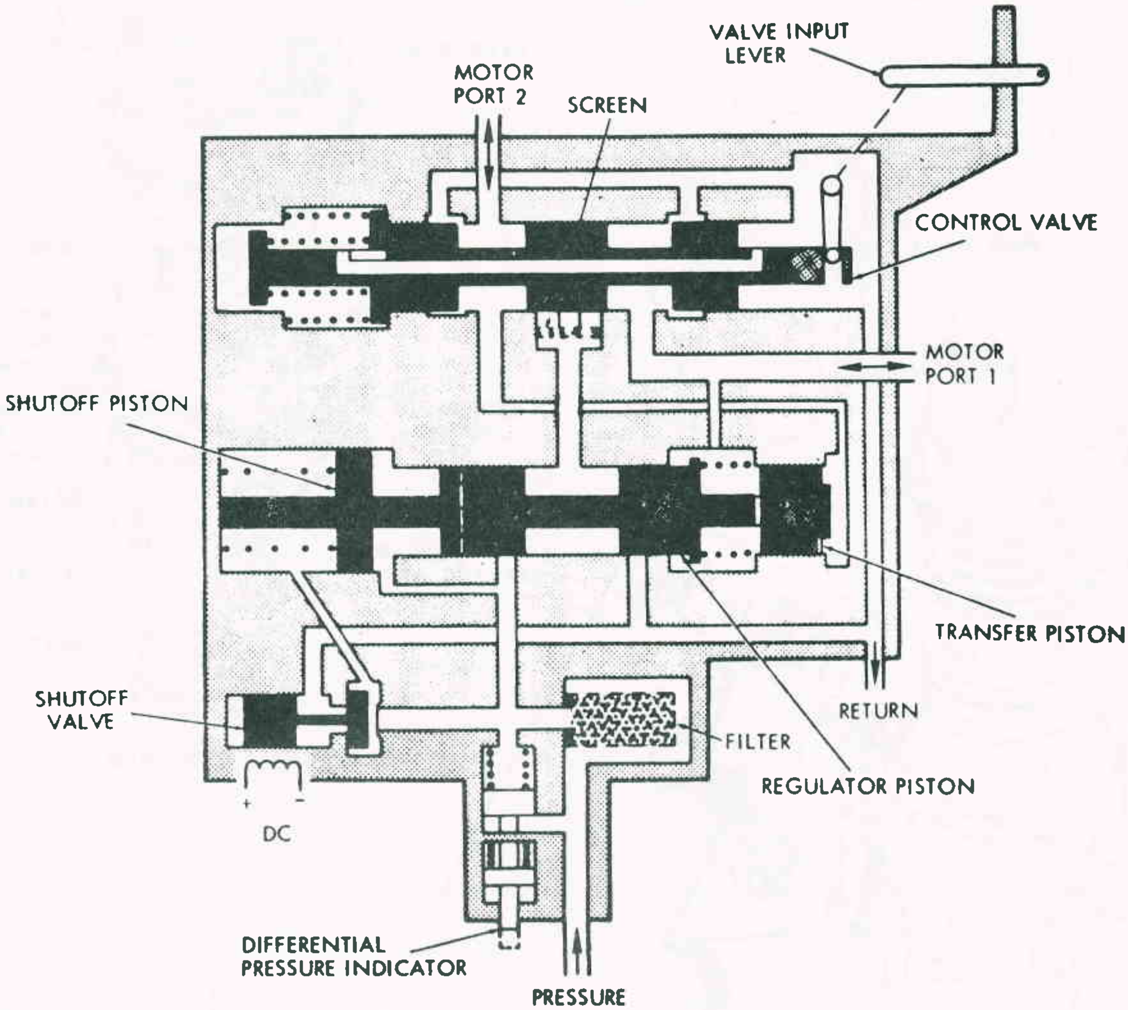
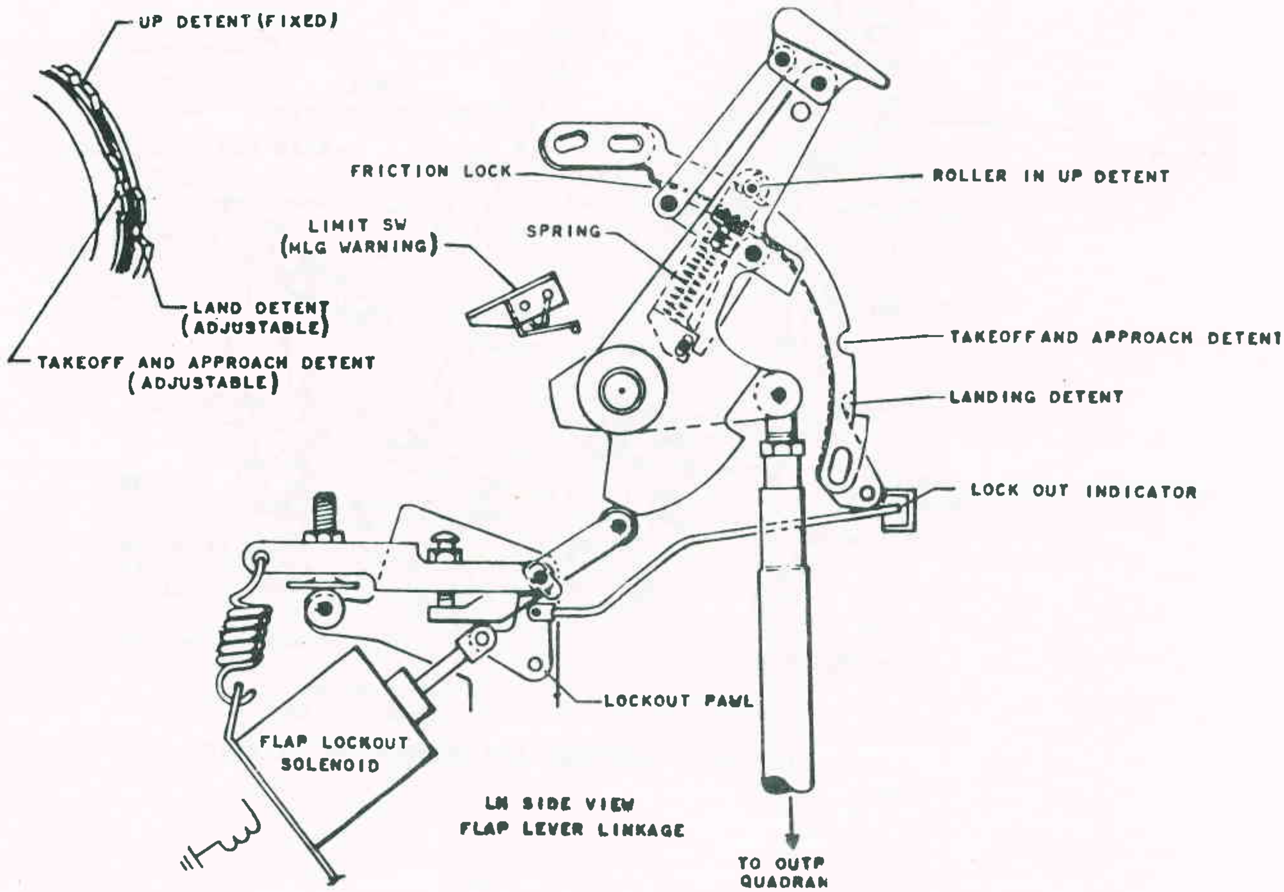

UPPER BRACKET
HOISTING RING
ELECTRIC MOTOR
MANUAL DRIVE COVER
GEAR BOX
DUST COVER
HYDRAULIC NUT DRIVE GEAR BOX
SHUTOFF VALVE
HYDRAULIC MOTOR
CONTROL VALVE INPUT ARM
LOWER HOUSING BEARING ASSY
LOWER ATTACHMENT
DUST COVER
HORIZONTAL STABILIZER TRIM ACTUATOR
FWD

Figure 4-32

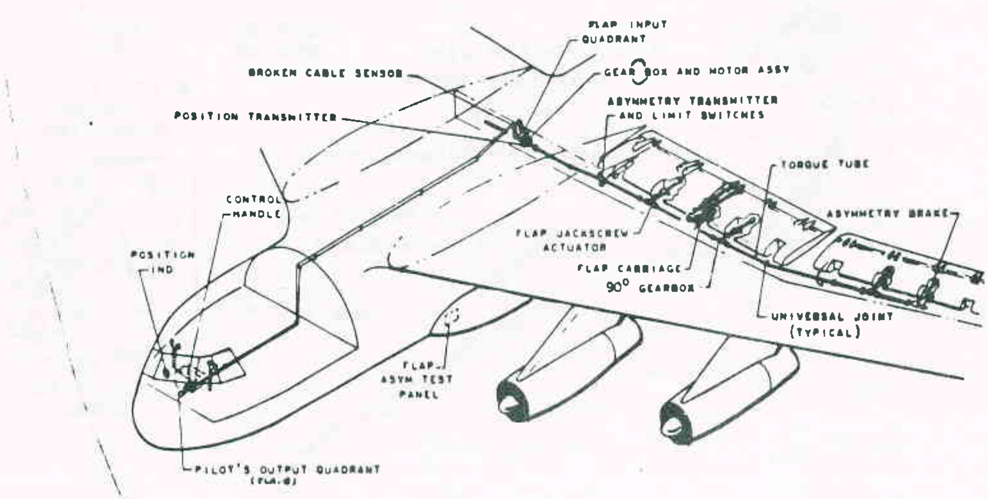


Pitch Trim Control Valve Schematic Diagram

Figure 4-33

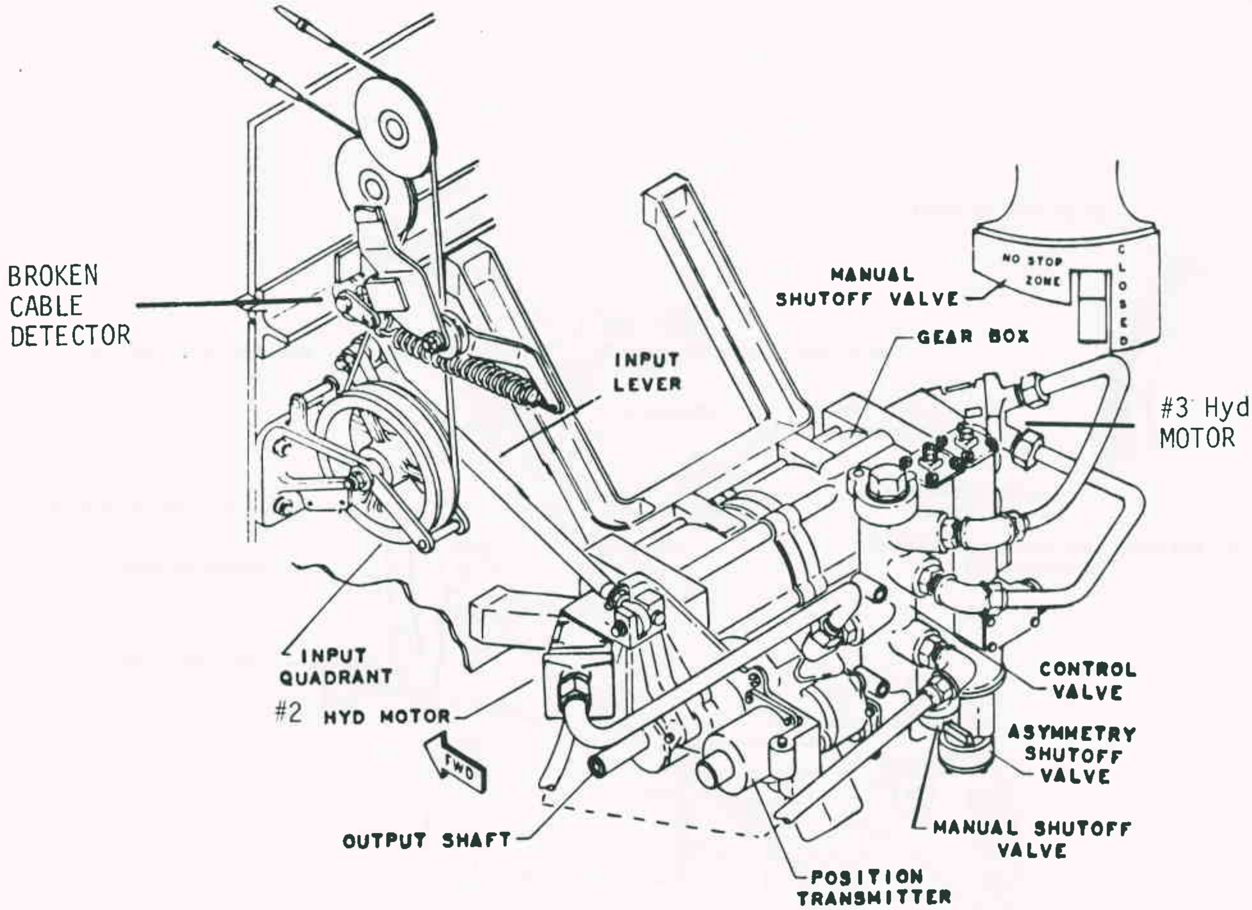


FLAP CONTROL HANDLE LINKAGE

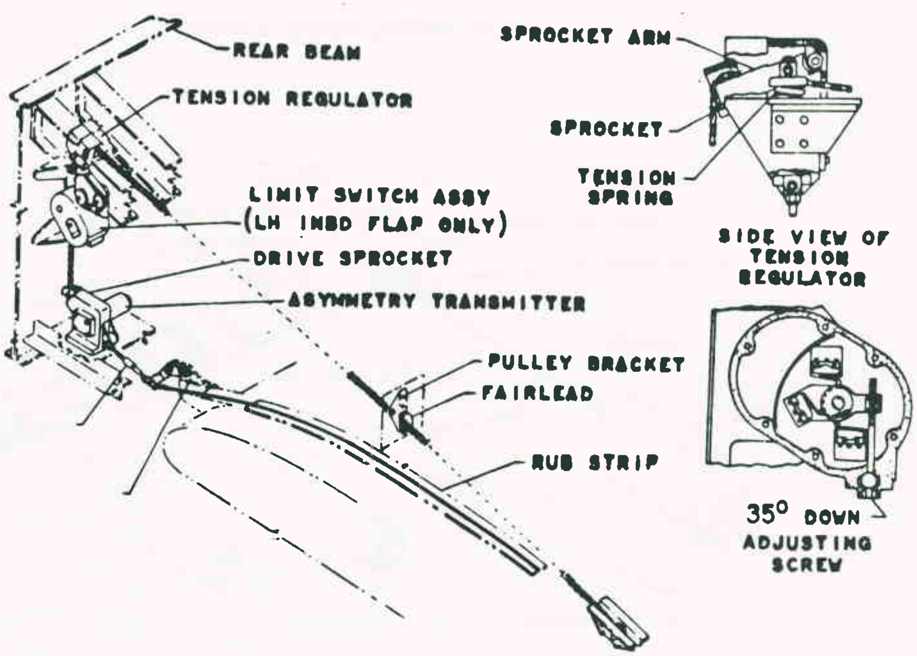


FLAP SYSTEM INSTALLATION

Figure 4-34



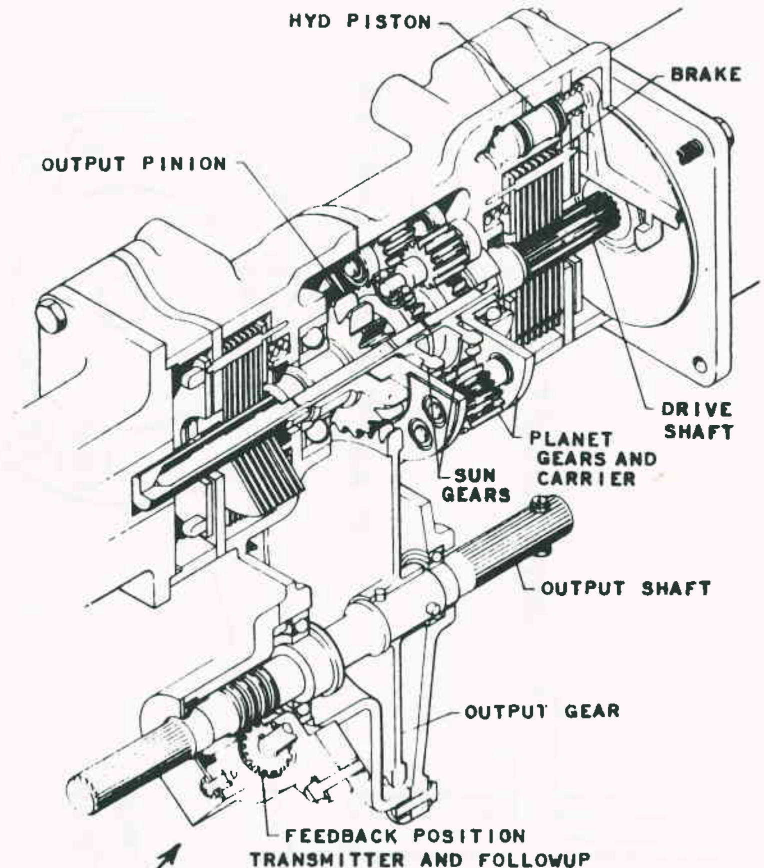
FLAP INPUT QUADRANT AND GEARBOX INSTALLATION

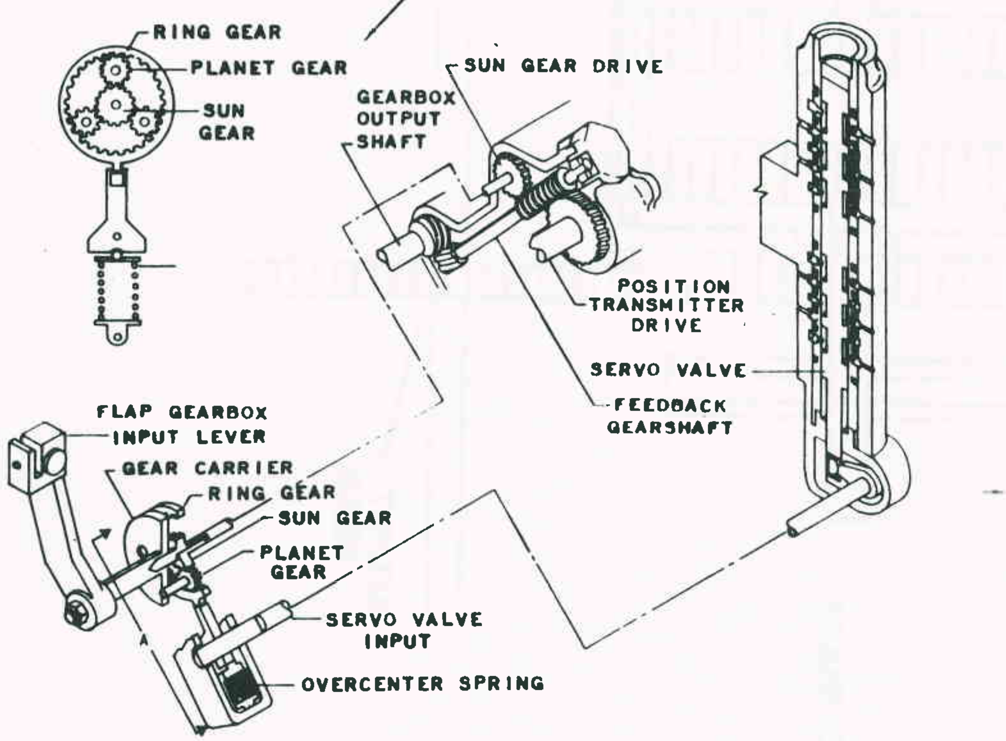


WING FLAP ASYMMETRY TRANSMITTER DRIVE

Figure 4-35

FLAP GEARBOX





FLAP FOLLOWUP MECHANISM

Figure 4-36

FLAP GEARBOX

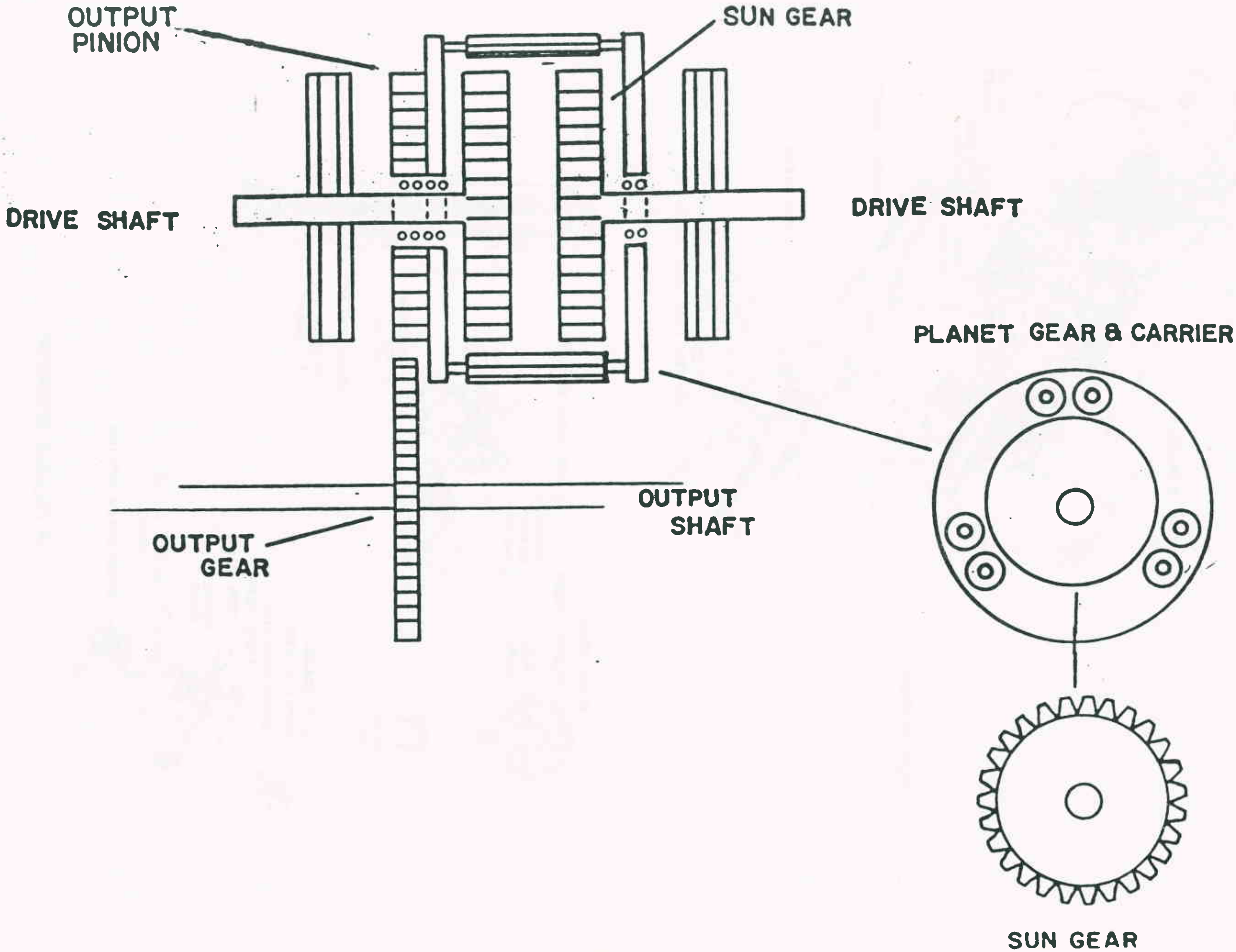
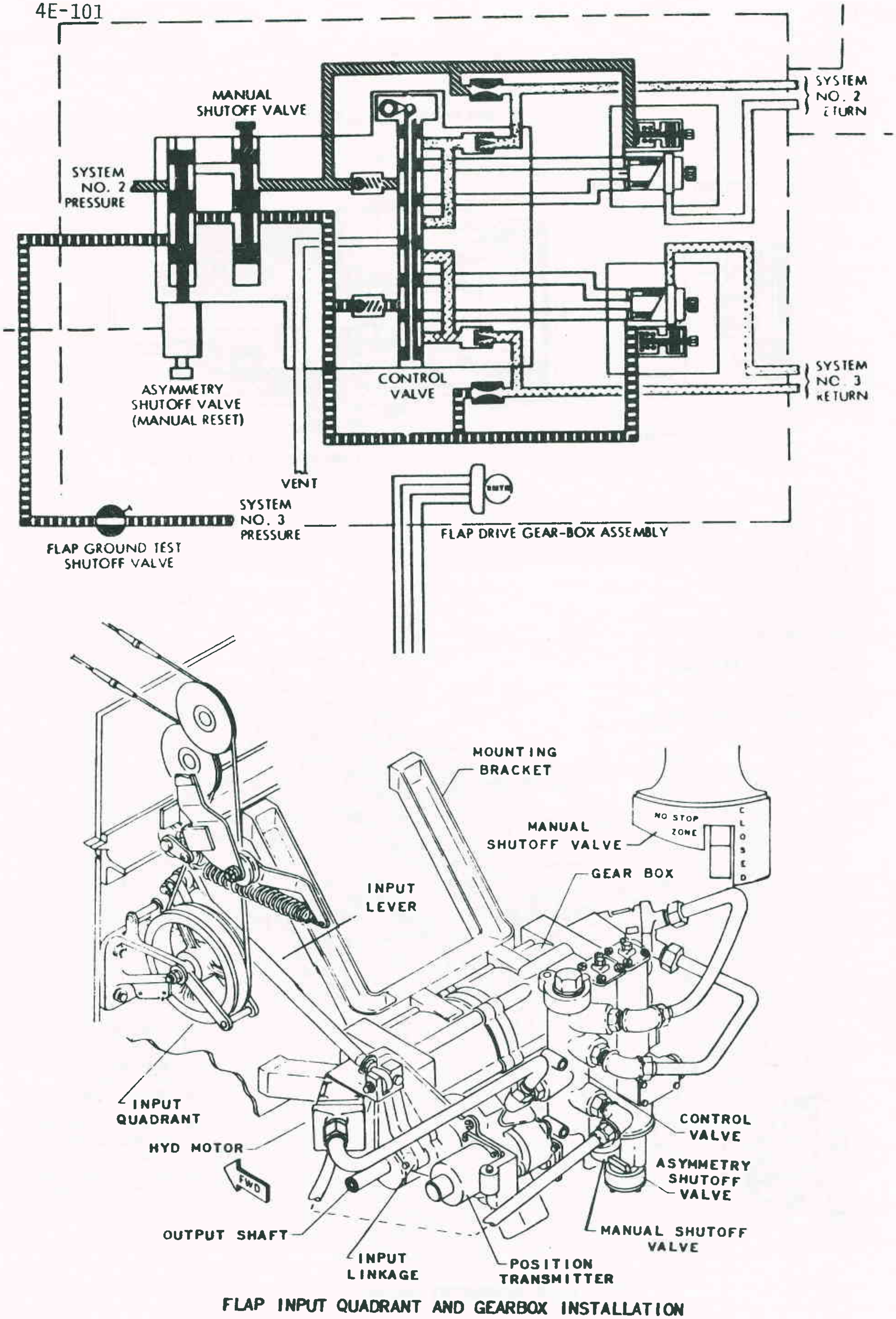
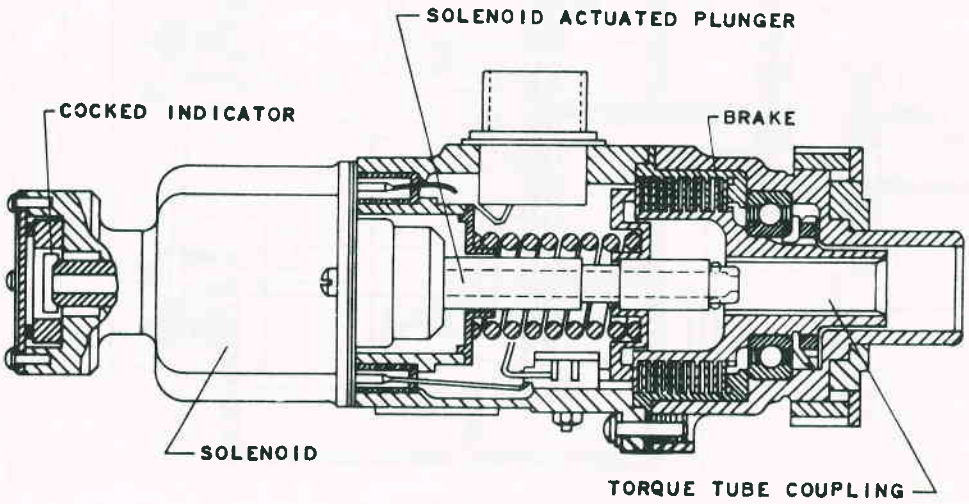


Figure 4-37

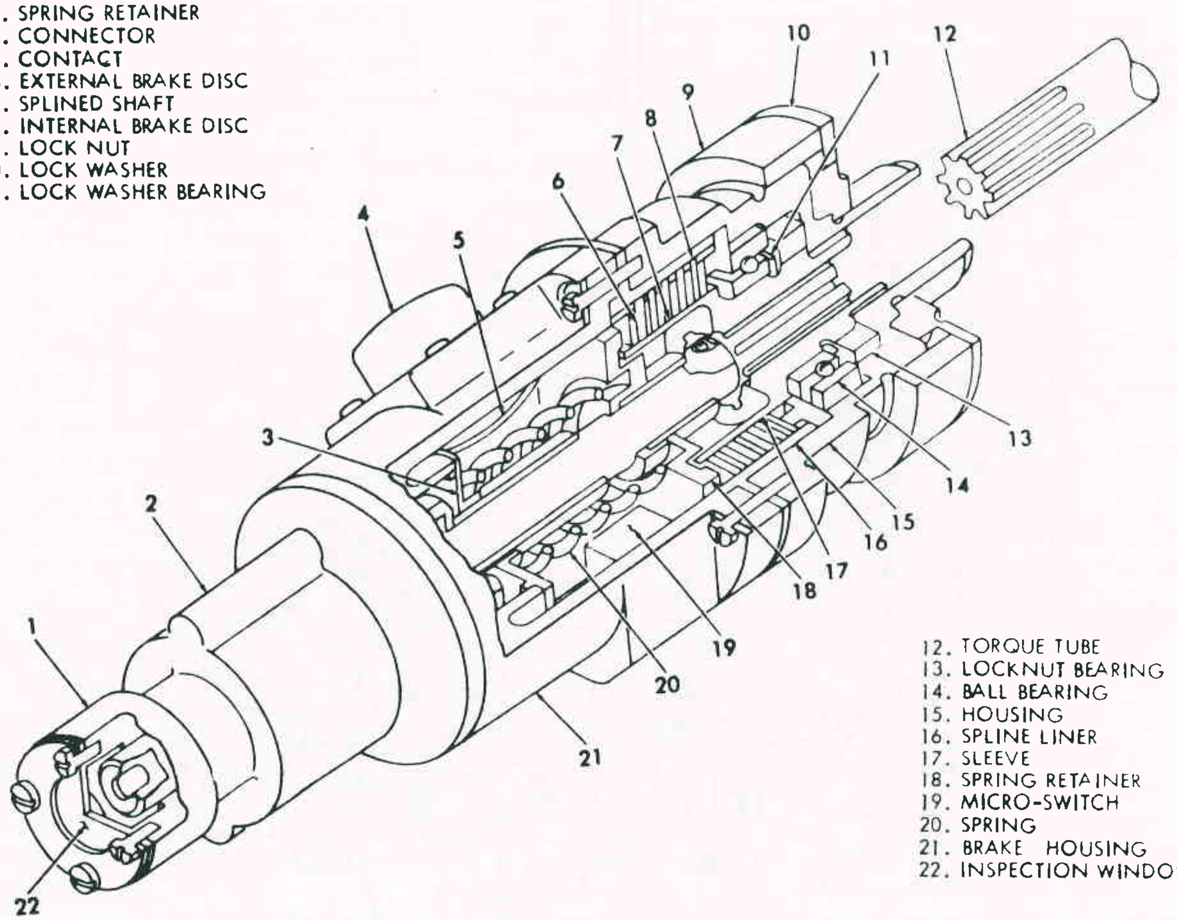


FLAP INPUT QUADRANT AND GEARBOX INSTALLATION

Figure 4-38



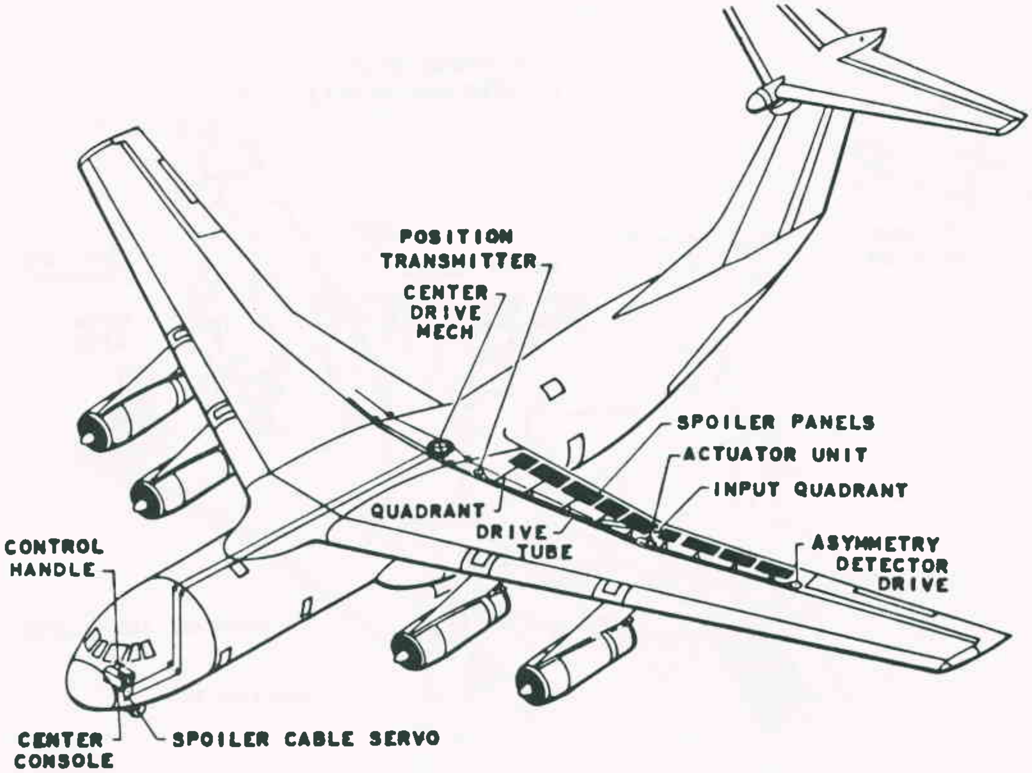
1. BRAKE ASSEMBLY
2. LOCK MECHANISM
3. SPRING RETAINER
4. CONNECTOR
5. CONTACT
6. EXTERNAL BRAKE DISC
7. SPLINED SHAFT
8. INTERNAL BRAKE DISC
9. LOCK NUT
10. LOCK WASHER
11. LOCK WASHER BEARING

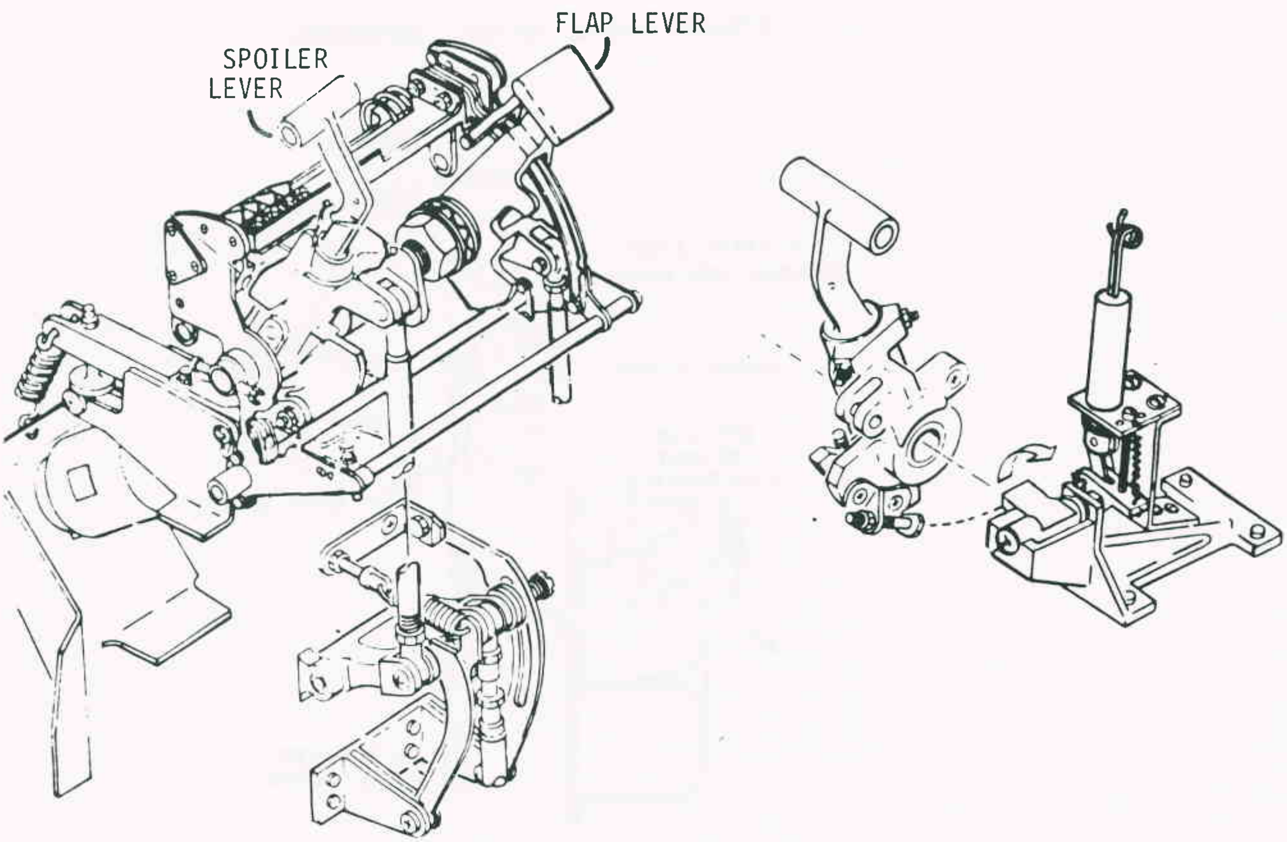


12. TORQUE TUBE
13. LOCKNUT BEARING
14. BALL BEARING
15. HOUSING
16. SPLINE LINER
17. SLEEVE
18. SPRING RETAINER
19. MICRO-SWITCH
20. SPRING
21. BRAKE HOUSING
22. INSPECTION WINDOW

FLAP ASYMMETRY BRAKE

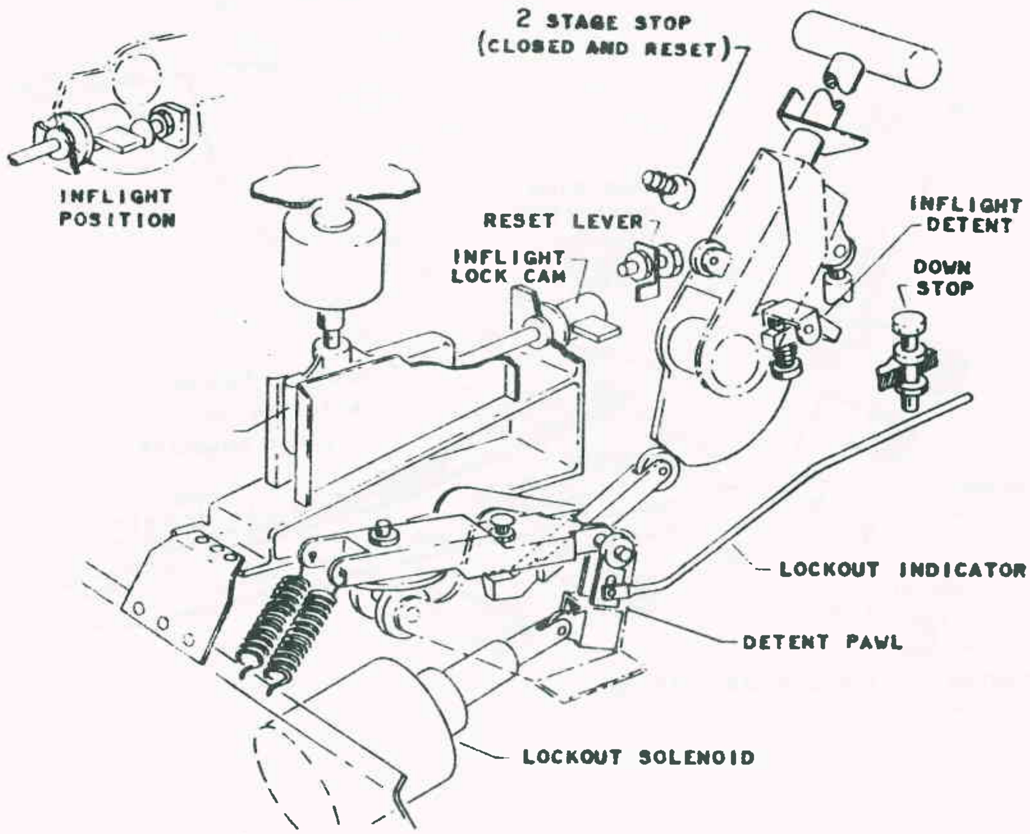
Figure 4-39



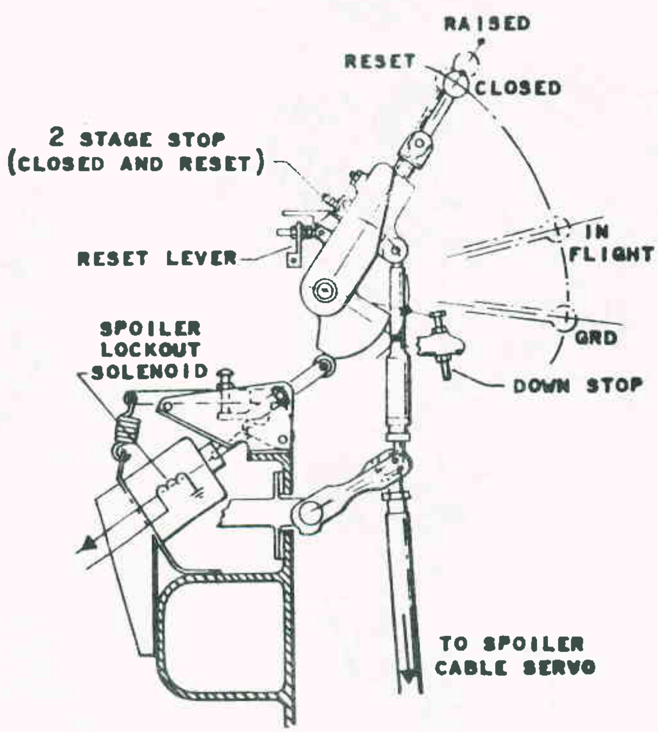


PEDESTEL INSTALLATION

Figure 4-40

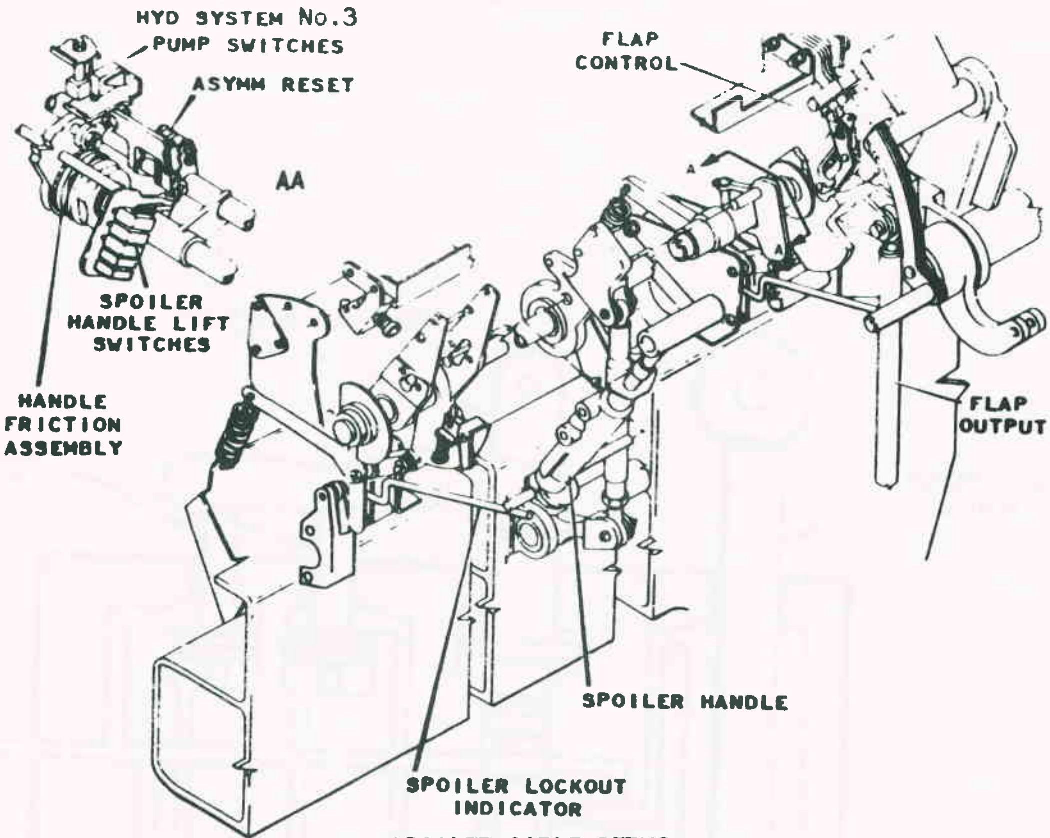


SPOILER HANDLE CONTROL COMPONENTS

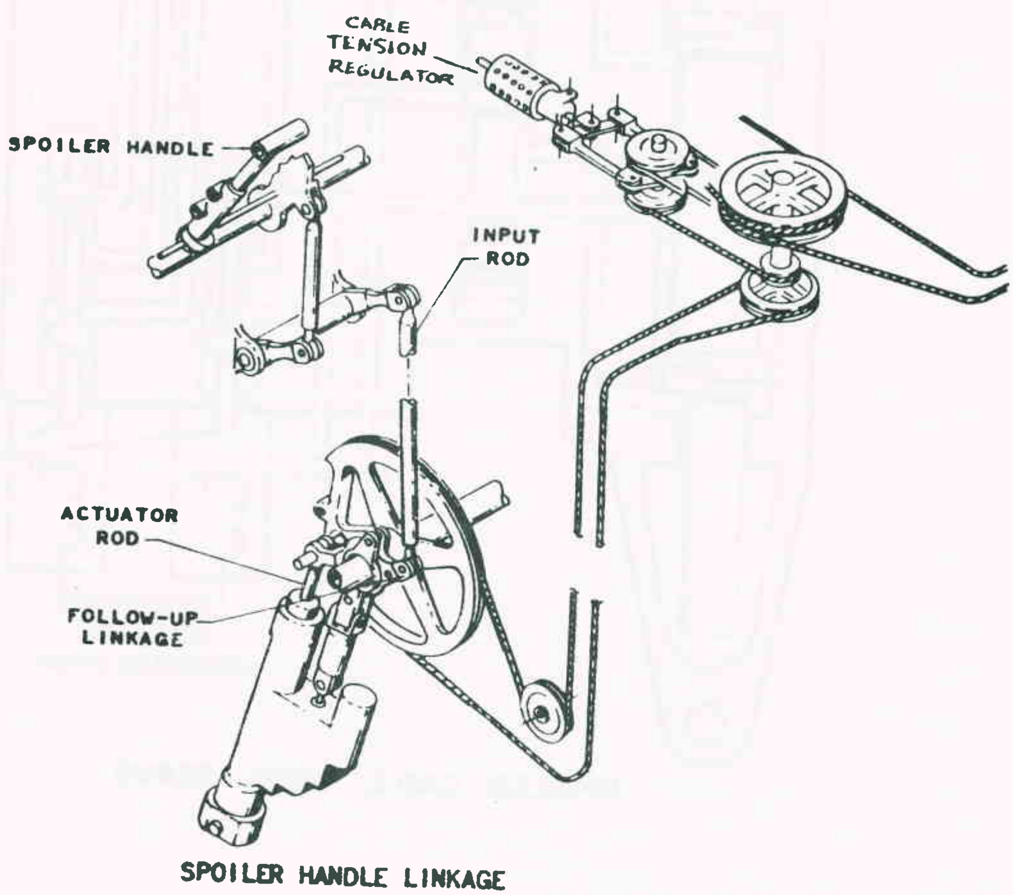


SPOILER HANDLE POSITIONS

Figure 4-41

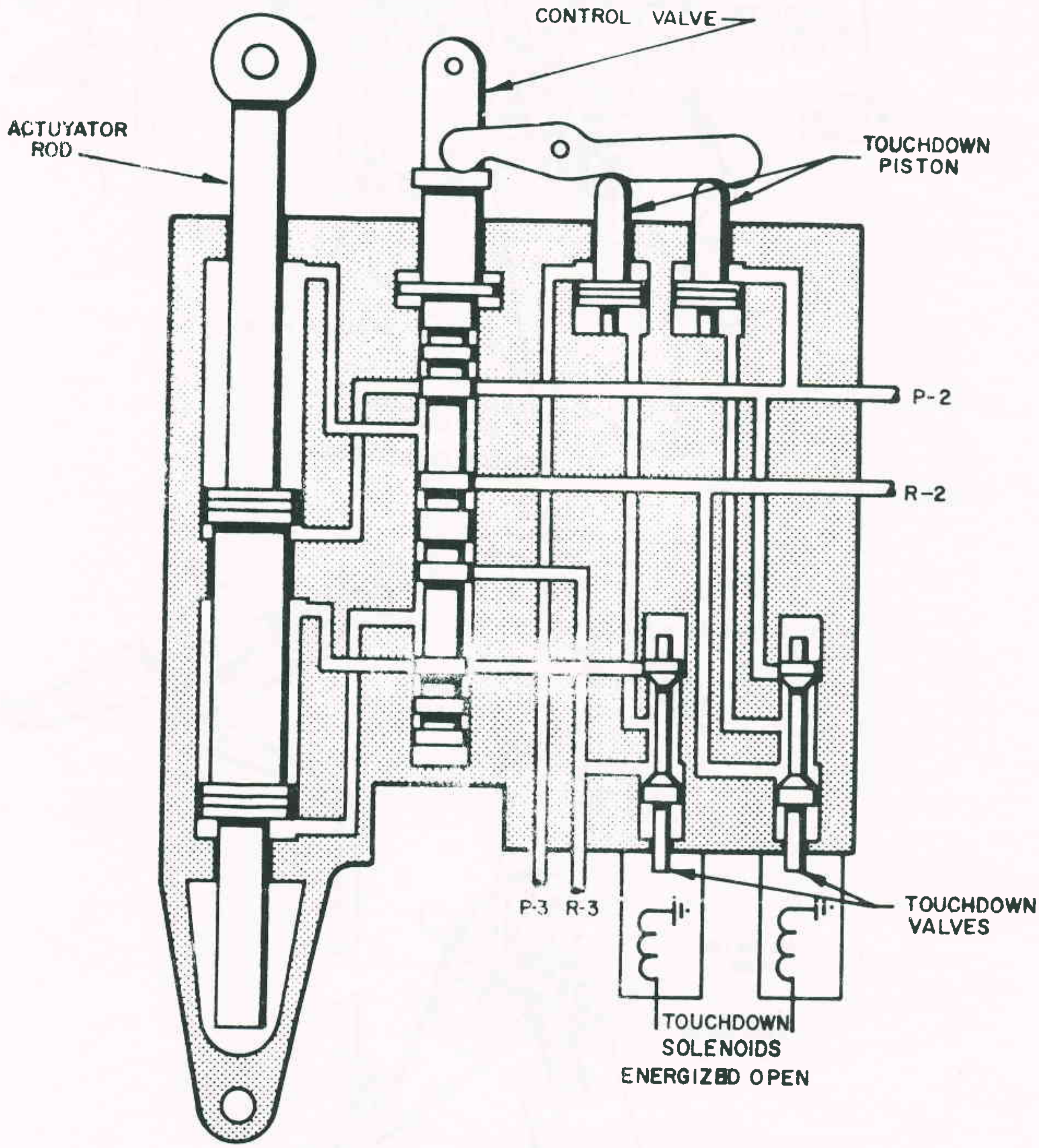


SPOILER CABLE SERVO



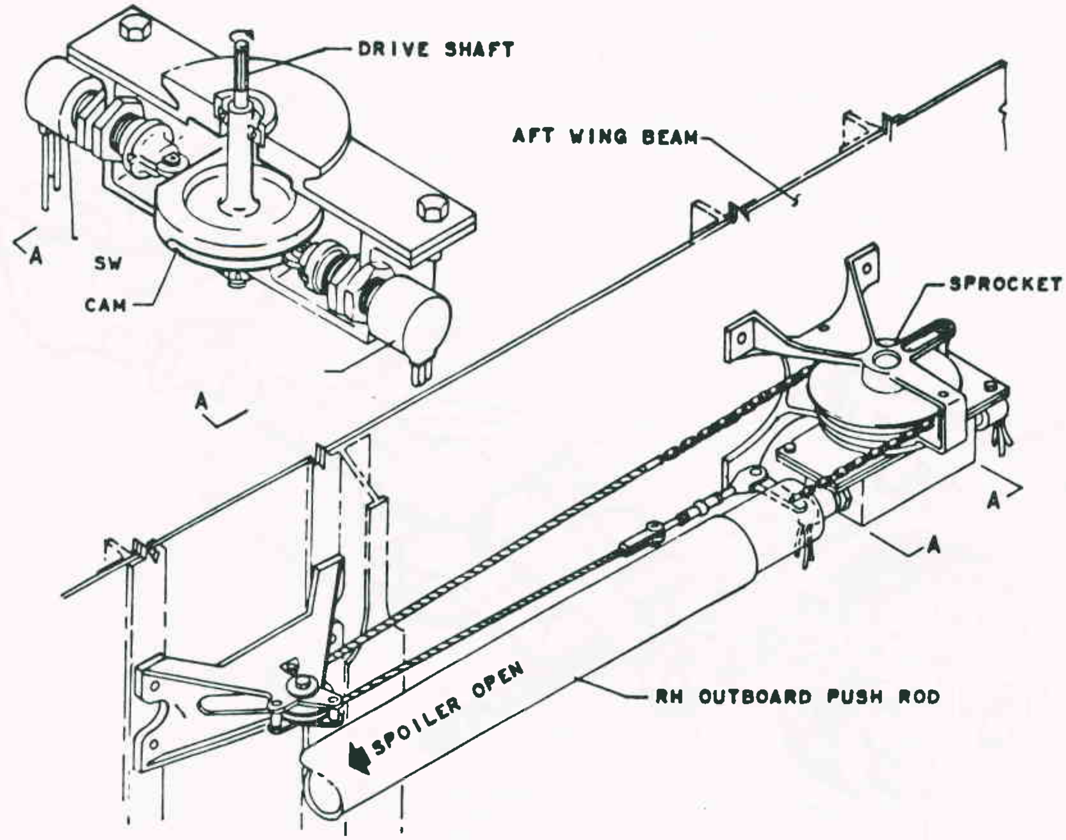
SPOILER HANDLE LINKAGE

Figure 4-42



SPOILER CABLE DRIVE SERVO

Figure 4-43



ASYMMETRY DETECTOR DRIVE

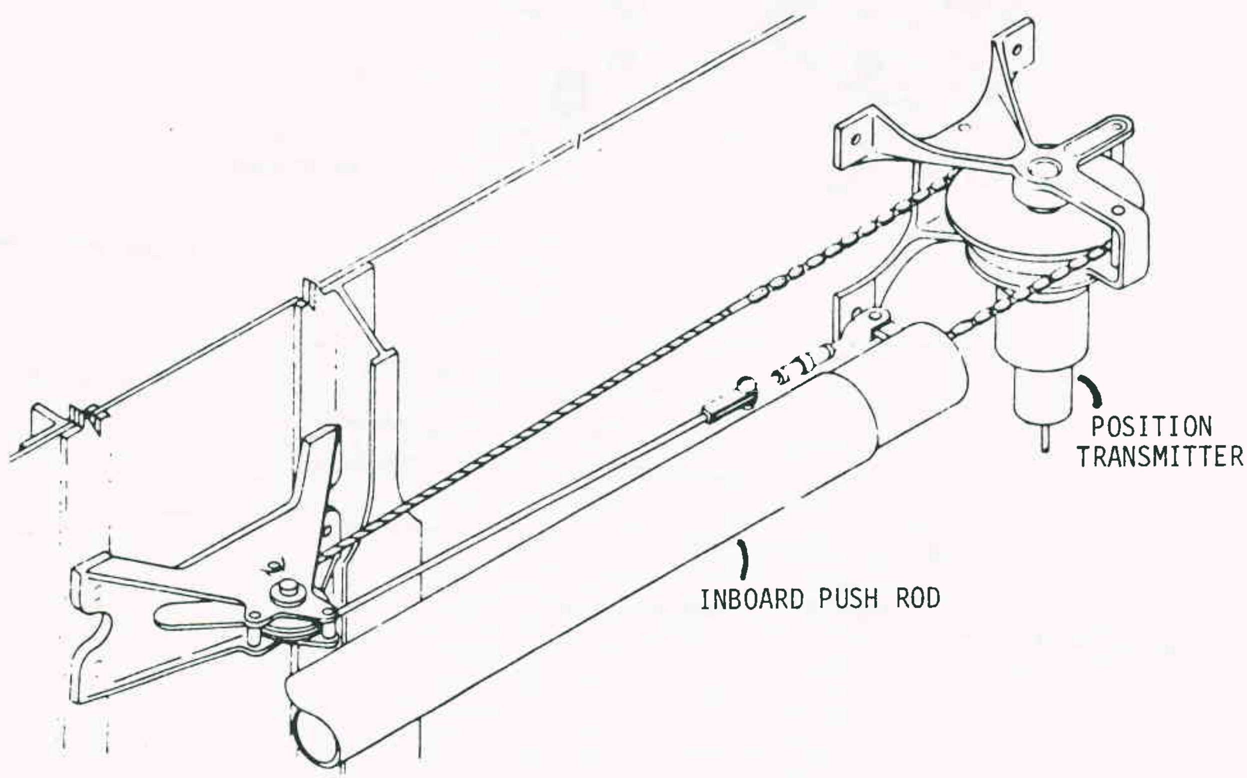


Figure 4-44

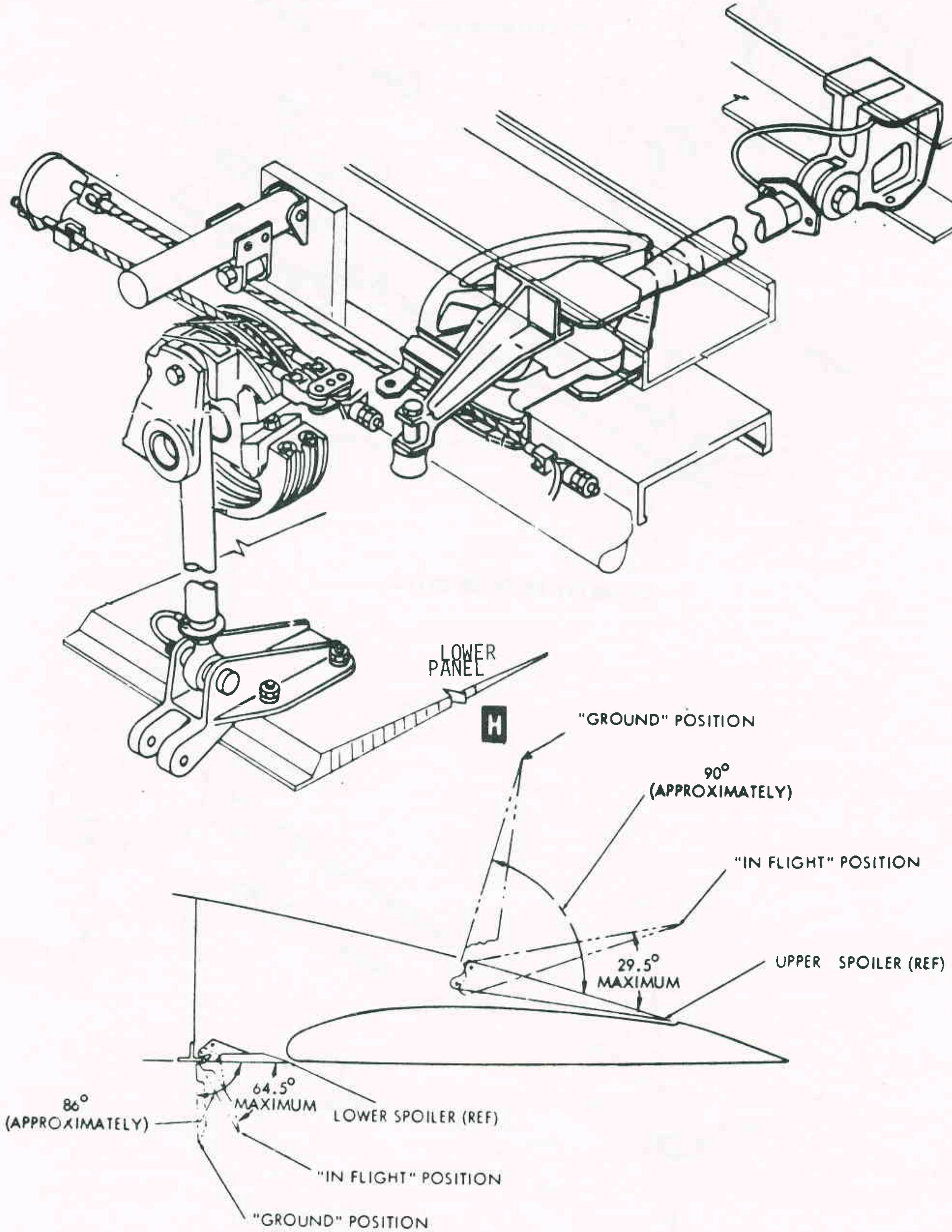
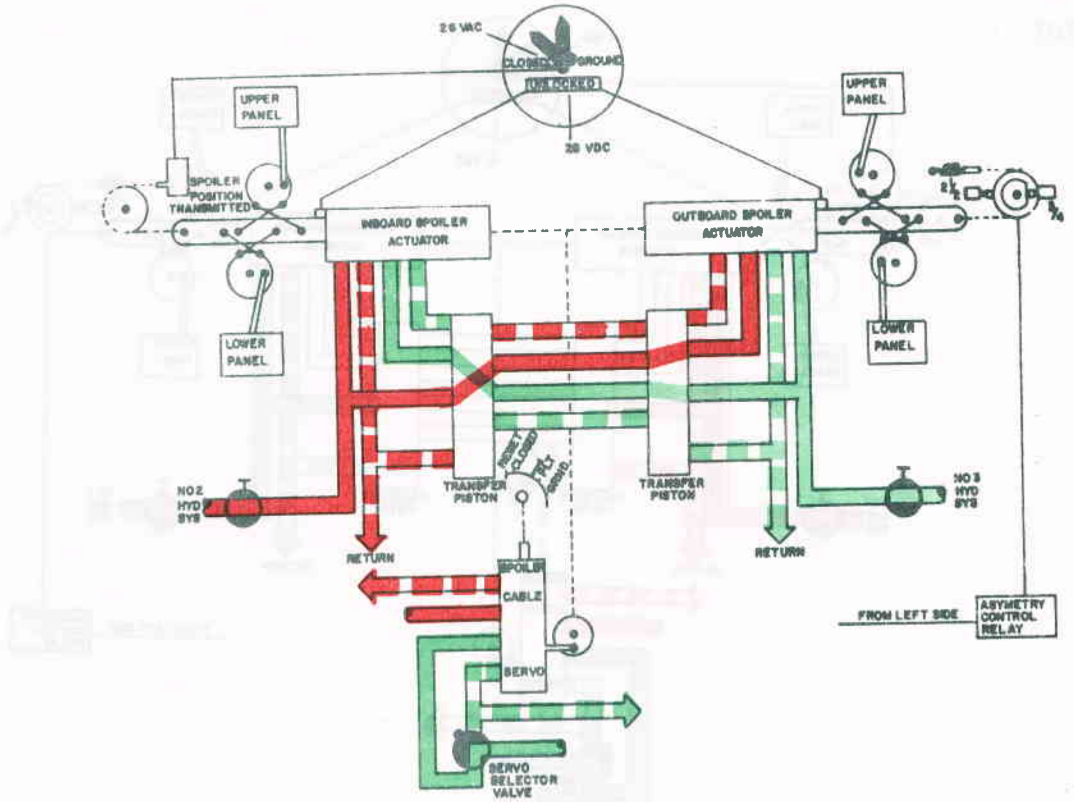
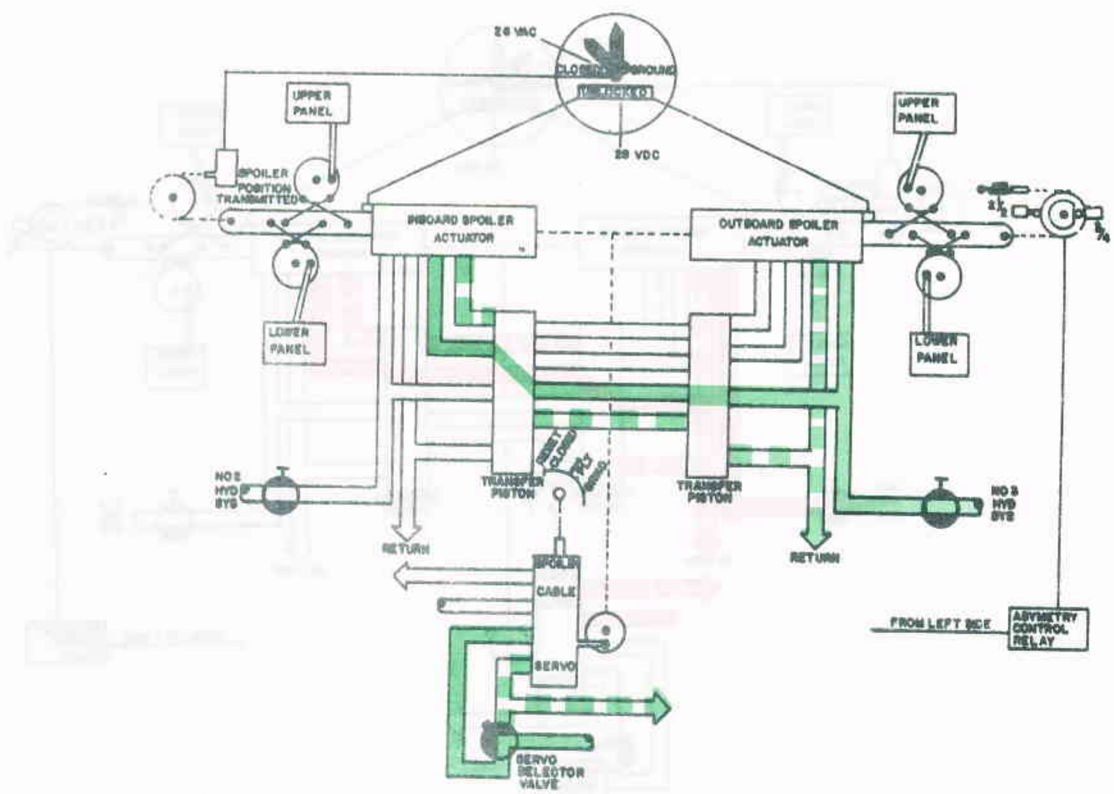

LOWER PANEL
H
"GROUND" POSITION
90°
(APPROXIMATELY)
"IN FLIGHT" POSITION
29.5°
MAXIMUM
UPPER SPOILER (REF)
64.5°
MAXIMUM
86°
(APPROXIMATELY)
LOWER SPOILER (REF)
"IN FLIGHT" POSITION
"GROUND" POSITION

Figure 4-45

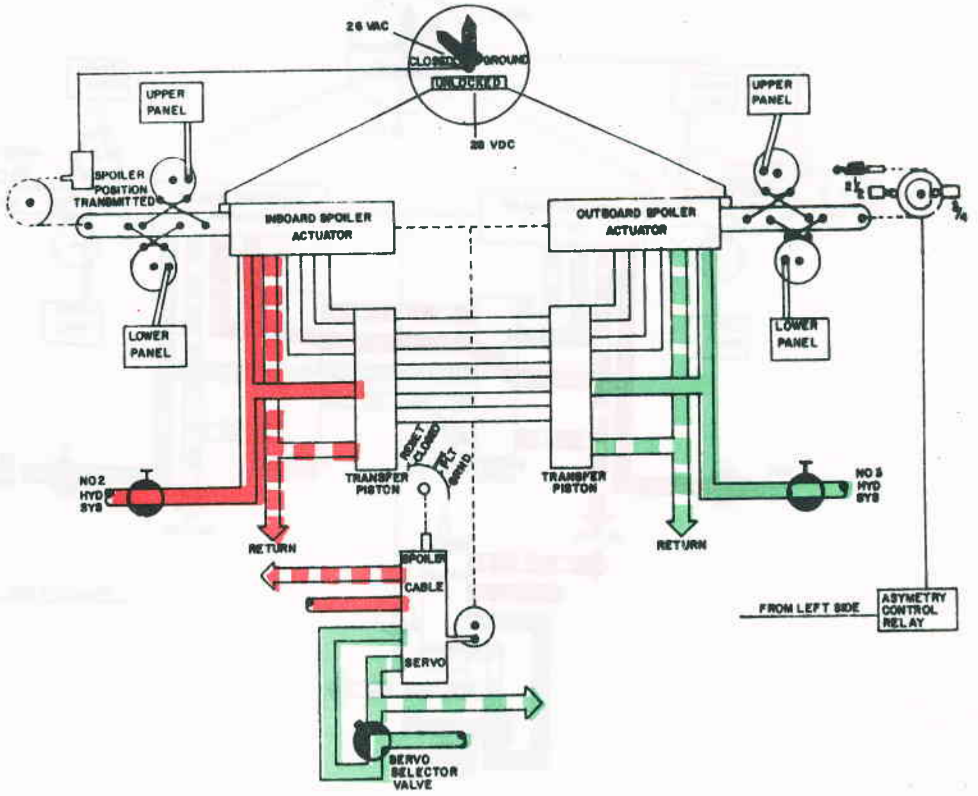


NO. 2 AND NO. 3 HYD SYSTEM OPERATING

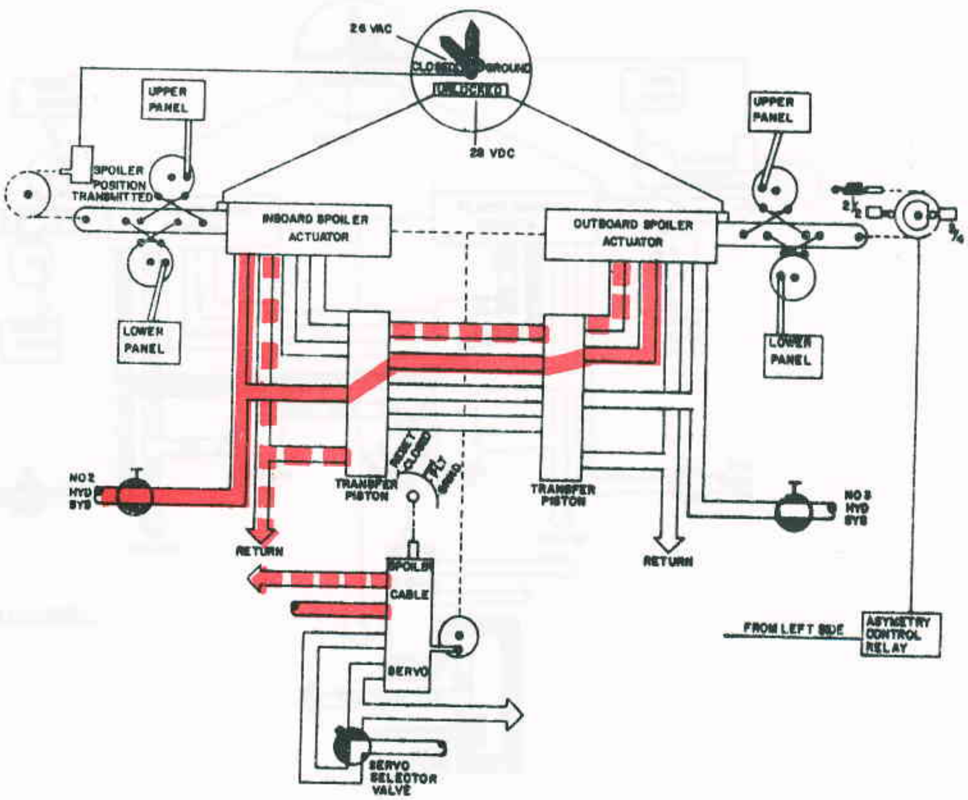


LOSS OF NO. 2 HYD SYSTEM

Figure 4-46



NO 2 AND NO 3 HYD. SYSTEM-OPERATING



LOSS OF NO 3 HYD. SYSTEM

Figure 4-47

LANDING GEAR SELECTOR VALVE
(TYPICAL FOR NLG, MLG)

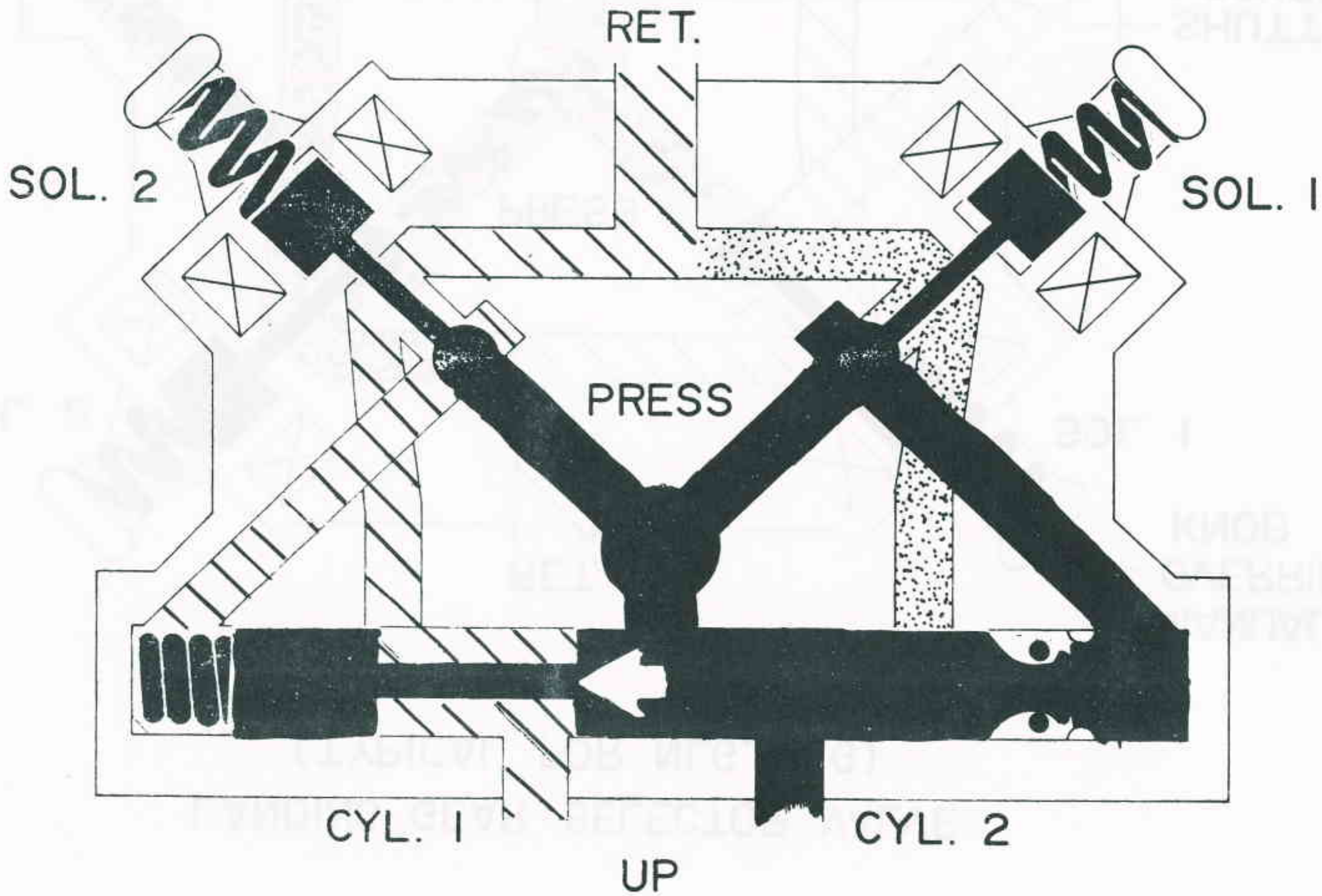


Figure 4-48

LANDING GEAR SELECTOR VALVE
(TYPICAL FOR NLG, MLG)

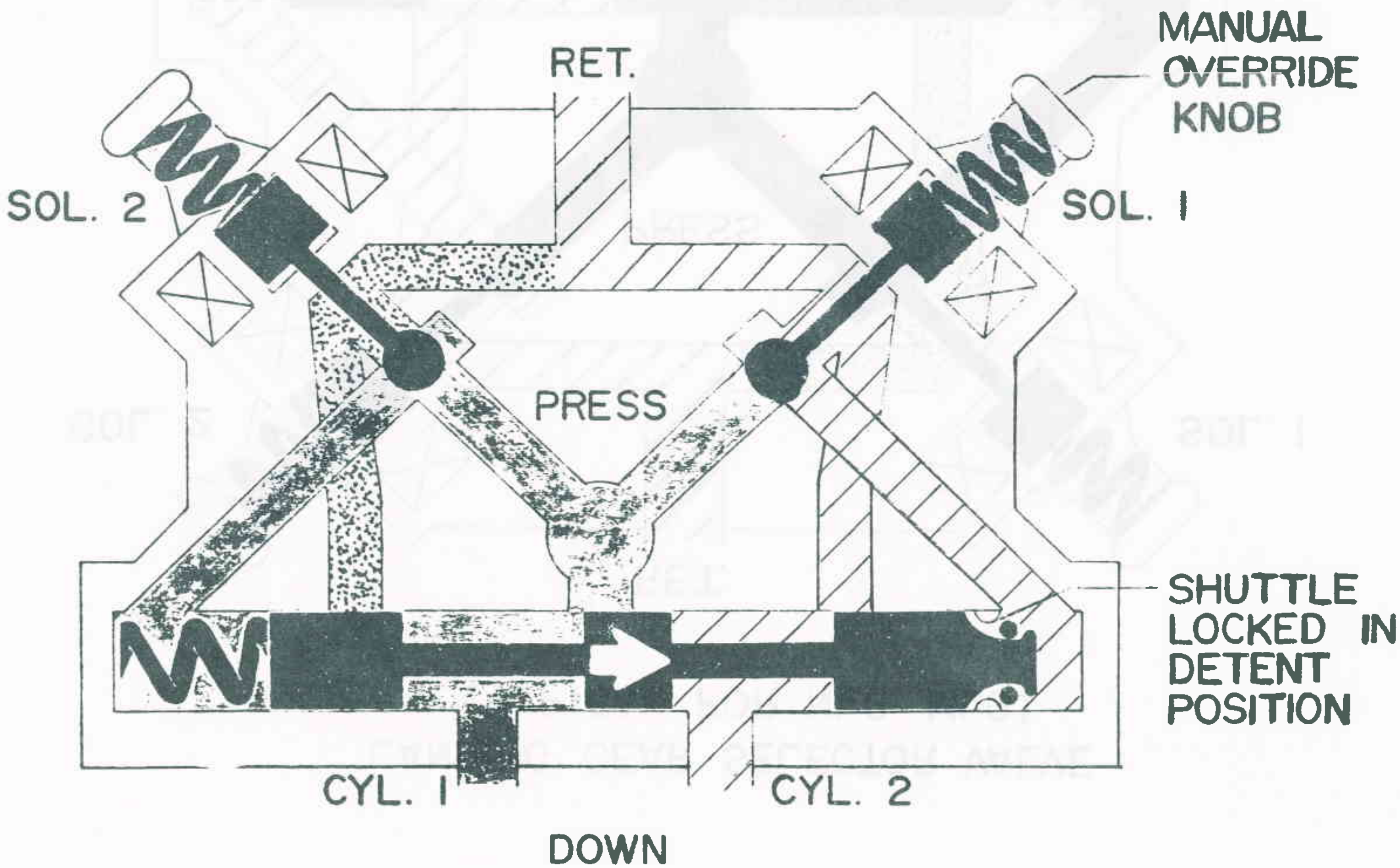


Figure 4-49

LANDING GEAR SELECTOR VALVE (TYPICAL FOR NLG, MLG)

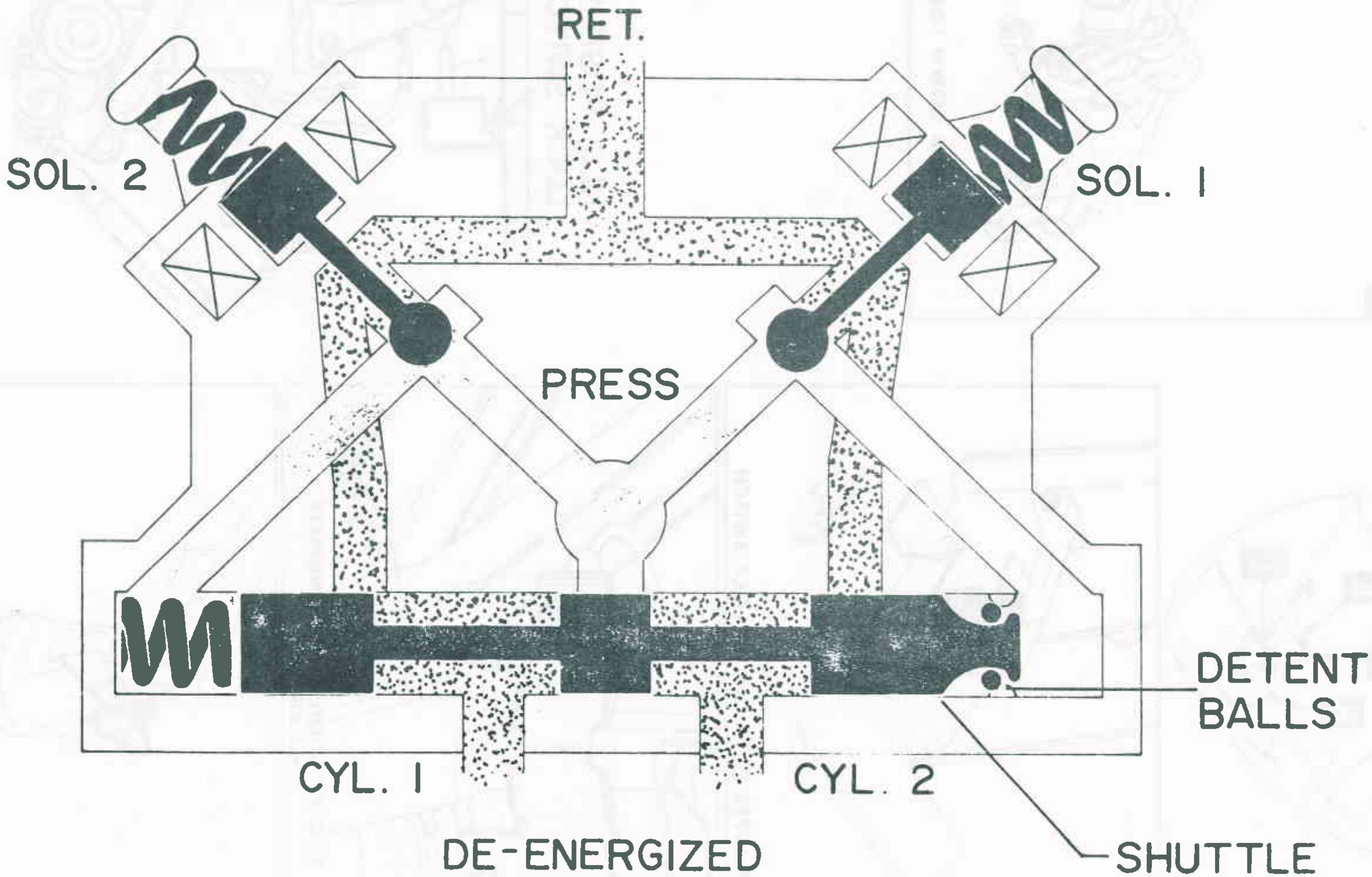


Figure 4-50

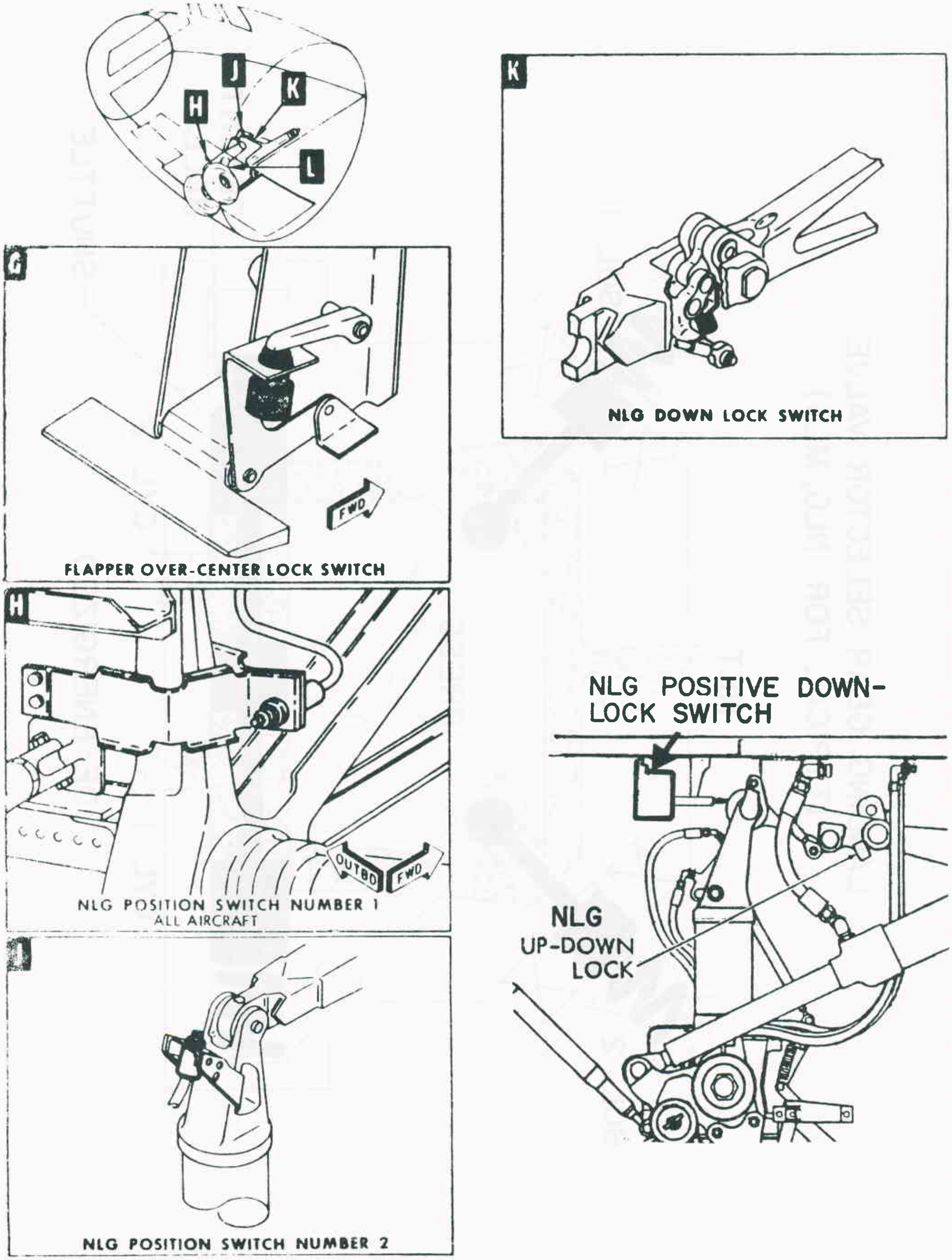
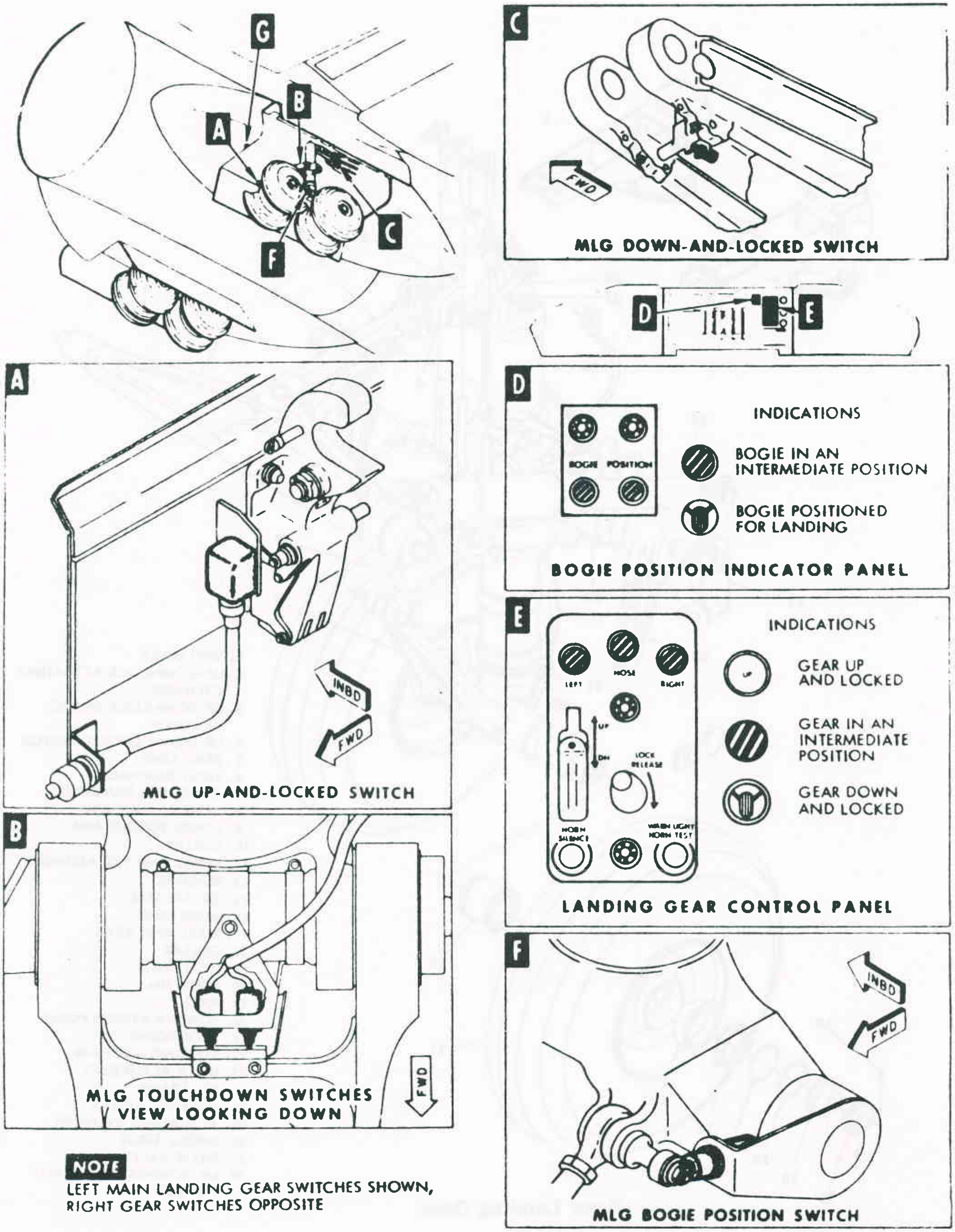
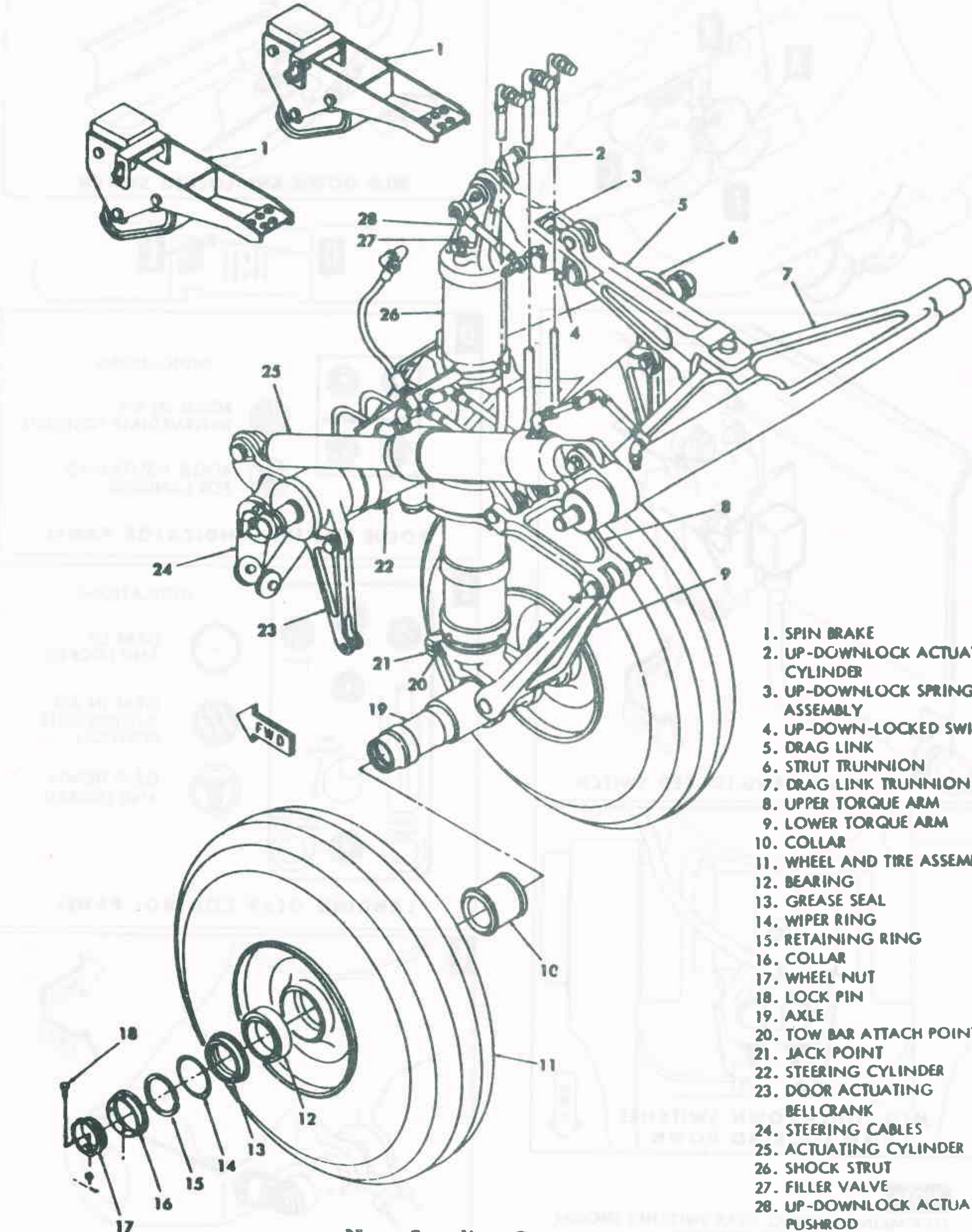

H
J
K
L
K
NLG DOWN LOCK SWITCH
G
FWD
FLAPPER OVER-CENTER LOCK SWITCH
H
OUTBD
FWD
NLG POSITION SWITCH NUMBER 1
ALL AIRCRAFT
J
NLG POSITION SWITCH NUMBER 2
NLG POSITIVE DOWN-
LOCK SWITCH
NLG
UP-DOWN
LOCK

Figure 4-51



Landing Gear System Electrical Component Locations

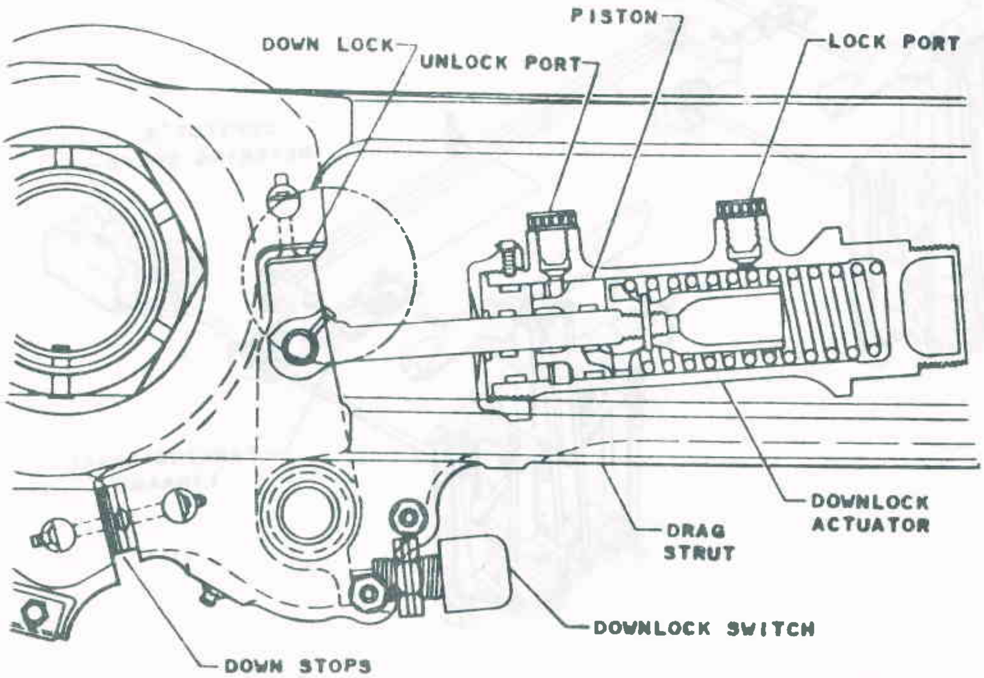
Figure 4-52



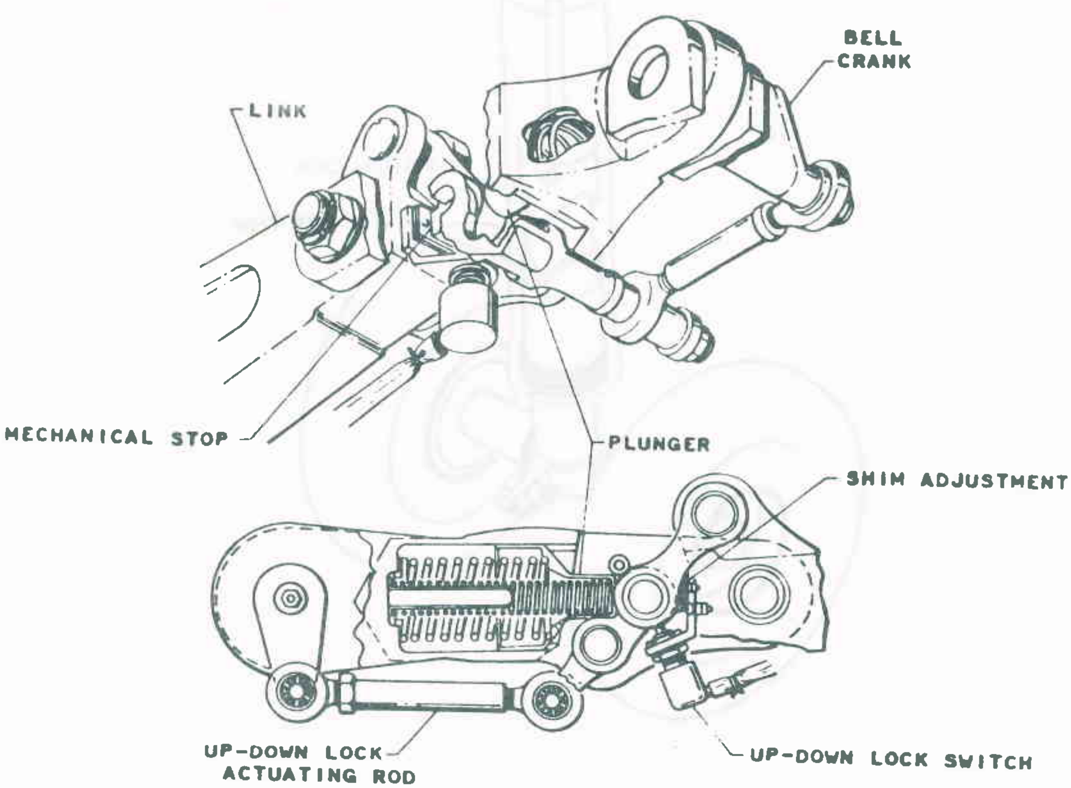
1. SPIN BRAKE
2. UP-DOWNLOCK ACTUATING CYLINDER
3. UP-DOWNLOCK SPRING ASSEMBLY
4. UP-DOWN-LOCKED SWITCH
5. DRAG LINK
6. STRUT TRUNNION
7. DRAG LINK TRUNNION
8. UPPER TORQUE ARM
9. LOWER TORQUE ARM
10. COLLAR
11. WHEEL AND TIRE ASSEMBLY
12. BEARING
13. GREASE SEAL
14. WIPER RING
15. RETAINING RING
16. COLLAR
17. WHEEL NUT
18. LOCK PIN
19. AXLE
20. TOW BAR ATTACH POINT
21. JACK POINT
22. STEERING CYLINDER
23. DOOR ACTUATING BELLCRANK
24. STEERING CABLES
25. ACTUATING CYLINDER
26. SHOCK STRUT
27. FILLER VALVE
28. UP-DOWNLOCK ACTUATI' PUSHROD

Nose Landing Gear

Figure 4-53

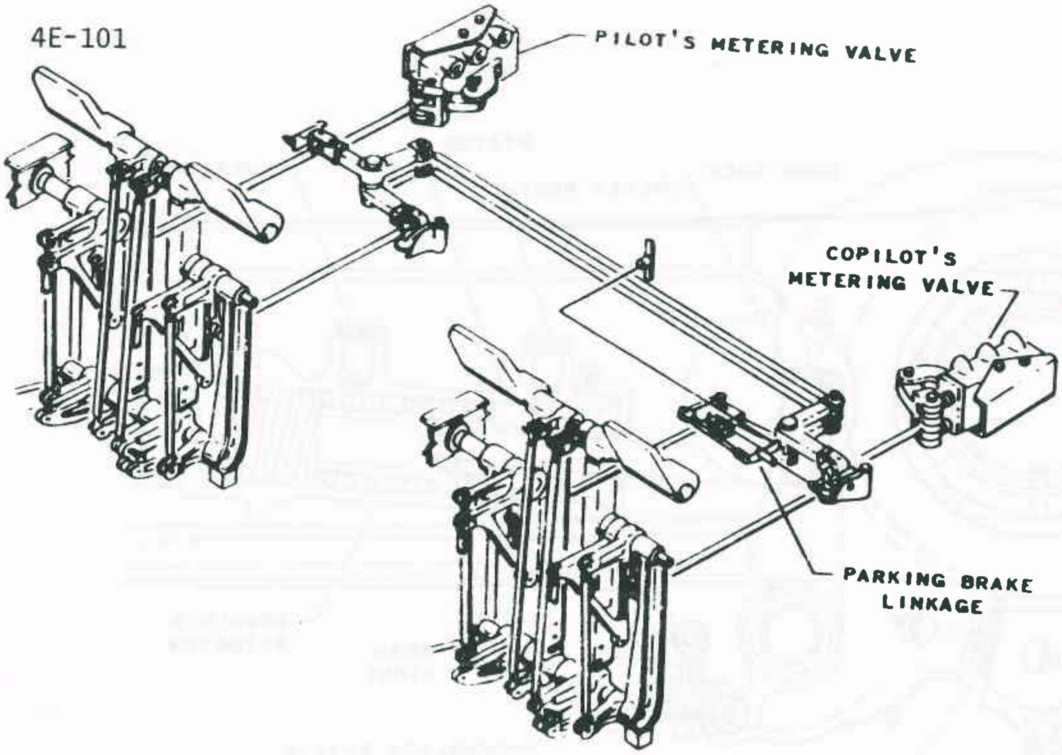


MAIN LANDING GEAR DOWNLOCK

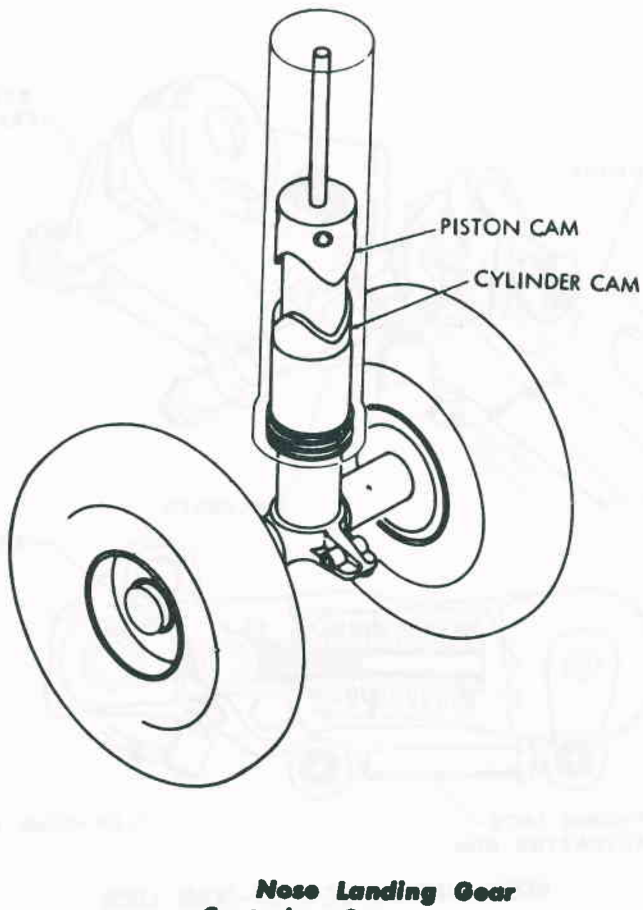


NOSE LANDING GEAR UP-DOWN LOCK

Figure 4-54



BRAKE CONTROL LINKAGE



Nose Landing Gear Centering Cams

Figure 4-55

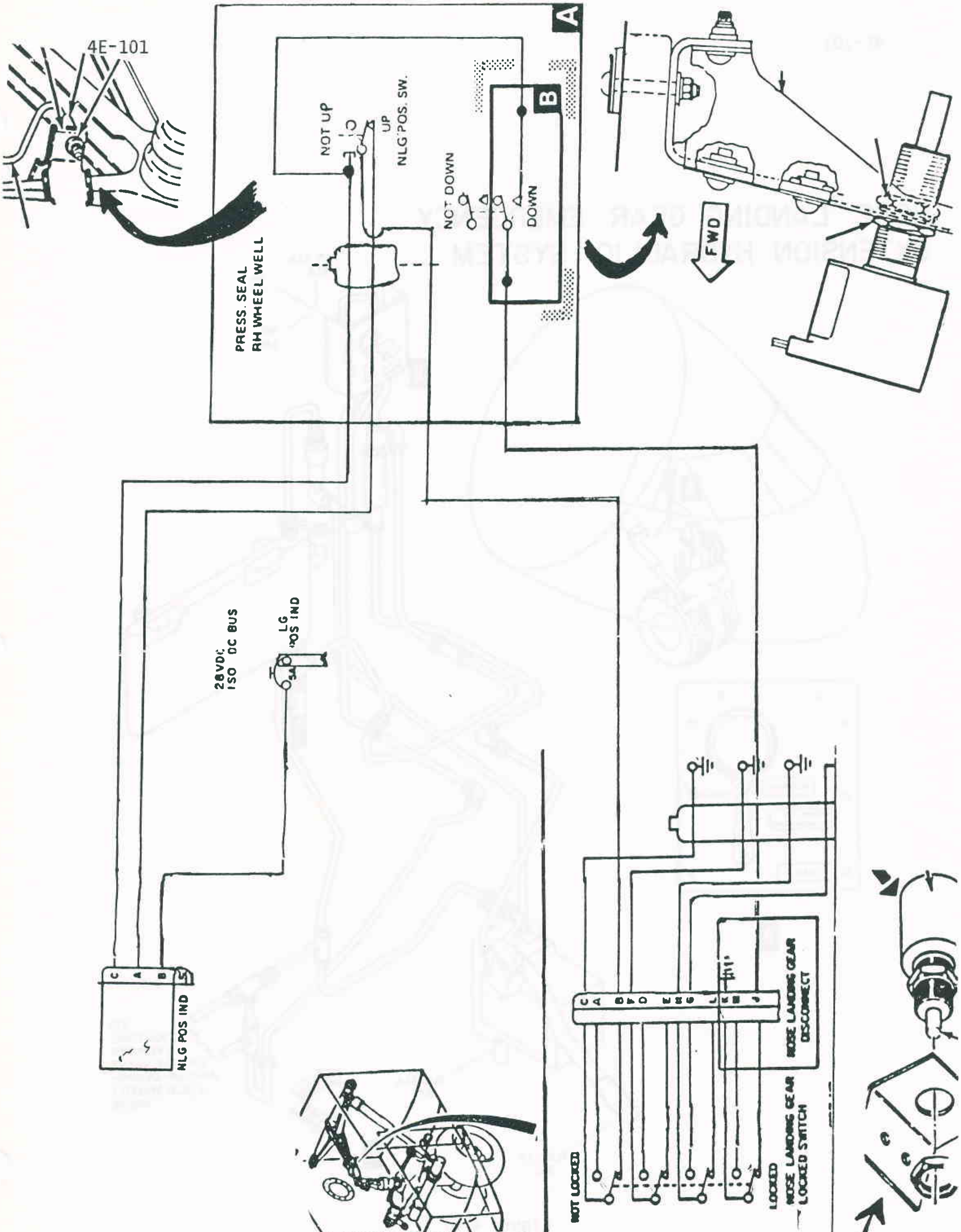

4E-101
A
B
NOT UP
UP
NLG POS. SW.
NOT DOWN
DOWN
PRESS. SEAL
RH WHEEL WELL
FWD
28VDC
ISO DC BUS
LG
POS IND
NLG POS IND
NOT LOCKED
LOCKED
NOSE LANDING GEAR
LOCKED SWITCH
NOSE LANDING GEAR
DISCONNECT

Figure 4-56

NOSE LANDING GEAR EMERGENCY EXTENSION HYDRAULIC SYSTEM

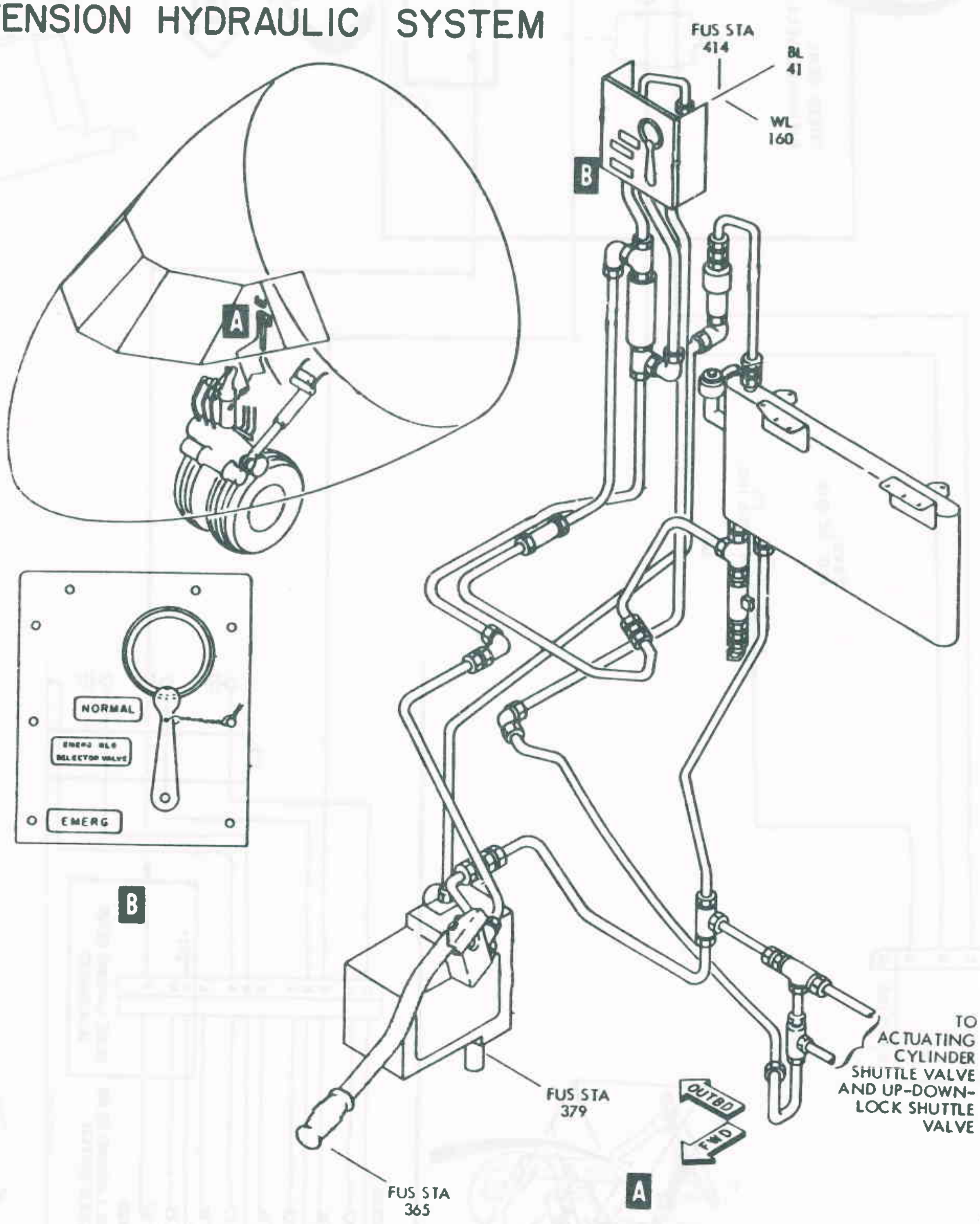
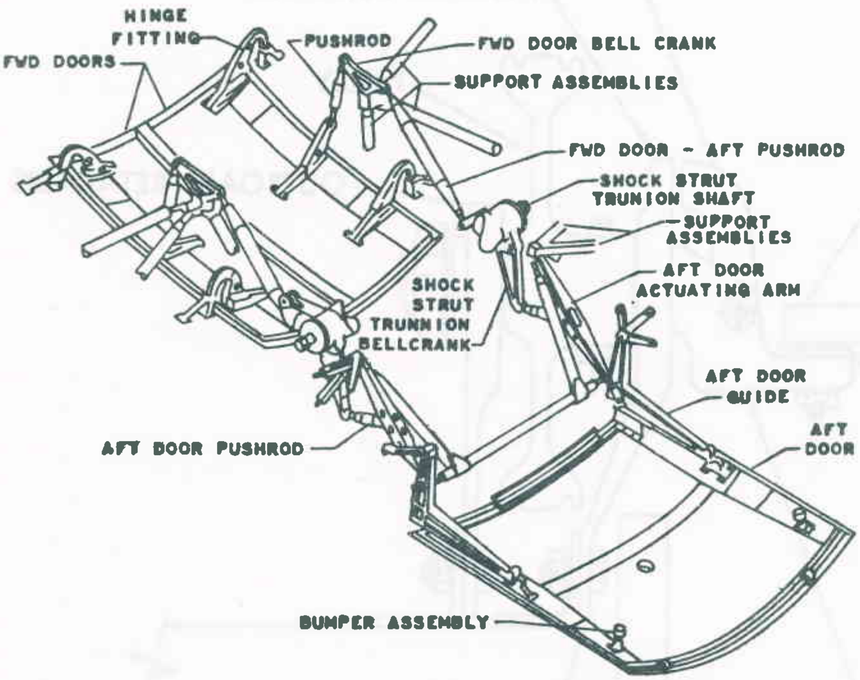
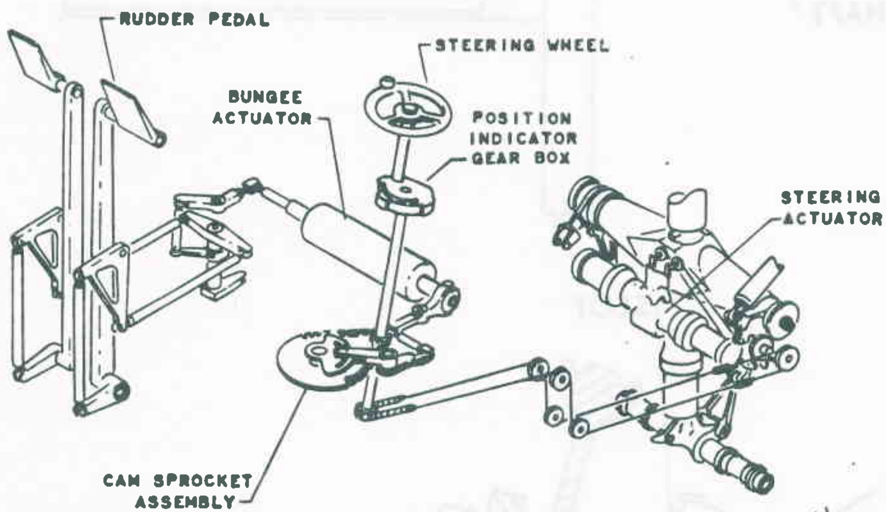


Figure 4-57



NOSE LANDING GEAR DOORS



NOSE GEAR STEERING CONTROL LINKAGE

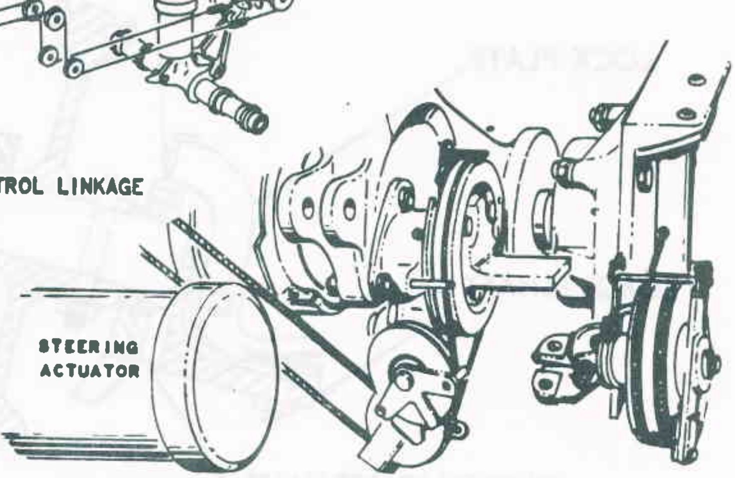
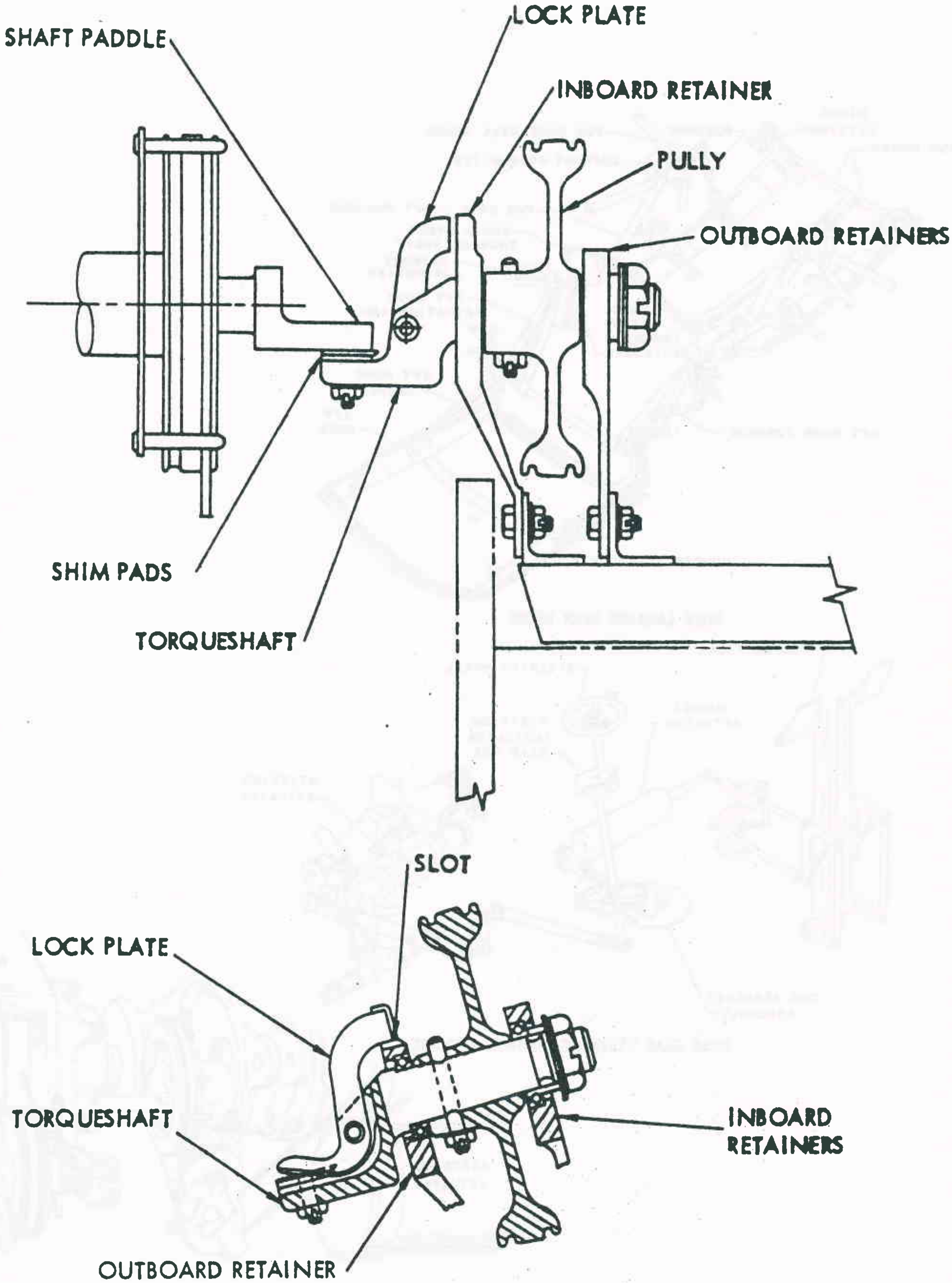


Figure 4-58



NOSE WHEEL STEERING CONNECTION

Figure 4-59

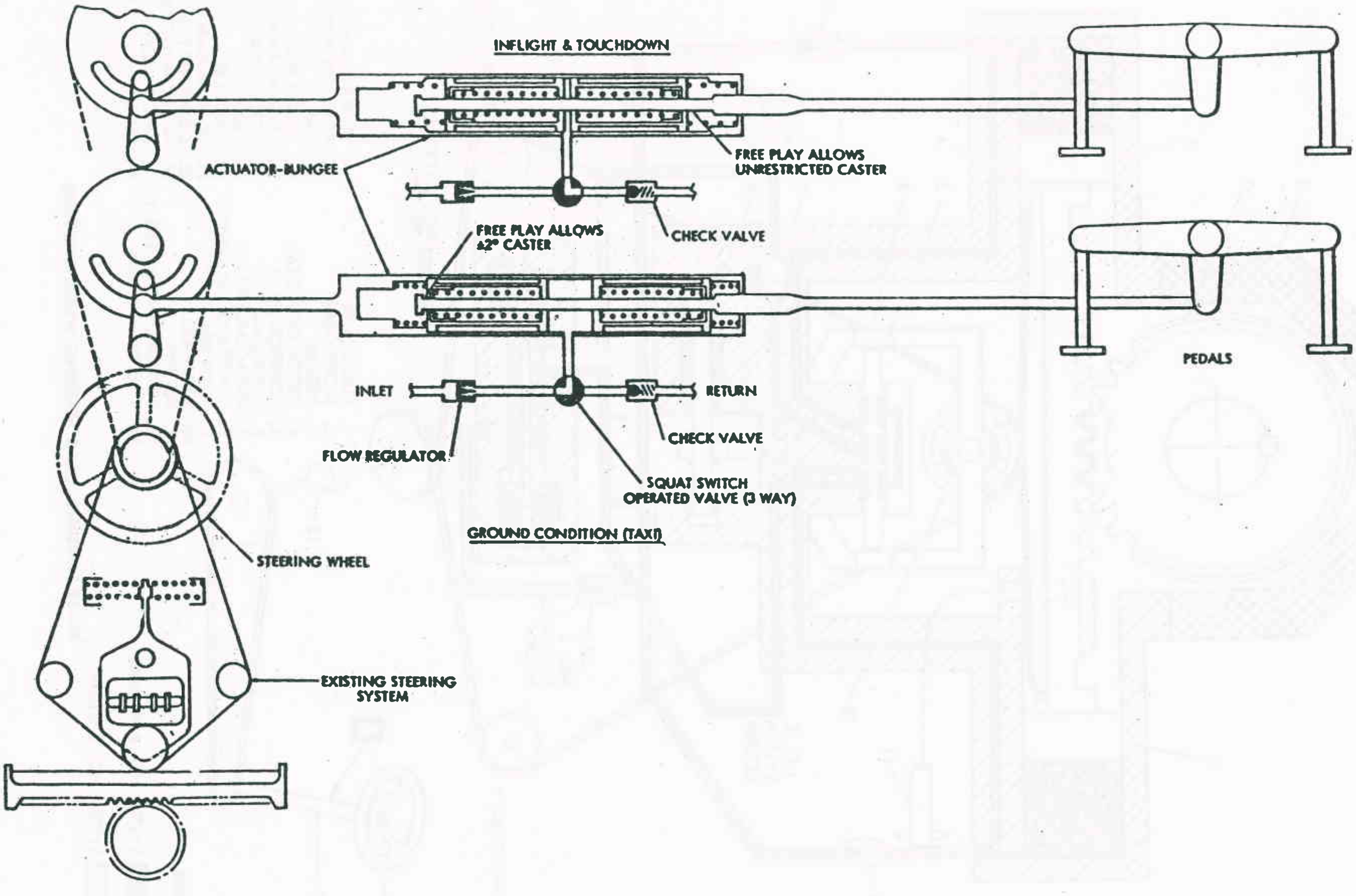
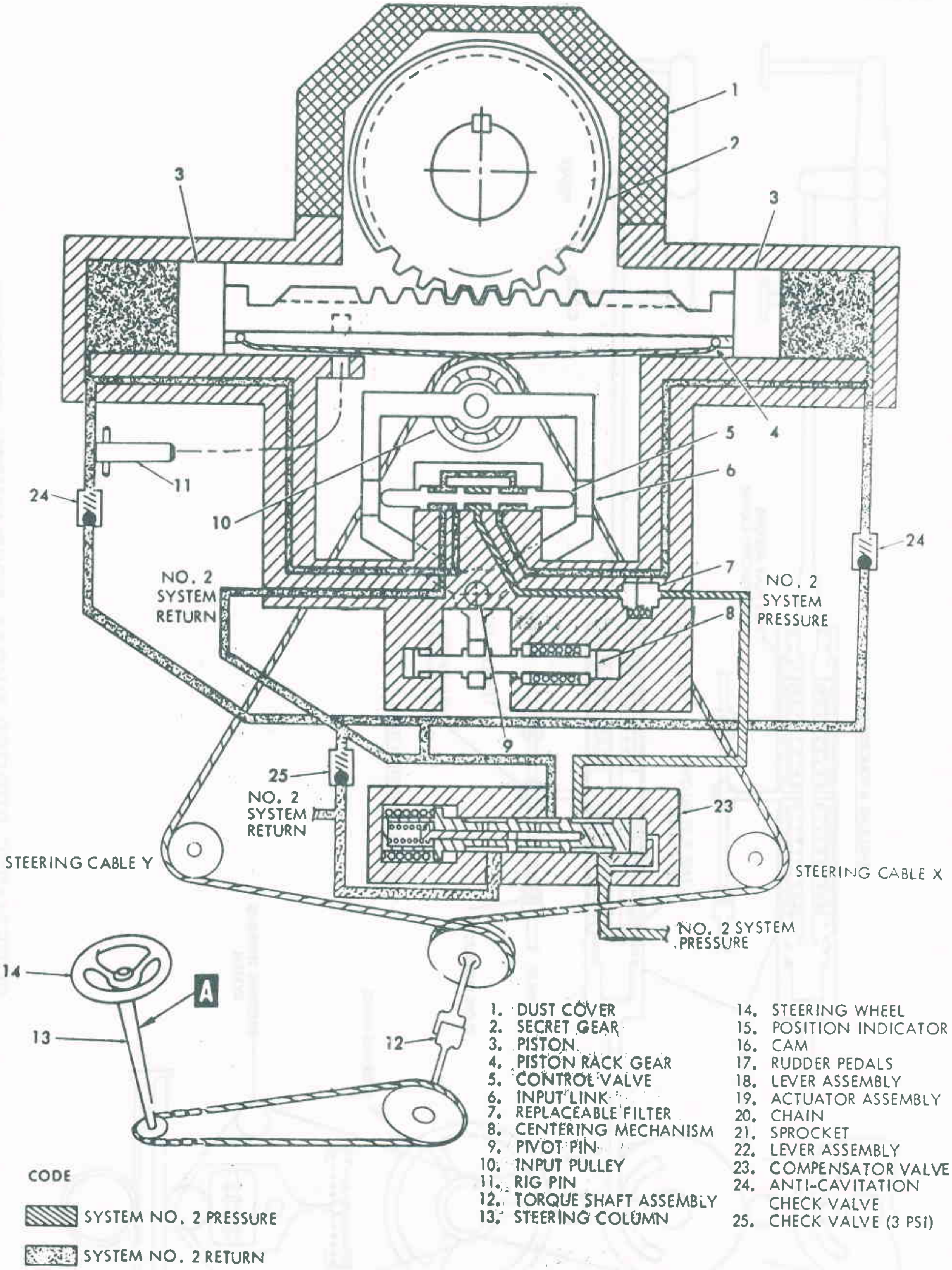


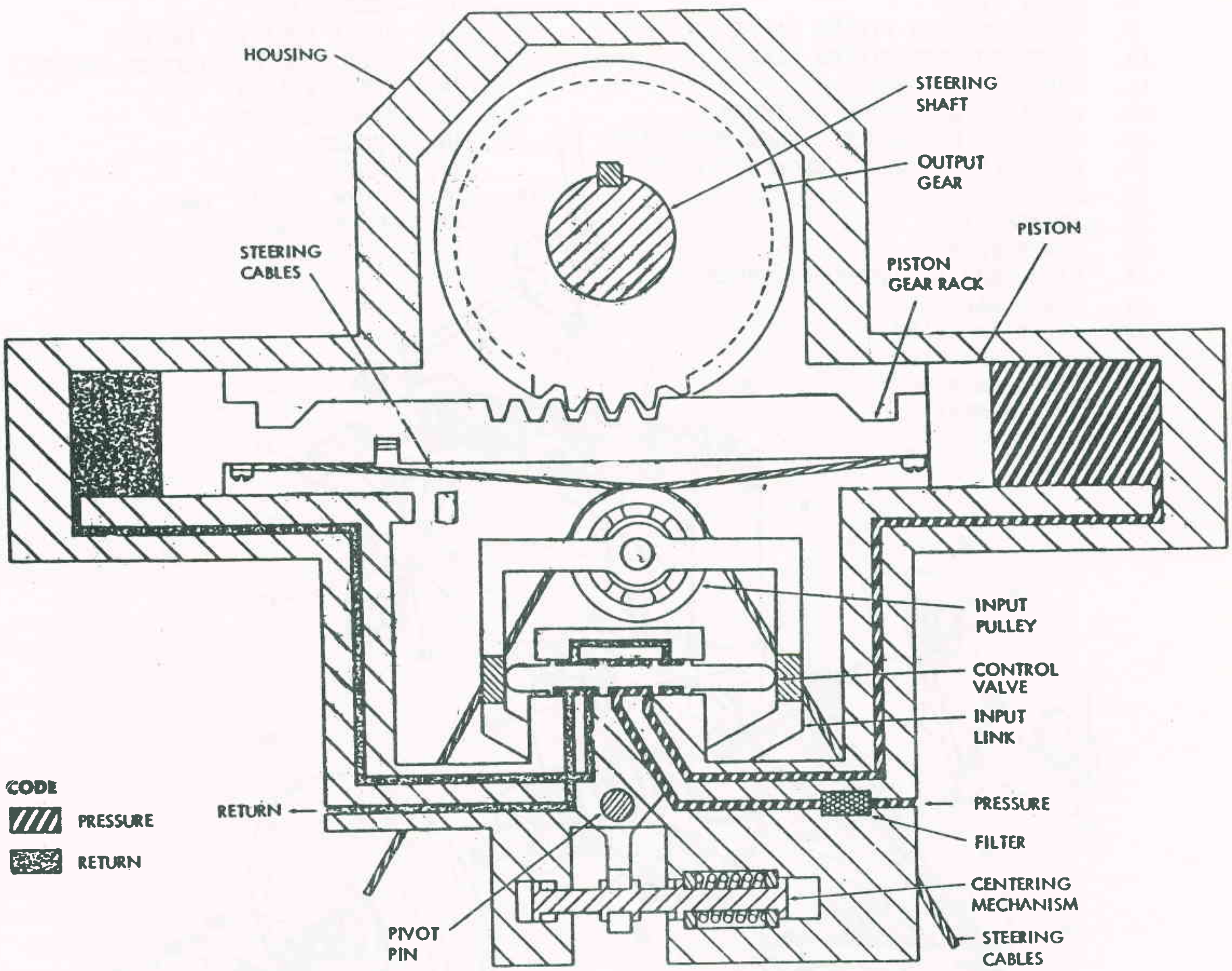
Figure 4-60

SCHEMATIC RUDDER PEDAL NOSE WHEEL STEERING



NOSE LANDING GEAR STEERING WHEEL STEERING

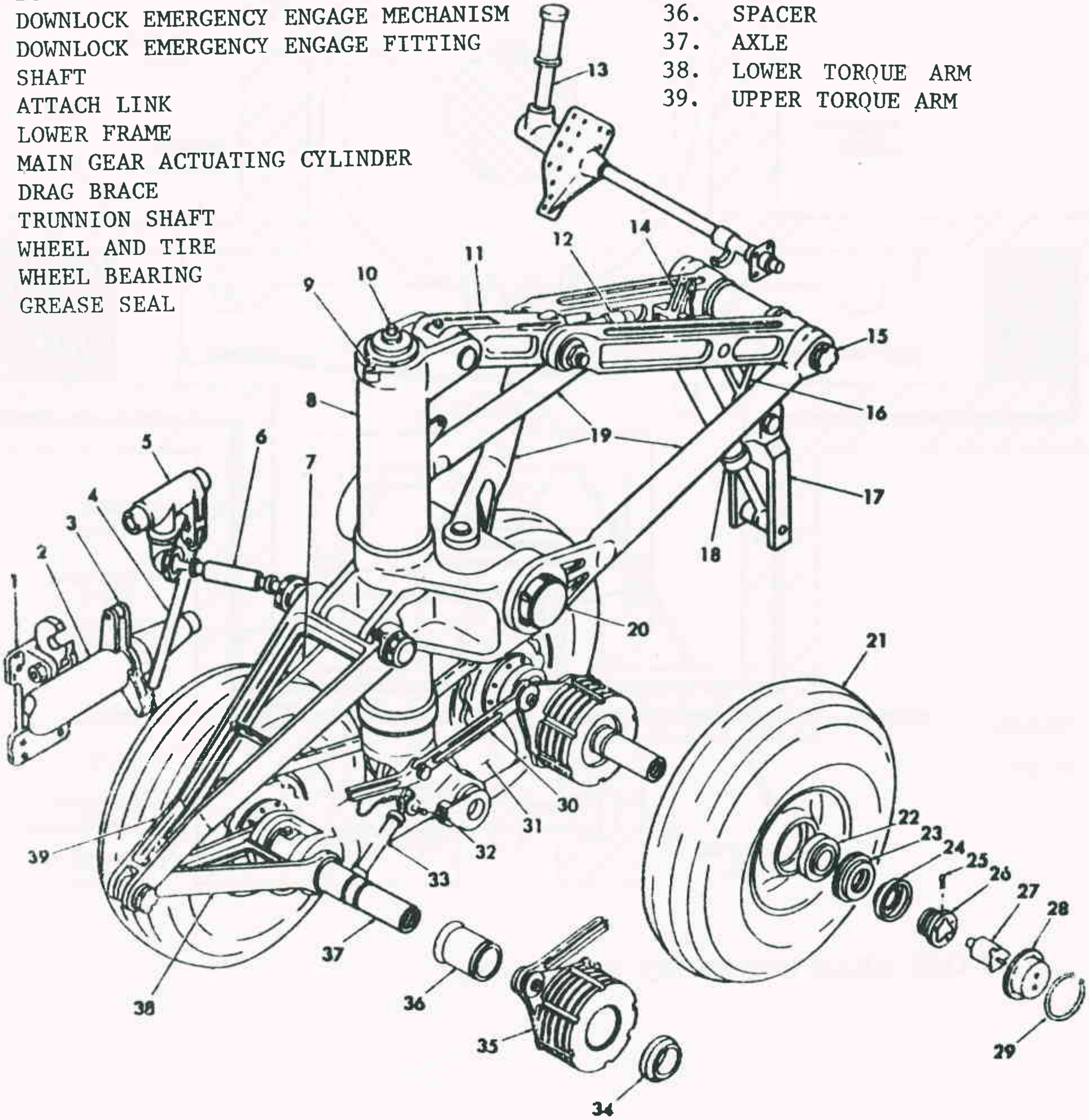
Figure 4-61



NOSE GEAR STEERING SCHEMATIC

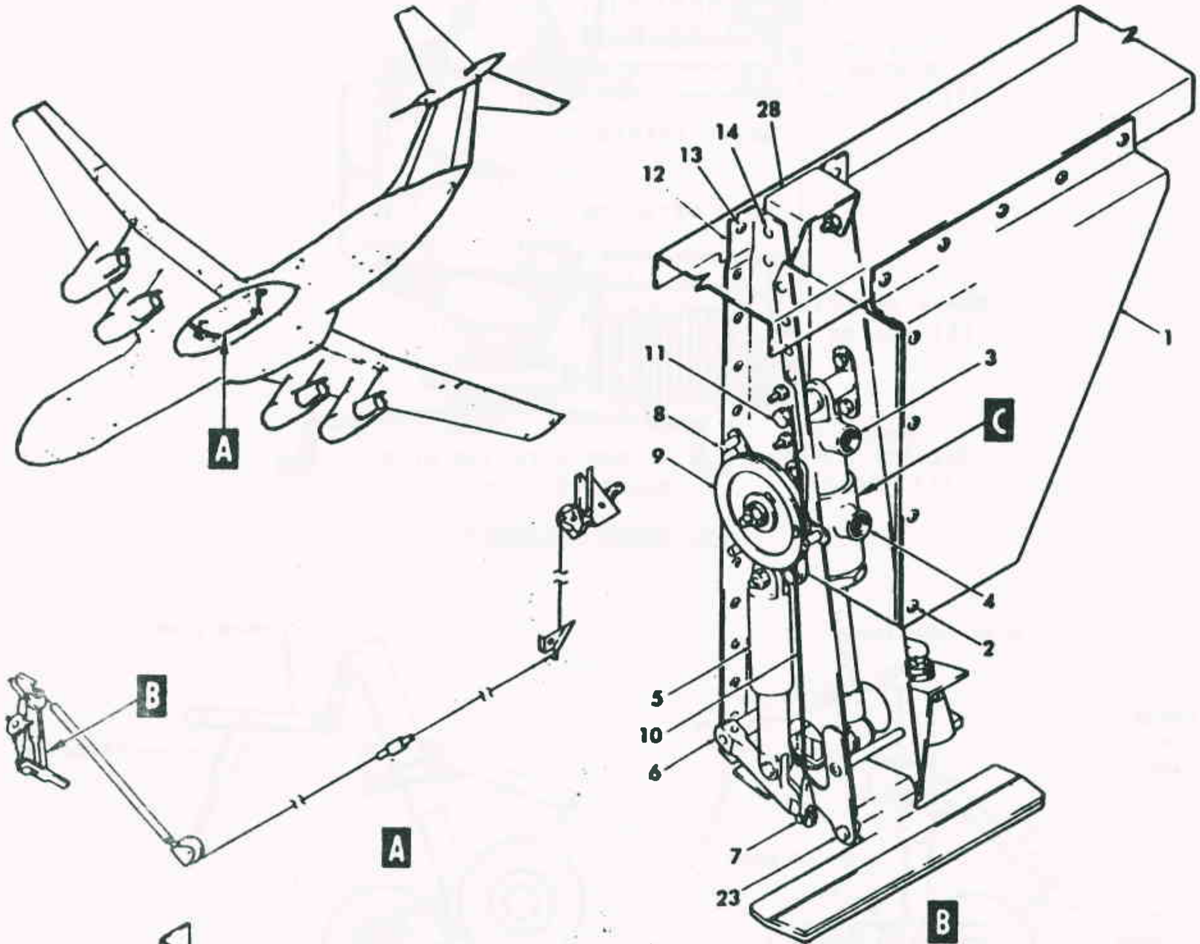
Figure 4-62

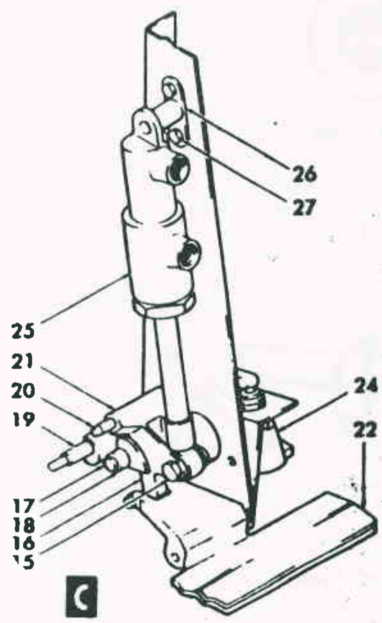
1. UPLOCK ASSEMBLY
2. TORQUE TUBE
3. UPLOCK ACTUATING ARM
4. PUSH ROD
5. BELLCRANK ASSEMBLY
6. ADJUSTABLE SHAFT
7. LEVELER ROD ASSEMBLY
8. SHOCK STRUT
9. OUTER CHAMBER FILLER VALVE
10. INNER CHAMBER FILLER VALVE
11. DRAG LINK ASSEMBLY
12. DOWNLOCK ACTUATING CYLINDER
13. DOWNLOCK EMERGENCY ENGAGE MECHANISM
14. DOWNLOCK EMERGENCY ENGAGE FITTING
15. SHAFT
16. ATTACH LINK
17. LOWER FRAME
18. MAIN GEAR ACTUATING CYLINDER
19. DRAG BRACE
20. TRUNNION SHAFT
21. WHEEL AND TIRE
22. WHEEL BEARING
23. GREASE SEAL
24. BEARING RETAINING WASHER
25. COTTER PIN
26. WHELL NUT
27. SKID DETECTOR
28. HUB CAP
29. HUB CAP RETAINING RING
30. BRAKE COMPENSATING ROD
31. AXLE BEAM
32. BOGIE POSITION SWITCH
33. AXLE BEAM POSITIONER ASSEMBLY
34. WHEEL SPACER
35. BRAKE ASSEMBLY
36. SPACER
37. AXLE
38. LOWER TORQUE ARM
39. UPPER TORQUE ARM



Main Landing Gear

Figure 4-63

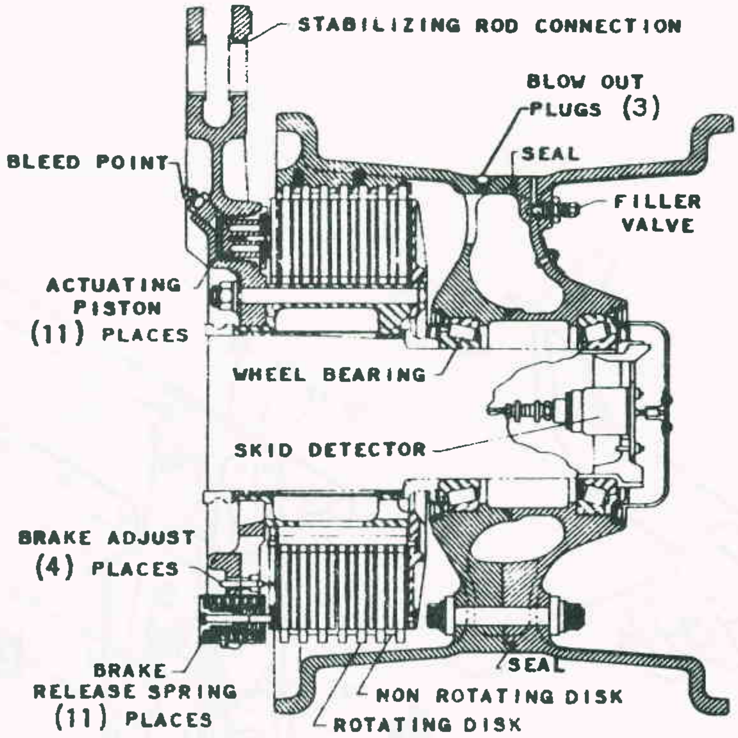




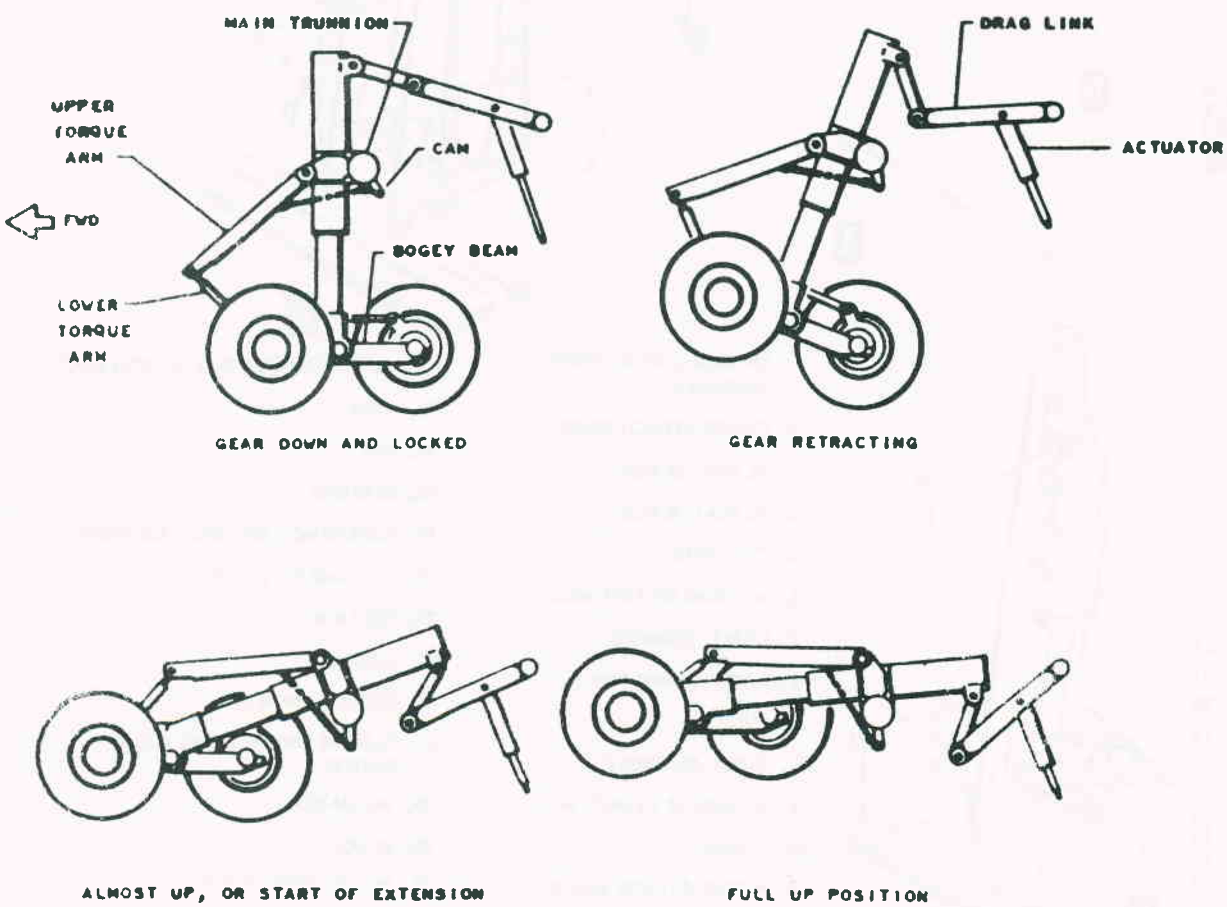
1. UPLOCK LATCH COVER ASSEMBLY
2. COVER ATTACH SCREW
3. ACTUATOR PORT
4. ACTUATOR PORT
5. CYLINDER
6. MANUAL RELEASE ARM
7. CABLE TERMINAL
8. CABLE GUARD PIN
9. PULLEY
10. CABLE ASSEMBLY
11. ACTUATOR ATTACH BOLT
12. ANGLE
13. ANGLE ATTACH SCREW
14. CHANNEL ATTACH SCREW
15. ACTUATOR ROD END ATTACH BOLT
16. LINK
17. PIN
18. BEARING
19. EMERGENCY RELEASE CAM SHAFT
20. TEE LINK PIVOT PIN
21. TEE LINK
22. CATCH
23. CATCH HINGE PIN
24. FLAPPER OVER-CENTER LOCK SWITCH
25. ACTUATOR
26. BLOCK
27. BLOCK ATTACH BOLT
28. CHANNEL

Main Landing Gear Door Uplock Latch Assembly

Figure 4-64

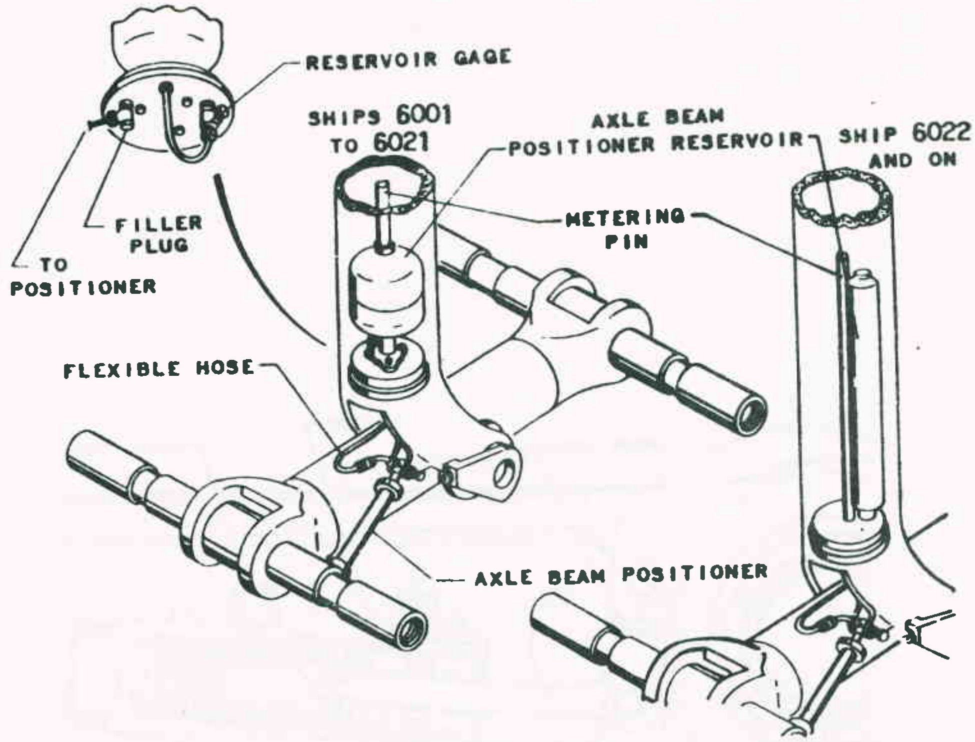


WHEEL BRAKE ASSEMBLY

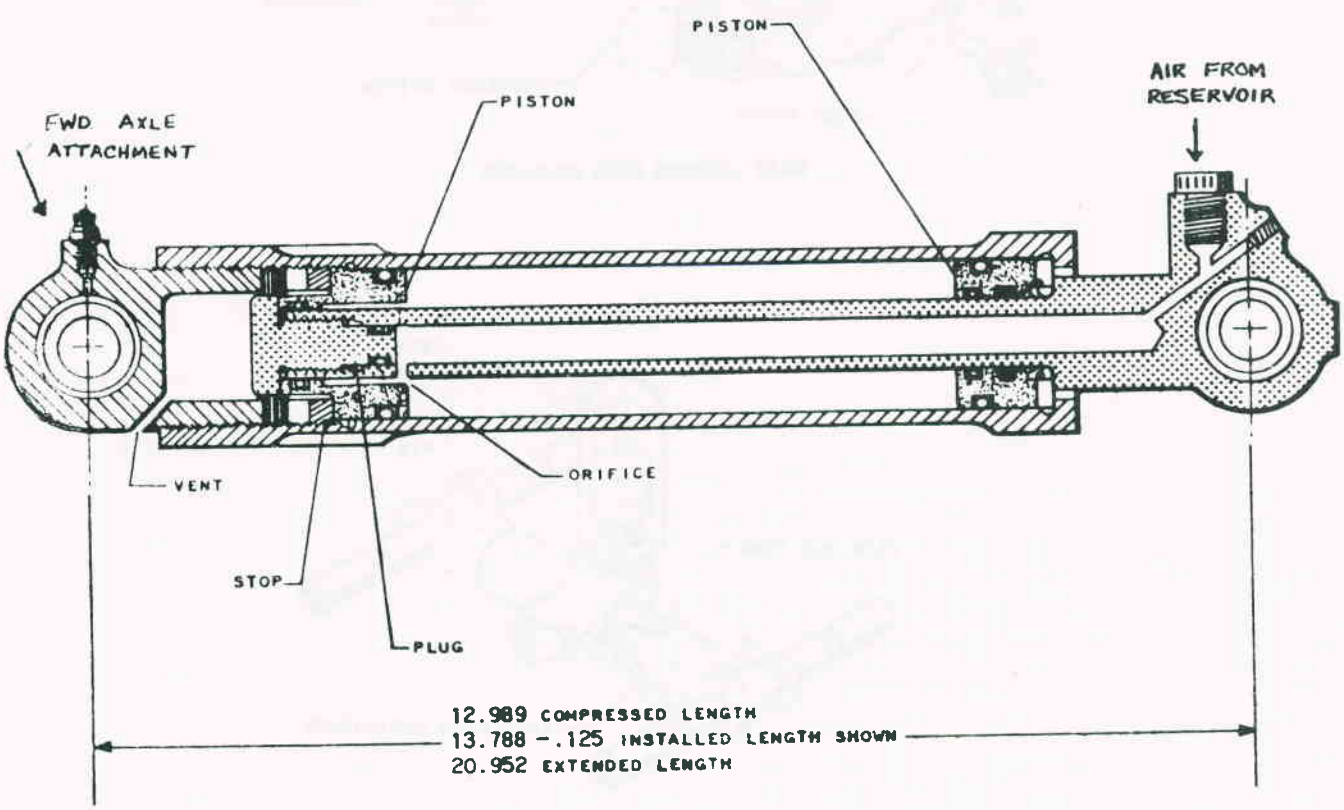


MAIN LANDING GEAR LEVELER

Figure 4-65

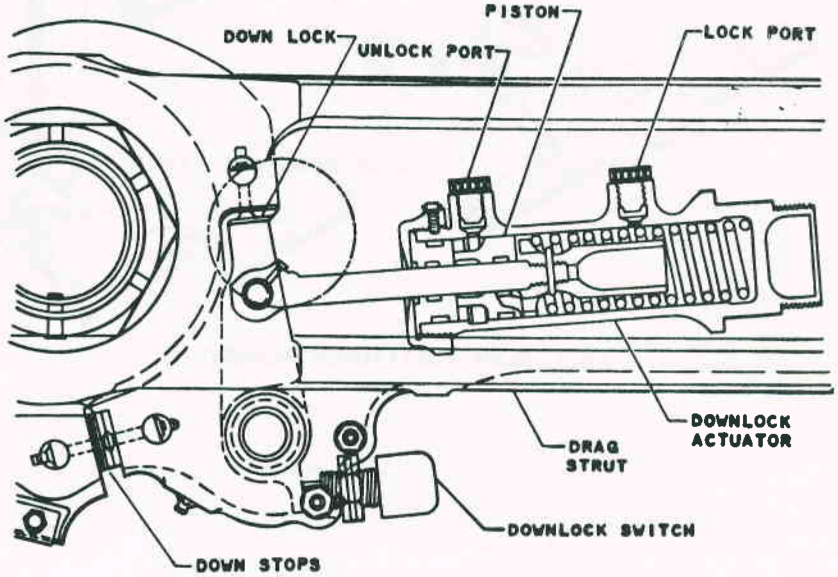


AXLE BEAM POSITIONER RESERVOIR



BOGEY POSITIONER CYLINDER

Figure 4-66



MAIN LANDING GEAR DOWNLOCK

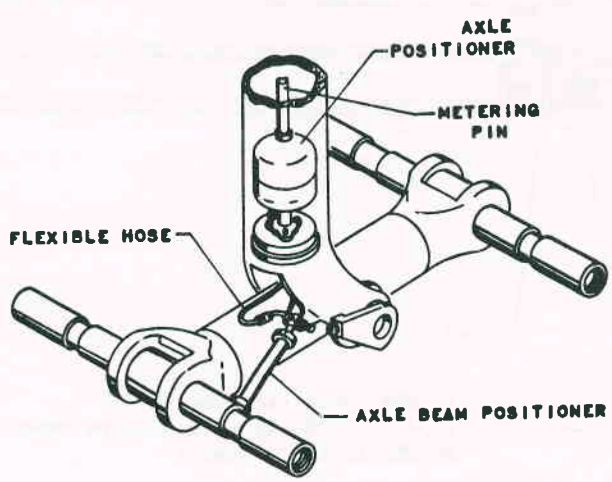
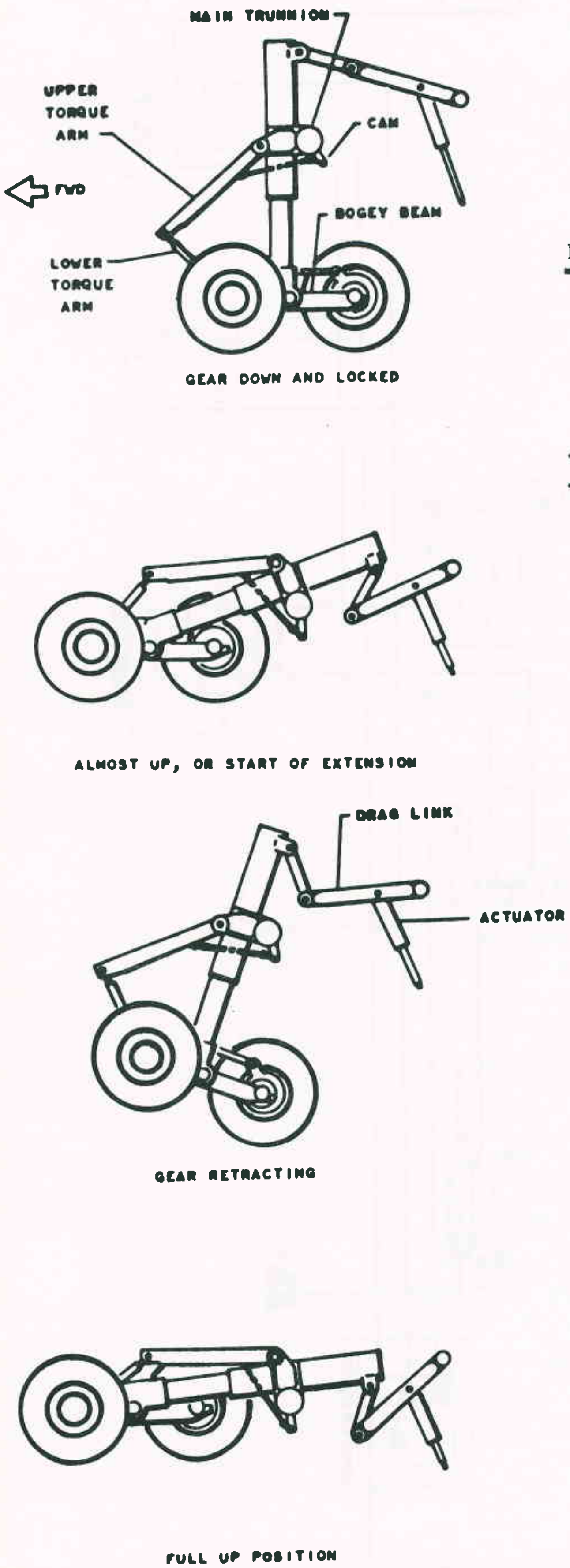


Figure 4-67



MAIN LANDING GEAR UPLOCK

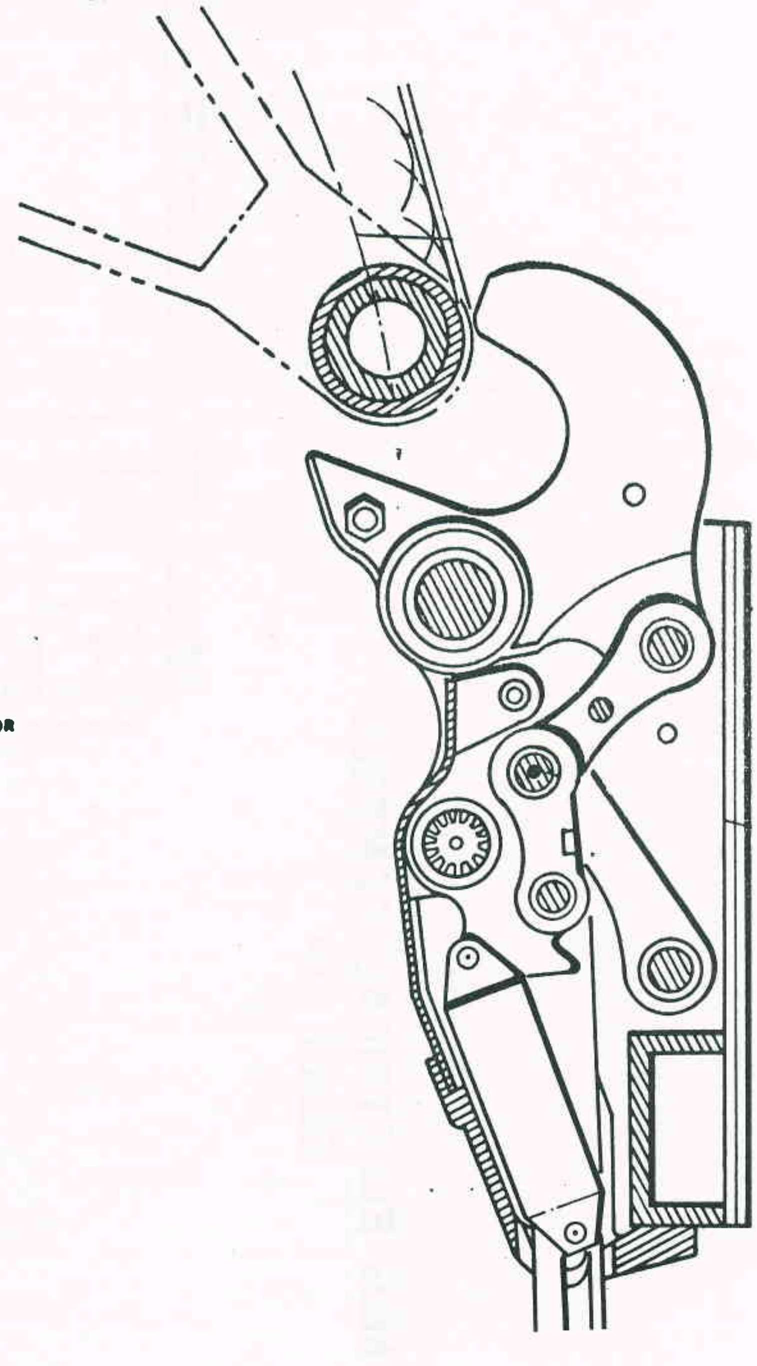


Figure 4-68

MLG ELECTRICAL CONTROL
GEAR UP

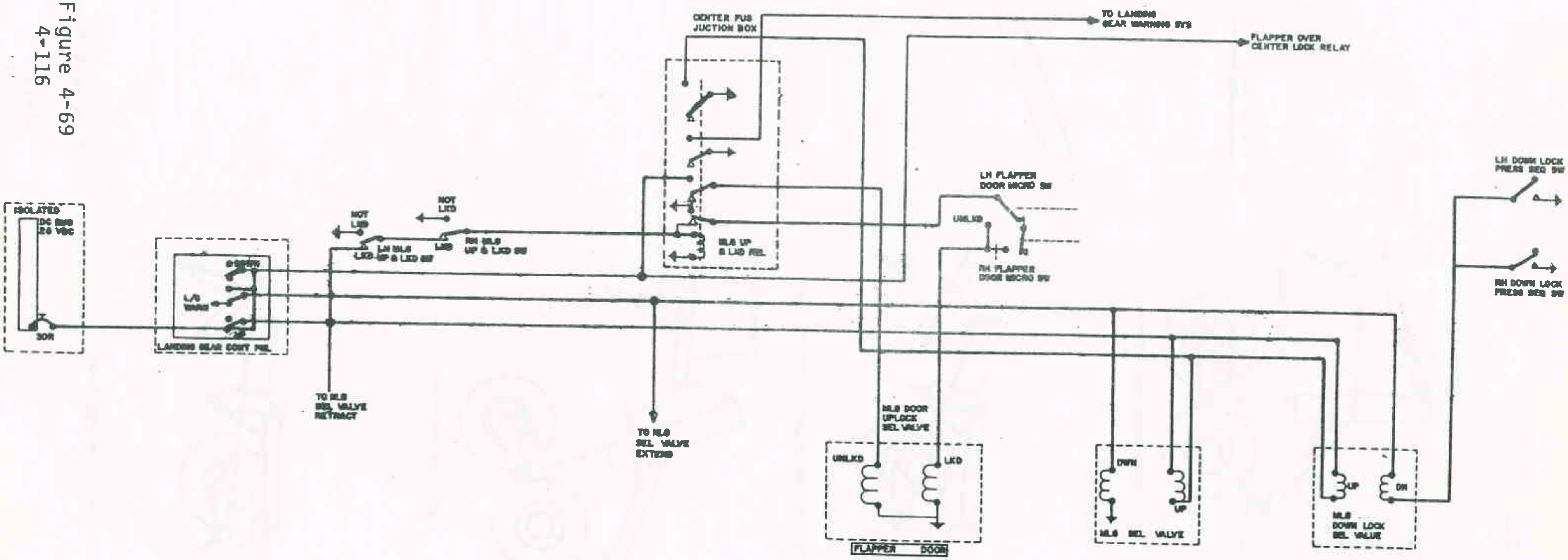


Figure 4-69
4-116

MLG ELECTRICAL CONTROL
GEAR DOWN

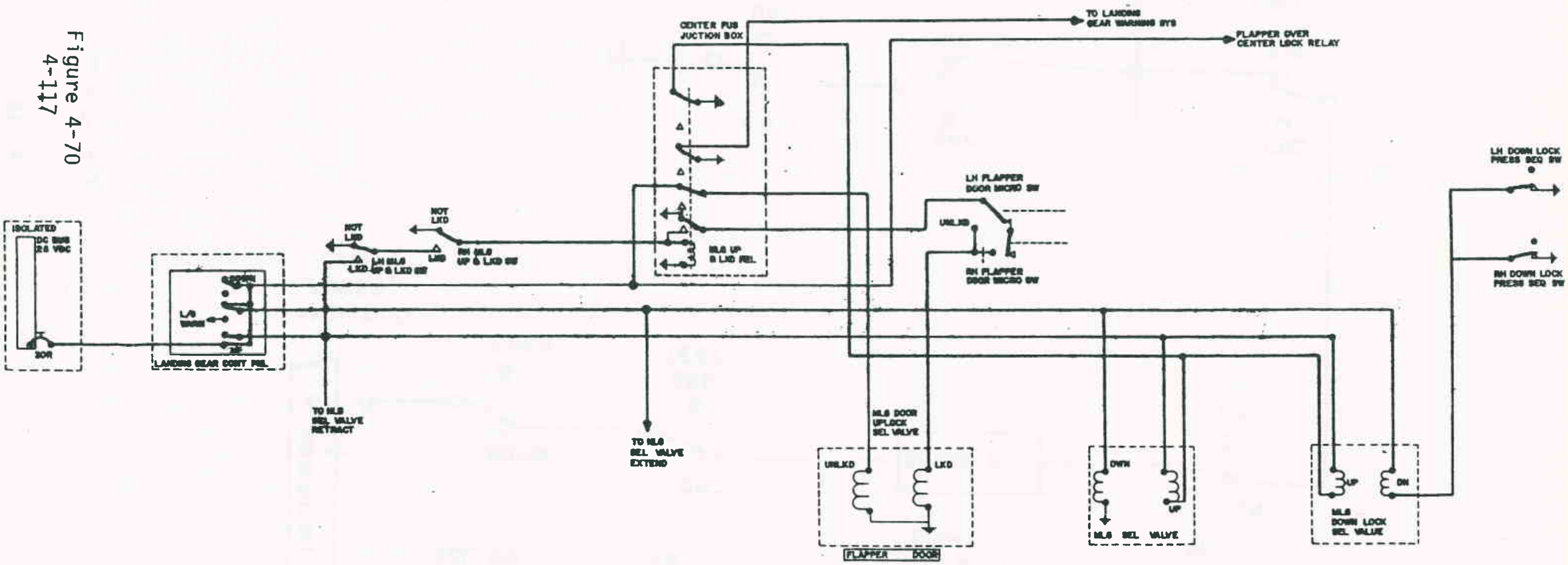
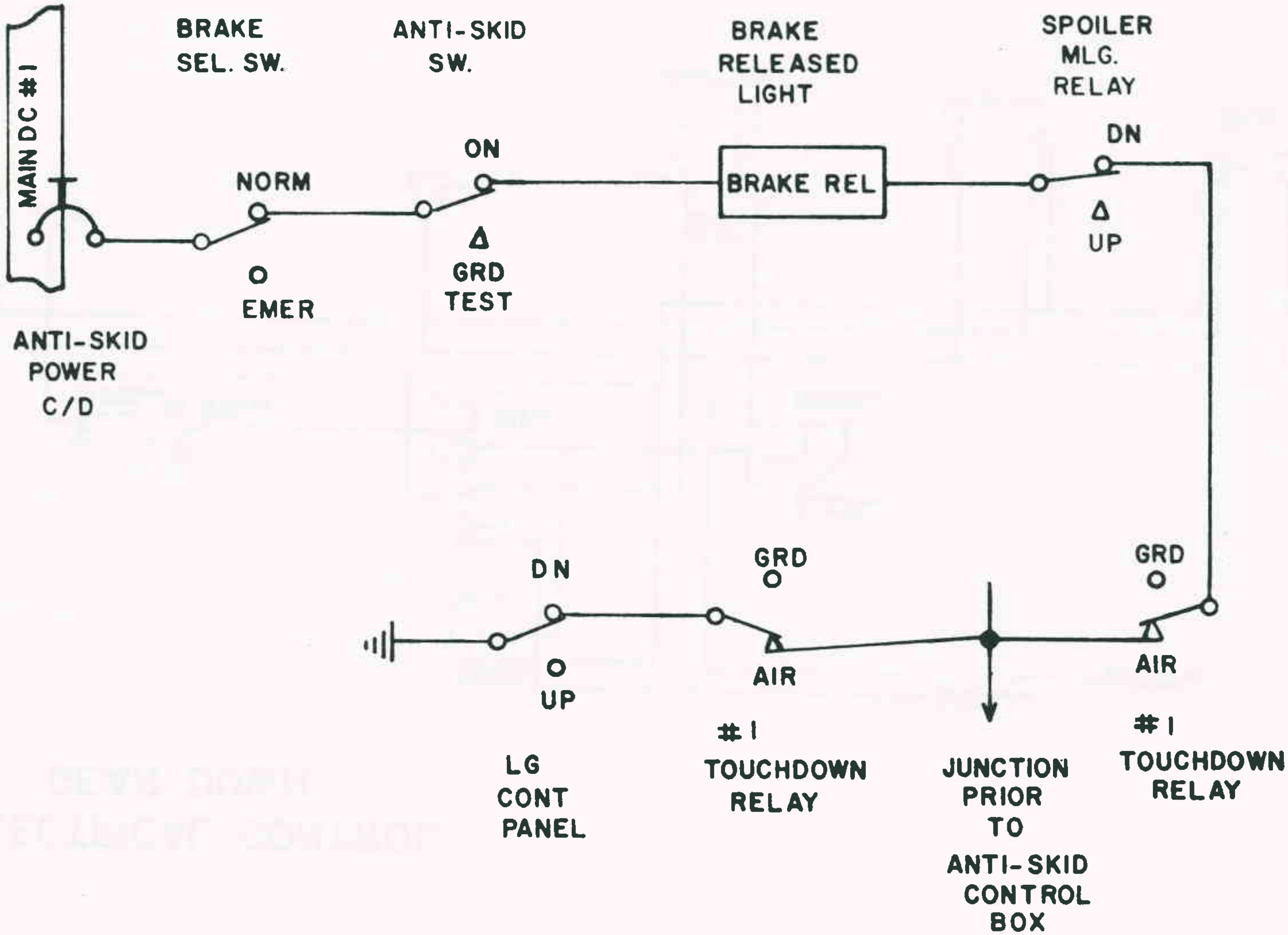


Figure 4-70
4-117

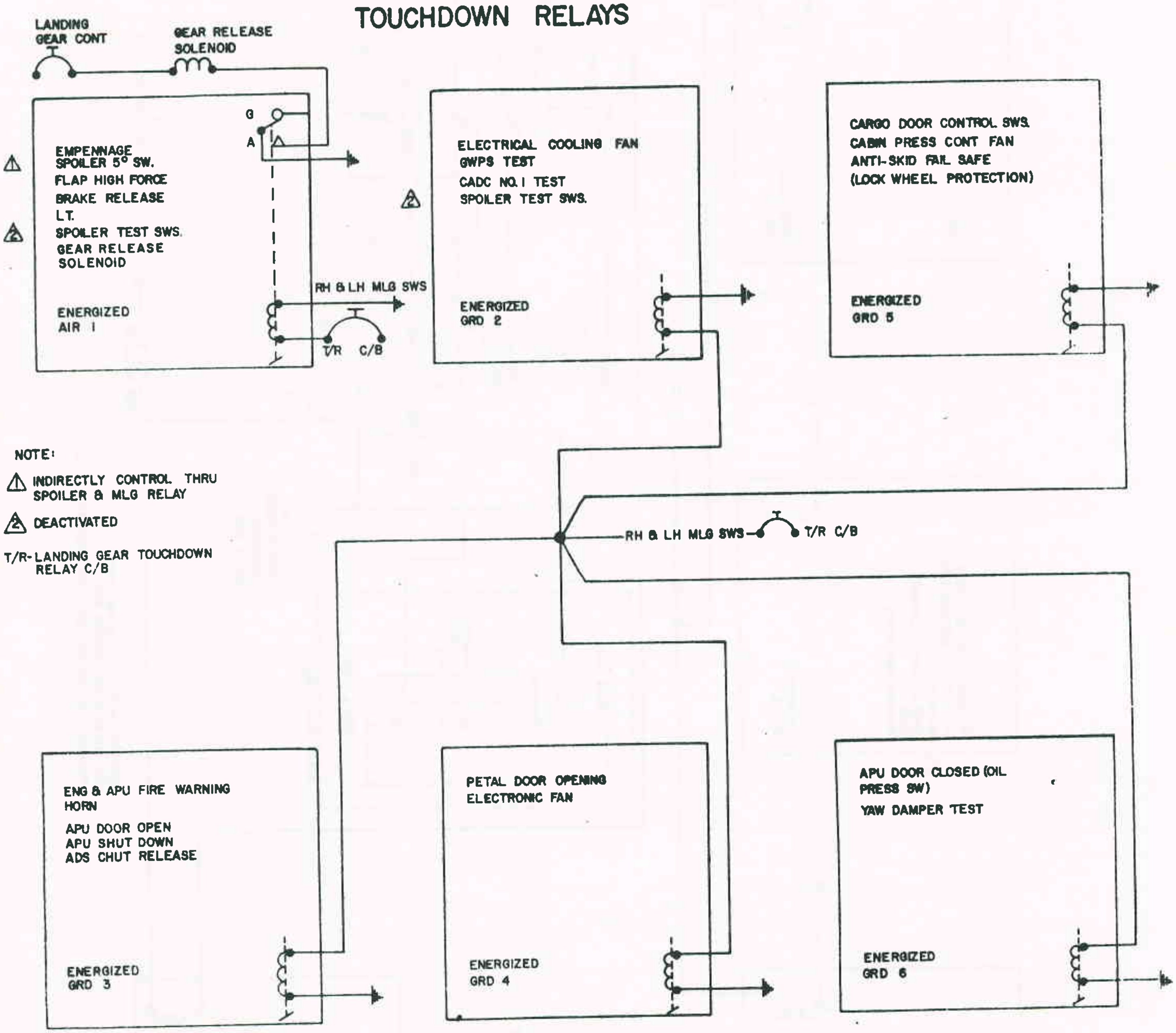


SIMPLIFIED SCHEMATIC DEPICTING
ILLUMINATION OF BRAKE REL LIGHT

Figure 4-71

AIRCRAFT 66-7959 AND UP

TOUCHDOWN RELAYS



NOTE:

⚠ INDIRECTLY CONTROL THRU SPOILER & MLG RELAY

⚠2 DEACTIVATED

T/R- LANDING GEAR TOUCHDOWN RELAY C/B

THRUST REVERSES
AIRCRAFT 61-2775 THRU 66-7958
2+3 RH MLG TOUCHDOWN SW.
1+4 TOUCHDOWN RELAY # 7
AIRCRAFT 66-7959 AND UP
1+4 LH MLG TOUCHDOWN SW.
2+3 RH MLG TOUCHDOWN SW.

Figure 4-72

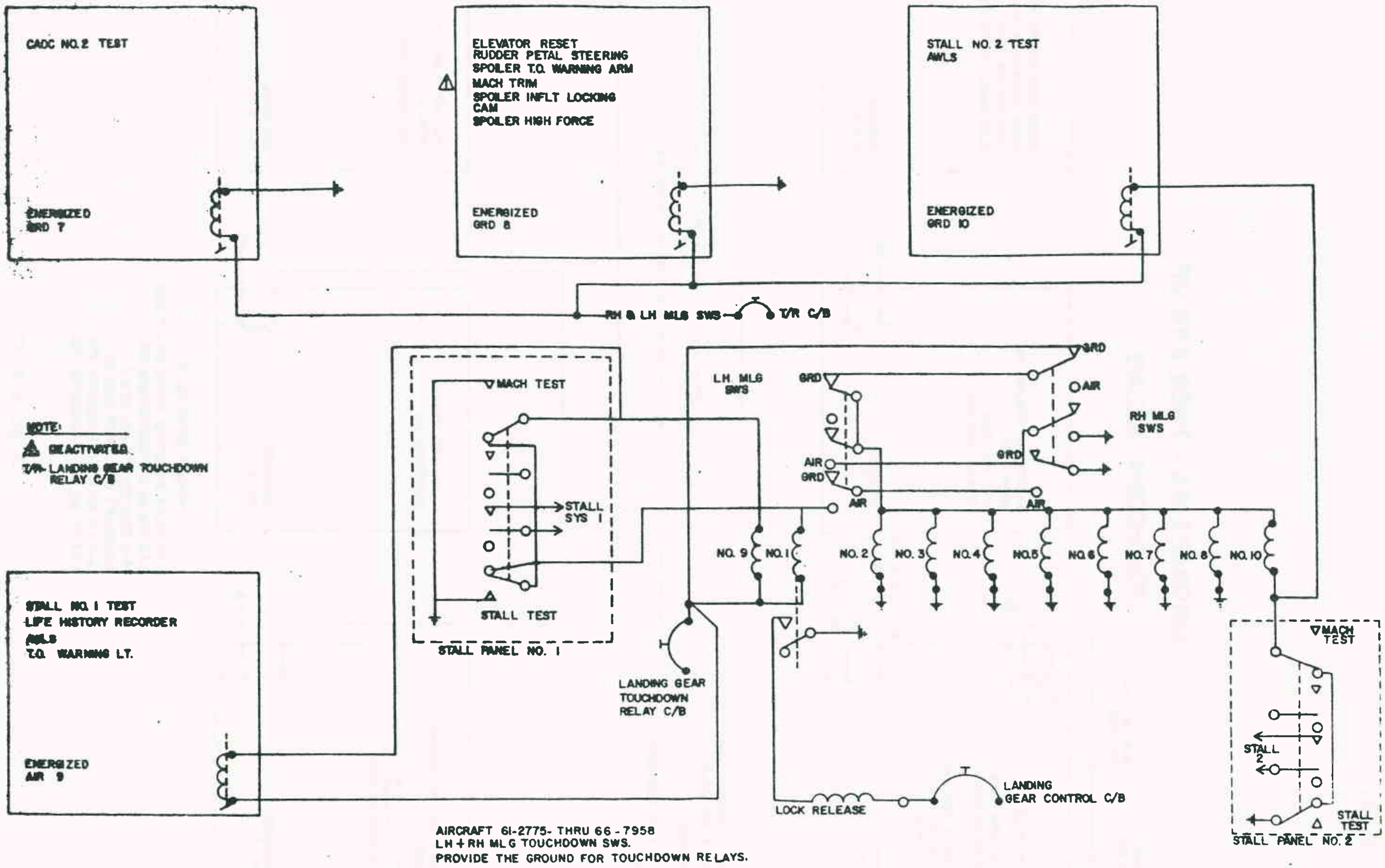
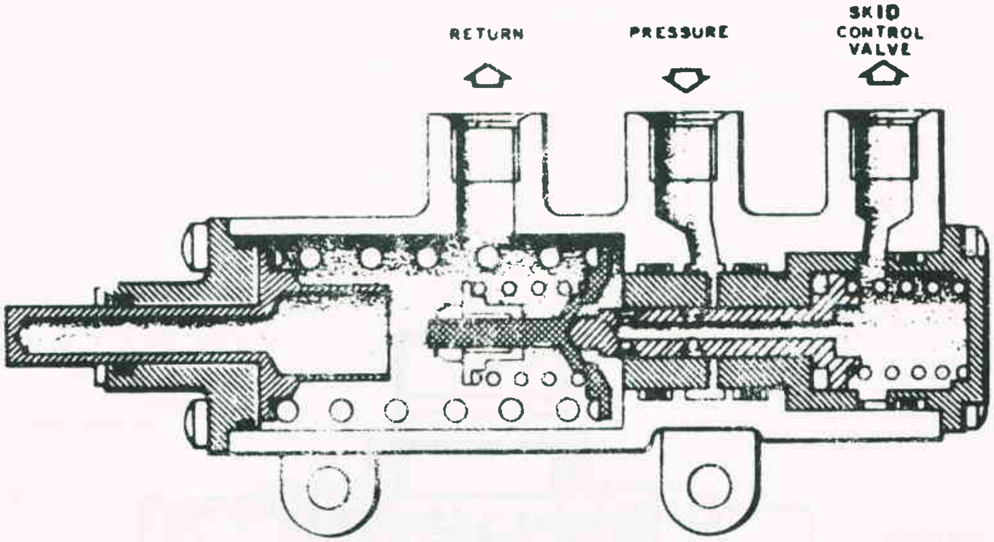
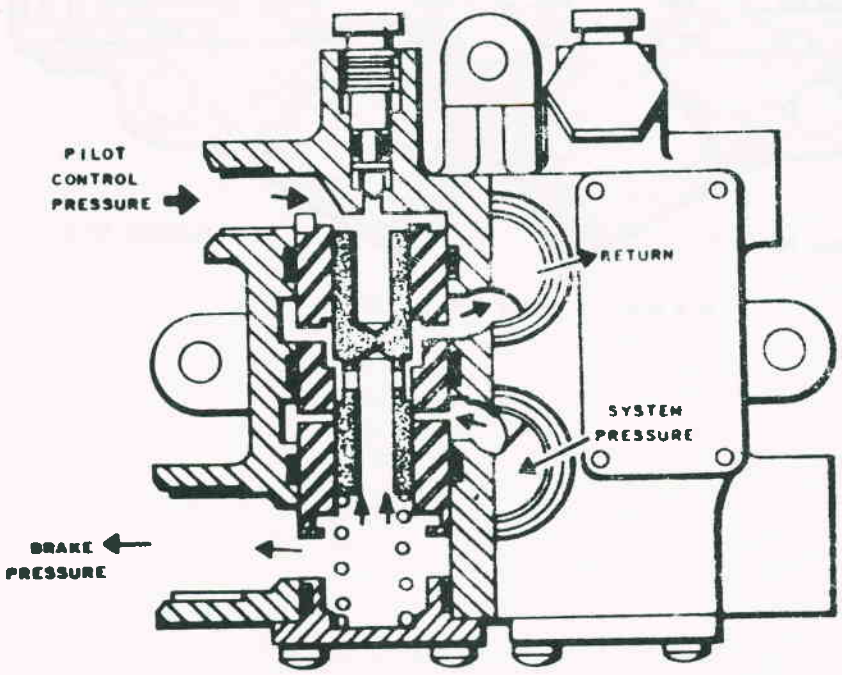


Figure 4-73
4-120

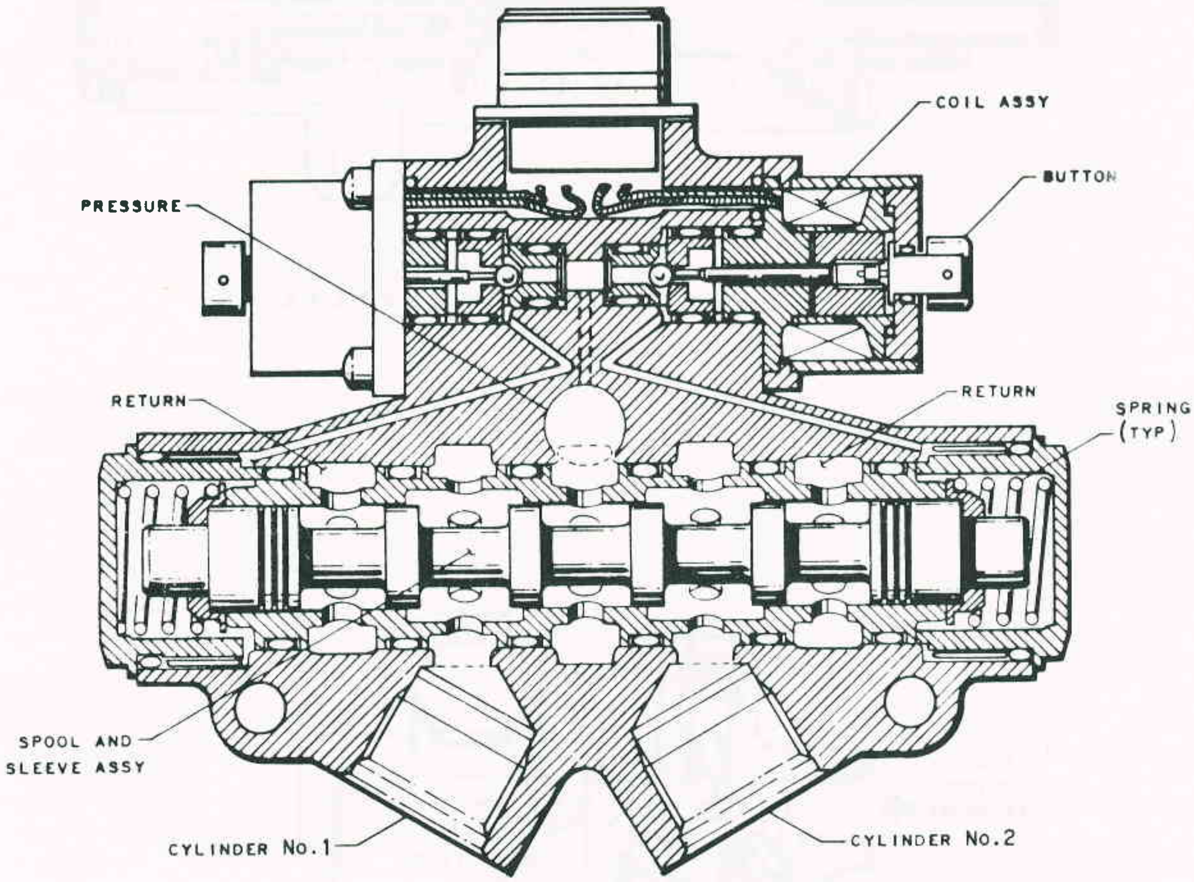


PILOT METERING VALVE



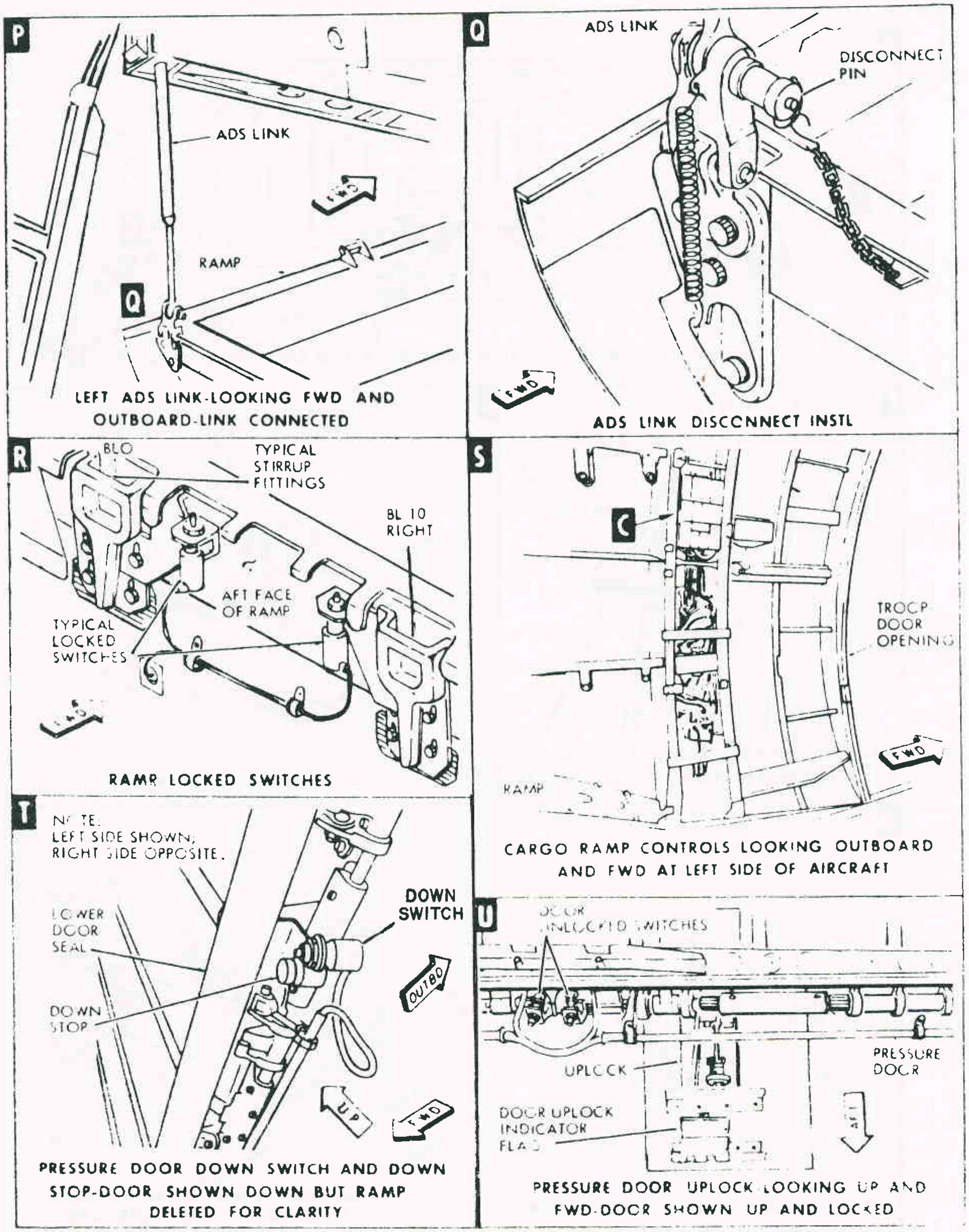
EMERGENCY BRAKE MAIN METERING VALVE

Figure 4-74



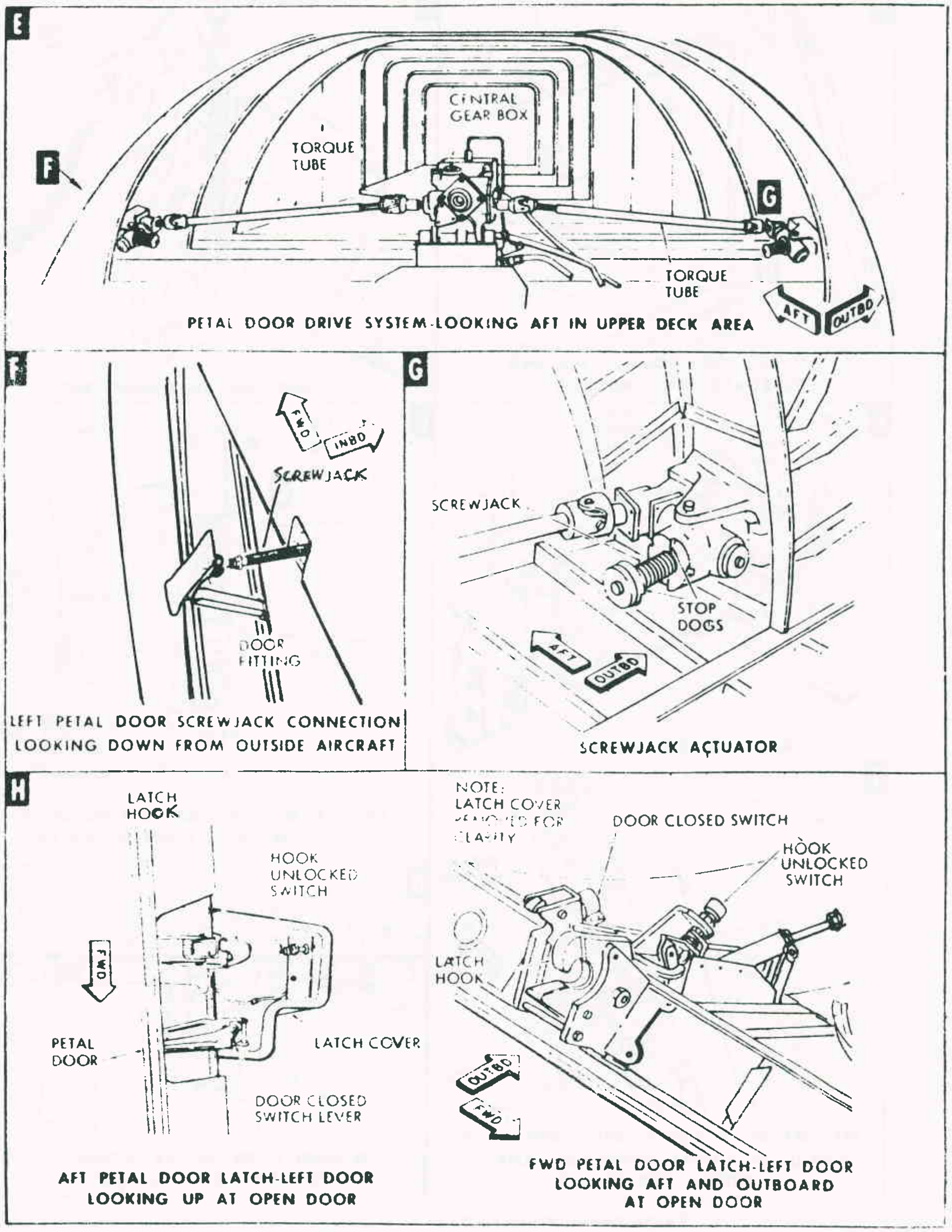
RAMP CONTROL VALVE

Figure 4-75



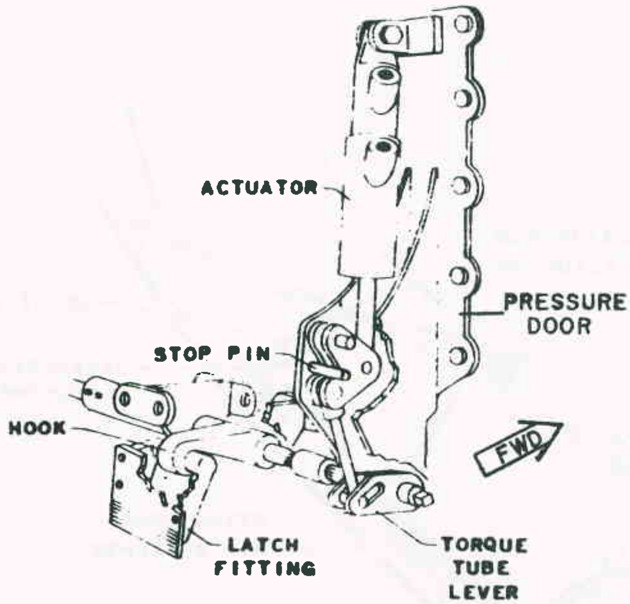
Cargo Ramp, Pressure Door

Figure 4-76

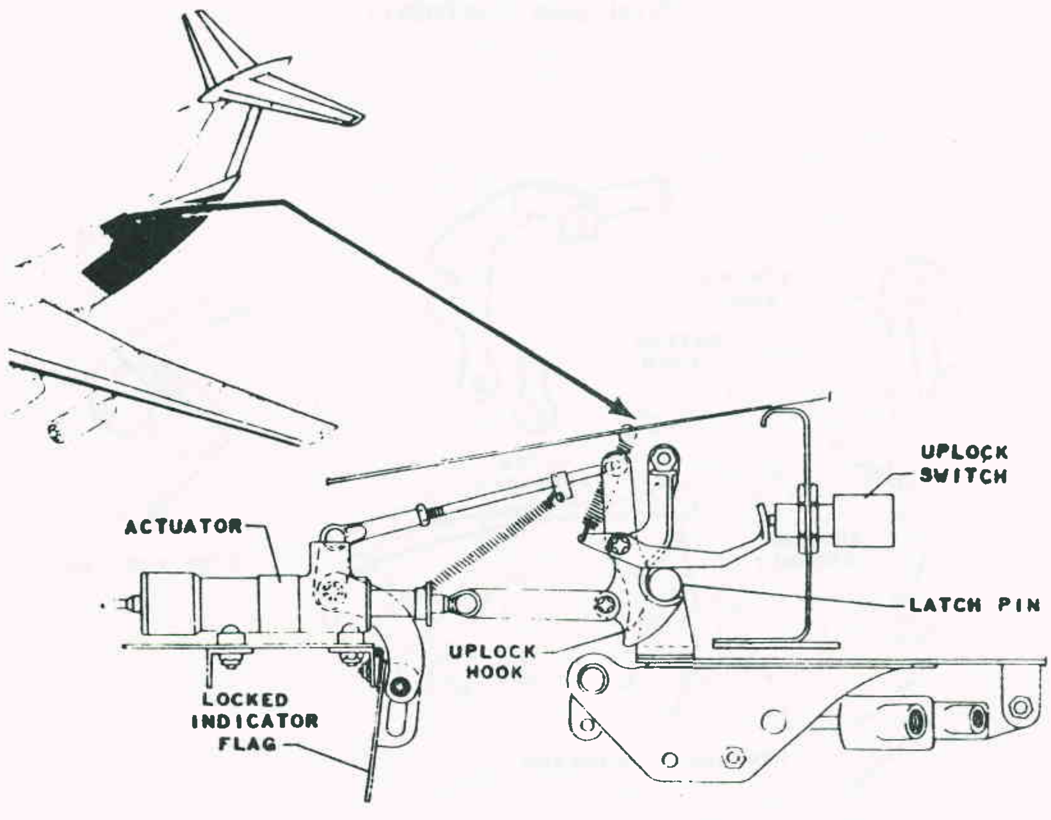


Petal Door Components and Locations

Figure 4-77

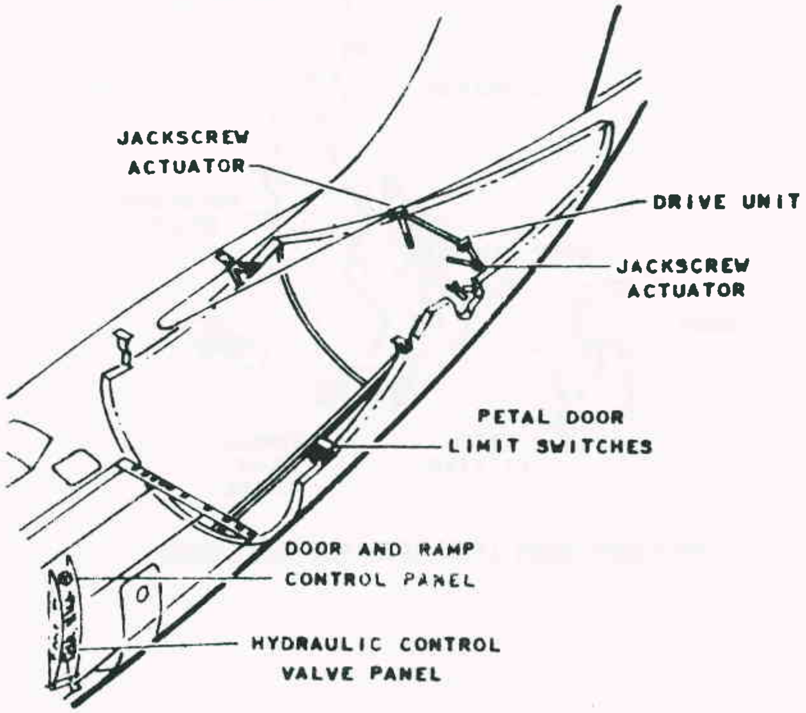


PRESSURE DOOR LOCK ACTUATOR AND LOCKS

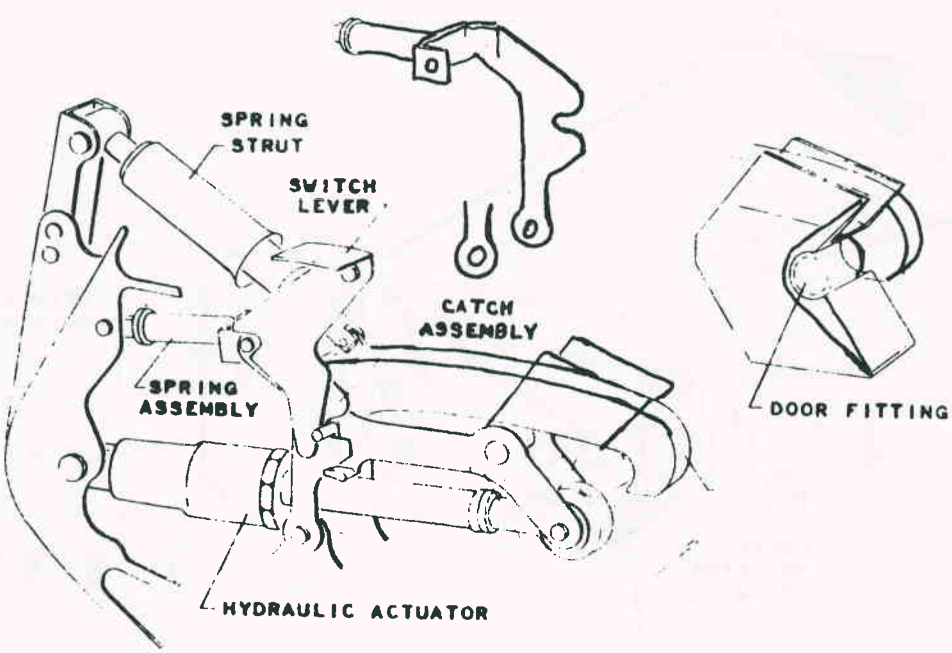


PRESSURE DOOR UPLOCK

Figure 4-78



PETAL DOOR COMPONENTS



PETAL DOOR LOCKS

Figure 4-79