CHAPTER

27

Flight Controls

CHAPTER 27
FLIGHT CONTROLS

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FLIGHT CONTROLS

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FLIGHT CONTROLS - FLIGHT COMPARTMENT CONTROLS AND INDICATIONS - 1

General

The flight control indication and control components are in the flight compartment.

Aileron

The aileron control wheel is on the top of the elevator control column. The aileron trim indication is on the top of the control wheel.

Elevator

The elevator control columns are forward of the pilot seats.

Rudder

The rudder pedals are forward of the pilot seats.

Flaps and Slats

The alternate flap switches are on the flight control panel on the P5 forward overhead panel. The indication for the leading edge devices is on the P5 aft overhead panel. The trailing edge flaps indication and the flap load relief indication are on the P1 captain's panel.

Spoilers and Speedbrakes

A green SPEED BRAKE ARM light and an amber SPEED BRAKE DO NOT ARM light are on the P1 panel. The SPEEDBRAKES EXTENDED light is on the P3 panel.

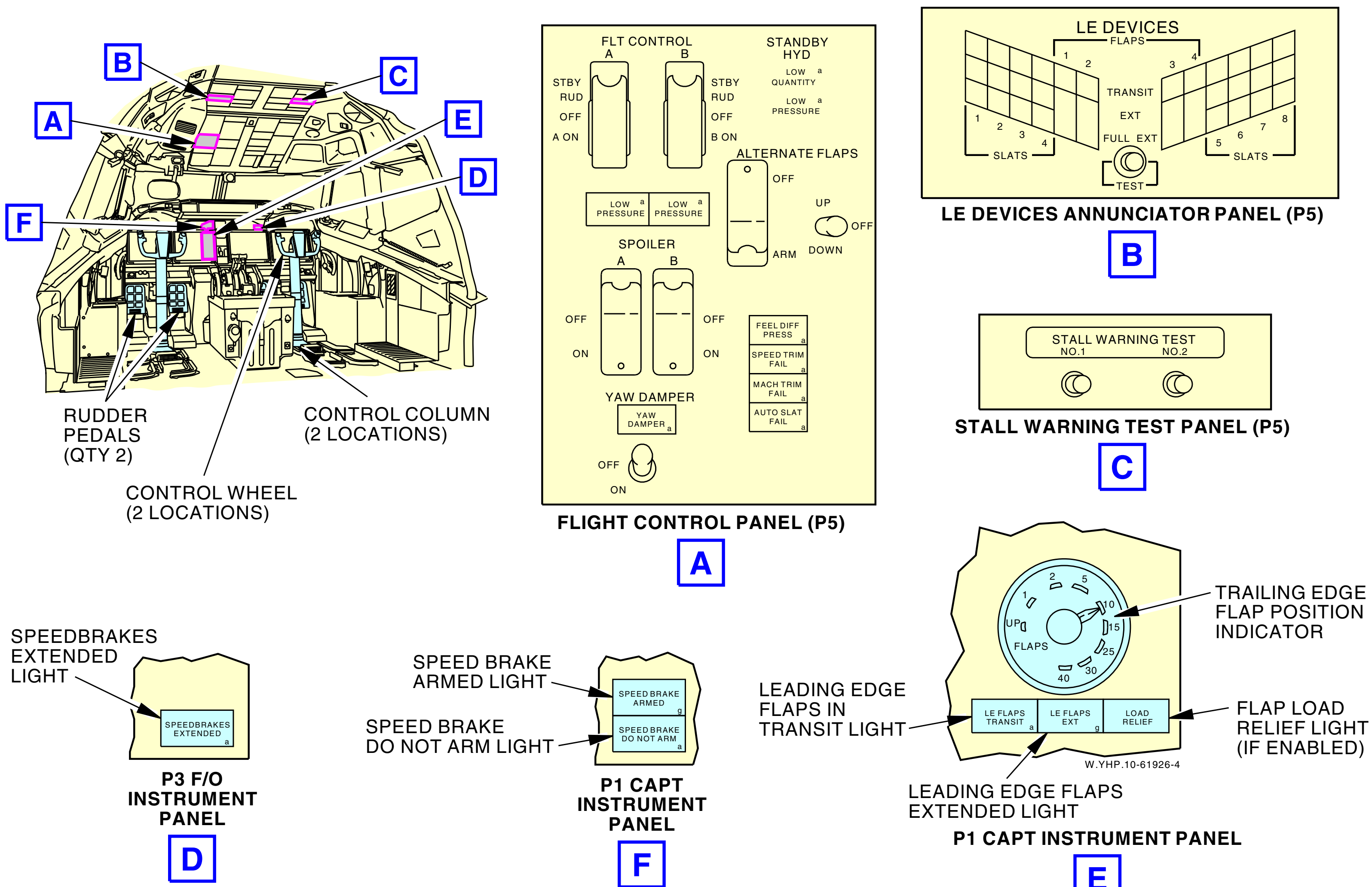
Horizontal Stabilizer

The electric trim switches are on the outboard side of each control wheel.

Stall Warning

The stall warning test switches are on the P5 aft overhead panel.

FLIGHT CONTROLS - FLIGHT COMPARTMENT CONTROLS AND INDICATIONS - 1



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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - INTRODUCTION

General

The flight controls system has some multiple use components. This section supplies information for these multiple use components:

- Flight control cables
- Flight control panel
- Flight control hydraulic modular packages.

Flight Control Cables

You use the flight control cables to give manual input to each flight control system.

Flight Control Panel

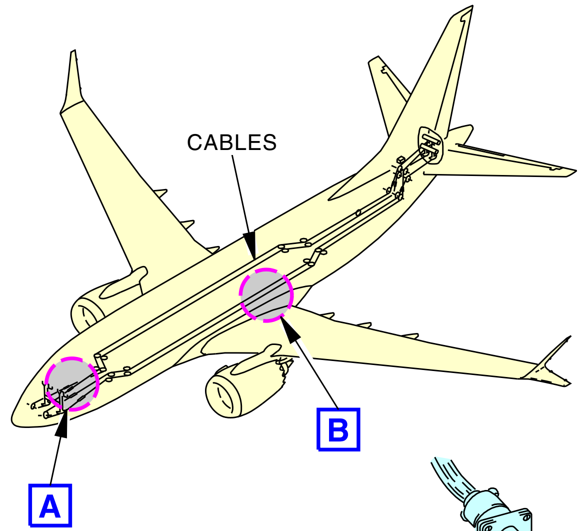
The flight control panel has hydraulic control switches and caution lights for several of the flight control systems.

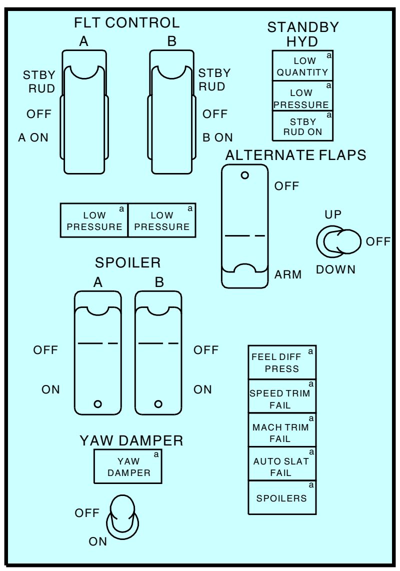
Flight Control Hydraulic Modular Packages

The two flight controls hydraulic modular packages control and monitor hydraulic pressure to the flight controls. Each package contains these components:

- Flight controls shutoff valve
- Low pressure warning switch
- Spoiler shutoff valve

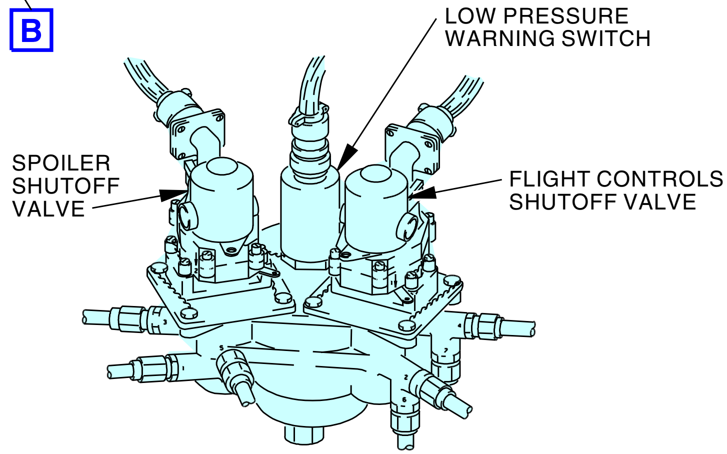
FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - INTRODUCTION





FLIGHT CONTROL PANEL (P5-3)

A



FLIGHT CONTROL HYDRAULIC MODULAR PACKAGE

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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - INTRODUCTION

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL CABLES

Purpose

The flight control cables give manual input to each flight control system.

Location

Most cables are under the floor and go from the flight compartment to the respective flight controls.

Physical Description

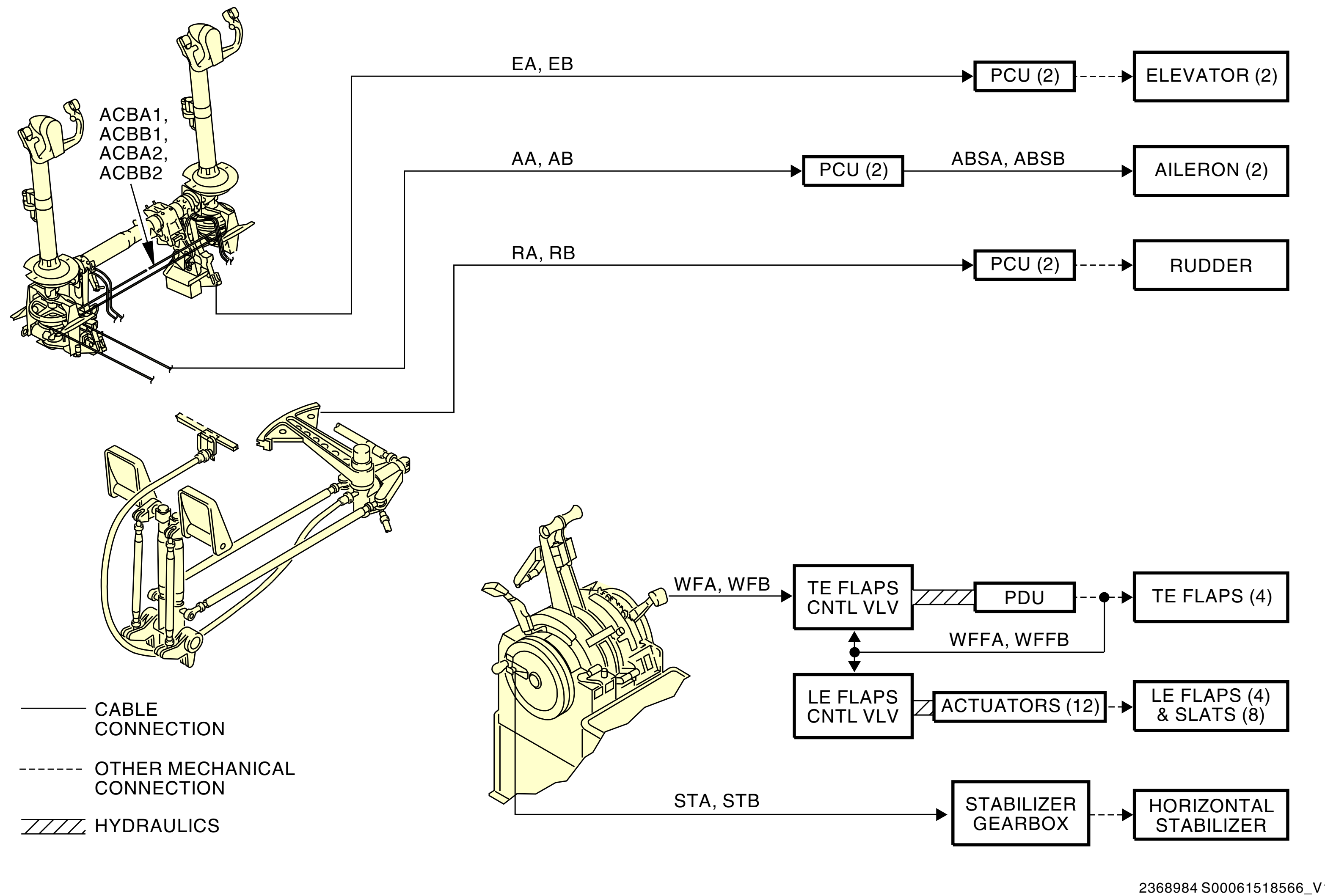
The cables are steel components specially treated for corrosion protection.

Functional Description

Each cable set is a pair. During a normal input, the tension in one cable increases and moves the components downstream. These are the pairs of cables:

- Aileron control bus cables (ACBA1, ACBA2, ACBB1, ACBB2)
- Aileron left body cables (AA, AB)
- Aileron wing cables (ABSA, ABSB)
- Elevator control cables (EA, EB)
- Rudder control cables (RA, RB)
- Flap control cables (WFA, WFB)
- Flap follow-up cables (WFFA, WFFB)
- Stabilizer control cables (STA, STB)

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL CABLES



FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL CABLES

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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL PANEL

Purpose

The flight control panel has hydraulic control switches and caution lights for several of the flight control systems.

Location

The flight control panel is in the flight compartment on the P5 forward overhead panel.

Flight Control Switch

Each flight control switch has these positions:

- STDBY RUD position: Removes system pressure from ailerons, elevators, elevator feel computer, and rudder. Turns on the standby pump and pressurizes the standby power control unit.
- OFF position: Removes system pressure from ailerons, elevators, elevator feel computer, and rudder.
- ON position: System pressure is on to the ailerons, elevators, elevator feel computer, and rudder. The ON position is normal with the guard closed.

Flight Control Low Pressure Light

Each flight control low pressure light monitors the pressure to the ailerons, elevators, elevator feel computer, and rudder.

Each flight control low pressure light monitors the position of the standby rudder shutoff valve when the flight control switch is in the STDBY RUD position.

Flight Spoiler Switch

Each flight spoiler switch has these positions:

- OFF position: Removes system pressure from the flight spoilers.
- ON position: System pressure is on to the flight spoilers. The ON position is normal with the guard closed.

Yaw Damper Switch and Warning Light

The yaw damper switch controls the yaw damper system operation. The yaw damper warning light comes on when the system is disengaged. See the yaw damper system section for more information. (SECTION 22-23)

Standby Hydraulic Low Quantity, Low Pressure and Rudder On Lights

The standby hydraulic low quantity light comes on when the standby reservoir quantity is low. The standby hydraulic low pressure light comes on when the standby system pressure is low. The standby hydraulic rudder on light comes on when there is low hydraulic pressure in either system A or B, the flaps are not up and the in-air or wheel speed is greater than 60 knots or if the force fight monitor trips in the main PCU. See the standby hydraulic system section for more information. (SECTION 29-22)

Alternate Flaps Arm Switch and Control Switch

The alternate flaps arm switch and the alternate flaps control switch are used for alternate flaps operation. See the TE flap system section for more information about the alternate flaps switches and the functional description of alternate operation. (SECTION 27-51) See the LE flap and slat control system section for more information about alternate operation. (SECTION 27-81)

Flight Control Panel Warning Lights

The feel differential pressure light comes on when there is a difference between the system A and system B metered pressures in the elevator feel computer. See the elevator and tab control system section for more information about the elevator feel computer functional description. (SECTION 27-31)

The speed trim fail light comes on when the speed trim system function in the flight control computers (FCCs) is not available. See the digital flight control system section for more information. (SECTION 22-11)

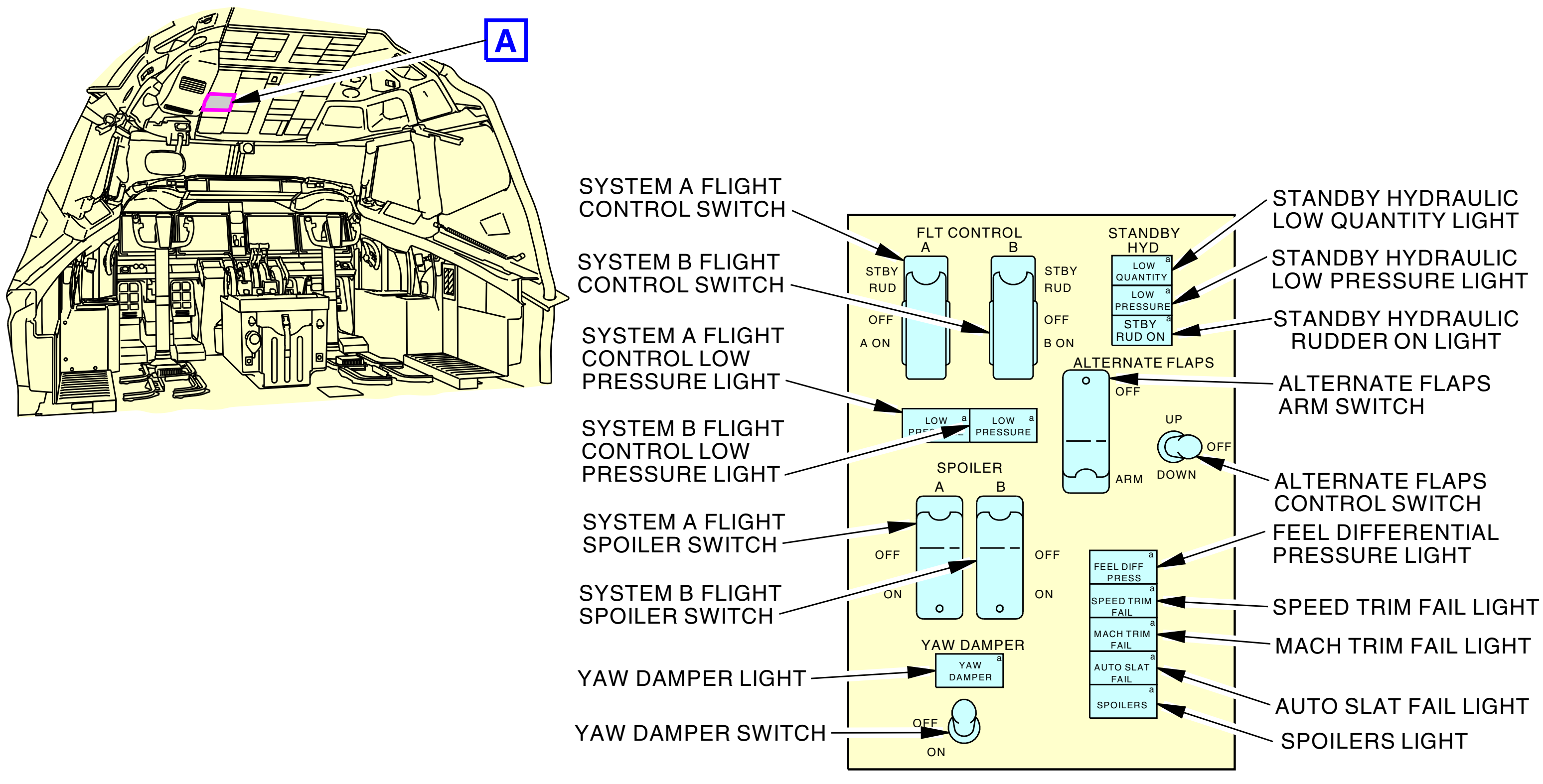
The mach trim fail light comes on when the mach trim function in the flight control computers (FCCs) is not available. See the digital flight control system section for more information. (SECTION 22-11)

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL PANEL

The autoslat fail light comes on when the autoslat function is not available. See the LE autoslat system section for more information about the LE autoslat system functional description. (SECTION 27-83)

The spoilers light comes on when the spoilers function is not available. See flight spoilers section for more information about the flight spoilers functional description. (SECTION 27-61)

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL PANEL



FLIGHT CONTROL PANEL (P5-3)

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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROL PANEL

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROLS HYDRAULIC MODULAR PACKAGES

Purpose

The flight controls hydraulic modular packages have the components that control the hydraulic pressure to the primary flight controls and to the flight spoilers.

Location

The flight controls hydraulic modular packages are on the forward bulkhead of the main landing gear wheel well. The system A package is on the left and the system B package is on the right.

Physical Description

Each flight controls hydraulic modular package is a manifold assembly and contains these components:

- Flight controls shutoff valve
- Spoiler shutoff valve
- Low pressure warning switch

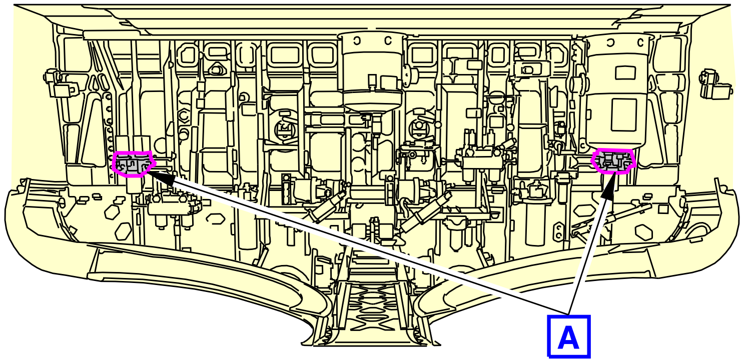
The flight controls shutoff valve and spoiler shutoff valve each have a position indicator/manual override lever with positions 1 and 2.

Functional Description

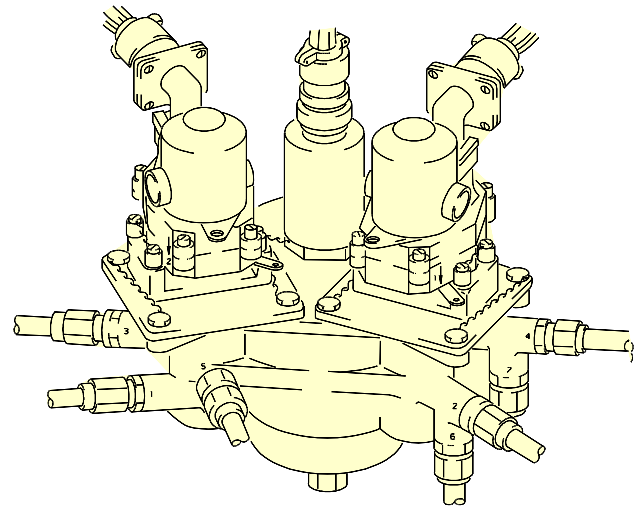
The flight control shutoff valves have 28v dc motors. The respective flight control switch on the flight control panel controls each valve. They are normally open which allows pressure to the flight controls.

The spoiler shutoff valves have 28v dc motors. The respective spoiler switch on the flight control panel controls each valve. They are normally open which allows pressure to the spoilers.

The low pressure warning switch is downstream of the flight control valve. It turns on an amber light when it senses low pressure to the flight controls.



MAIN GEAR WHEEL WELL
(VIEW IN THE FORWARD DIRECTION)



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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROLS SHUTOFF VALVE

Purpose

The flight controls shutoff valves control the system A and B pressure to the aileron PCUs, elevator PCUs, elevator feel computer, and the main rudder PCU.

Location

The flight controls shutoff valves are on the right side of each flight controls hydraulic modular package.

Physical Description

Each flight controls shutoff valve is a spool valve attached by four bolts to a cavity of the flight controls hydraulic modular package. A splined cam converts rotary motor action to linear spool travel.

Control

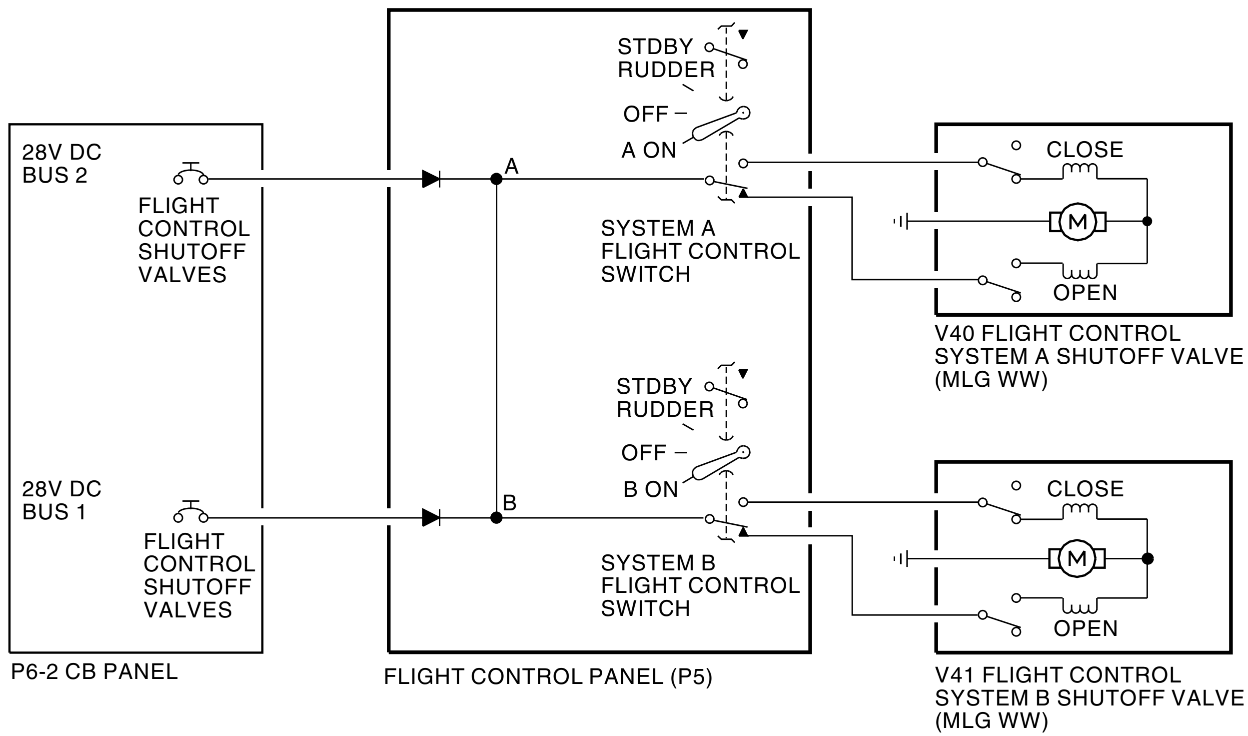
The system A flight control switch (FLT CONTROL A) on the flight control panel controls the system A flight control shutoff valve. The system B flight control switch (FLT CONTROL B) controls the system B flight control shutoff valve.

Operation

A 28v dc motor controls each flight control shutoff valve. The valves are normally open which allow pressure from each system to the flight controls. When you move the flight control switch to the OFF position, the valve closes.

Monitor

When the valve is open, the indicator lever is in position 1. When the valve closes, the indicator lever moves to position 2.



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FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FLIGHT CONTROLS SHUTOFF VALVE

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - LOW PRESSURE WARNING SWITCH

Purpose

The low pressure warning switch gives an amber light indication when there is low system A or B pressure to the flight control system.

Location

The low pressure switches are a part of each flight controls hydraulic modular package.

The amber indicator lights are on the flight control panel on the P5 forward overhead panel.

Power

The master dim and test (MD&T) system supplies power to the lights.

Control

The low pressure light connects to the low pressure warning switch only when the flight control switch is in the ON or OFF positions. When the flight control switch is in the STDBY RUD position, the standby rudder shutoff valve controls the low pressure light through the valve position relay. See the standby hydraulic system section for more information about the standby rudder shutoff valve. (SECTION 29-22)

Operation

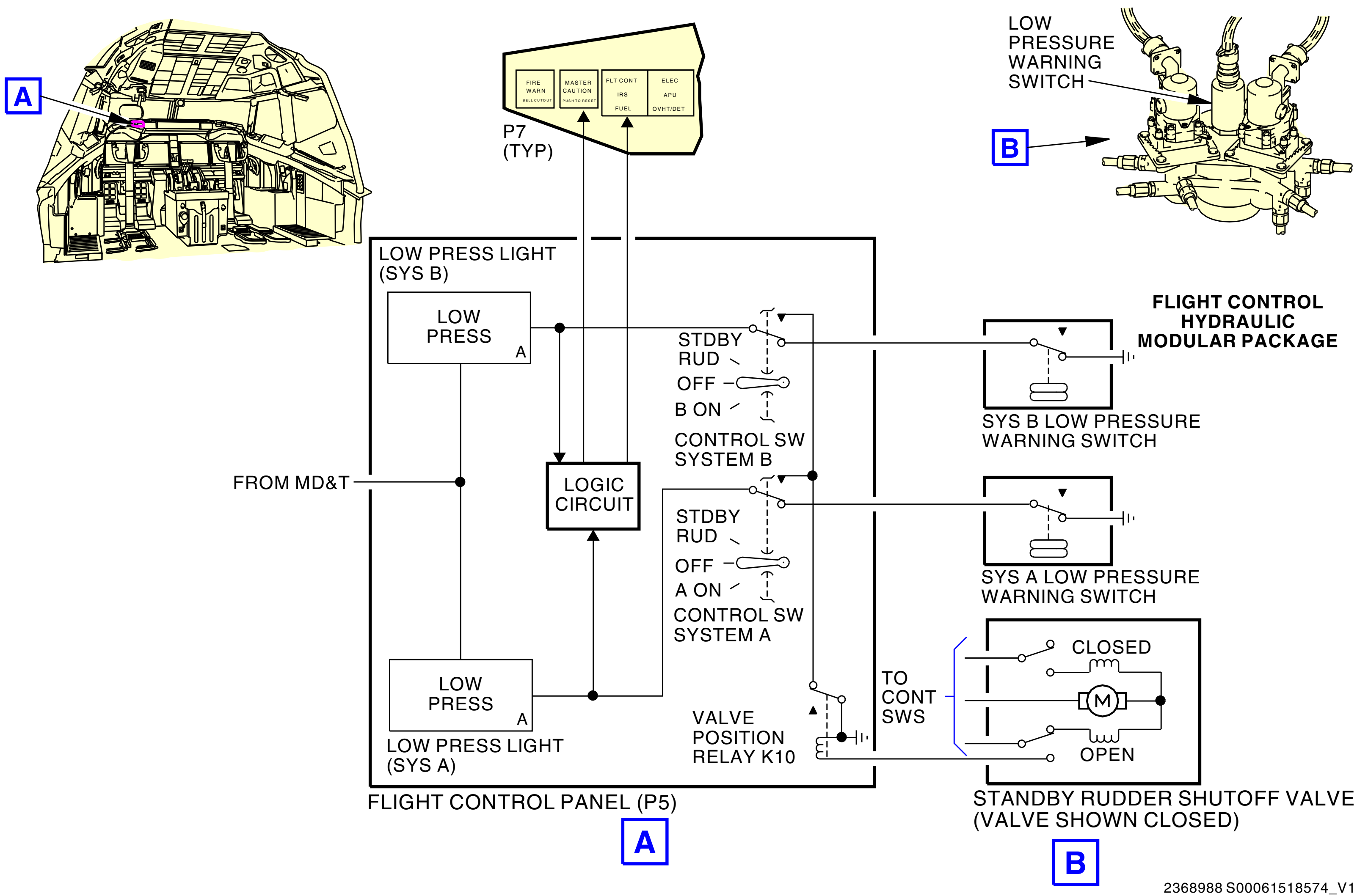
The low pressure switch is open when hydraulic pressure is available to the flight controls. The switch closes when the pressure is less than 1300 psi and opens when the pressure is above 1600 psi. This supplies a ground to the low pressure light when closed.

When the flight control switch is in the STDBY RUD position, the low pressure warning switch is not connected to the low pressure light. When the standby rudder shutoff valve is in the closed position, the valve position relay provides a ground to the low pressure light. When the standby rudder shutoff valve moves to the open position, the valve position relay energizes and removes the ground to the low pressure light.

Monitor

When the low pressure light comes on, the master caution and the FLT CONT annunciator also come on.

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - LOW PRESSURE WARNING SWITCH



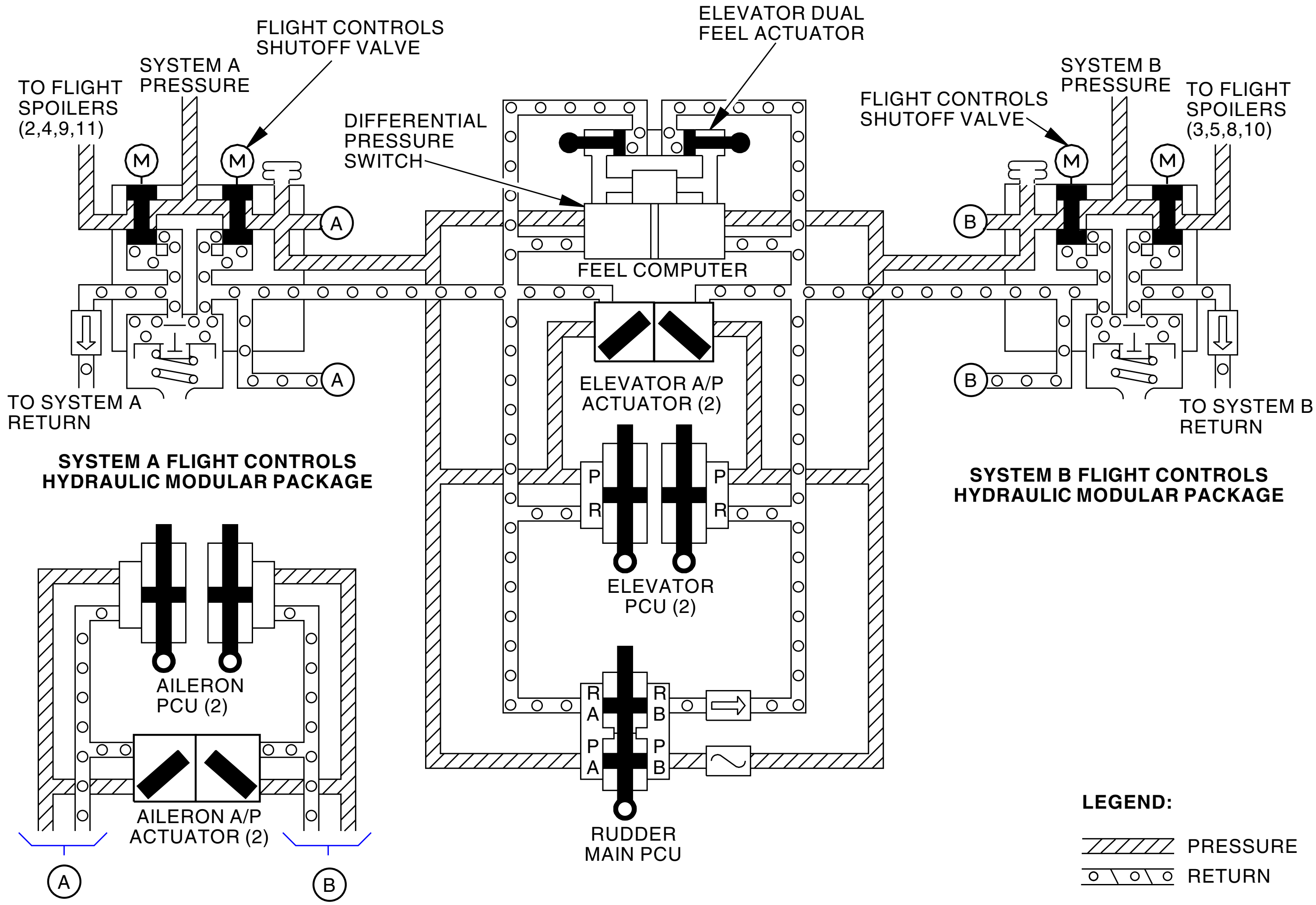
FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - LOW PRESSURE WARNING SWITCH

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FUNCTIONAL DESCRIPTION

General

This is the system A and B hydraulic distribution to the primary flight controls. The pressure goes to the flight control hydraulic modular package. Then it goes through the flight controls shutoff valve. A low pressure warning switch monitors for low pressure to the flight controls. Then the pressure goes to the using components.

FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FUNCTIONAL DESCRIPTION



FLIGHT CONTROLS MULTIPLE USE SYSTEMS/UNITS - FUNCTIONAL DESCRIPTION

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AILERON AND AILERON TRIM CONTROL SYSTEM - INTRODUCTION

Purpose

The ailerons control the flight attitude of the airplane about the longitudinal axis.

Location

The ailerons are on the wing outboard trailing edge.

Roll Control

During roll control, the aileron on one wing moves up, and the aileron on the other wing moves down.

The pilots turn the control wheels to control roll manually. When engaged, the autopilot automatically controls the ailerons. During autopilot operation, actuators give inputs to move the control wheels.

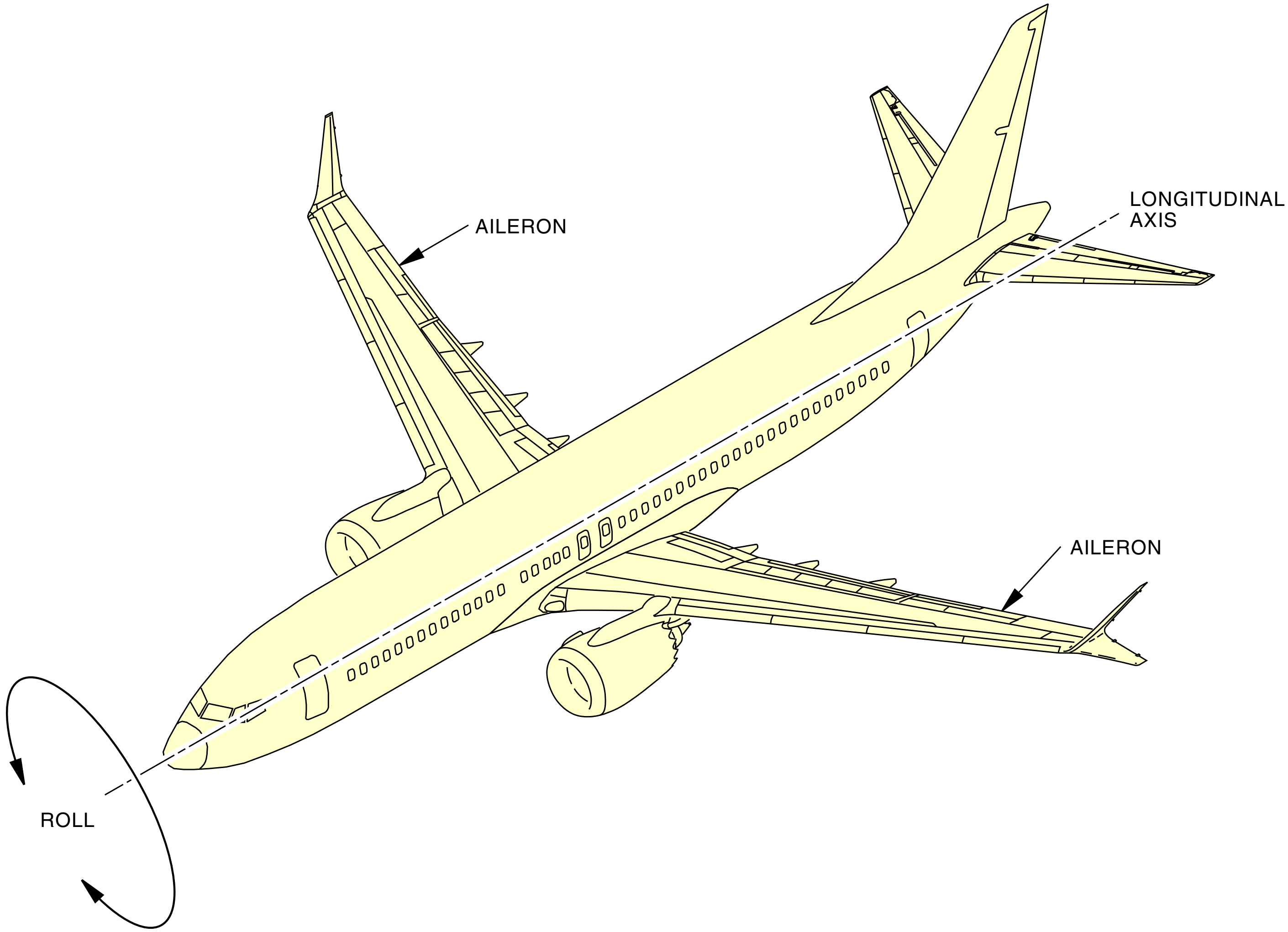
The flight spoilers also supply roll control.

See the flight spoiler control system section for more information on the spoiler and speedbrake control. (SECTION 27-61)

Abbreviations and Acronyms

- A/P - autopilot
- A/S - airspeed
- C/W - control wheel
- CWS - control wheel steering
- FCC - flight control computer
- FDAU - flight data acquisition unit
- LE - leading edge
- MLG - main landing gear
- NLG - nose landing gear
- PCU - power control unit
- S/B - speedbrake
- SOV - shutoff valve
- STAB - stabilizer
- TE - trailing edge
- xfer - transfer

AILERON AND AILERON TRIM CONTROL SYSTEM - INTRODUCTION



AILERON AND AILERON TRIM CONTROL SYSTEM - INTRODUCTION

AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

General

The pilots use the aileron control wheels to move the ailerons and flight spoilers. The autopilot, when engaged, automatically controls them.

Manual Operation - Control Wheels

The flight crew uses two conventional control wheels to control the roll attitude of the airplane. A transfer mechanism on the first officer side, supplies a mechanical link between the control wheels. If one control wheel cannot move, the other continues to control.

The control wheel gives mechanical input to the power control unit (PCU) through cables and linkages. Hydraulic pressure goes to the PCU and makes the housing move. The aileron PCU movement mechanically moves the aileron through the wing cables and the quadrant.

When the control wheel moves, it also gives a mechanical input to the roll control wheel steering (CWS) force transducer and the control wheel position sensor. The roll CWS force transducer sends signals to the flight control computers (FCC) proportional to control wheel turning forces. The control wheel position sensor sends signals to the flight data acquisition unit (FDAU) for control wheel position.

See the digital flight control system section for more information about the FCCs and the roll CWS force transducer. (SECTION 22-11)

See the flight data recorder section for more information about the aileron control wheel position sensor and FDAU. (SECTION 31-31)

Manual Operation - Control Wheels - Manual Reversion

During manual reversion, the control wheel gives mechanical input to the power control unit (PCU) through cables and linkages. Mechanical stops in the PCU make the housing move. The aileron PCU movement mechanically moves the aileron through the wing cables and the quadrant.

Manual Operation - Aileron Trim

The aileron trim switches and the trim actuator let the flight crew trim out unwanted control wheel forces. When the pilots move the aileron trim switches on the aileron/rudder trim panel, the switches send a signal to the aileron trim actuator and FDAU. The trim actuator moves the feel and centering unit. This movement goes to the aileron PCU. Aileron PCU movement mechanically moves the aileron through the wing cables and quadrant.

During aileron trim, the control wheels also move to supply an indication on the top of the control wheel column.

Autopilot Operation

When engaged, the flight control computers control the aileron autopilot actuators. The actuators give mechanical input to the feel and centering unit and aileron position sensor. Movement of the feel and centering unit goes to the aileron PCU and signal from the aileron position sensor go to the FCCs. The aileron PCU movement moves the aileron through the wing cables and the quadrant. The quadrant also gives mechanical input to the aileron position transmitter. The transmitter sends position signals to the (FDAU).

See the digital flight control system section for more information on the aileron autopilot operation and aileron position sensor. (SECTION 22-11)

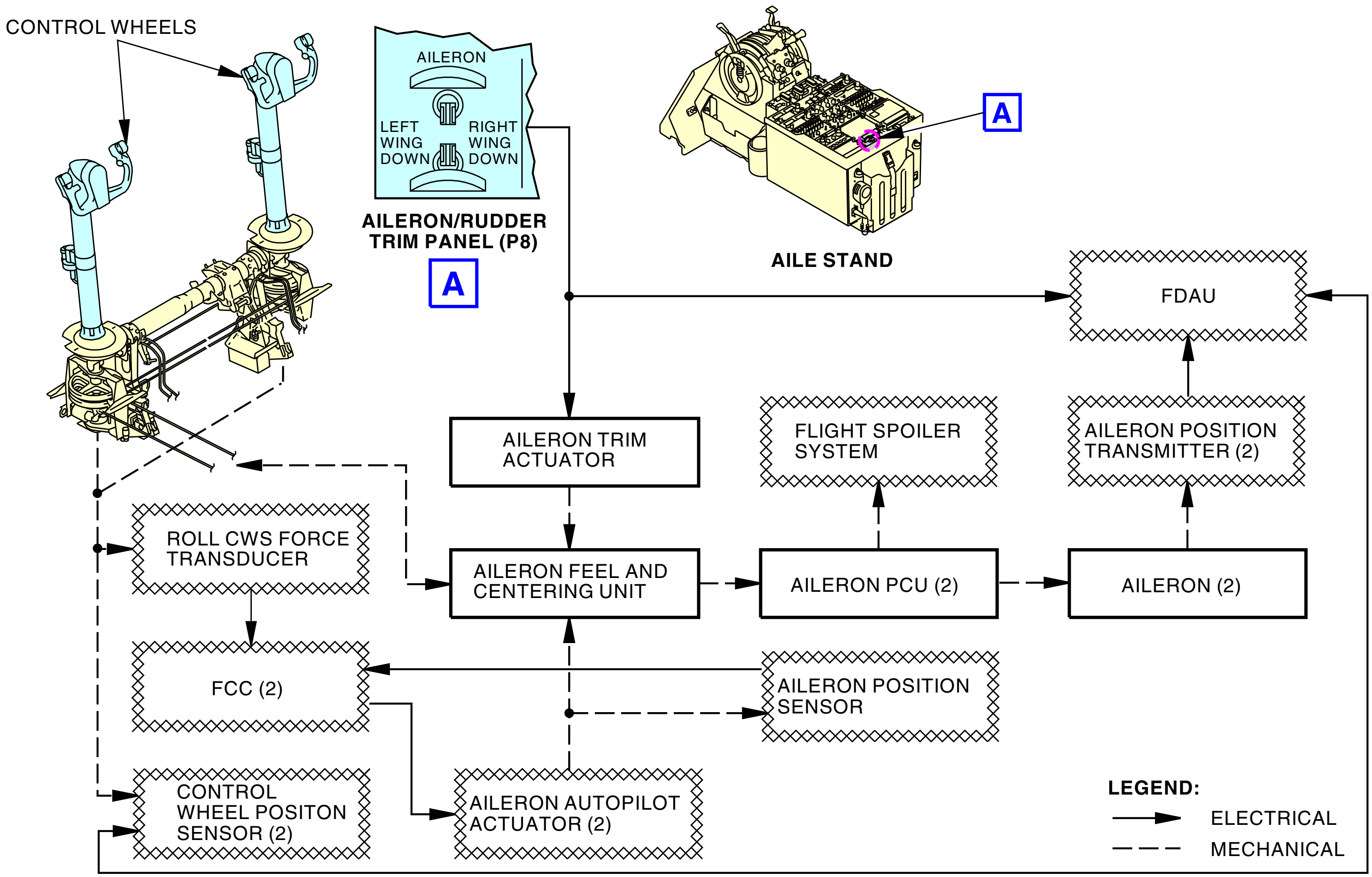
See the digital flight recorder system section for more information about the aileron position transmitter. (SECTION 31-31)

Flight Spoilers

The flight spoilers also supply roll control. When the aileron PCU moves, it supplies an input to the flight spoiler system.

See the flight spoiler control system section for more information on the spoiler and speedbrake control. (SECTION 27-61)

AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1



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AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

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AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

General

These are the components of the aileron control system:

- Aileron control wheels (2)
- Aileron control wheel drum
- ACBA1, ACBA2, ACBB1 and ACBB2; bus drum cables
- AA and AB, left body cables
- ABSA and ABSB, left and right wing cables
- Aileron control quadrant
- Aileron feel and centering unit
- Aileron power control units (2)
- Aileron body quadrants (2)
- Ailerons and wing quadrants (2)
- Balance panels (8) and tabs (2)

Aileron Control Wheels

The aileron control wheels transmit pilot inputs to the aileron trim control system. Forces from the captain control wheel go through an input shaft to the aileron control wheel drum. Forces from the first officer control wheel go through an input shaft to the aileron bus drum and cables. Input forces from the first officer go through the bus drum cables to the captain bus drum.

Aileron Control Wheel Drum

Control wheel input from the captain and first officer control wheels goes through the aileron control wheel drum to the aileron left body cables.

Control Cables

Bus drum cables ACBA1, ACBA2, ACBB1 and ACBB2 connect the left and right control wheels together.

Left body cables AA and AB provide inputs from the control wheels to the aileron control quadrant during normal operation.

Left and right wing cables ABSA and ABSB transmit force from the body quadrant to the wing quadrant to move the ailerons.

Aileron Control Quadrant

The aileron control quadrant connects to the aileron input shaft. The aileron control quadrant transmits force from the left body cables through the aileron input shaft to the aileron feel and centering unit and aileron power control units.

Aileron Feel and Centering Unit

The aileron feel and centering unit connects to the bottom of the aileron input shaft. When the shaft moves, feel force is provided by two springs in the feel and centering unit.

During electric trim, the pilots move the aileron trim switches on the aisle stand. This sends a signal to the aileron trim actuator. The trim actuator moves the aileron feel and centering unit. This moves the aileron input pogos and the aileron PCUs. Input from the trim actuator to the feel and centering unit also backdrives the aileron control wheels to a new neutral position.

Aileron Power Control Units

The two aileron power control units (PCUs) move the aileron body quadrants. The PCU rod end is fixed and the housing moves the aileron body quadrants. Input from the aileron input shaft is transmitted through input pogos to the PCUs.

Aileron Body Quadrants

The aileron body quadrants move the aileron left and right wing cables and wing quadrants. The upper aileron body quadrant also moves the aileron spring cartridge.

Ailerons and Wing Quadrants

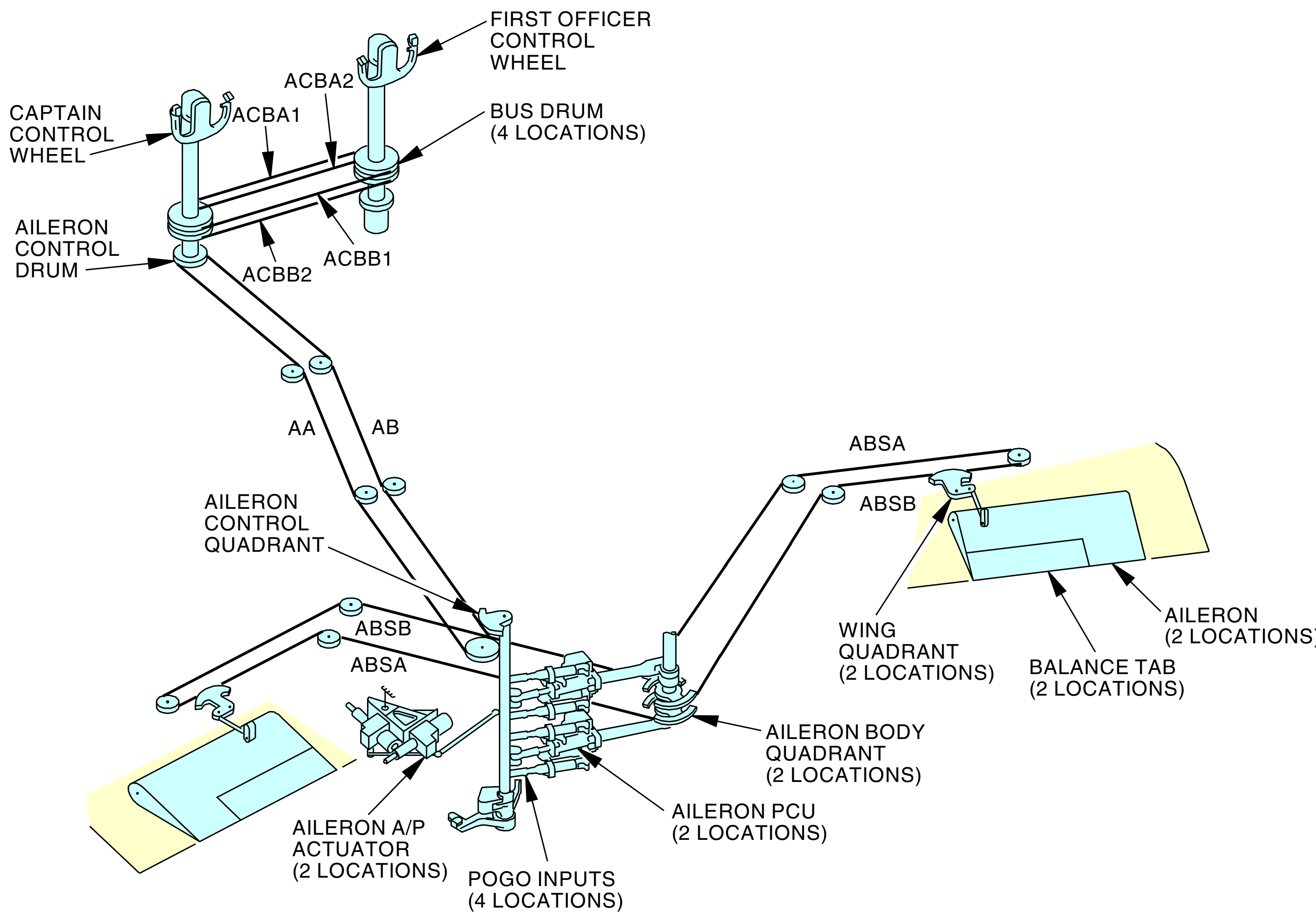
The aileron wing quadrants transmit forces from the aileron body quadrants and wing cables to the ailerons.

AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

Balance Panels and Tabs

The aileron balance panels and tabs use aerodynamic forces to help decrease the force necessary to move the ailerons in flight.

AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2



AILERON AND AILERON TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 1

General

The aileron and aileron trim control system has components in these locations:

- Flight compartment
- Forward equipment compartment
- Body.

Flight Deck Components

These are the flight compartment components:

- Aileron control wheels on the control columns
- Trim switches on the aileron/rudder trim control panel.

Forward Equipment Compartment Components

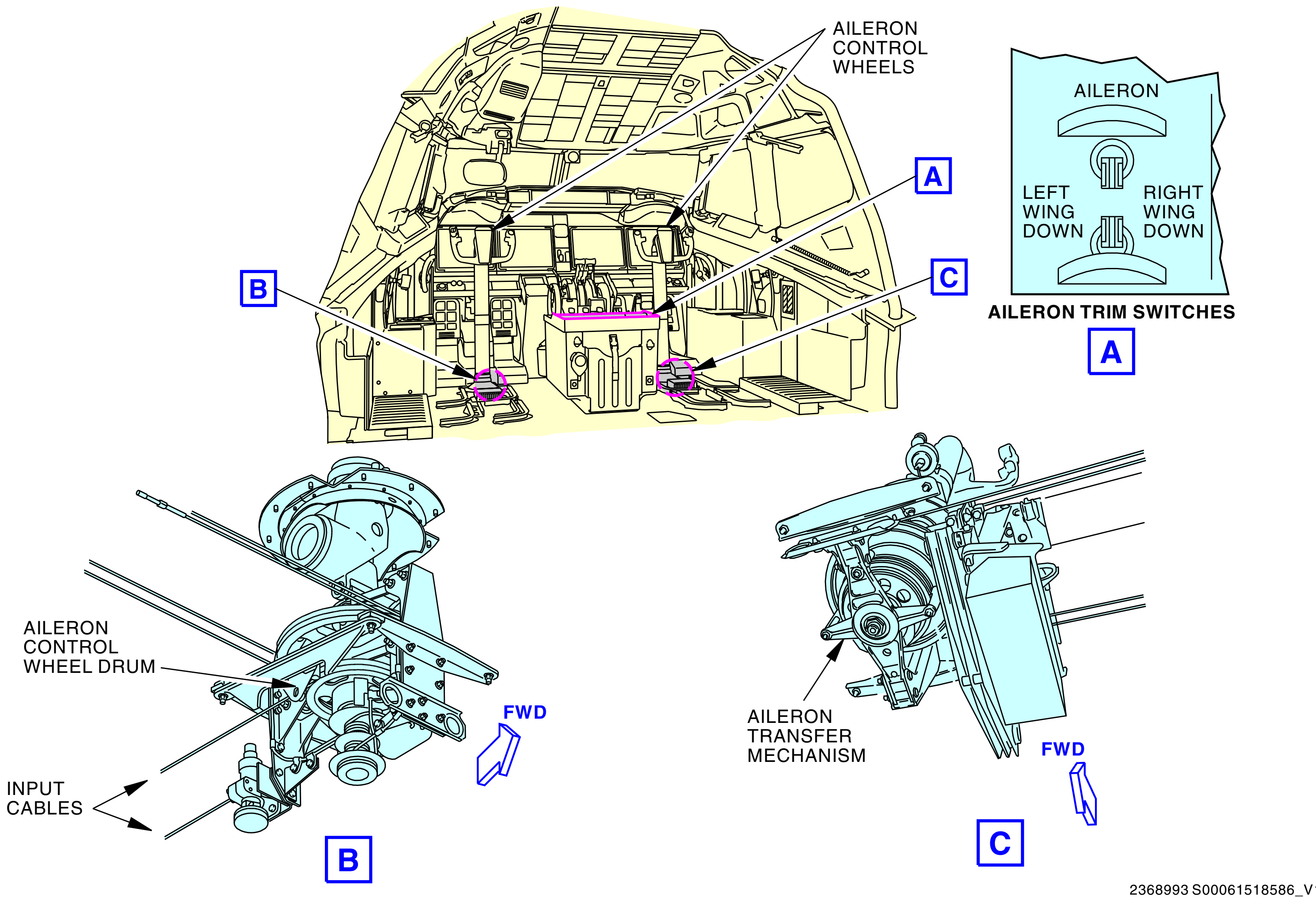
These are the forward equipment compartment components:

- Aileron control wheel drum
- Aileron transfer mechanism.

Body Components

The body components are the input cables.

AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 1



AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 1

AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 2

General

The aileron and aileron trim control system also has components in these locations:

- Main landing gear wheel well
- Wings.

Main Landing Gear Wheel Well Components

These are the main landing gear wheel well components:

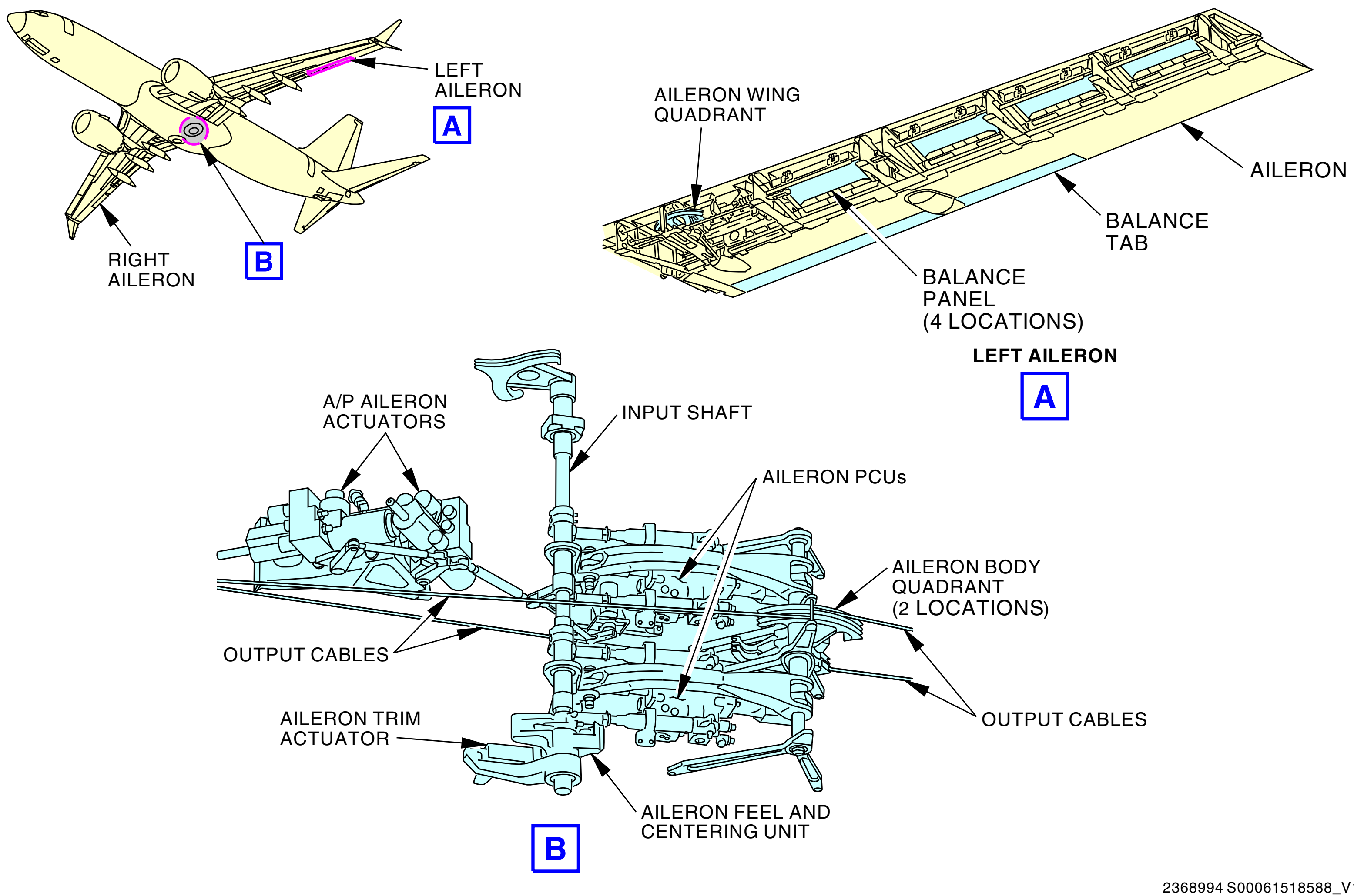
- Autopilot actuator (2)
- Input shaft
- Aileron feel and centering unit
- Aileron trim actuator
- Aileron PCU (2)
- Aileron body quadrant (2).

Wing Components

These are the wing components:

- Output cables
- Aileron wing quadrant
- Balance panel (4)
- Aileron
- Aileron balance tab.

AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 2



AILERON AND AILERON TRIM CONTROL SYSTEM - COMPONENT LOCATIONS 2

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL

Purpose

The flight crew uses two control wheels for roll control operation.

Location

The aileron control wheels are on the top of the two elevator control columns.

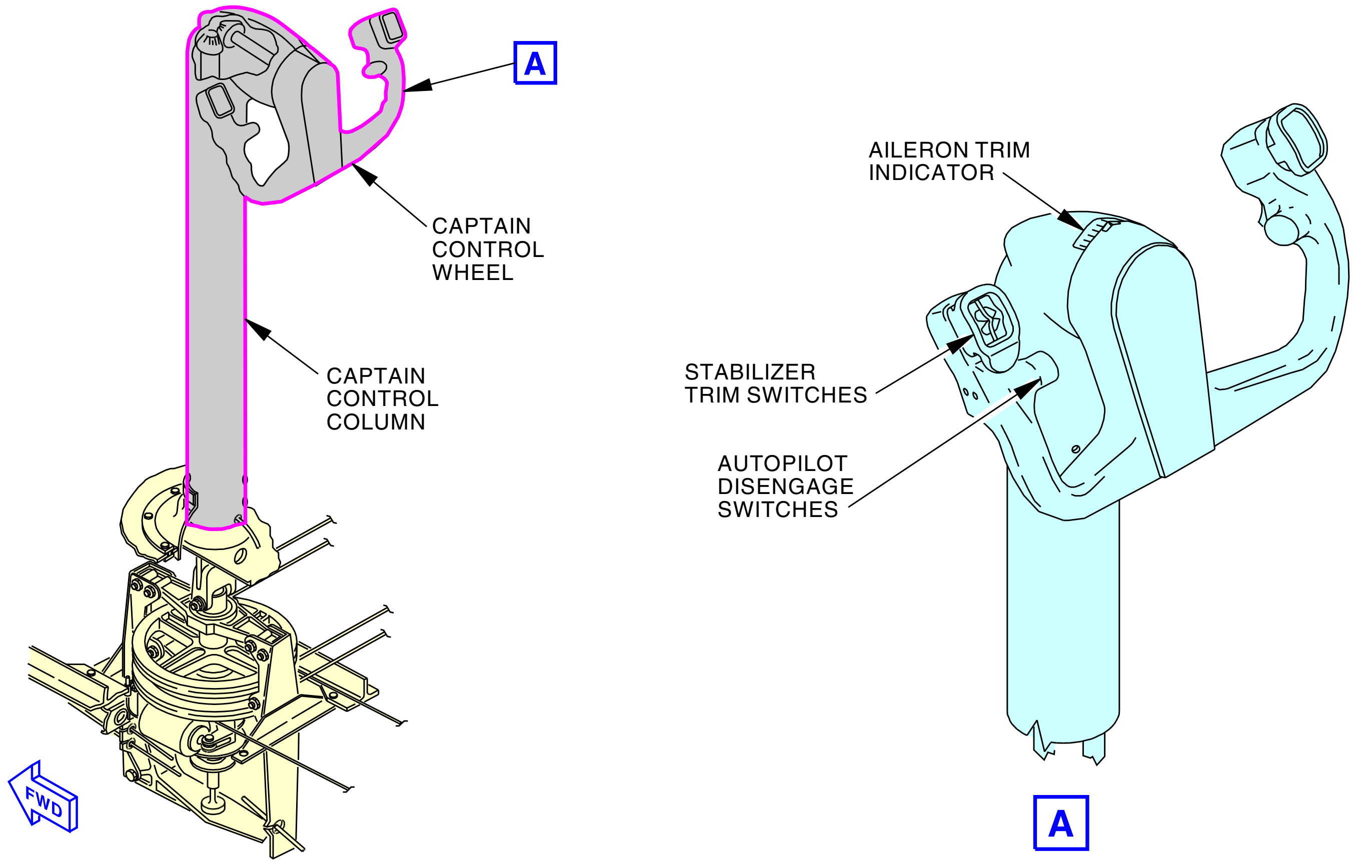
Physical Description

The aileron control wheels are similar to control wheels in other Boeing airplanes. The outboard side of each wheel contains the stabilizer trim switches and the autopilot disengage switches. The aileron trim indicator placard is on the top of the control wheel.

Functional Description

When the pilot turns the control wheel, the control cables move. Mechanical stops in the aileron control wheel drum and aileron transfer mechanism keep the control wheel movement to a limit of 107.5 degrees left and right.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL DRUM

Purpose

The aileron control wheel drum assembly connects the two control wheels and the left body cables.

Location

The aileron control wheel drum is below the captain's control column. You get access through the forward equipment compartment door.

Physical Description

The aileron control wheel drum assembly has these components:

- Bus drum
- Crank
- Roll control wheel steering (CWS) force transducer
- Control drum
- Control wheel stops.

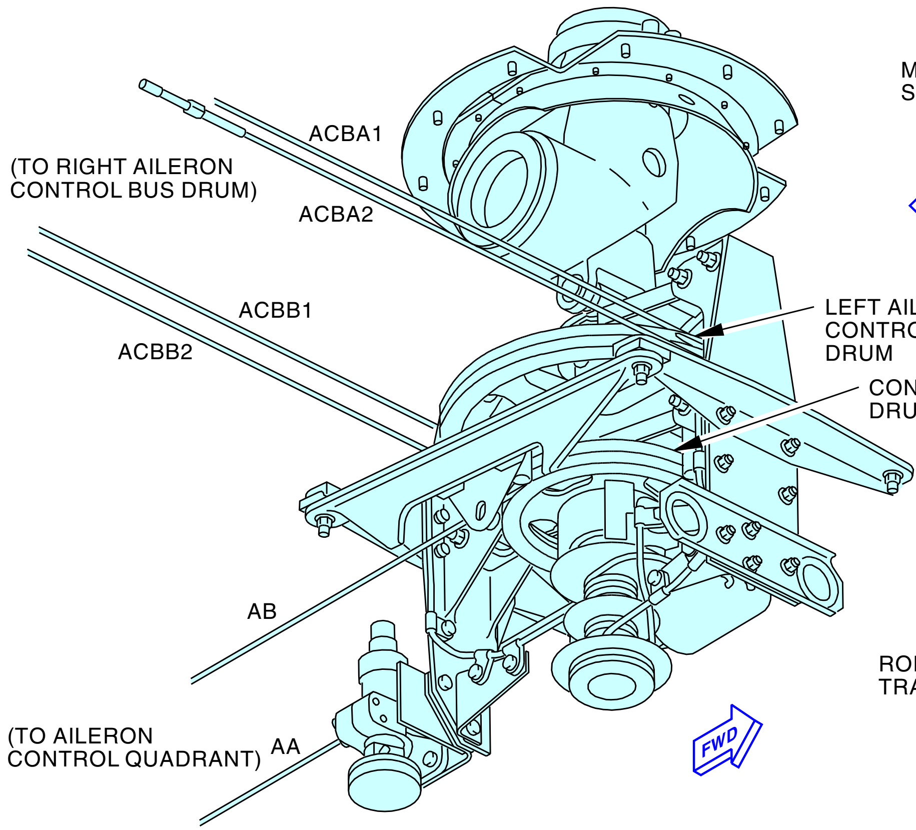
The bus drum and crank are part of the shaft. The control drum is bearing mounted. The roll CWS force transducer connects the crank and the control drum. The control wheel stops are on the control drum and airplane structure.

Functional Description

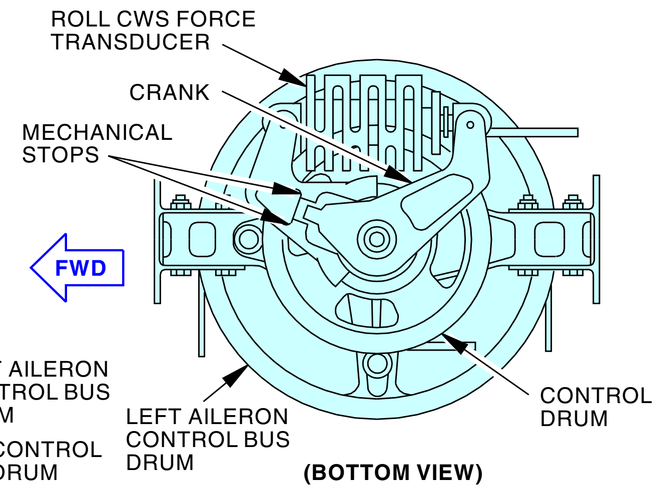
When the pilot turns the control wheel, the shaft turns the crank. The crank movement goes through the roll CWS force transducer to the control drum. Mechanical stops give protection if the roll CWS force transducer connection has a failure. The left body cables move when the control drum moves. Control wheel stops on the control drum limit the control drum and control wheel movement.

See the autoflight chapter for more information on the roll CWS force transducer operation. (SECTION 22-11)

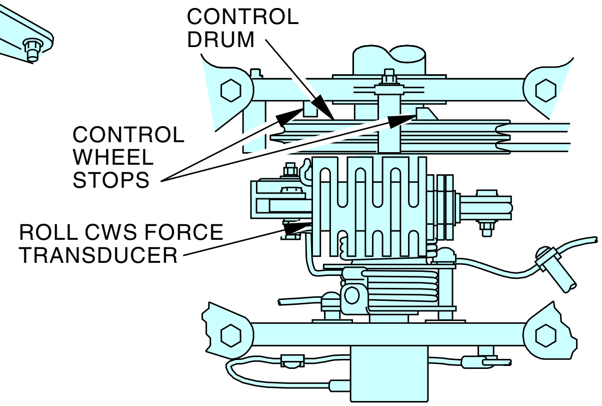
AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL DRUM



AILERON CONTROL WHEEL DRUM



(BOTTOM VIEW)



(SIDE VIEW)

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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON CONTROL WHEEL DRUM

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRANSFER MECHANISM

Purpose

The aileron transfer mechanism supplies a load path for roll control. In normal operation, the mechanism lets either pilot make the roll control commands. If the control wheel cannot move, the transfer mechanism lets the pilot operate the other control wheel. If the cable or a connection breaks, you can use the other control wheel.

Location

The aileron transfer mechanism is below the first officer's control column. You get access through the forward equipment compartment door.

Physical Description

The aileron transfer mechanism has a torsion spring and a transducer.

The torsion spring connects the aileron control bus drum to the shaft of the right control wheel.

The transducer is at the bottom of the aileron transfer mechanism.

Functional Description

During normal operation, the torsion spring supplies the load path for roll control.

Movement of the left control wheel bus drum goes through the right aileron bus drum to the torsion spring. The torsion spring transmits the movement to the right aileron control wheel and shaft.

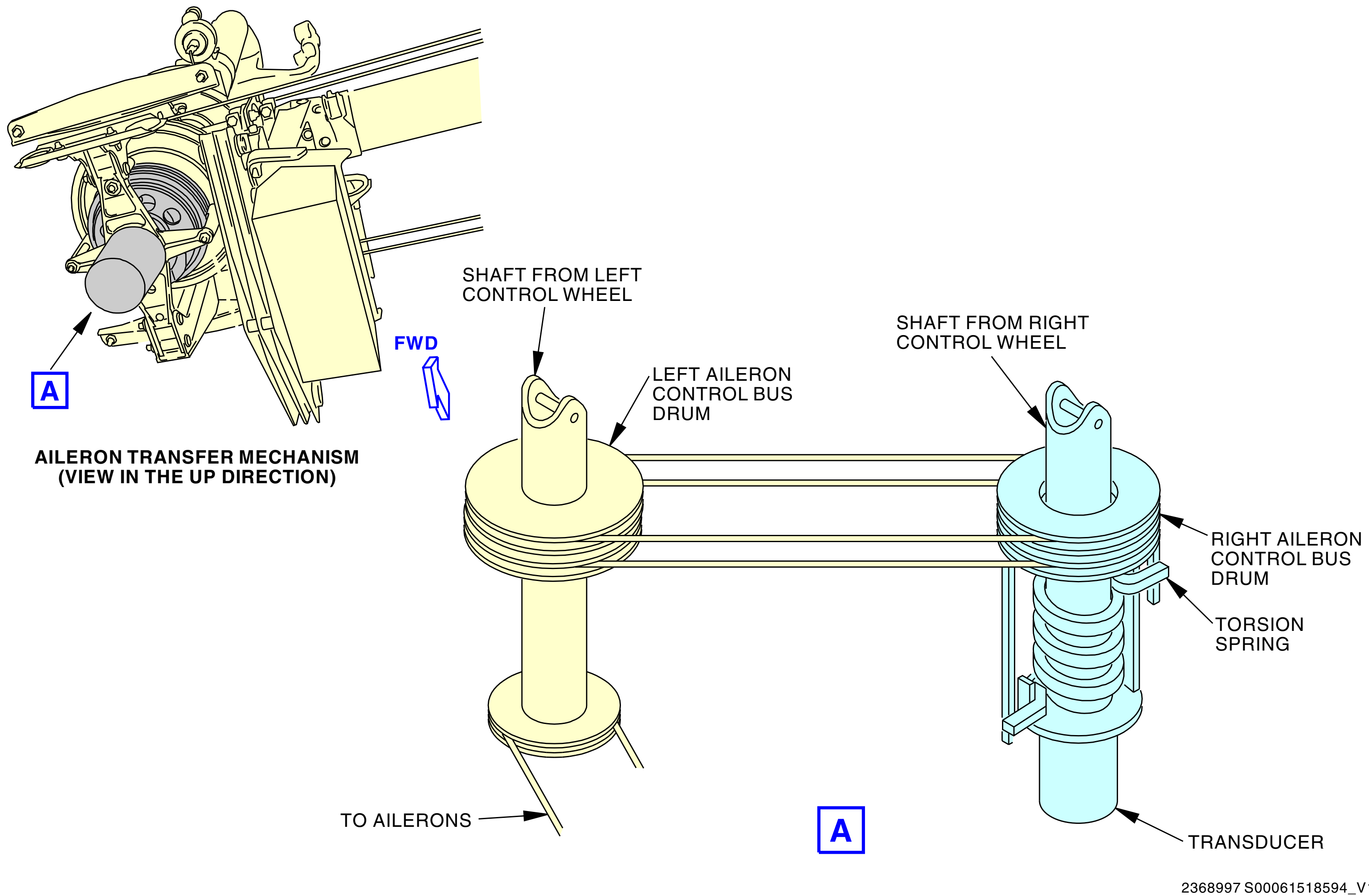
Movement of the right control wheel goes through the shaft to the torsion spring. The torsion spring transmits the movement to the right aileron control bus drum. The movement goes through the left aileron bus drum to the left control wheel and the left body cables.

If the right control wheel cannot move, the captain can operate the left wheel and override the force of the torsion spring and the force of the feel and centering mechanism. This allows control of the ailerons only.

If the left control wheel cannot move, the first officer can operate the right control wheel and override the force of the torsion spring. The torsion spring in the transfer mechanism will shift based on lack of tension in the left control wheel and the transducer's spoiler control electronics (SCE) will take over. This allows control of the flight spoilers only.

If a connection breaks, the pilot can operate the other control wheel.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRANSFER MECHANISM



AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRANSFER MECHANISM

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON PCU LINKAGE

Purpose

The aileron PCU linkage sends the aileron inputs to the aileron PCUs.

Location

The aileron PCU linkage is on the left forward bulkhead of the main landing gear wheel well.

Physical Description

The aileron PCU linkage includes these components:

- Control quadrant
- Autopilot input rod
- Aileron trim actuator
- Aileron feel and centering unit
- Input shaft
- Input pogo cranks (4)
- Input pogo (4).

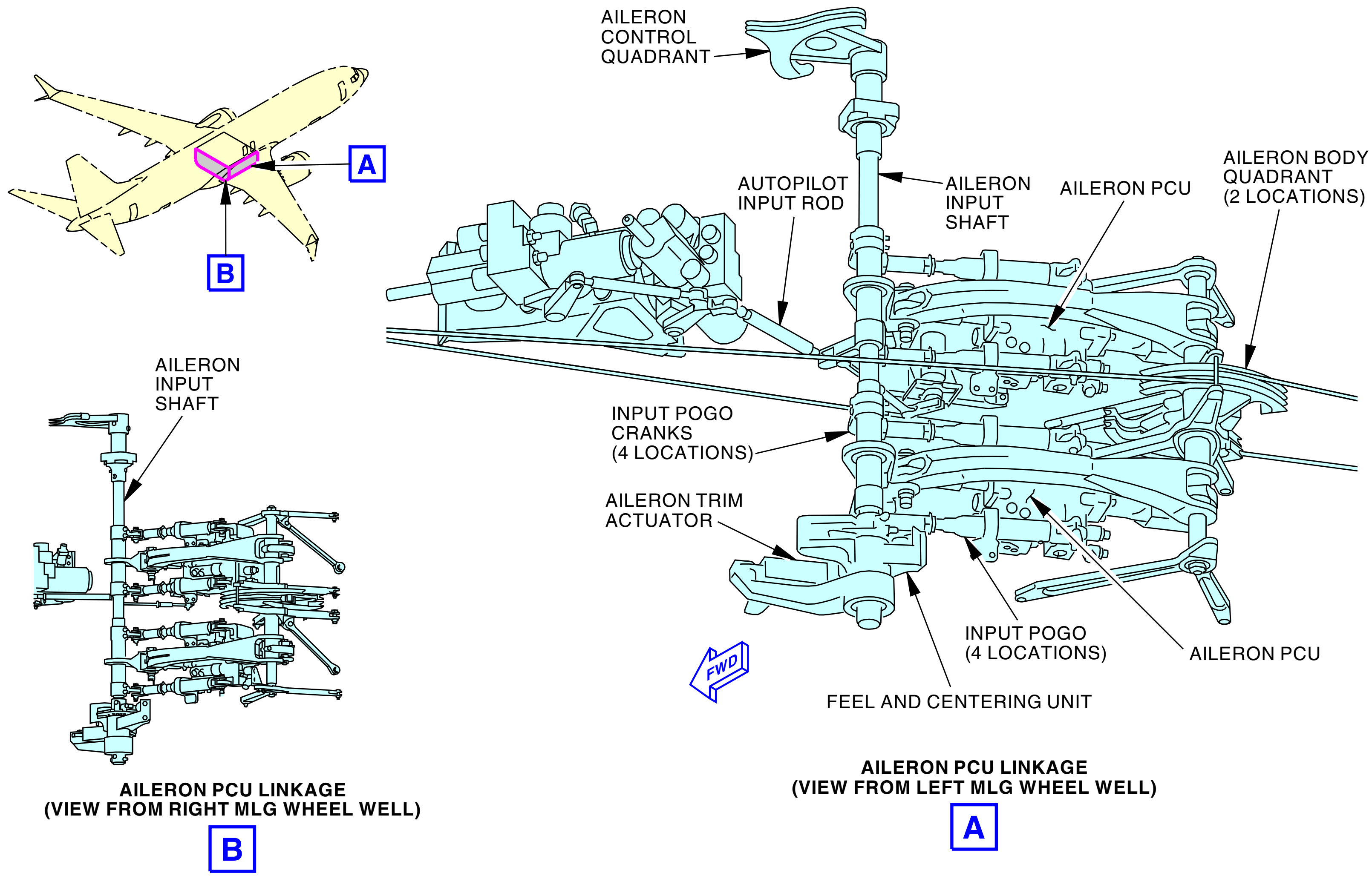
Functional Description

The aileron input shaft receives inputs from the:

- Pilot through the aileron control quadrant
- Autopilot through the aileron autopilot input rod
- Trim switches through the aileron trim actuator.

When the shaft moves, it moves the input pogo cranks. This moves the input pogos which control the aileron PCUs.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON PCU LINKAGE



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON PCU LINKAGE

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON FEEL AND CENTERING UNIT

Purpose

The aileron feel and centering unit receives the aileron inputs and controls the aileron PCUs. The unit gives a feel force to the pilot. It also moves the control wheel to a neutral position when there is no input. The aileron trim actuator changes the neutral position of the ailerons and the control wheels.

Location

The feel and centering unit is at the bottom of the aileron input shaft. The aileron trim actuator is on the aileron feel and centering unit.

Physical Description

The aileron feel and centering unit has two springs, a cam, and a roller. The cam attaches to the shaft with bolts. A cam roller attaches to the roller arm which attaches to the support. The two springs connect the roller with the support.

The aileron trim actuator connects to the fixed bracket and the roller arm support. The actuator is a 115v ac, single phase, reversible motor. The motor has limit switches, mechanical stops at the stroke ends, and a brake. The limit switches control the amount of trim available.

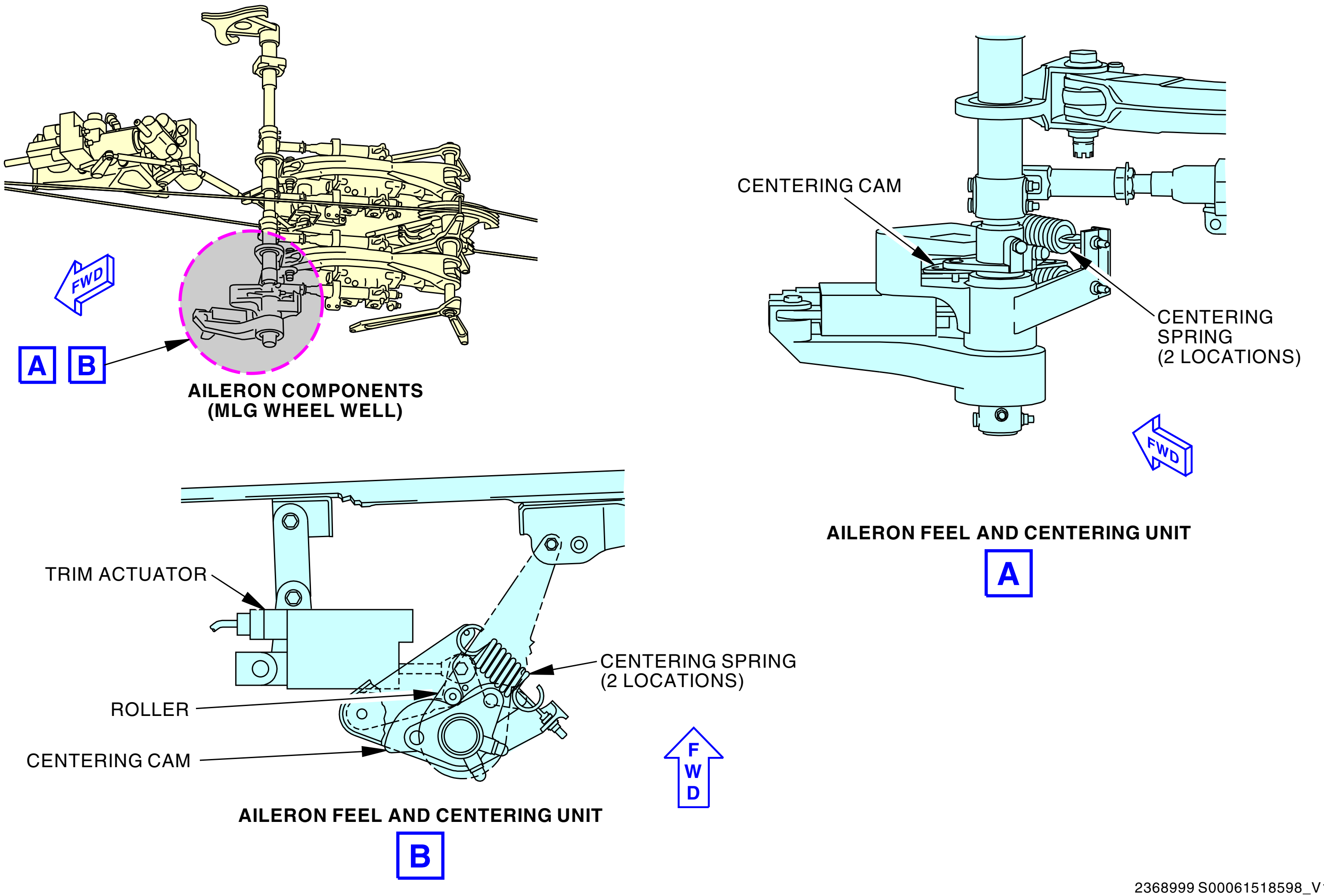
Functional Description

The centering springs hold the roller in the center of the cam. When the control wheel moves, the cam turns with the shaft and moves the roller up on the cam. This extends the springs and supplies the feel force to the pilot.

When the pilot releases the control wheels, the spring force causes the roller to move to the center of the cam. The system goes to the neutral trim position.

During trim operation, the aileron trim actuator moves the roller up on the cam. The springs keep the cam in the center and the quadrant and shaft move. This gives an input to the aileron PCUs to move the ailerons. It also moves the control wheels and supplies trim indication on the top of the aileron control wheel.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON FEEL AND CENTERING UNIT



AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON FEEL AND CENTERING UNIT

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRIM ACTUATOR

Purpose

The aileron trim switches control the electrical trim actuator. The actuator moves the ailerons and the control wheels to a new neutral position.

Location

The two aileron trim switches are on the aileron/rudder trim control panel.

The aileron trim indicator placards are on the top of each control column.

Physical Description

The aileron trim switches are between fixed guards. They are part of the aileron/rudder trim control panel.

Functional Description

The pilot controls the aileron trim with the two switches. The switches control the aileron trim actuator. The pilot must operate both switches at the same time to supply power to the trim actuator.

The aileron trim can operate at all times when electrical power is available. The forward switch controls aileron trim direction and sends signals to the flight data acquisition unit (FDAU). The aft switch supplies a ground for the motor.

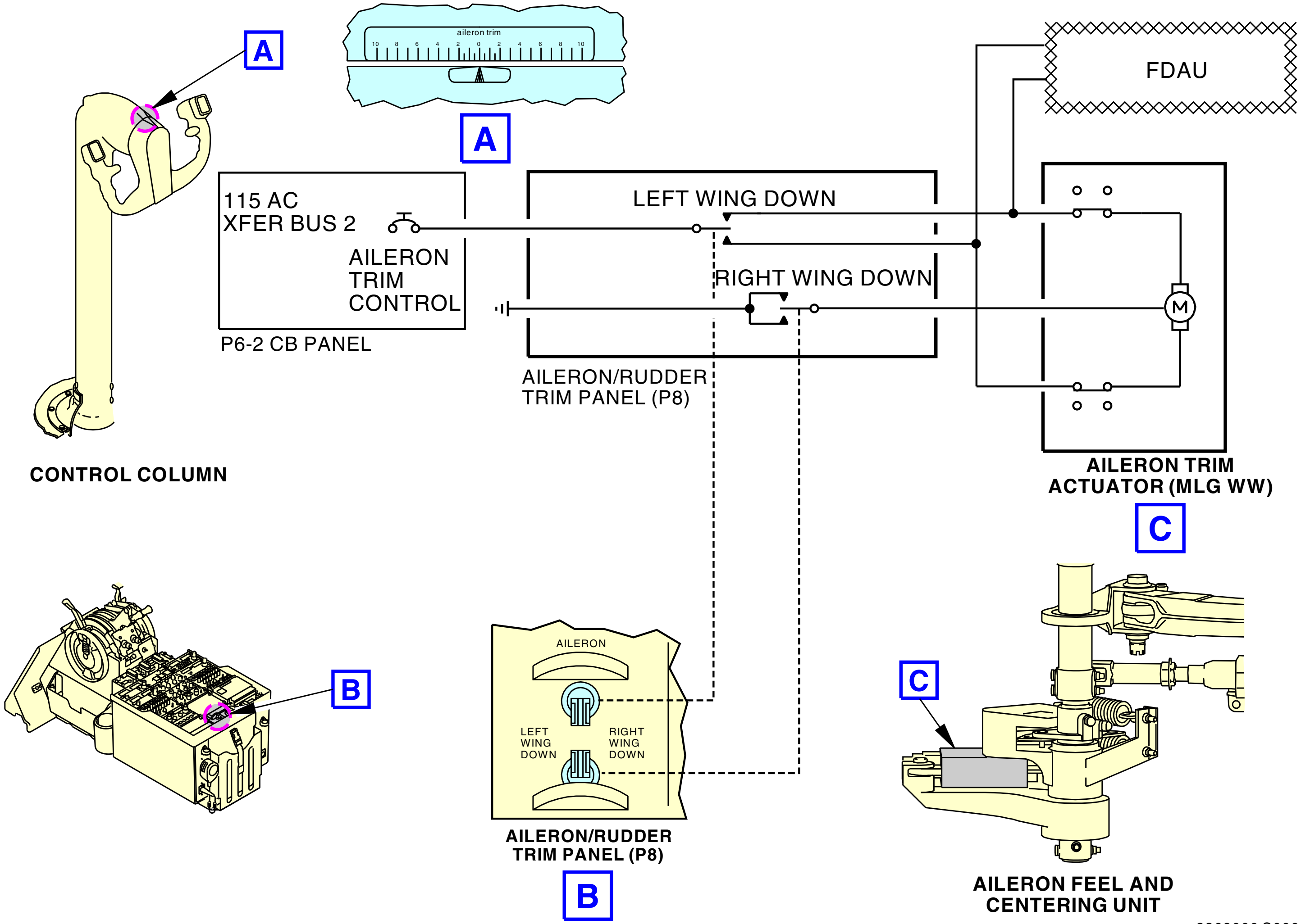
See the flight data recorder system section for more information about the FDAU (SECTION 31-31).

The aileron trim indicator placards show the amount of trim in units. Each unit shows six degrees of control wheel rotation. The trim actuator lets a maximum trim of ±10 units (±60 degrees) of control wheel rotation.

Training Information Point

There must be hydraulic pressure for the trim input to move the ailerons.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRIM ACTUATOR



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON TRIM ACTUATOR

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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON POWER CONTROL UNIT

Purpose

The aileron power control units (PCUs) supply the hydraulic power to move the ailerons.

Location

The two PCUs are on the forward bulkhead of the main landing gear wheel well. The upper PCU gets system B pressure and the lower PCU gets system A pressure.

Physical Description

The PCU has these parts:

- Movable housing connected with a shaft to the aileron body quadrants
- Fixed piston connected to structure.

The PCU housing has these parts:

- Actuator
- Filter
- Bypass valve
- Control valve
- Primary and secondary input cranks
- Primary and secondary slides
- External mechanical stops (2).

Functional Description

The ailerons move when any of these conditions occur:

- Normal operation
- System pressure failure
- Rate jam
- Manual reversion.

Normal Operation

During normal operation, an aileron input goes through the input pogos of each PCU to its respective input cranks. The upper and lower input cranks move slides in the control valve and supply hydraulic pressure to the actuator.

The lower input crank connects to the primary slide and the upper input crank connects to the secondary slide. A torsion spring inside the PCU connects the two input cranks. Movement of the primary slide supplies one-half the total flow rate, and movement of the secondary slide supplies the other half. The primary slide moves to its full effective stroke before the secondary crank starts to move the secondary slide.

When the primary and secondary slides move, hydraulic pressure goes through the control valve to one side of the actuator. This moves the actuator housing and the respective aileron body quadrant to the commanded position. The other side of the actuator is connected to return.

System Pressure Failure

If one PCU cannot supply hydraulic pressure, its bypass valve moves to the bypass position. This connects the two sides of the actuator, and prevents a hydraulic lock condition. When the pilot moves the control wheel, the ON side PCU still moves to its commanded position normally. As the ON side PCU moves it also moves its respective aileron body quadrant and back drives the OFF side PCU actuator housing. When the OFF side housing moves, hydraulic fluid is pushed from one side of the actuator to the other through the bypass valve.

Rate Jam

If one PCU input pogo cannot move freely, then the pilot must supply approximately 20 pounds of additional force to compress or extend a spring inside the pogo. The other PCU input pogo still moves its respective input crank and slide to the commanded position. This equalizes pressure on both sides of the actuator and prevents a hydraulic lock condition. Now the other PCU can move the aileron body quadrant assembly normally. As the ON side PCU moves its respective aileron body quadrant it also back drives the OFF side PCU actuator housing. When the OFF side housing moves, hydraulic fluid is pushed from one side to the other through the bypass valve.

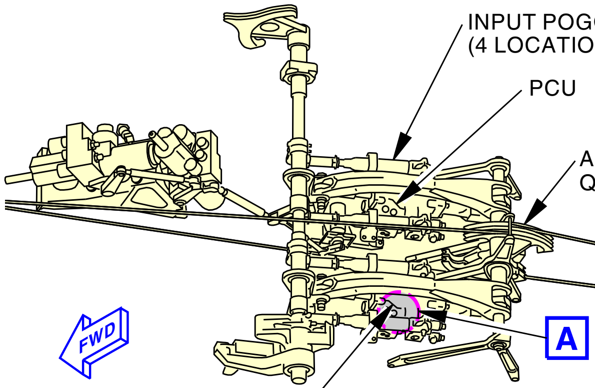
Manual Reversion

During a manual reversion, the bypass valve receives no hydraulic pressure and moves to the bypass position. This connects the two sides of the actuator and prevents a hydraulic lock condition. When the pilot moves the control wheel more than three degrees, the primary and secondary input cranks hit mechanical stops on the outside of the actuator housing. As the housing moves, hydraulic fluid in the actuator is pushed from one side to the other through the bypass valve. Movement of the housing also moves the aileron body quadrant assembly to the commanded position.

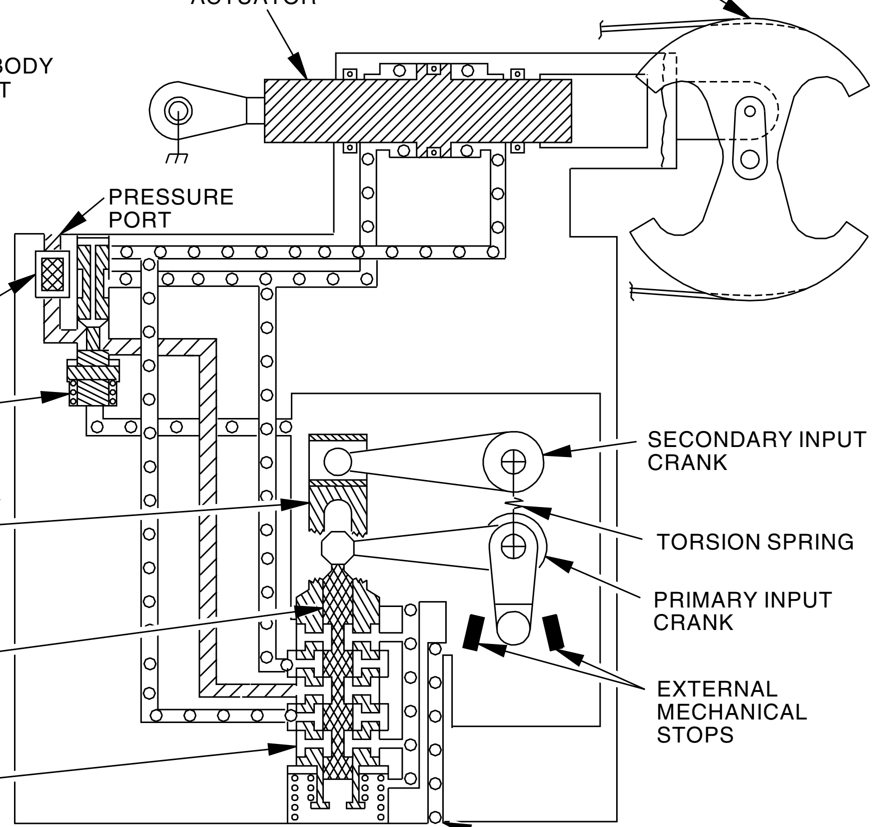
Training Information Point

The two aileron PCUs are identical and interchangeable with the elevator PCUs.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON POWER CONTROL UNIT



AILERON COMPONENTS
(MLG WHEEL WELL)



AILERON PCU SCHEMATIC

A

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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON POWER CONTROL UNIT

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BODY QUADRANTS

Purpose

The aileron body quadrants move the wing cables to control the aileron position.

Location

The body quadrants are on the forward bulkhead of the main landing gear wheel well.

Physical Description

Each aileron body quadrant connects to one crankshaft. The PCU housing connects through a crank to the related crankshaft.

Three shear rivets connect each quadrant and the related output shaft.

The cables from the upper quadrant connect to the right wing quadrant. The cables from the lower quadrant connect to the left wing quadrant.

A fork and lug assembly connects the upper and lower quadrants.

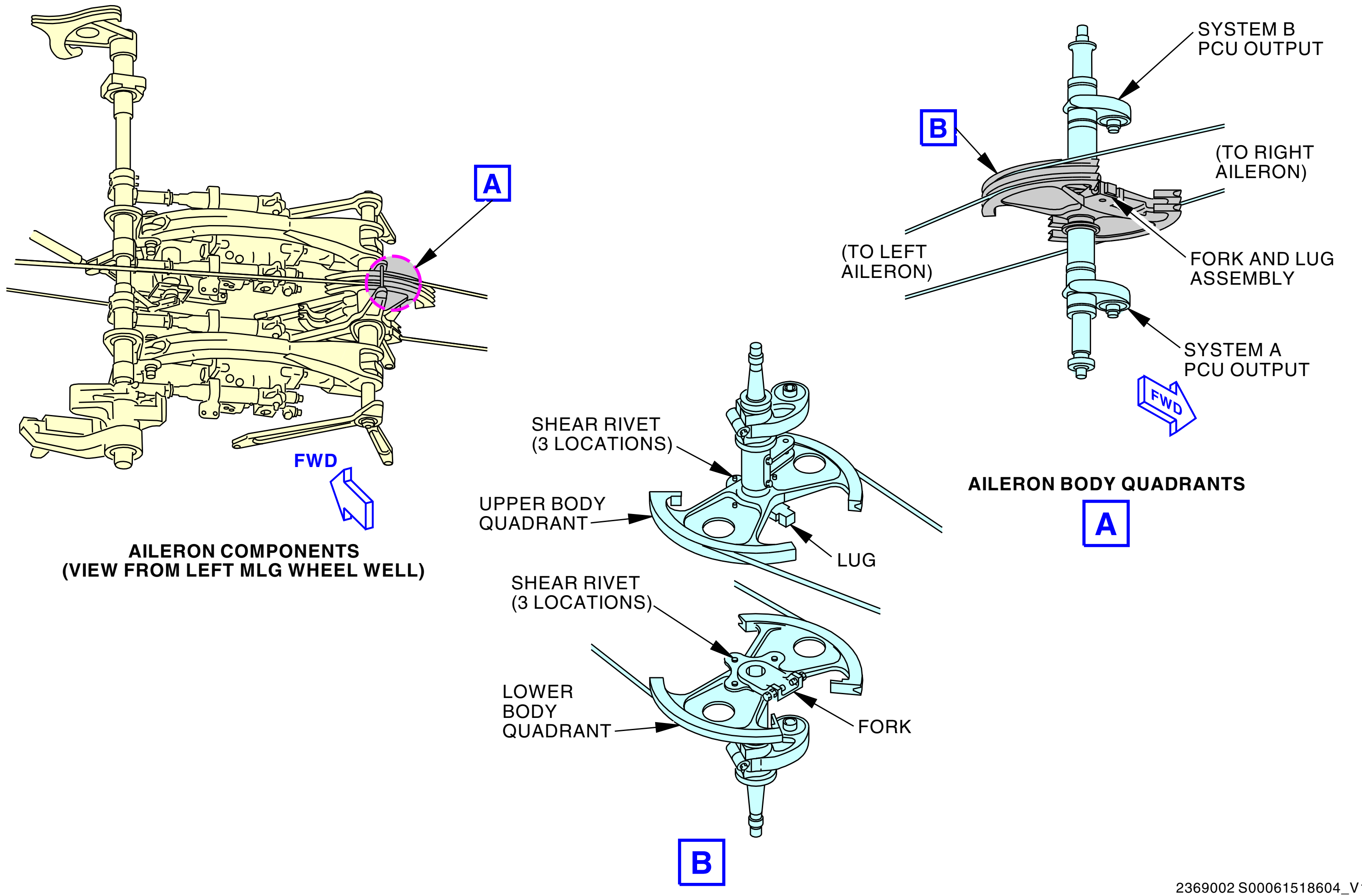
Functional Description

The PCU housing moves the crankshaft through the crank. This moves the body quadrant and the related aileron.

If one hydraulic system is OFF, the other system PCU moves the two quadrants through the fork and lug assembly.

If one body quadrant cannot move, the related system PCU moves its crankshaft and shears the three shear rivets. Now both PCUs and crankshafts still can move but input to the ailerons is only from the other body quadrant.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BODY QUADRANTS



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BODY QUADRANTS

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERONS AND WING QUADRANTS

Purpose

The ailerons control the airplane around the longitudinal axis.

Location

The ailerons are on the outboard and trailing edge of each wing.

Physical Description

The aileron assembly contains these components:

- Wing quadrant
- Cable tension spring
- Aileron
- Balance panel (4)
- Balance weights
- Aileron tab control rods
- Aileron balance tab
- Pushrod that connects the quadrant to aileron.

Each wing cable connects the body quadrant with the aileron wing quadrant. A cable tension spring is at the end of the cable run. The aileron front spar connects to the wing structure by six hinges. The forward side of the aileron connects to the balance panels. The balance weights attach to the lower surface of the balance panels. The tab connects to the aileron rear spar by five hinge fittings.

Functional Description

When a wing cable moves, it moves the related wing quadrant and aileron. The aileron tab rod gets input from aileron movement and moves the tab in a direction opposite to aileron movement.

The aileron and the tab on the other wing move an equivalent amount but in the opposite direction

When the control wheel is centered, the ailerons are downrigged one degree. The range of travel is limited by the aileron PCU stroke. The ailerons can move 20 degrees up and 15 degrees down.

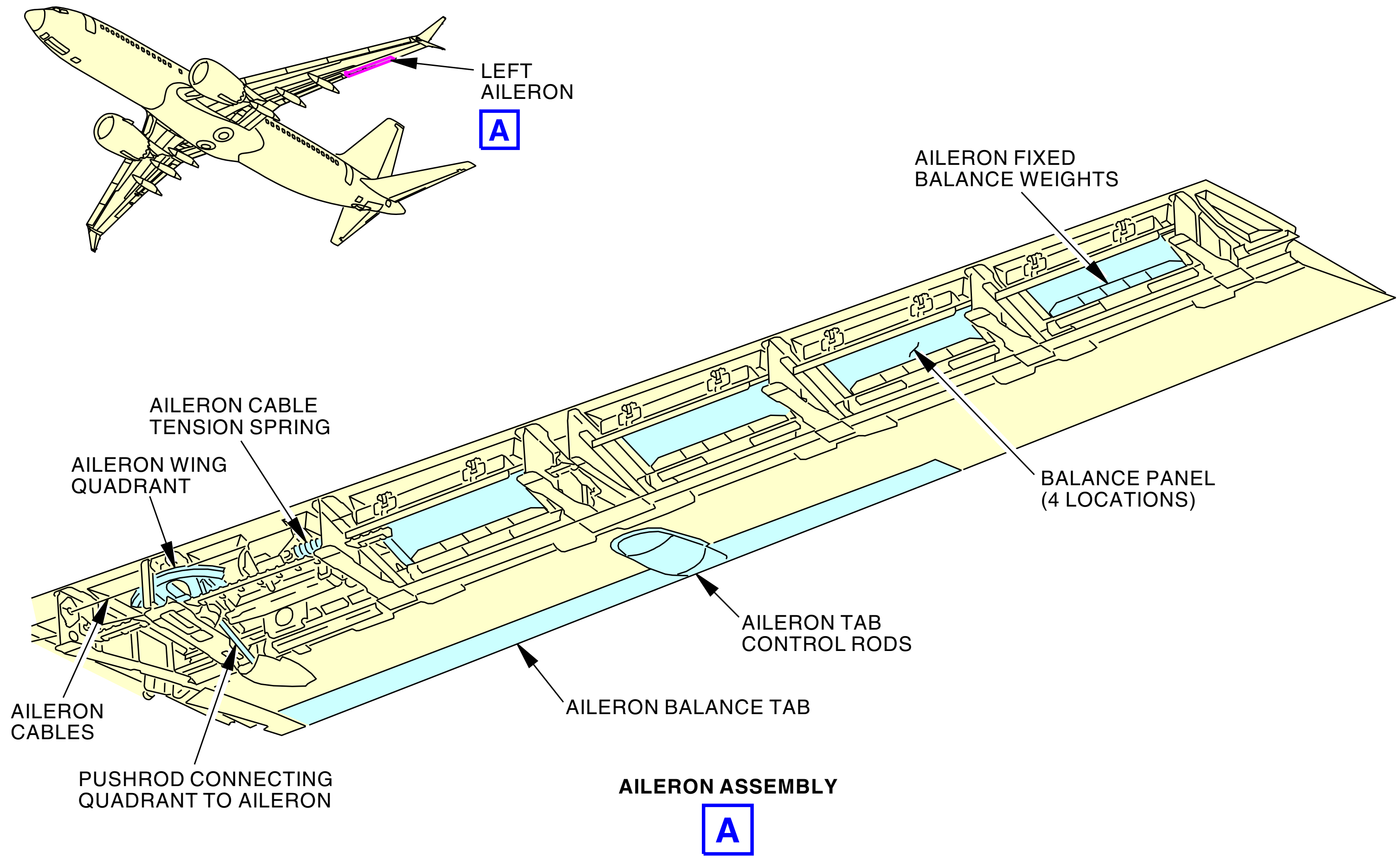
Training Information Point

You balance the aileron and the tab independently.

A data plate attached to each tab has the correct number of weights stamped on it.

If you replace the balance tabs and weights, it is not necessary to balance the aileron again.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERONS AND WING QUADRANTS



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERONS AND WING QUADRANTS

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BALANCE PANEL AND TAB

Purpose

The aileron balance panels and tab decrease the force necessary to move the aileron in flight.

Location

The balance panels are in the number one through four aileron bays.

Physical Description

The forward edge of the balance panel attaches to the wing structure through an idler hinge. The aft edge attaches to the aileron.

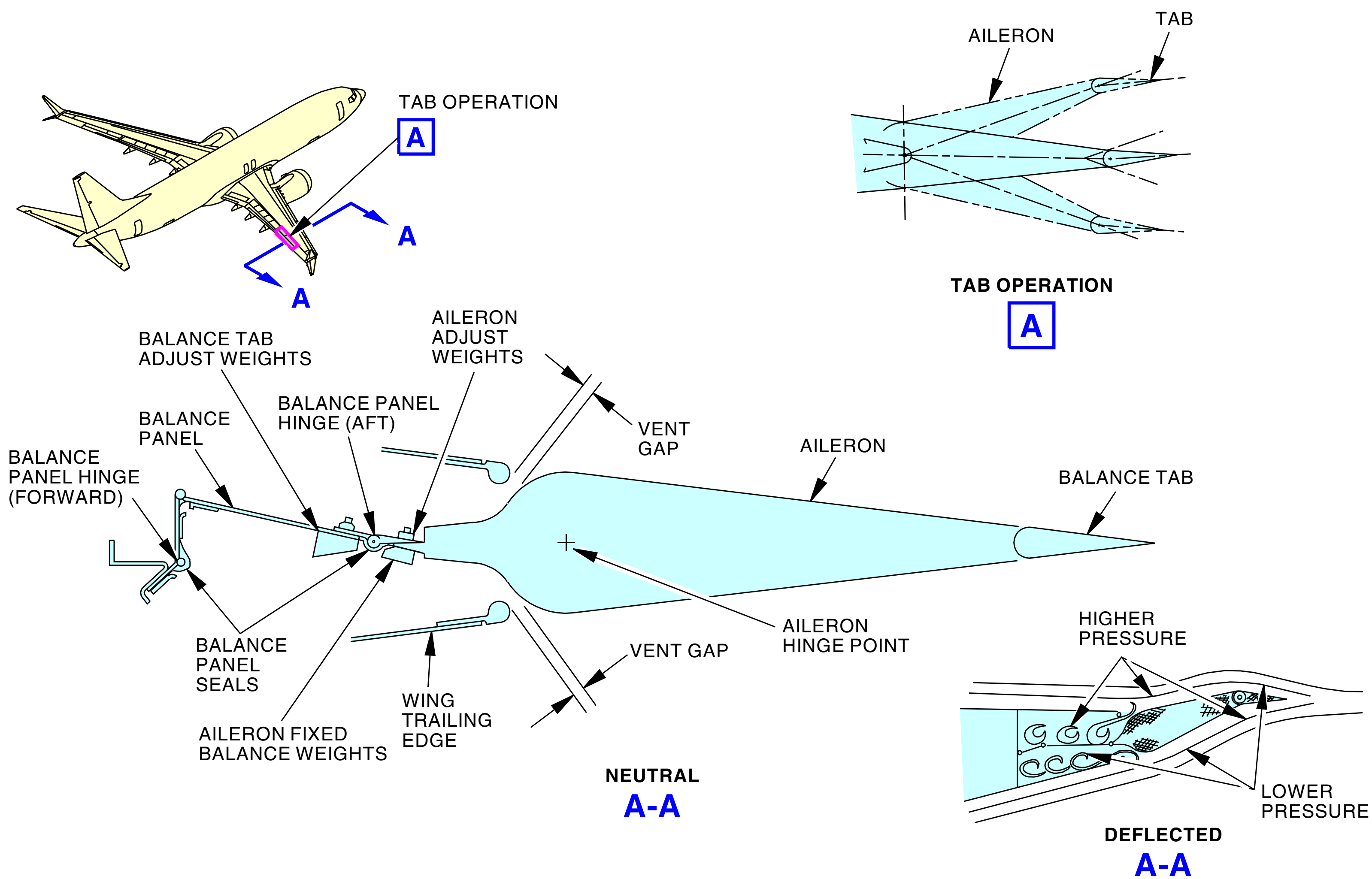
Seals connect the hinge assemblies along the two sides of the balance panel. This makes two separate chambers. The upper chamber vents to the airstream over the wing and the lower to the airstream under the wing.

Functional Description

When there is no lateral input, pressure forces occur across the balance panel and keep the aileron in the neutral position. When the aileron is commanded, there is an incremental differential pressure between the upper and lower surfaces of the aileron. These pressures are vented into the balance bays and provide a force on the balance panel that assists aileron motion.

As the balance tab moves, differential forces occur at the tail of the aileron. They help the power source that moves the aileron. These forces are always applied but they are most useful during manual control.

AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BALANCE PANEL AND TAB



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AILERON AND AILERON TRIM CONTROL SYSTEM - AILERON BALANCE PANEL AND TAB

AILERON AND AILERON TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

General

The aileron control system use cable movement input from the control wheels.

Physical Description

The aileron control system has these cables:

- Bus drum cables
- Left and right wing cables.

Functional Description - Normal

When the control wheels move, the left body cables move and control the PCUs. The PCU housing moves and controls the aileron wing cables.

When the PCU housing moves, it also controls the right body cables and completes the loop to the right control column.

Functional Description - Manual

Manual operation is almost the same as normal operation with one difference. There are three degrees of control wheel movement at the aileron PCUs before the input crank meets the mechanical stops. Then the PCU housing moves, but the pilot supplies the force.

Functional Description - One Control Cannot Move

If one control wheel cannot move, the related side cable will not move.

If the right control wheel cannot move, the crew can only use the left control wheel to move the ailerons normally.

If the left control wheel cannot move, the crew can only use the right control wheel. This will move the right body cables after 12 degrees of control wheel movement. This controls the flight spoiler actuators to move after a predetermined amount of control wheel movement.

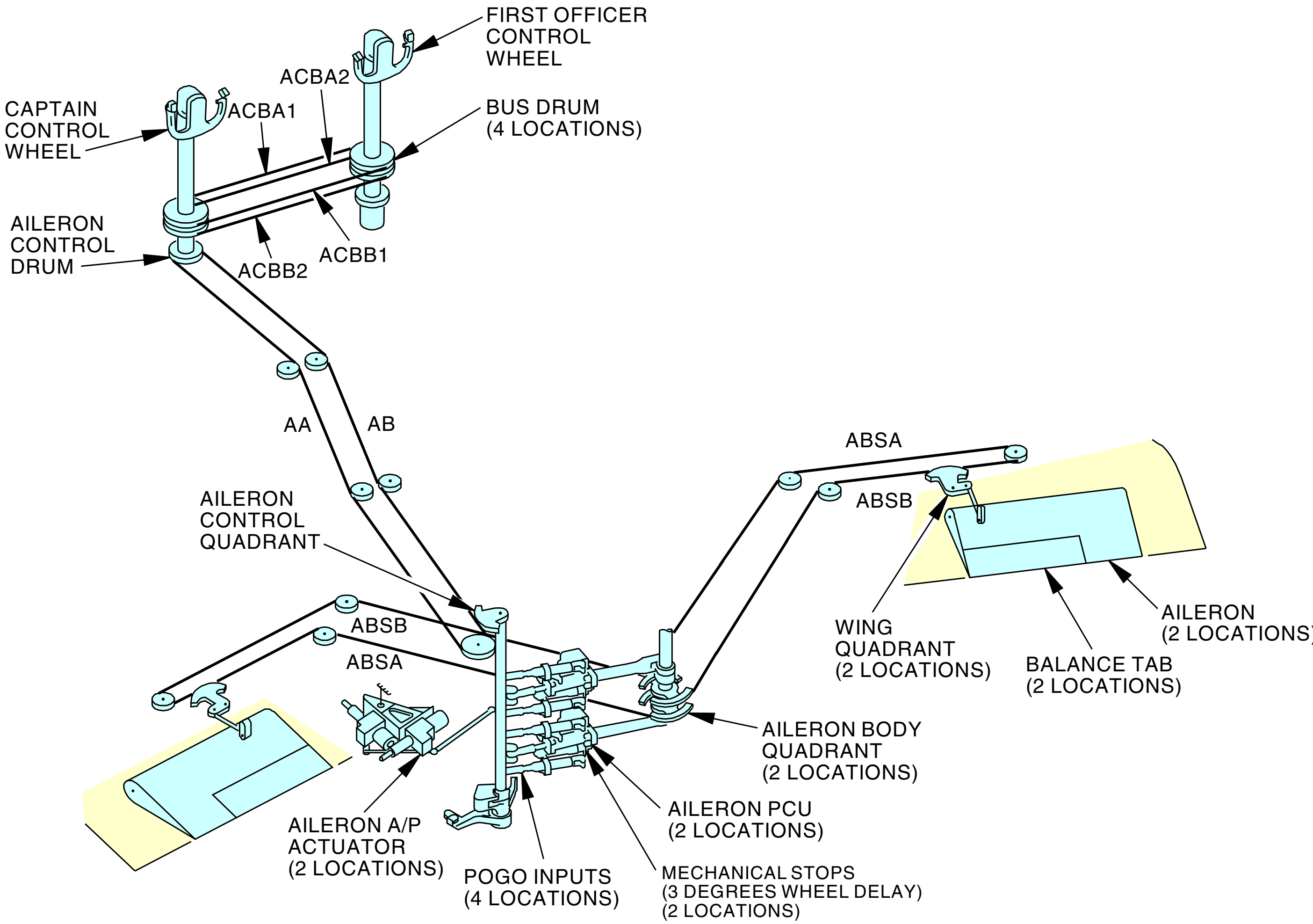
Functional Description - One Aileron Cannot Move

If one aileron cannot move, the shear rivets at the body quadrants will shear and isolate this aileron. The other part of the aileron control system operates normally.

Functional Description - One PCU Input Cannot Move

If one PCU pogo input cannot move freely, then it compresses or extends. The other PCU pogo still moves to the commanded position. This equalizes pressure on both sides of the actuator. This prevents hydraulic lock to the PCU and lets the other PCU move it through the aileron body quadrant.

AILERON AND AILERON TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



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AILERON AND AILERON TRIM CONTROL SYSTEM - CABLE SYSTEM - FUNCTIONAL DESCRIPTION

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RUDDER AND RUDDER TRIM CONTROL SYSTEM - INTRODUCTION

Purpose

The rudder controls the flight attitude of the airplane about the vertical axis.

Location

The rudder hinges aft of the rear spar of the vertical stabilizer.

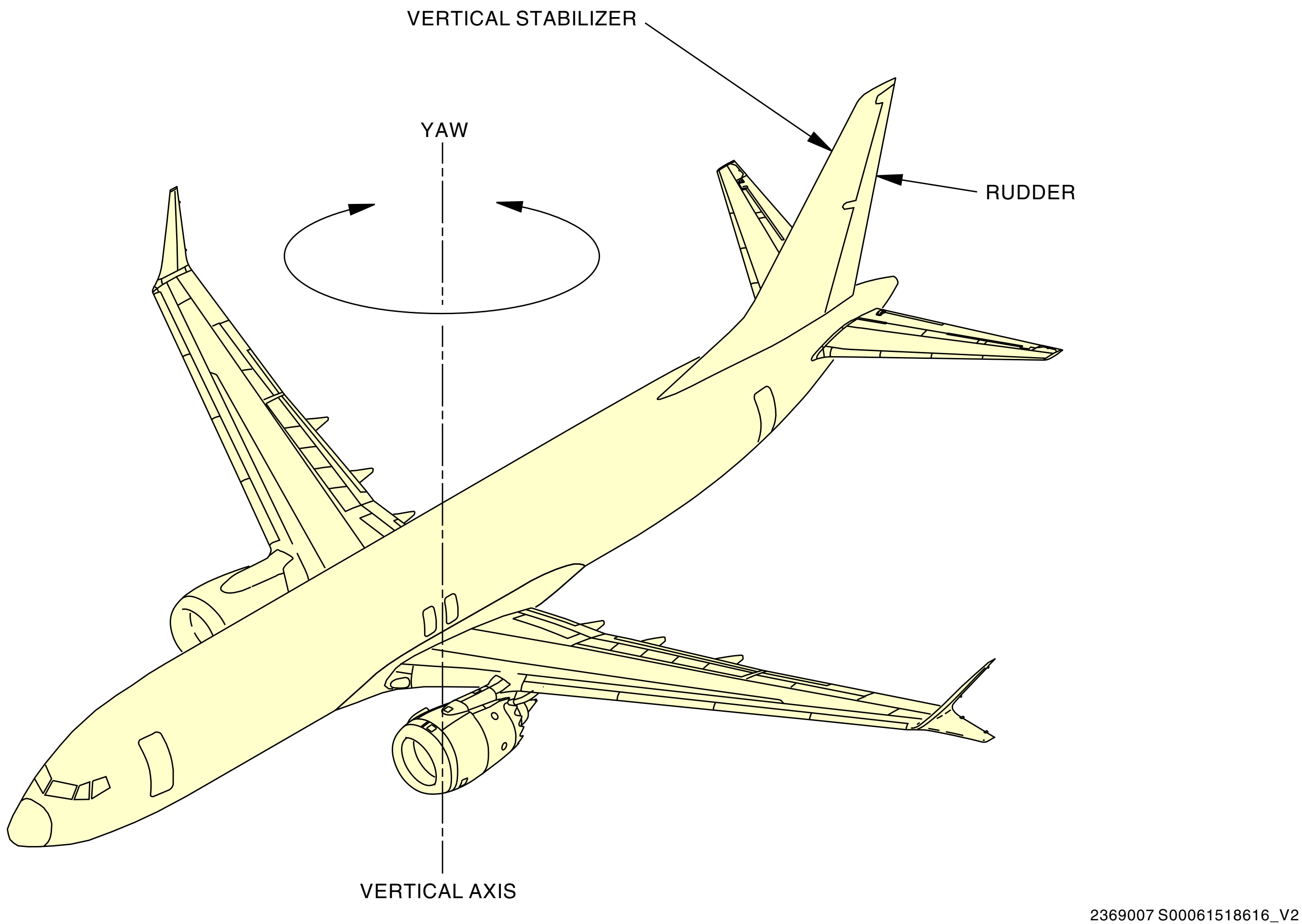
Yaw control

The pilots manually command a yaw input with the rudder pedals. When engaged, the yaw damper automatically makes small yaw corrections. During yaw damper operation, there is no feedback to the rudder pedals.

Abbreviations and Acronyms

- ac - alternating current
- auth - authority
- FDAU - flight data acquisition unit
- EHSV - electrohydraulic servo valve
- FSEU - flap/slat electronic unit
- Hz - Hertz
- LVDT - linear variable differential transformer
- PCU - power control unit
- SMYD - stall management yaw damper
- soln - solenoid
- v - Volt
- vlv - valve
- WTRIS - wheel-to-rudder interconnect system

RUDDER AND RUDDER TRIM CONTROL SYSTEM - INTRODUCTION



RUDDER AND RUDDER TRIM CONTROL SYSTEM - INTRODUCTION

RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

General

The pilot uses the rudder pedals or the rudder trim control knob to control the rudder. The yaw damper and wheel-to-rudder interconnect system automatically control the rudder.

Manual Operation - Rudder Pedals

The flight crew uses the rudder pedals to control the rudder through these components:

- Forward quadrants
- Control cables
- Aft quadrant and output rod
- Feel and centering unit
- Main rudder PCU.

The aft quadrant output rod also has an integral rudder pedal force transducer. The force transducer sends signals to the flight data acquisition unit proportional to rudder pedal forces.

See the flight data recorder system section for more information about the rudder pedal force transducer. (SECTION 31-31)

Movement of the feel and centering unit also backdrives the rudder pedals through the rudder control system. Rudder PCU movement moves the rudder and the rudder position transmitter. The rudder position transmitter sends signals to the flight data acquisition unit (FDAU) for rudder position.

See the flight data recorder system section for more information about the rudder position transmitter and FDAU. (SECTION 31-31)

Manual Operation - Rudder Trim

The rudder trim control knob and the trim actuator let the flight crew trim out unwanted rudder pedal forces. When the pilot moves the rudder trim control knob on the aisle stand, the control sends signals to the rudder trim actuator and the FDAU. The rudder trim actuator moves the feel and centering unit which creates an input to the rudder PCUs. The rudder trim actuator also sends signals to the rudder position indicator on the aisle stand above the rudder trim control knob.

Yaw Damper

The yaw damper keeps the airplane stable around the vertical axis. When engaged, the yaw damper system gives input to the main or the standby rudder PCUs. During normal operation, SMYD 1 controls the rudder through the main rudder PCU. During manual reversion, SMYD 2 controls the rudder through the standby rudder PCU.

See the yaw damper system section for more information about yaw damper. (SECTION 22-23)

See the stall management yaw damper system section for more information about stall management yaw damper. (SECTION 27-32)

Wheel-To-Rudder Interconnect System (WTRIS)

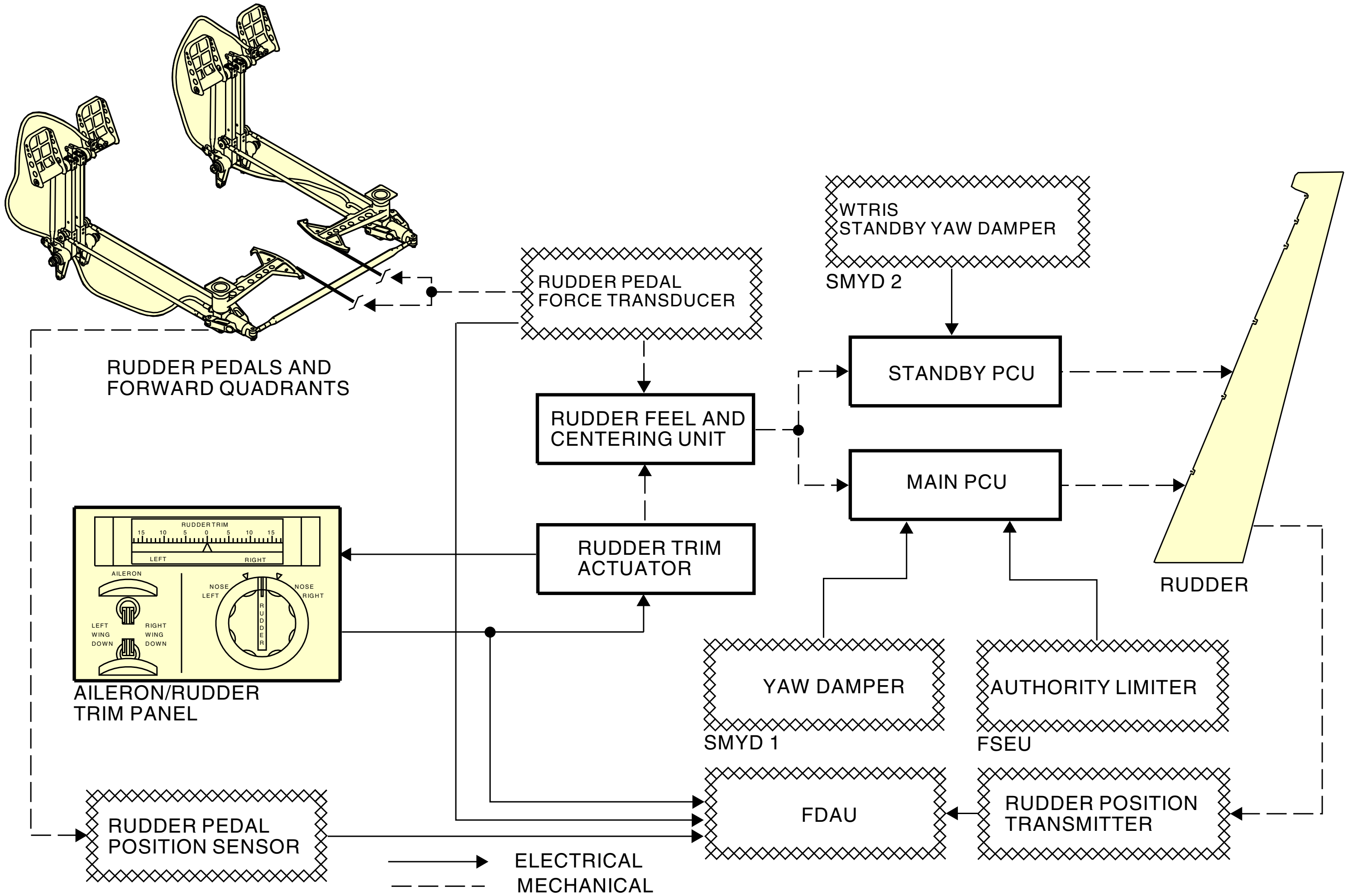
The WTRIS system helps lateral control during manual reversion turns. The WTRIS system provides a small amount of rudder movement in response to control wheel inputs. When engaged, the WTRIS system gives input to the standby rudder PCU.

See the wheel-to-rudder interconnect system section for more information. (SECTION 27-24)

Authority Limiter

The authority limiter reduces the maximum rudder movement. At specified air speeds, the FSEU opens the main rudder PCU authority limiter solenoid valve. This limits the hydraulic force produced by the PCU, which limits the rudder authority.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1



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RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

General

These are the components of the rudder control system:

- Rudder pedals (4) and forward quadrants (2)
- RA and RB; left and right rudder control cables
- Rudder aft control quadrant
- Rudder feel and centering unit
- Main rudder power control unit
- Standby rudder power control unit
- Rudder.

Rudder Pedals and Forward Quadrants

The rudder pedals move the forward control rods and bus rods, which move the rudder forward quadrants.

Rudder Control Cables

The rudder forward quadrants move the RA and RB rudder control cables. The cables move the rudder aft control quadrant.

Rudder Aft Control Quadrant

The aft control quadrant moves the rudder quadrant output rod, which provides input to the rudder feel and centering unit, torque tube, and input rods for the main and standby rudder PCUs.

Rudder Feel and Centering Unit

The feel and centering unit provides feel forces to the rudder pedals.

During electric trim operation, the pilots move the rudder trim control on the aisle stand which sends a signal to the rudder trim actuator. The rudder trim actuator moves the rudder feel and centering unit. This moves the rudder torque tube and the main and standby rudder PCU input rods and it backdrives the rudder pedals to the new commanded position. The trim actuator movement also creates a new neutral position for the feel and centering unit.

Main Rudder Power Control Unit

The main rudder PCU piston moves and controls the rudder position.

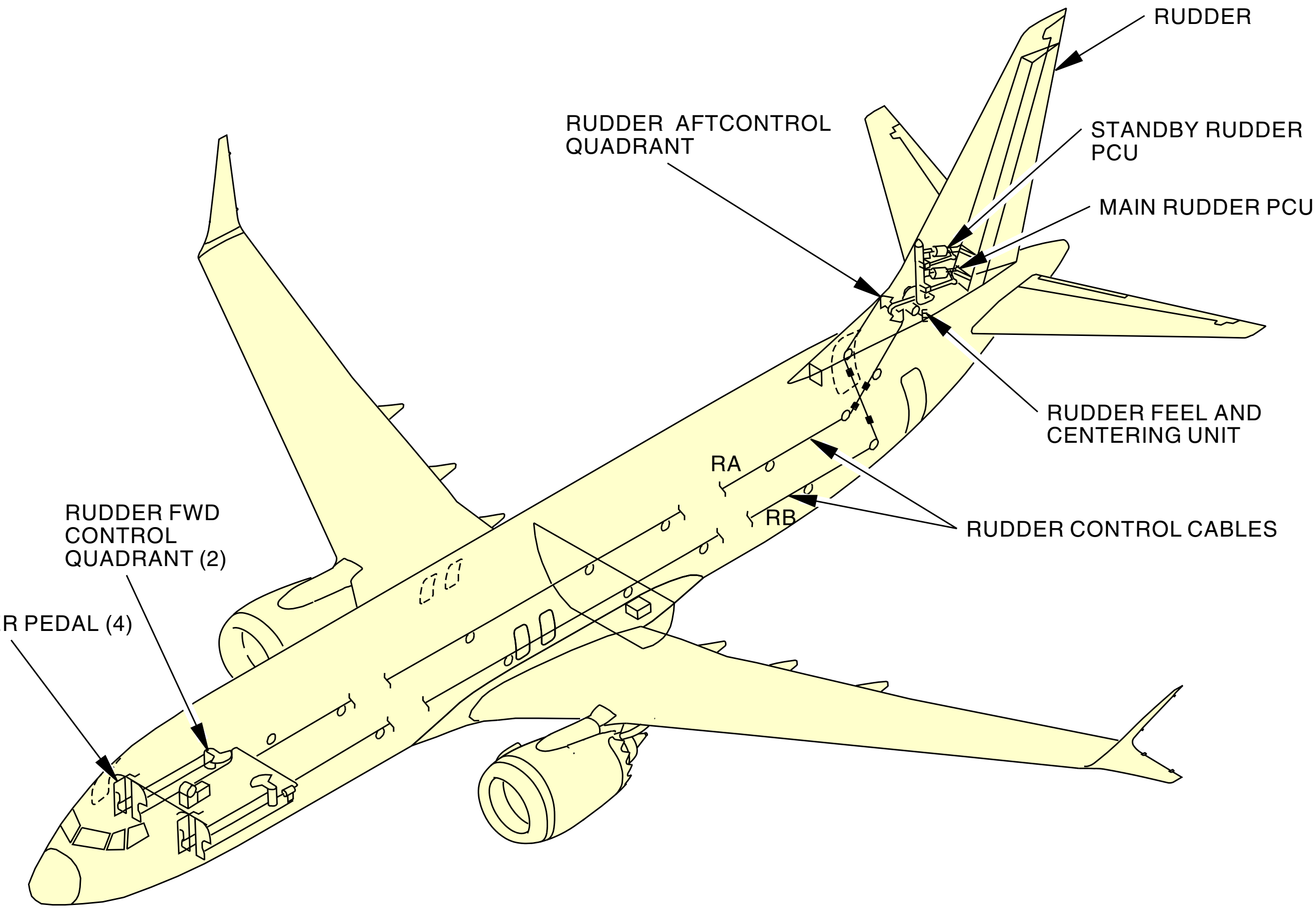
Standby Rudder Power Control Unit

When the standby rudder system is operated, the standby rudder PCU piston moves and controls the rudder position.

Rudder

The rudder attaches to the trailing edge of the vertical stabilizer and moves left or right to control yaw.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2



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RUDDER AND RUDDER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

RUDDER AND RUDDER TRIM CONTROL SYSTEM - COMPONENT LOCATIONS

General

The rudder components are in these three locations:

- Flight compartment
- Forward equipment compartment
- Vertical stabilizer.

Flight Compartment Components

The flight compartment has these rudder components:

- Rudder pedals (4)
- Rudder Trim control knob and rudder trim indicator on the aileron/rudder trim panel.

Lower Nose Compartment Components

The lower nose compartment has these rudder components:

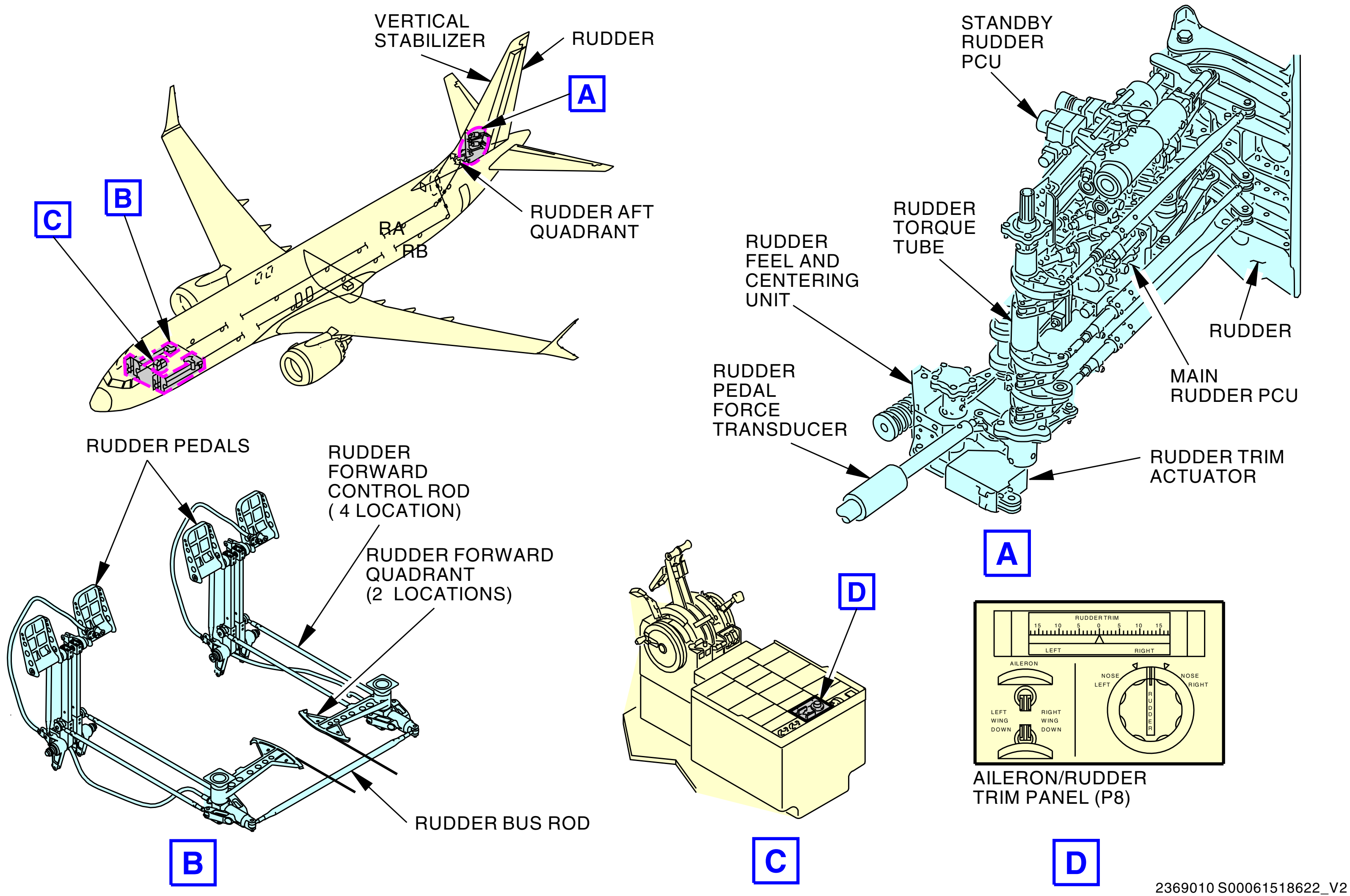
- Rudder forward quadrant (2)
- Control rods (4)
- Bus rod.

Vertical Stabilizer

The vertical stabilizer has these rudder components:

- Rudder aft quadrant
- Rudder pedal force transducer
- Rudder torque tube
- Rudder feel and centering unit
- Rudder trim actuator
- Main rudder PCU
- Standby rudder PCU
- Rudder
- Rudder position transmitter.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - COMPONENT LOCATIONS



RUDDER AND RUDDER TRIM CONTROL SYSTEM - COMPONENT LOCATIONS

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER PEDALS AND FORWARD QUADRANTS

Purpose

The pilots use the rudder pedals to command a yaw control through the rudder forward quadrants.

Location

The rudder pedals are in the flight compartment. The rudder pedal support and forward quadrant assemblies are in the forward equipment compartment.

Physical Description

Each pedal assembly has these components:

- Pedals (2)
- Pedal arm (2)
- Pushrods (2)
- Yoke
- Jackshaft
- Forward quadrant
- Bus rod
- Adjustment crank
- Adjustment flexshaft
- Pedal adjustment nut.

Functional Description

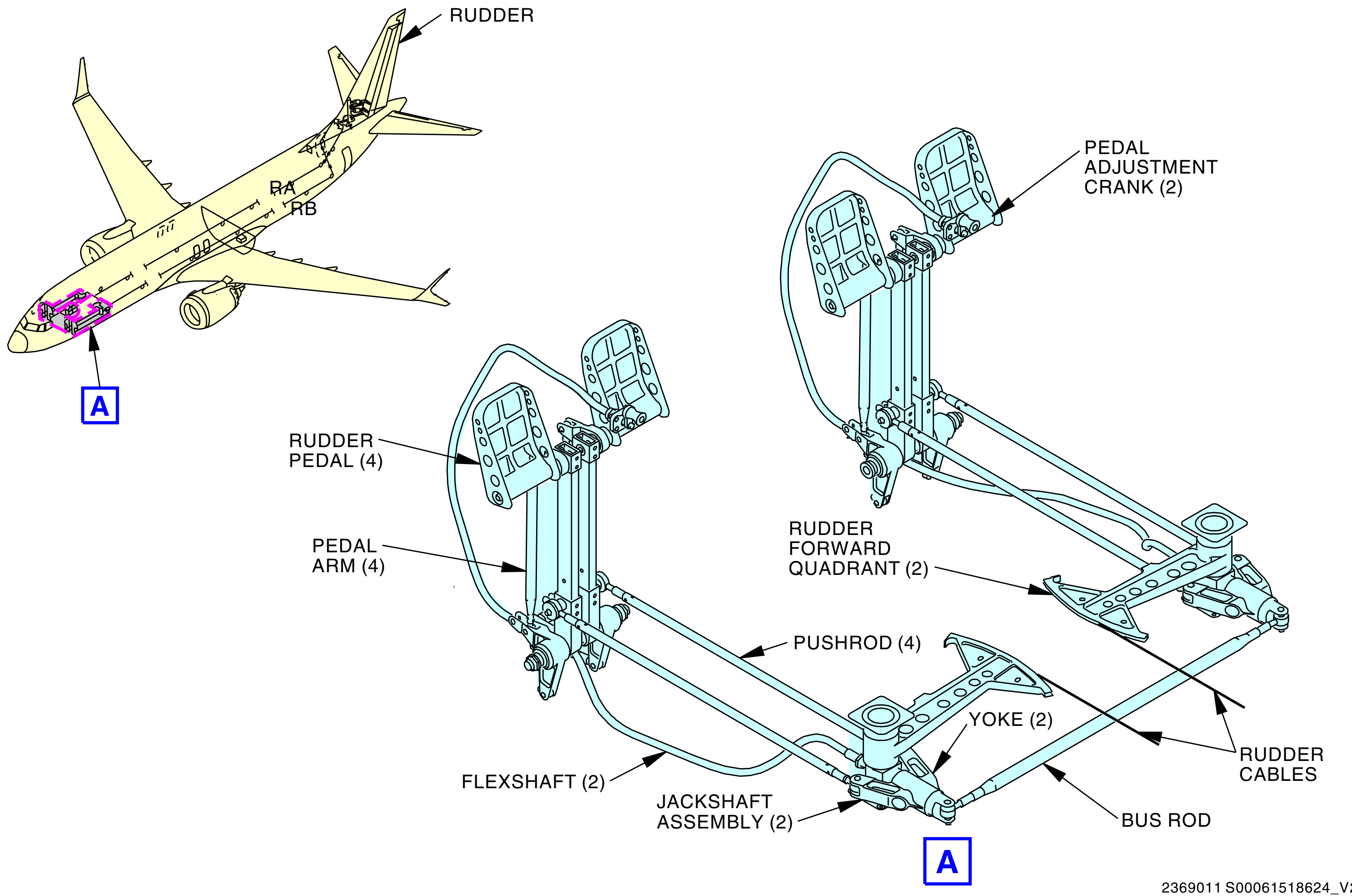
The pedals of each pair move in opposite direction to each other. When the pedals move, they move the pushrods and the jackshaft yoke. This moves the jackshaft and the forward quadrant. This also moves the bus rod and makes the other pair of pedals move equally.

The two pairs of rudder pedals can be adjusted independently to suit the captain and first officer. This is accomplished by means of the rudder pedal adjust shaft . The rudder pedal adjustment mechanism consists of an adjustment crank, adjustment shaft, a jackscrew, and pedal adjustment nut attached to the jackshaft assembly.

The adjustment crank is located on the instrument panel forward of the control wheel. The crank is connected to a flexshaft routed forward under the instrument panel, then down under the floor, and aft to the universal joint in the rudder control jackshaft assembly. Rotation of the rudder pedal adjustment crank actuates the jackscrew which causes the yoke, containing the pedal adjustment nut, to move fore and aft.

Rudder pedal adjustment crank and crank handle stops are installed to prevent the rudder pedal adjustment screw from being backdriven by heavy foot pressure simultaneously applied to both rudder pedals. The crank incorporates a spring-loaded pin within the knob. The stops are incorporated into the crank housing bearing retainer. Rotation of the crank handle is prevented in either direction beyond the stop blocks, by contact of the spring-loaded pin that protrudes from the crank handle. To permit crank rotation for rudder pedal adjustment, the knob must be pulled aft so the pin clears the stops.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER PEDALS AND FORWARD QUADRANTS



RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER PEDALS AND FORWARD QUADRANTS

RUDDER AND RUDDER TRIM CONTROL SYSTEM - AFT RUDDER CONTROL COMPONENTS

Purpose

The aft rudder control components transmit rudder pedal input to the hydraulic power control units.

Location

The aft rudder control components are in the vertical stabilizer, forward of the hydraulic PCUs.

Physical Description

There are these aft rudder control components:

- Rudder aft quadrant
- Quadrant pushrod
- Rudder pedal force transducer
- Rudder control torque tube with five cranks.

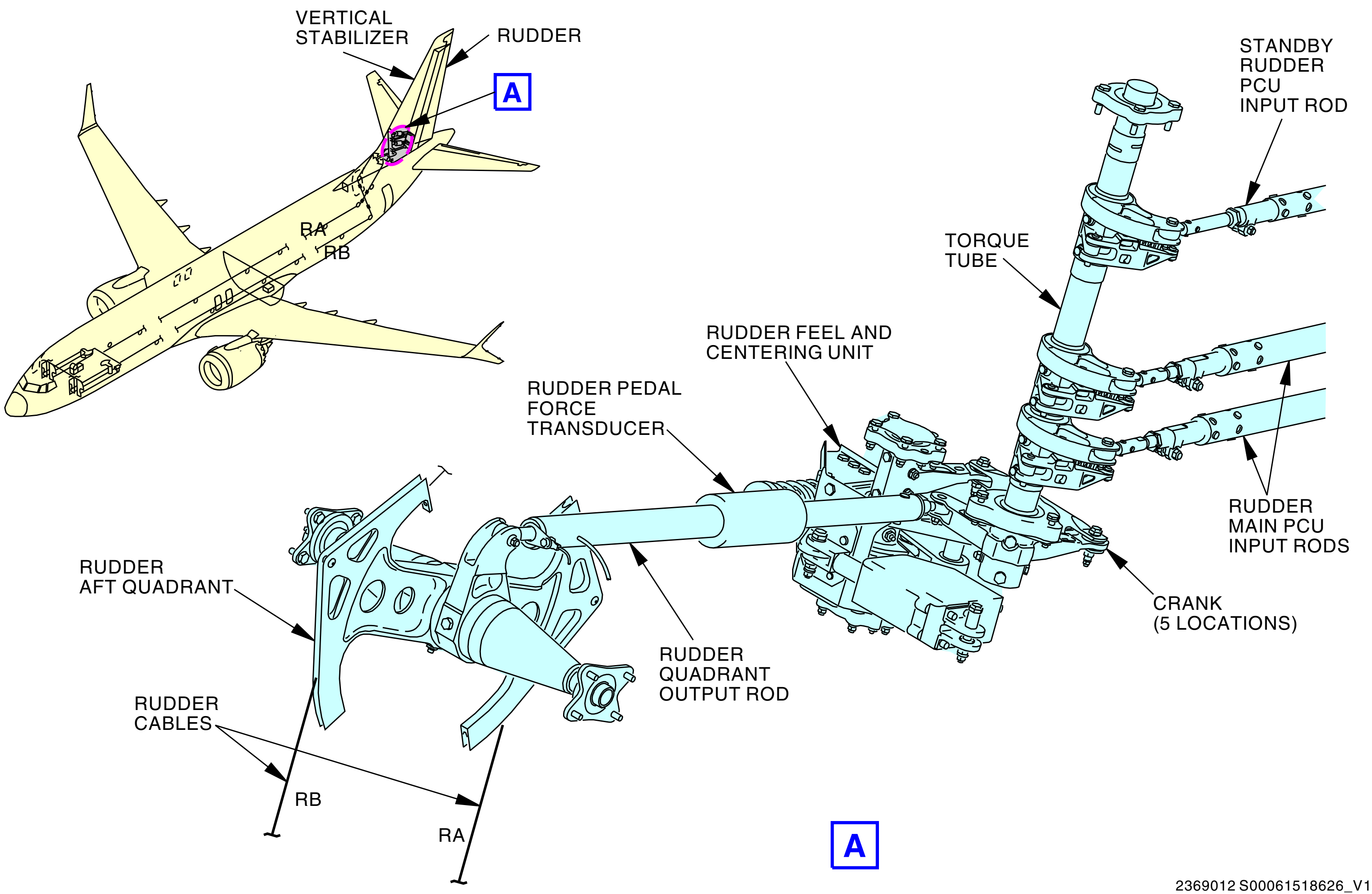
Functional Description

When the rudder cables move, they move the aft control quadrant. This moves the quadrant output rod and the torque tube with the five cranks. When the rudder control torque tube turns, it moves the input rods to the main PCU and to the standby PCU. It also turns the feel and centering unit out of the detent position.

The rudder pedal force transducer sends signals to the flight data acquisition unit (FDAU).

See the flight data recorder system section for more information about the FDAU. (SECTION 31-31)

RUDDER AND RUDDER TRIM CONTROL SYSTEM - AFT RUDDER CONTROL COMPONENTS



RUDDER AND RUDDER TRIM CONTROL SYSTEM - AFT RUDDER CONTROL COMPONENTS

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER FEEL AND CENTERING UNIT

Purpose

The rudder feel and centering unit gives artificial feel to the rudder pedals, centers the input to the PCU, and transmits trim inputs to the aft control components.

Location

The rudder feel and centering unit is in the vertical stabilizer on the bottom of the torque tube.

Physical Description

The rudder feel and centering unit has these components:

- Support shaft
- Crank
- Frame
- Spring (2)
- Cam
- Roller
- Roller arm.

The cam attaches to the shaft with bolts. A cam roller attaches to the roller arm which attaches to the support. The two springs connect the roller arm with the support.

The rudder trim actuator connects to a fixed bracket and the frame. The trim actuator is a 115v ac, 400Hz single phase, reversible motor. The motor has limit switches, mechanical stops at the stroke ends, and a brake to limit overcoast.

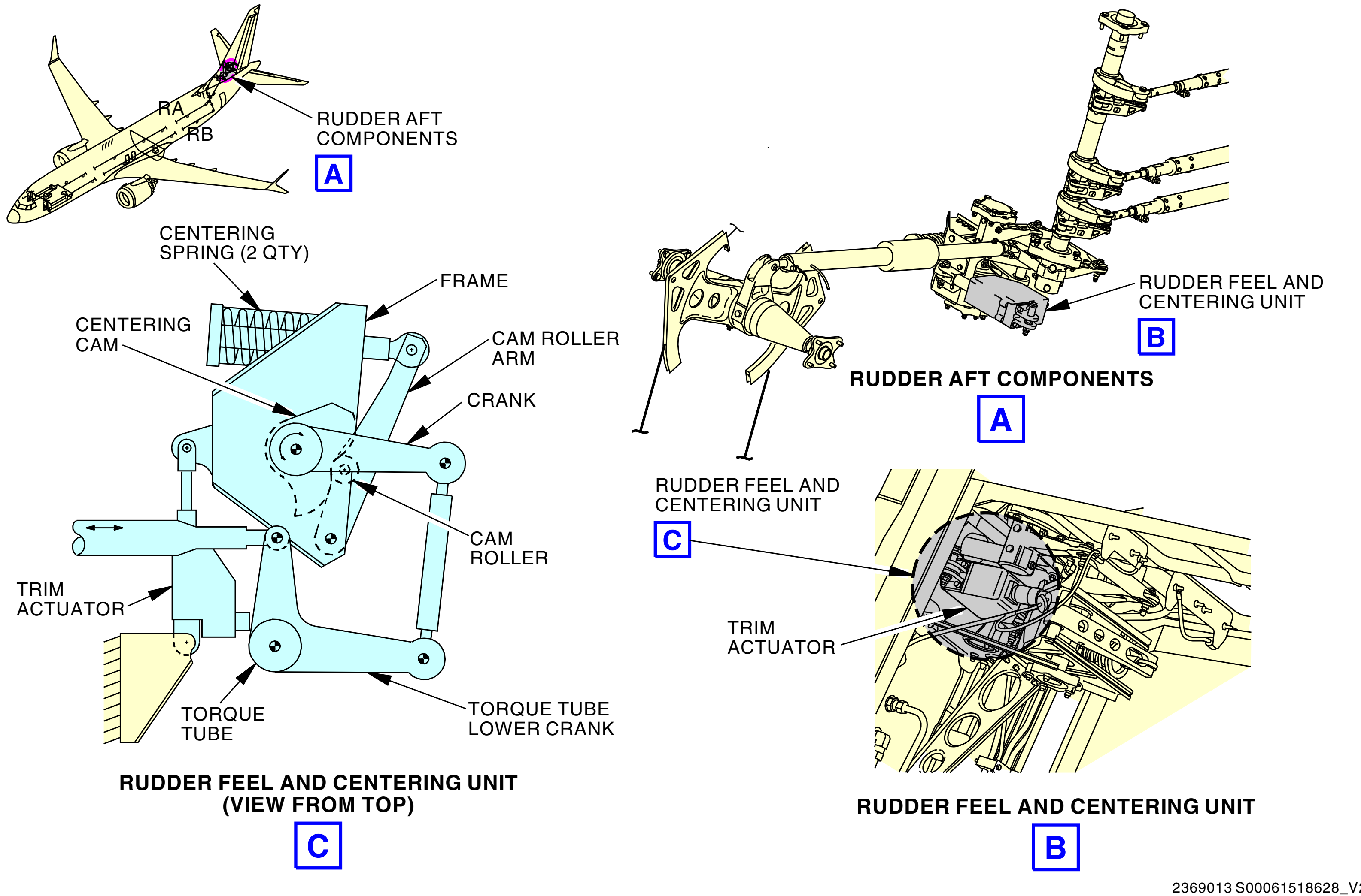
Functional Description

The centering springs hold the roller in the center of the cam. When the rudder pedals move, the cam turns with the shaft and moves the roller up on the cam. This compresses the springs and supplies feel force to the pilot.

When the pilots release the rudder pedals, the spring force causes the roller to move to the cam detent. The system is now at the neutral trim position.

During trim operation, the electrical trim actuator piston moves the frame. The springs keep the roller in the center of the cam and thus the shaft and crank will backdrive the torque tube. This gives an input to the rudder PCUs to move the rudder. It also moves the rudder pedals and supplies rudder trim indication on the P8 control stand.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER FEEL AND CENTERING UNIT



RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER FEEL AND CENTERING UNIT

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER TRIM ACTUATOR

Purpose

The rudder trim control operates the electrical trim actuator. The trim actuator changes the neutral position of the rudder and the rudder pedals.

Location

The rudder trim control knob and indicator are on the aileron/rudder trim panel.

The rudder trim actuator is in the vertical stabilizer connected to the rudder feel and centering unit.

Physical Description

The rudder trim control knob operates the two rudder trim switches. They are part of the aileron/rudder trim panel.

Functional Description

The pilot controls the rudder trim with the rudder trim control knob. The switches control the rudder trim actuator.

The rudder trim can operate at all times when electrical power is available. There are two switches internal to the control. One switch connects to supply power, controls rudder trim direction, and sends signals to the flight data acquisition unit (FDAU). The other switch connects to ground.

See the flight data recorder system section for more information about the FDAU. (SECTION 31-31)

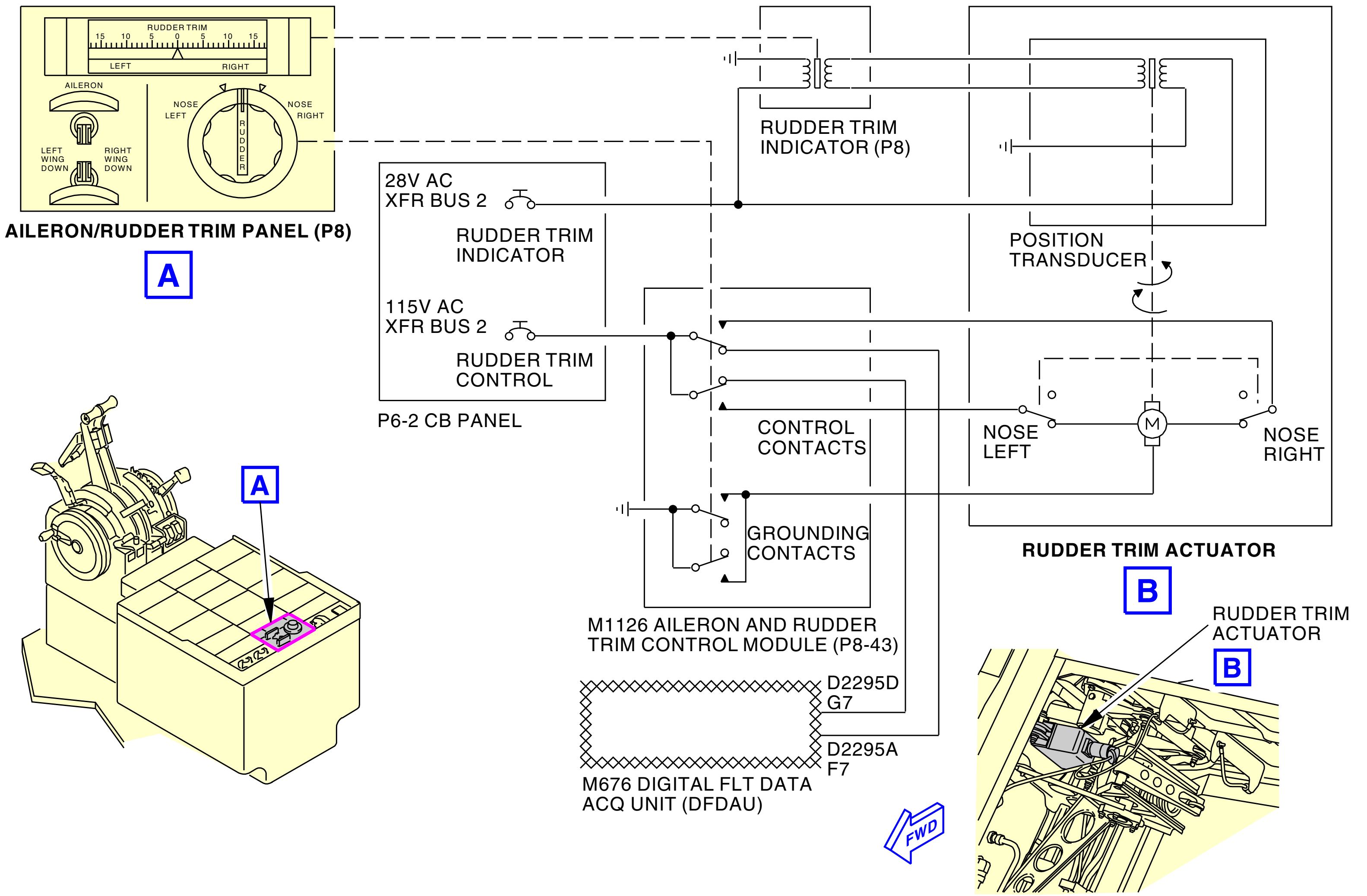
The rudder trim indicator shows the amount of trim in units. A screw located on the back of the indicator is used for adjustment.

If there is electric failure to the trim indication, an OFF flag shows. When the rudder trim indicator fails the trim function is still available.

Training Information Point

There must be hydraulic pressure to the PCUs for the trim input to move the rudder.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER TRIM ACTUATOR



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RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER TRIM ACTUATOR

RUDDER AND RUDDER TRIM CONTROL SYSTEM - MAIN RUDDER POWER CONTROL UNIT

Purpose

The main rudder power control unit (PCU) uses hydraulic power to move the rudder.

Location

The main rudder PCU is above the rudder feel and centering unit in the vertical stabilizer. To get access to the PCU, remove the panel on the left side of the vertical fin.

Physical Description

The PCU has these parts:

- Housing connected to structure
- Piston connected to the rudder
- Input and summing cranks
- Yaw damper solenoid valve
- Yaw damper EHSV
- Load limiter solenoid valves.

Functional Description

When the pilot moves the rudder pedals, the rudder input rod moves. This moves the external summing lever and the input crank. This causes the PCU piston to move the rudder. As the PCU piston moves, the summing lever moves the input crank to null out the input. This stops the PCU movement at the commanded position.

The yaw damper solenoid valve sends pressure to the yaw damper EHSV when the yaw damper system is engaged.

The yaw damper EHSV sends pressure to move the yaw damper actuator when the yaw damper system is engaged.

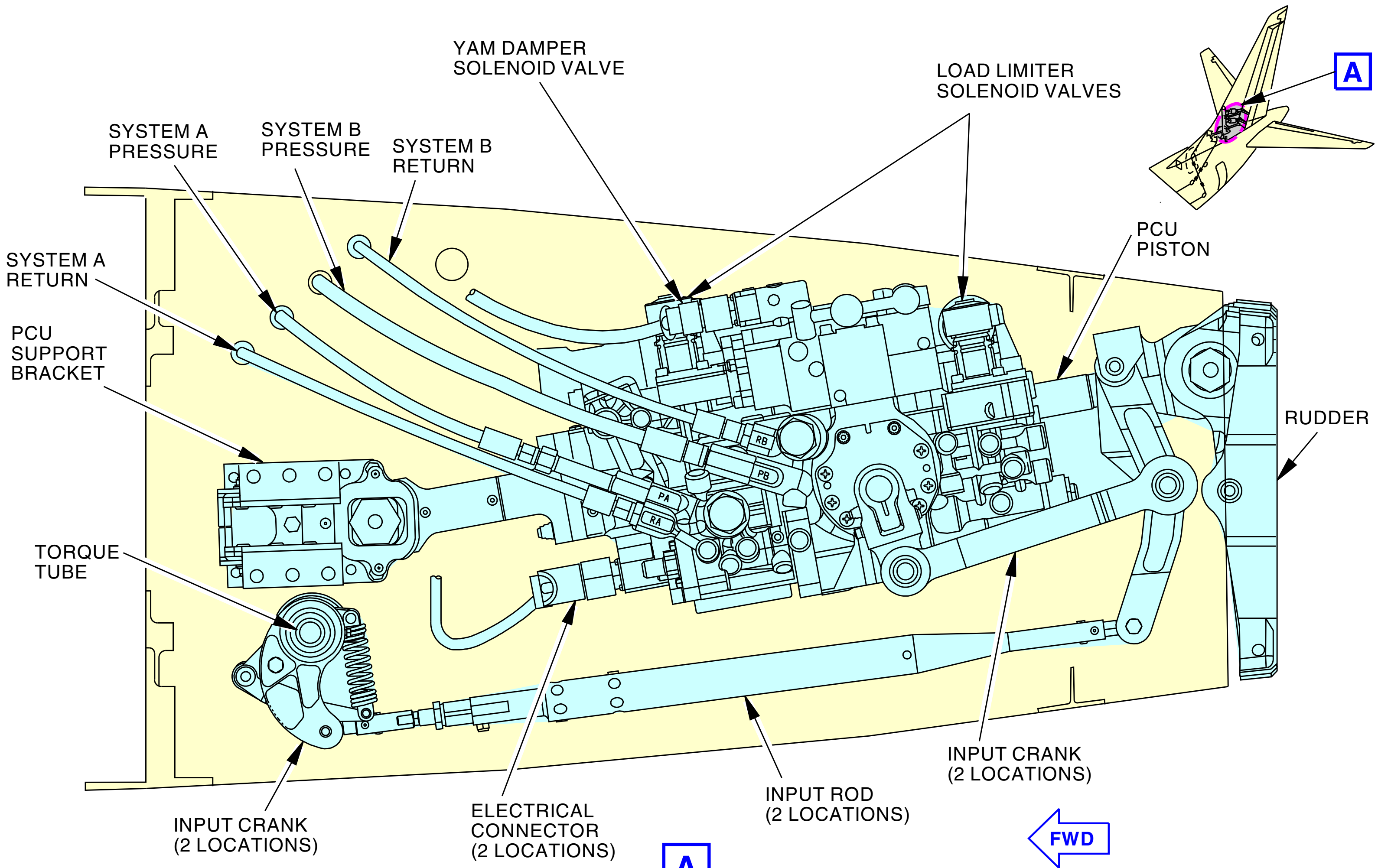
When energized, the load limiter solenoid valves send hydraulic pilot pressure to the respective load limit relief valves.

The force fight monitor (FFM) finds opposite pressure on the A and B sides of the tandem actuator. The FFM commands pressure to the standby PCU when the FFM sends a force fight signal to the P5-3 panel. See the standby hydraulic operation section of the AMM 29-22 for more information about the standby system. The FFM also commands the STBY RUD ON light (P5-3 panel) ON.

Maintenance Tip

A combination of different hose lengths and union coupling sizes prevents cross connection of hydraulic hoses.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - MAIN RUDDER POWER CONTROL UNIT



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RUDDER AND RUDDER TRIM CONTROL SYSTEM - MAIN RUDDER POWER CONTROL UNIT

RUDDER AND RUDDER TRIM CONTROL SYSTEM - MAIN RUDDER PCU - FUNCTIONAL DESCRIPTION

Physical Description

The PCU housing contains:

- Control valve (2)
- Authority limiter solenoid valve (2).
- Tandem actuator
- Bypass valve (2)
- Inlet Filter (2)
- Yaw damper actuator
- Yaw damper LVDT
- Yaw damper solenoid valve
- Yaw damper EHSV

Functional Description

When each hydraulic system pressure is on, hydraulic pressure moves each bypass valve to the non-bypass position. Pressure from system A and system B goes to the control valve. When the pilot gives an input to the rudder system, the control valve moves and sends pressure to the tandem actuator. This moves the PCU piston and the rudder.

The summing lever resets the control valve when the rudder moves to the selected position.

When hydraulic system A or B pressure is removed, the associated bypass valve moves to the bypass position. This connects both sides of the piston, prevents a hydraulic lock, and lets the hydraulic system with pressure move the actuator.

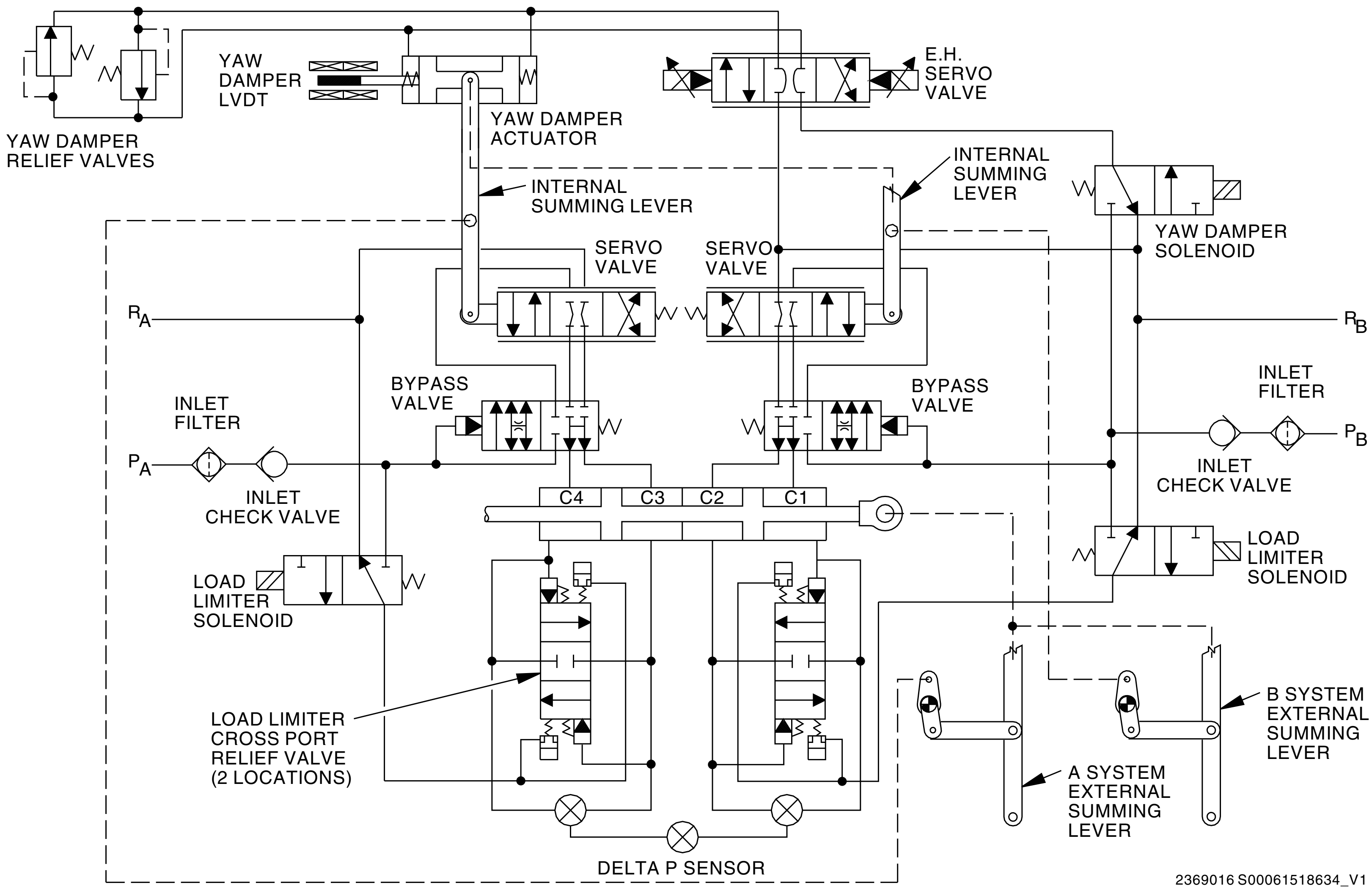
Load Limiter

The load limiter function limits rudder authority when the airspeed is more than 137 knots. When the load limiter solenoid valves energize, it sends pressure to the lock pistons in the load limit relief valve. The lock pistons move and release the modulating valve. The modulating valve reduces the working pressure to both the A and B pistons to 2200 psi. The rudder output force is now 25% less which reduces rudder authority at blowdown.

Yaw Damper

When engaged, the yaw damper system gives input to the main PCU yaw damper solenoid valve. The solenoid valve moves and sends pressure from system B to the electrohydraulic servo valve (EHSV). When the EHSV moves, it sends pressure to move the yaw damper actuator. The yaw damper actuator input mechanically adds to the pilot input. Then the control valve moves and sends pressure to the tandem actuator. This moves the PCU piston and the rudder. Rudder input from the yaw damper does not back drive the rudder pedals. See the yaw damper system section for more information. (SECTION 22-23)

RUDDER AND RUDDER TRIM CONTROL SYSTEM - MAIN RUDDER PCU - FUNCTIONAL DESCRIPTION



RUDDER CONTROL SYSTEM - MAIN RUDDER PCU - FUNCTIONAL DESCRIPTION

RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER POWER CONTROL UNIT

Purpose

The standby rudder power control unit (PCU) uses alternate hydraulic power to move the rudder.

Location

The standby rudder PCU is above the main rudder PCU in the vertical stabilizer.

Physical Description

The standby rudder PCU has these parts:

- Housing connected to structure
- Piston connected to the rudder
- Input and summing cranks
- Solenoid valve
- EHSV.

Functional Description

The standby rudder PCU gets alternate hydraulic power from the standby hydraulic pump. The standby hydraulic pump supplies power when system A or system B flight control switch is in the STDBY RUD position. The standby rudder shutoff valve, on the standby hydraulic system module, controls pressure to the standby rudder PCU. See the standby hydraulic system section for more information. (SECTION 29-22)

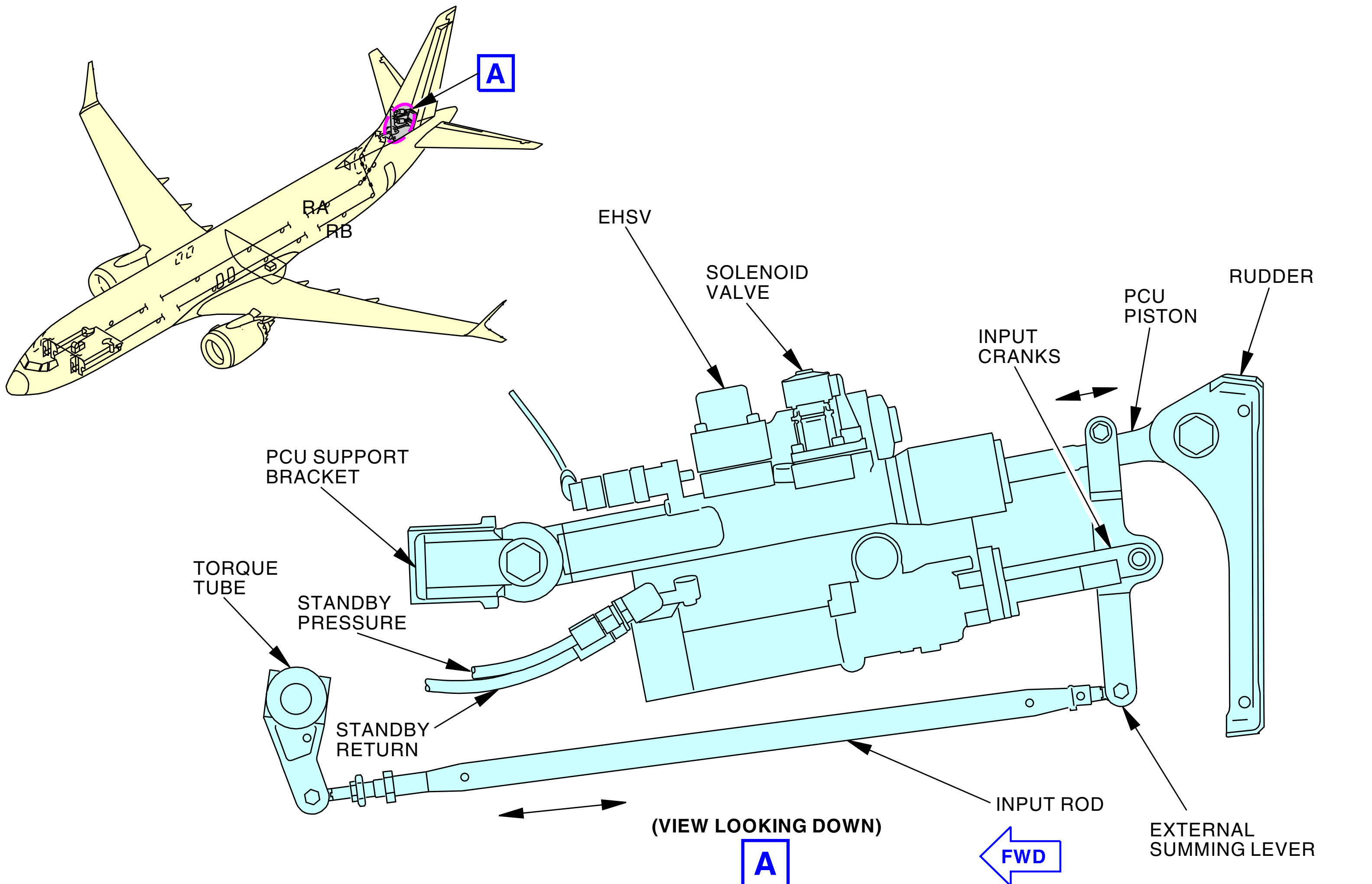
The standby hydraulic pump automatically supplies pressure to the standby rudder PCU when these conditions are present:

- System A or system B low pressure
- Airplane is in the air or wheel speed greater than 60 knots
- TE flaps are not up.
- Either system A or system B flight control switches are ON.

When the pilot moves the rudder pedals, the rudder input rods moves. This moves the external summing lever and the input crank. This causes the PCU piston to move the rudder. As the PCU piston moves, the summing lever moves the input crank to null out the input. This stops the PCU movement at the correct position.

The solenoid valve sends pressure to the EHSV when WTRIS is engaged. The EHSV sends pressure from the solenoid valve to the yaw damper actuator.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER POWER CONTROL UNIT



RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER POWER CONTROL UNIT

RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER PCU - FUNCTIONAL DESCRIPTION

Physical Description

The PCU contains these components:

- Bypass valve
- Filter
- Control valve, integrated with the yaw damper actuator
- Yaw damper LVDT
- Solenoid valve
- Shuttle valve
- Servo valve.

Functional Description

When standby hydraulic pressure is on, it opens the bypass valve and connects the actuator chambers to separate control ports.

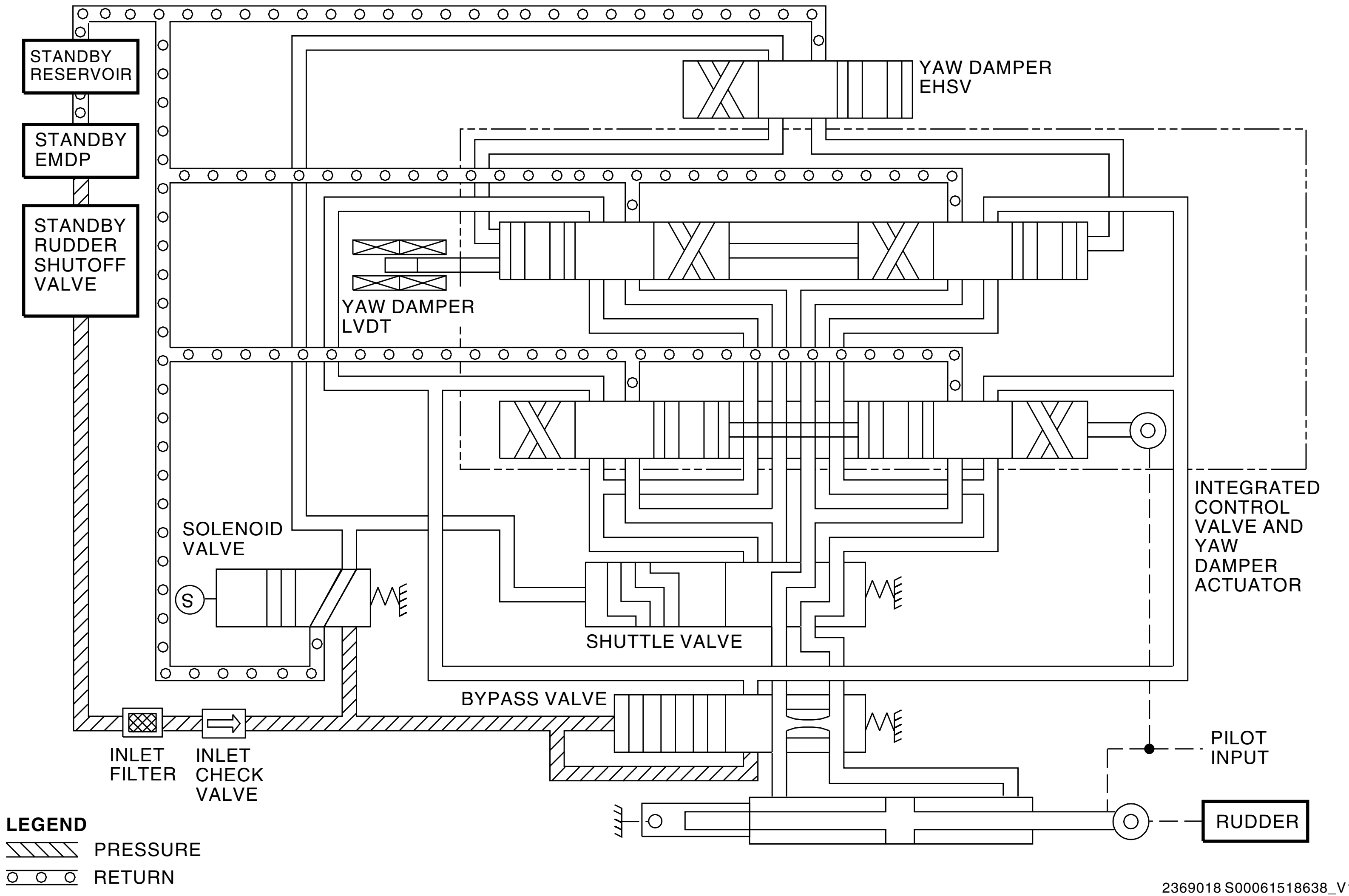
When the pilot moves the rudder pedals, the rudder input rod moves. This moves the external summing lever and the input crank. This positions the control valve to apply pressure to one chamber and open the other to return. The standby rudder PCU piston moves the rudder. This also moves the control valve to reset when the rudder moves to the position that the pilot selected.

Wheel-To-Rudder Interconnect System (WTRIS)

The WTRIS system gives input to the standby PCU to help in a manual reversion turn. The WTRIS engages when the flight control switches A and B are in the standby rudder position, and the yaw damper switch is on. When the WTRIS engages, the solenoid valve moves. This sends pressure to the EHSV. When the EHSV moves, it sends pressure to the yaw damper actuator. The yaw damper actuator moves and applies pressure to one chamber and opens the other to return. The standby rudder PCU piston moves and moves the rudder.

See the wheel-to-rudder interconnect section for more information. (SECTION 27-24)

RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER PCU - FUNCTIONAL DESCRIPTION



RUDDER AND RUDDER TRIM CONTROL SYSTEM - STANDBY RUDDER PCU - FUNCTIONAL DESCRIPTION

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER

Purpose

The rudder controls the flight attitude of the airplane about the vertical axis.

Location

The rudder attaches at the trailing edge of the vertical stabilizer.

Physical Description

The rudder attaches to the vertical stabilizer with hinges. Two PCUs attach to the rudder and move it.

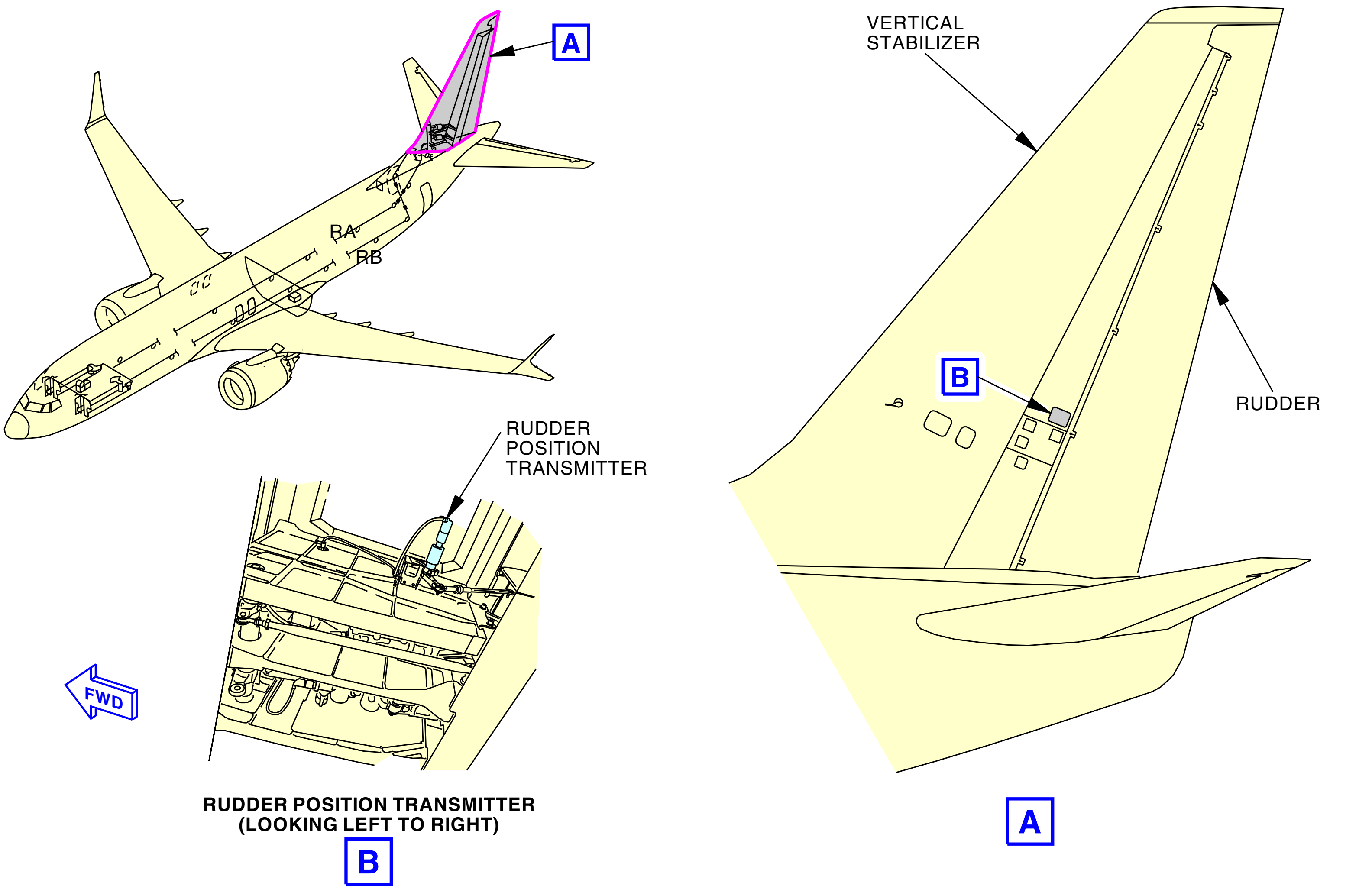
Functional Description

The rudder has a maximum deflection of 29 degrees left and 29 degrees right. Stops on the forward quadrant limit the input to the rudder PCUs.

When the rudder moves, the rudder position transmitter sends and signal to the flight data acquisition unit (FDAU).

See the flight data recorder system section for more information. (SECTION 31-31)

RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER



RUDDER AND RUDDER TRIM CONTROL SYSTEM - RUDDER

RUDDER AND RUDDER TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

General

The rudder control system uses cable input from the rudder pedals.

Physical Description

The yaw control system has these components:

- Rudder pedals and forward quadrant
- RA and RB rudder control cables
- Aft quadrant and trim, feel and centering
- Hydraulic PCUs (2)
- Rudder.

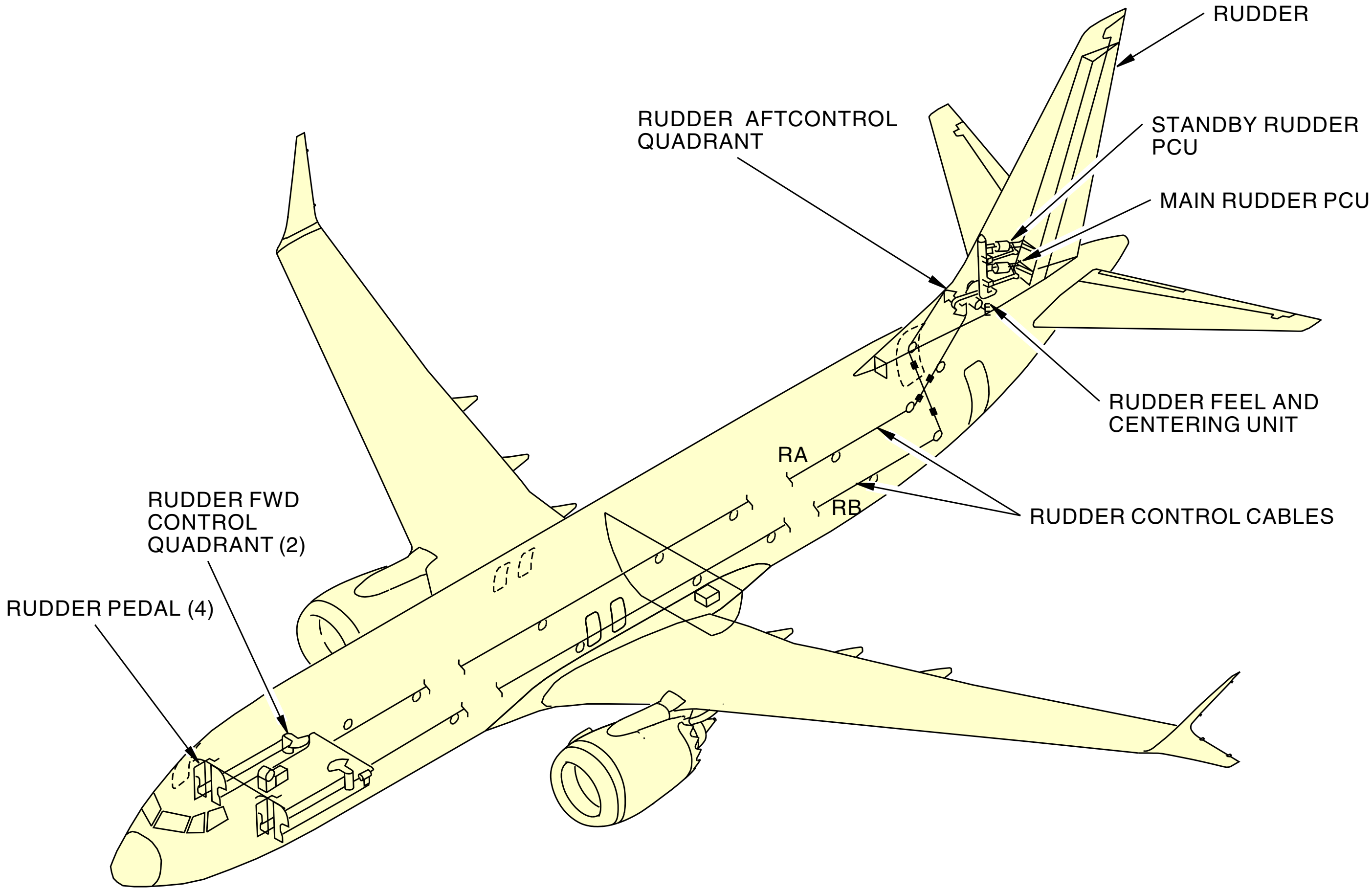
Functional Description - Normal

When the pedals move, they move the rudder forward control quadrants. This moves the RA and RB rudder control cables. The cables move the rudder aft control quadrant and the PCUs. The rudder PCUs pistons move and control the rudder position.

Functional Description - Electric Trim

During electric trim, the pilots move the rudder trim knob on the aisle stand, this sends a signal to the rudder trim actuator. The trim actuator moves the rudder feel and centering unit. This moves the rudder PCU and the rudder pedals. The rudder PCUs pistons move and control the rudder position.

RUDDER AND RUDDER TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



RUDDER AND RUDDER TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

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WHEEL TO RUDDER INTERCONNECT SYSTEM - INTRODUCTION

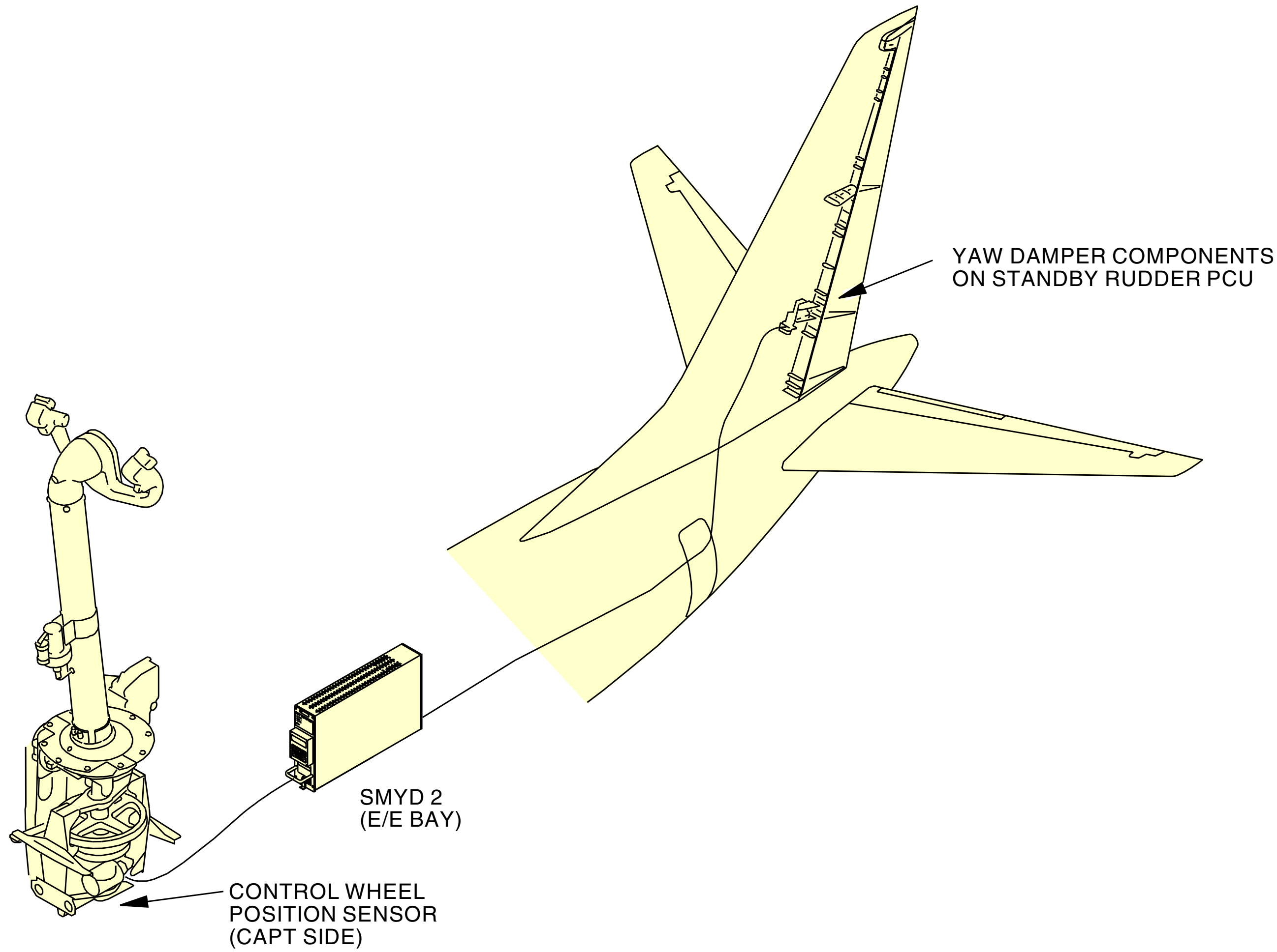
Purpose

The wheel to rudder interconnect system (WTRIS) assists turns during flight control manual reversion operations. The airspeed must be less than 0.4 Mach, both flight control A and B hydraulics are OFF, and the standby system is ON. The WTRIS commands a small amount of rudder movement as a function of the captain control wheel aileron input to help turns.

Abbreviations and Acronyms

- AC - alternating current
- ADR - air data reference
- ADIRU - air data inertial reference unit
- AOA - angle of attack
- ARINC - Aeronautical Radio Incorporated
- ATR - Austin Trumbull Radio
- BITE - built-in test equipment
- CPU - central processing unit
- DC - direct current
- DFCS - digital flight control system
- DPC - display processing computer
- EHSV - electrohydraulic servo valve
- FMC - flight management computer
- IR - inertial reference
- I/O - input/output
- LRU - line replaceable unit
- LVDT - linear variable differential transformer
- MCP - mode control panel (DFCS)
- MDS - MAX display system
- N1 - engine low pressure rotor (fan) speed
- N2 - engine high pressure rotor speed
- NN - a number from 01 to 99
- PCU - power control unit
- SMYD - stall management yaw damper
- V - volts
- WTRIS - wheel to rudder interconnect system
- YDS - yaw damper system

WHEEL TO RUDDER INTERCONNECT SYSTEM - INTRODUCTION



WHEEL TO RUDDER INTERCONNECT SYSTEM - INTRODUCTION

WTRIS - GENERAL DESCRIPTION

General

The Wheel-to-Rudder Interconnect System (WTRIS) moves the rudder to help turns during flight control manual reversion when on standby hydraulics. For the WTRIS function, Stall Management Yaw Damper (SMYD) 2 has interfaces with these components:

- Control wheel position sensor (captain)
- Yaw damper engage switch
- Yaw damper disengage light
- Flight control panel switches
- Standby yaw damper solenoid valve
- Standby Electro-Hydraulic Servo Valve (EHSV)
- Standby Linear Variable Differential Transformer (LVDT)
- Flight Management Computer (FMC)
- Trailing edge flaps up limit switches
- Left flap position transmitter.

Stall Management Yaw Damper

SMYD 2 commands rudder movement for WTRIS and standby yaw damping and turn coordination during flight control manual reversion when on standby hydraulics. SMYD 2 receives data from airplane sensors, switches and components, and uses the data to calculate and send commands to the standby rudder Power Control Unit (PCU) to move the rudder.

Control Wheel Position Sensor

The captain Control Wheel (CW) position sensor senses pilot aileron input and sends an analog signal to the SMYD 2 to calculate a command for left/right rudder movement for WTRIS.

Yaw Damper Engage Switch and Disengage Light

You engage WTRIS and standby yaw damping with the yaw damper switch on the flight control panel. The disengage warning light is above the switch.

Standby Rudder Power Control Unit (PCU)

The standby rudder PCU is a hydraulic actuator that moves the rudder in response to pilot rudder inputs when on standby hydraulic pressure. During standby operation, SMYD 2 sends commands to the yaw damper components on the standby rudder PCU.

ADIRU

The Air Data Inertial Reference Units (ADIRUs) send data to the SMYDs. The data includes airspeed, attitude, and yaw and roll rates and accelerations.

FMC

The FMC provides airplane gross weight to the SMYDs.

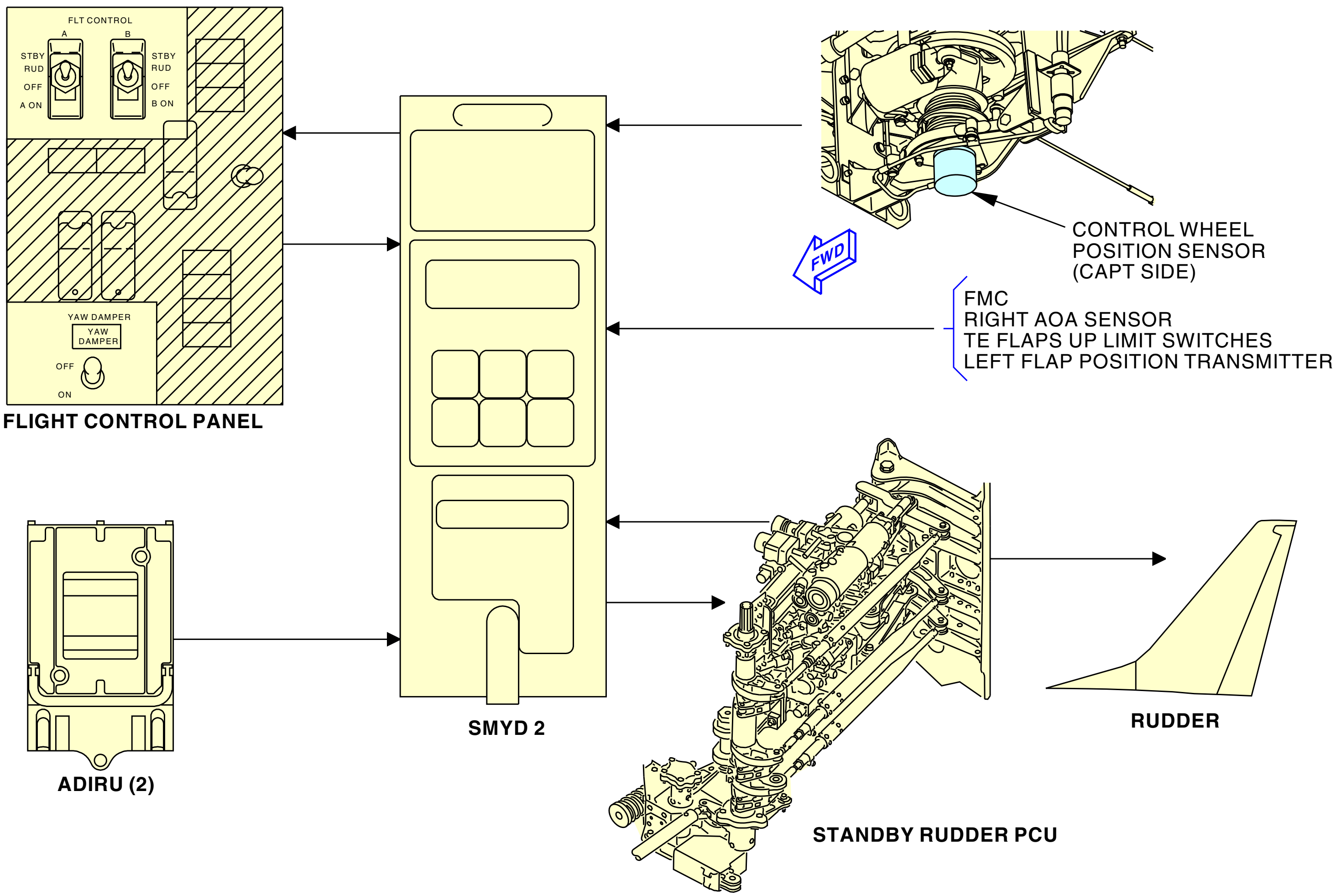
Trailing Edge Flaps Up Limit Switches

The trailing edge flaps up limit switches send data to the SMYD to put a limit on rudder travel when the flaps are up. The rudder travel limit is 2 degrees when the flaps are up and 2.5 degrees when the flaps are not up.

Left Flap Position Transmitter

The left flap position transmitter sends data to SMYD 2.

WTRIS - GENERAL DESCRIPTION



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WTRIS - GENERAL DESCRIPTIION

WTRIS - COMPONENT LOCATIONS

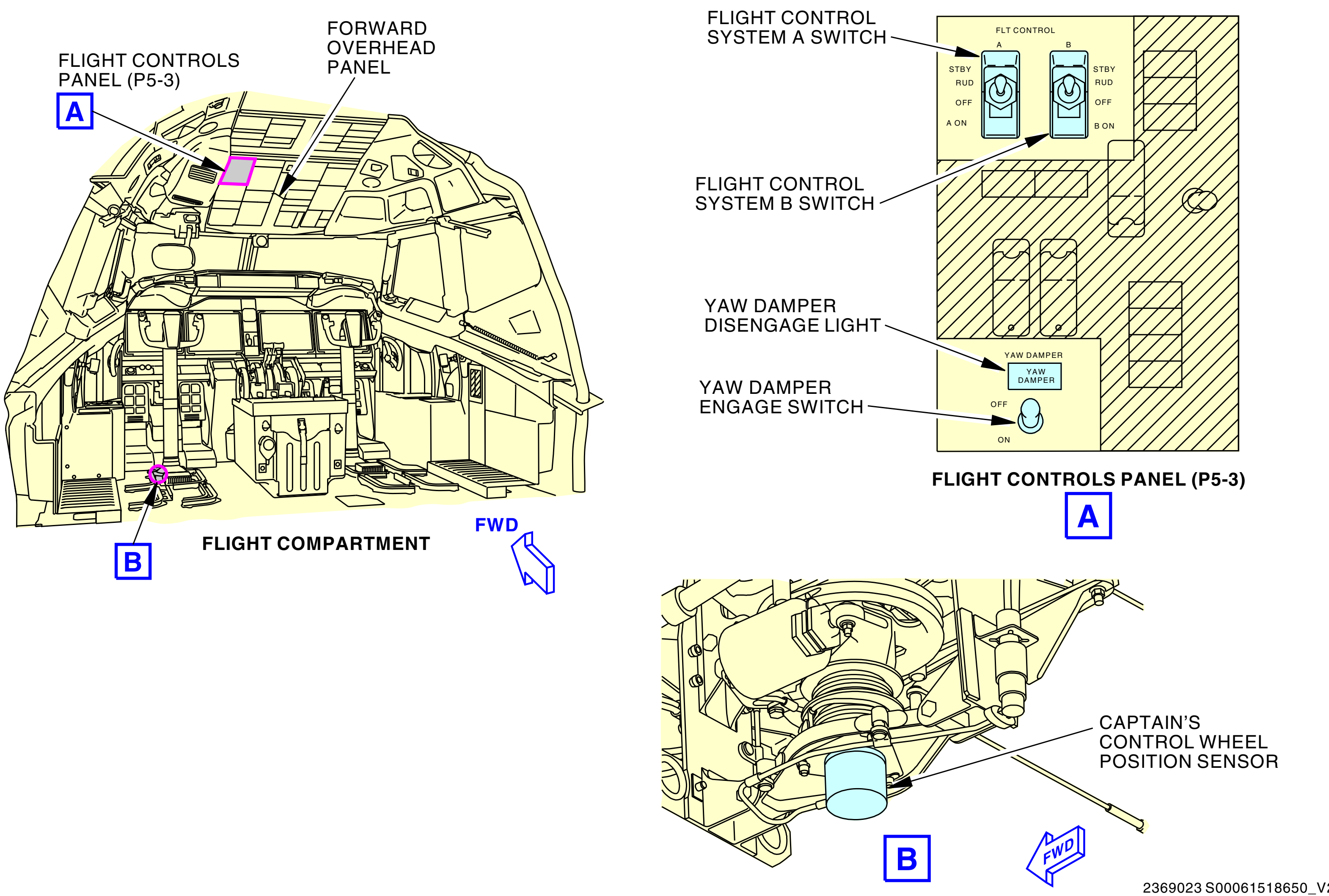
Flight Compartment

The yaw damper engage switch and the disengage light are on the flight control panel.

Forward Nose Compartment

The control wheel position sensors are at the bottom of the captain and first officer control columns, below the floor. Only the captain sensor sends data to SMYD 2.

WTRIS - COMPONENT LOCATIONS



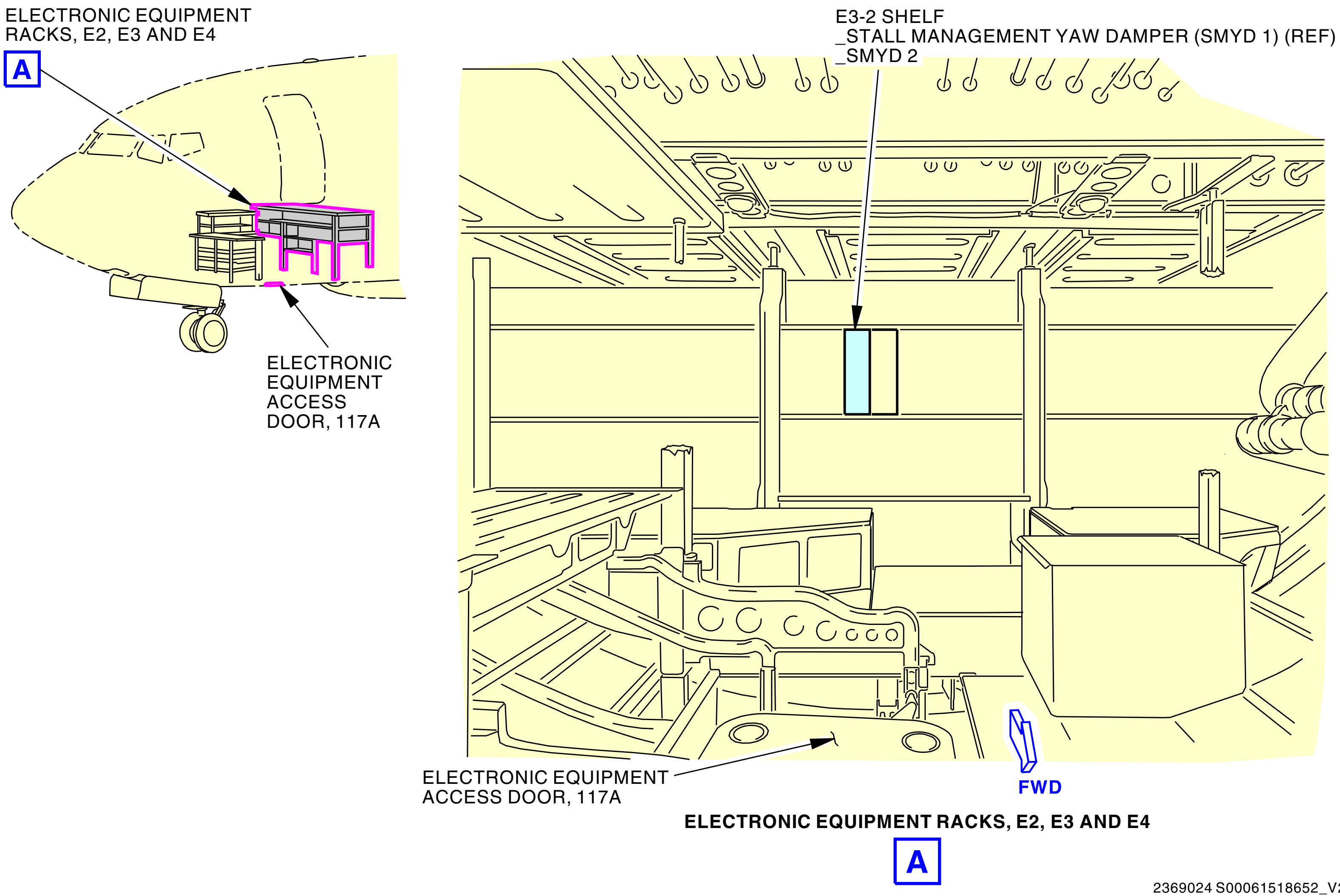
WTRIS - COMPONENT LOCATIONS

WTRIS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATIONS

Stall Management Yaw Damper

The SMYD 2 is on the E3-2 shelf in the electronic equipment bay.

WTRIS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATIONS



WTRIS - ELECTRONIC EQUIPMENT COMPARTMENT COMPONENT LOCATIONS

WTRIS - INTERFACES

Power

Stall Management Yaw Damper (SMYD) 2 gets 28v dc from DC bus 1 and 28v ac from transfer bus 1. 28v dc power goes from SMYD 2 to the yaw damper engage switch.

The Linear Variable Differential Transformer (LVDT) on the standby rudder Power Control Unit (PCU) gets 28v ac from the same circuit as SMYD 2.

Digital Data

SMYD 2 receives airplane gross weight from the Flight Management Computer (FMC).

SMYD 2 receives these air data from the right Air Data Inertial Reference Unit (ADIRU):

- Airspeed
- Impact pressure.

SMYD 2 receives these inertial data from the left and right ADIRUs:

- Lateral acceleration
- Roll angle
- Roll rate
- Yaw rate.

Analog Signals

SMYD 2 sends commands to the standby rudder PCU to assist turns during flight control manual reversion, and for standby yaw damping/turn coordination. The LVDT on the standby rudder PCU sends rudder position data to SMYD 2 about rudder movement.

The trailing edge flaps up limit switches send flaps up/not up data to SMYD 2 to limit rudder movement when the flaps are up.

The left flap position transmitter sends flap position data to SMYD 2 to use in stall warning, Wheel-to-Rudder Interconnect System (WTRIS) and yaw damping command calculation.

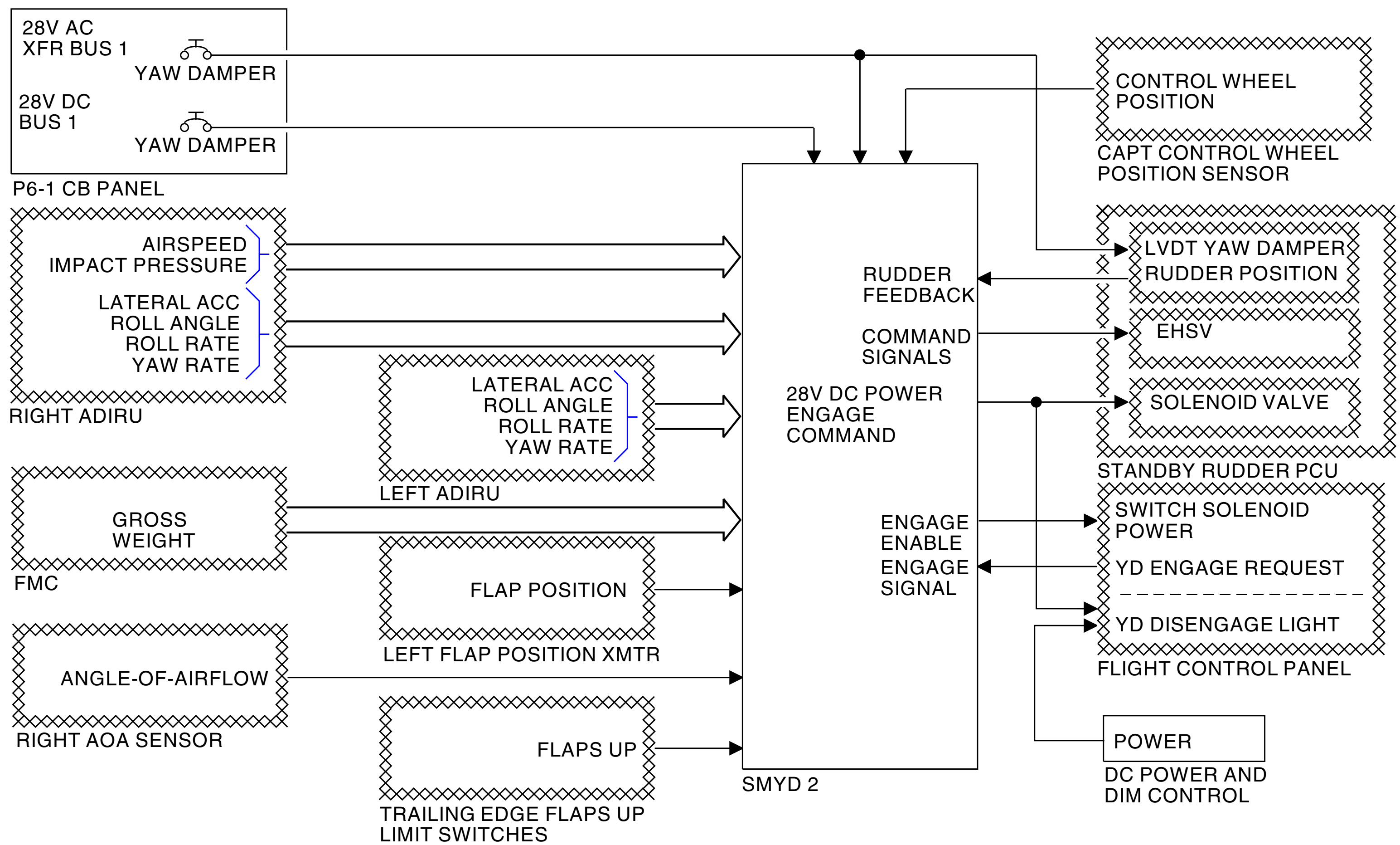
The right Angle of Attack (AOA) sensor sends angle-of-airflow information to SMYD 2 to use in stall warning, WTRIS and yaw damping command calculation.

Power goes from the DC power and dim control to the yaw damper disengage light.

The captain Control Wheel (CW) position sensor sends control wheel aileron input information to SMYD 2 for the WTRIS function.

During standby hydraulic operations, when you turn ON the yaw damper engage switch, an engage signal goes through SMYD 2 to the yaw damper solenoid valve on the standby rudder PCU to engage the yaw damper. SMYD 2 commands rudder movement using the standby Electro-Hydraulic Servo Valve (EHSV). The flight control panel switches for system A and B must be in the OFF or STBY RUD position to enable SMYD 2 for WTRIS and standby yaw damping.

WTRIS - INTERFACES



NOTE:

THIS DIAGRAM ONLY SHOWS SMYD INTERFACES FOR WTRIS AND STANDBY YAW DAMPING

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WTRIS - INTERFACES

WTRIS - STALL MANAGEMENT YAW DAMPER

Purpose

Stall Management Yaw Damper (SMYD) 2 calculates and sends commands to the yaw damper components on the standby rudder Power Control Unit (PCU) to move the rudder for Wheel-to-Rudder Interconnect System (WTRIS) and standby yaw damping/turn coordination. SMYD 2 uses control wheel (aileron) position data to command small amounts of rudder movement to help turns during flight control manual reversion, when on standby hydraulics. SMYD 2 uses inertial data from the Air Data Inertial Reference Unit (ADIRU) to detect unwanted yaw motion due to dutch roll or turbulence.

SMYD 2 also does stall management functions.

Physical Description

The SMYD weighs approximately 10 lbs. It uses 10 watts of power. A standard Boeing Built-In-Test Equipment (BITE) module is on the front of the LRU and interfaces with the SMYD to monitor operation and record faults. The BITE module has these features on the front of the unit:

- Bite instructions on the label
- Display
- Keypad.

Bite Instructions

Bite instructions on the BITE module tell how to test the unit and move through the BITE software.

Display

The SMYD BITE module has a two-line amber display. Each line has eight alphanumeric characters. The display shows messages about the type of fault, maintenance message number, and fault details when you do BITE. The SMYD 2 BITE interfaces with and provides fault data for stall management functions and for standby yaw damping and WTRIS.

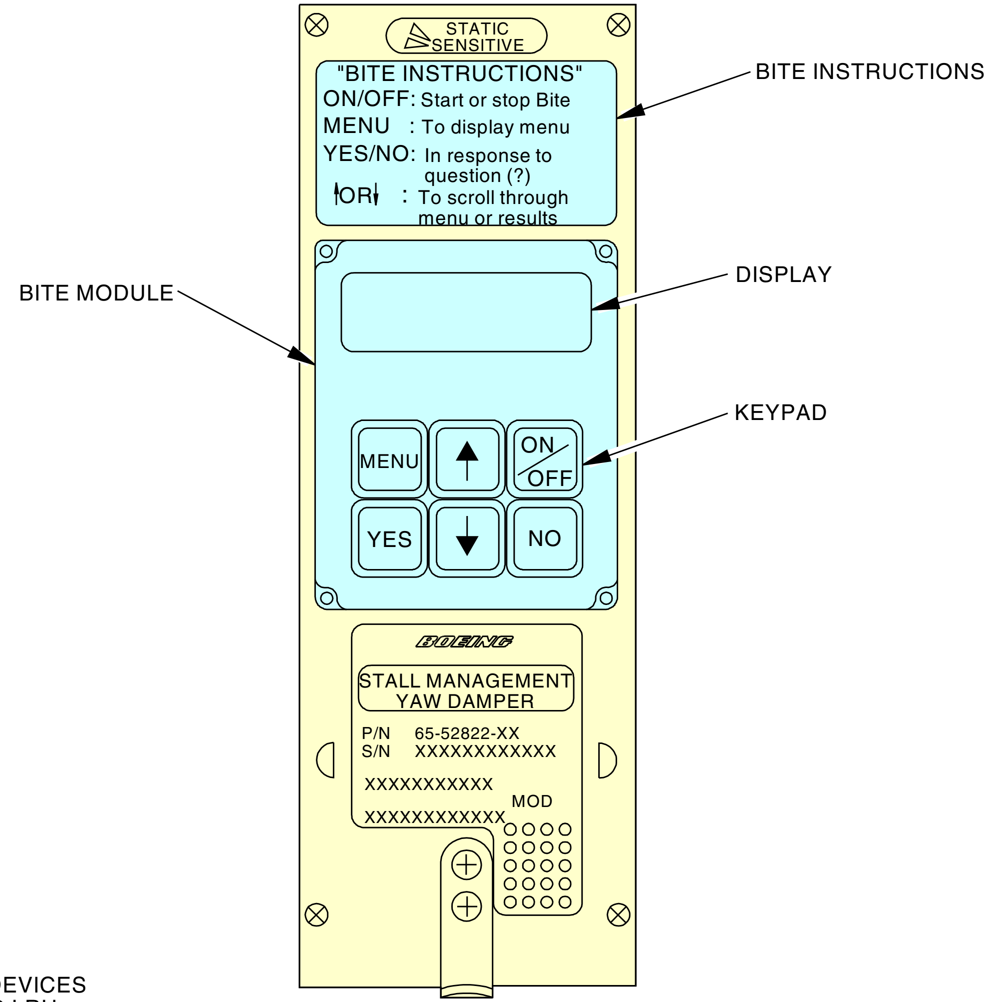
Keypad

You use the keys on the BITE module to operate the SMYD BITE. The keypad has these keys:

- ON/OFF
- MENU
- YES
- NO
- Up arrow (previous)
- Down arrow (next).

See the SMYD section for more information about BITE operation (SECTION 27-32).

WTRIS - STALL MANAGEMENT YAW DAMPER



NOTE:

OBSERVE PRECAUTIONS FOR ELECTRO-STATIC SENSITIVE DEVICES WHEN YOU HANDLE THE SMYD LRU.

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WTRIS - STALL MANAGEMENT YAW DAMPER

WTRIS - SMYD 2 - FUNCTIONAL DESCRIPTION

General

Stall Management Yaw Damper (SMYD) 2 uses analog and digital data inputs to calculate rudder commands for Wheel-to-Rudder Interconnect System (WTRIS) and standby yaw damping/turn coordination.

Engage Interlock

SMYD 2 supplies 28v dc to the yaw damper solenoid valve on the standby rudder Power Control Unit (PCU). When this solenoid valve is energized it supplies hydraulic fluid to the Electro-Hydraulic Servo Valve (EHSV) to operate the yaw damper actuator on the standby rudder PCU to move the rudder for WTRIS and standby yaw damping.

WTRIS

The WTRIS function of SMYD 2 uses control wheel aileron inputs from the captain control wheel position sensor to command small amounts of rudder movement. This helps turn the airplane during flight control manual reversion when operating on standby hydraulics.

The SMYD central processing unit (CPU) operates the control law software. For SMYD 2, the software calculations are based on inputs from these components:

- Captain control wheel position sensor
- Air Data Inertial Reference Units (ADIRUs) (inertial and air data)
- Right Angle of Attack (AOA) sensor
- Flight Management Computer (FMC)
- Standby rudder PCU Linear Variable Differential Transformer (LVDT)
- Trailing edge flap up limit switches.

SMYD 2 receives inertial data from the ADIRU to calculate commands for standby yaw damping and turn coordination. These commands go to the yaw damper EHSV on the standby rudder PCU to move the rudder.

The EHSV applies hydraulic pressure to the yaw damper actuator and the actuator makes a mechanical summing input to the rudder PCU to move the rudder to assist turns and to reduce unwanted yaw. The standby LVDT sends yaw damper actuator position data about rudder movement to SMYD 2.

WTRIS only operates at Mach < 0.4. The gain schedule changes from 1 (full gain) at Mach < 0.3 to zero gain at Mach > 0.4.

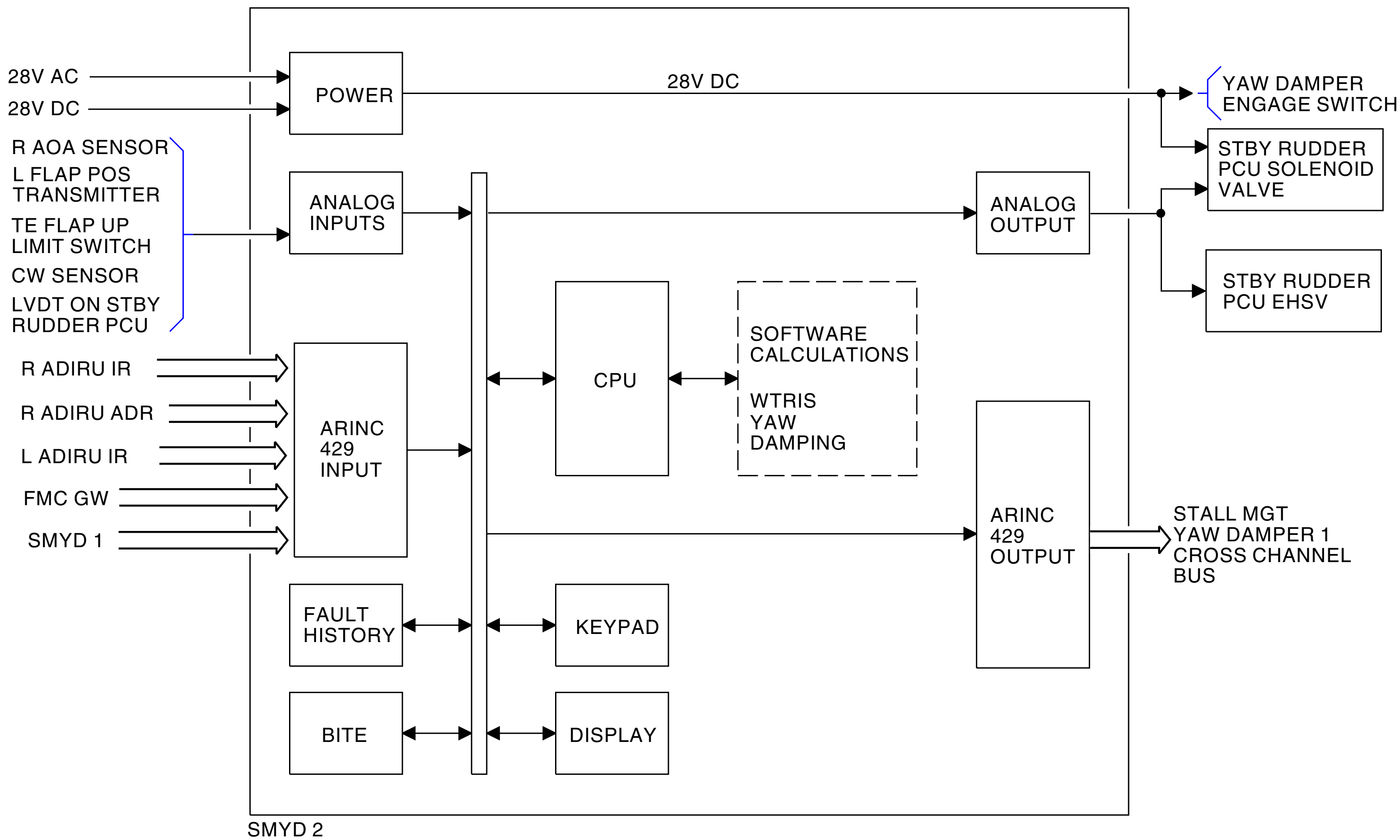
For WTRIS and standby yaw damping, these are the limits for rudder commands:

- 2 degrees with flaps up
- 2.5 degrees with flaps not up.

BITE

The SMYD has BITE test and continuous BITE. It stores failures in fault history. The keypad is for operator interface. The display shows test results and prompts for input.

WTRIS - SMYD 2 - FUNCTIONAL DESCRIPTION



NOTE:

ONLY INTERFACES FOR WTRIS AND STBY YAW DAMPING ARE SHOWN ON THIS DIAGRAM.

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WTRIS - SMYD 2 - FUNCTIONAL DESCRIPTION

WTRIS - OPERATIONS

General

The yaw damper engage switch on the flight control panel operates the Wheel-to-Rudder Interconnect System (WTRIS) and standby yaw damper. The yaw damper disengage warning light is above the engage switch.

Engage Switch and Warning Light

To turn on the WTRIS and standby yaw damper, do these steps on the flight control panel:

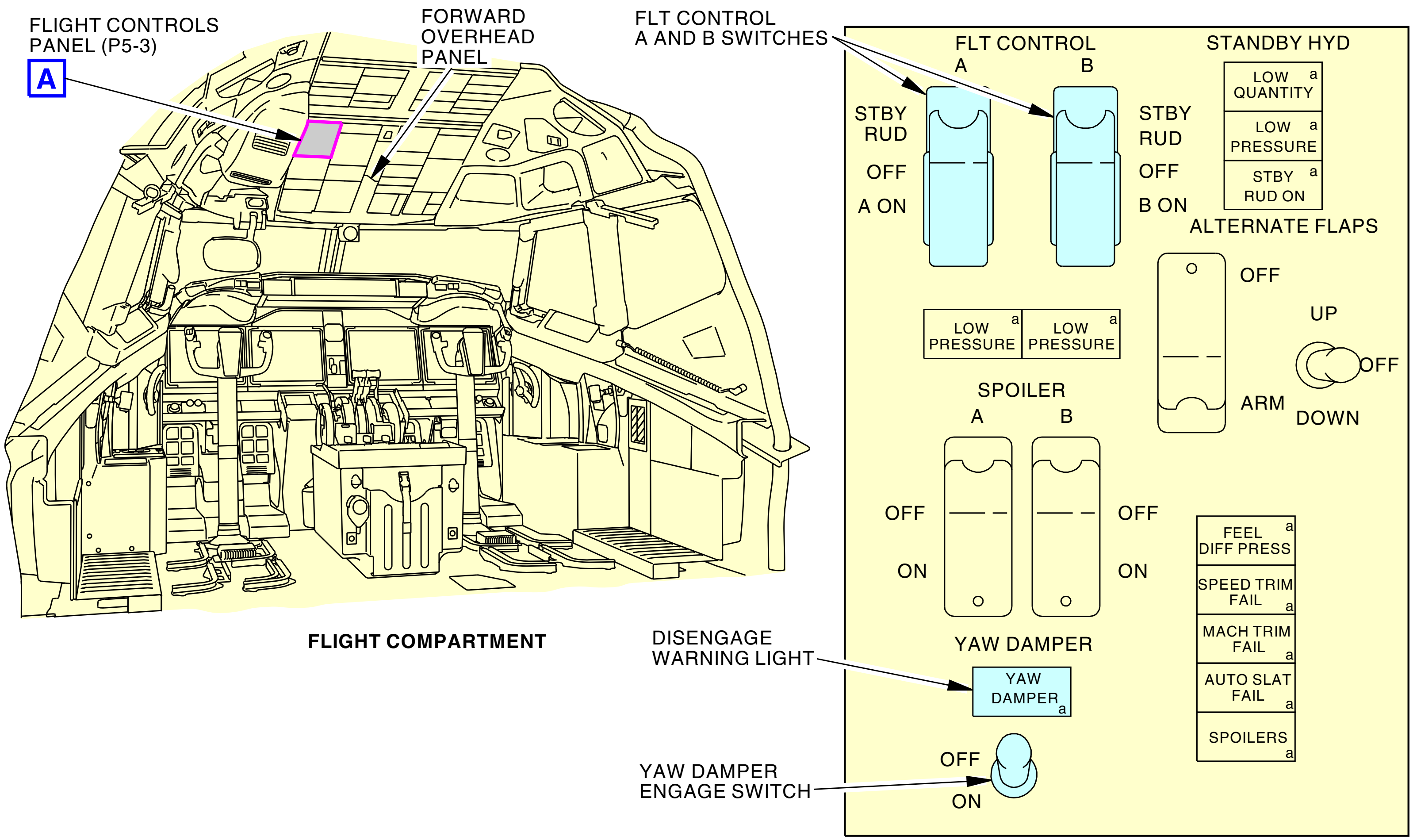
- Put the FLT CONT A and B switches to positions other than the ON position
- Put at least one of these switches to STBY RUD
- Put the yaw damper switch to ON.

When you put the flight control A and B switches to positions other than the ON position, a signal enables Stall Management Yaw Damper (SMYD) 2 for WTRIS and standby yaw damping. When you put one of these switches to the STBY RUD position, standby hydraulic pressure goes to the standby rudder Power Control Unit (PCU) to move the rudder.

When you put the yaw damper engage switch to ON and then after a two-second delay, the yaw damper engage light goes off to show that WTRIS and standby yaw damping are in operation.

If there is a system fault, the yaw damper disengage light comes ON. After a two-second delay, SMYD 2 removes power from the engage solenoid valve on the standby rudder PCU to stop hydraulic fluid to the Electro-Hydraulic Servo Valve (EHSV). SMYD 2 also removes power from the yaw damper engage switch on the flight control panel and the switch moves to OFF.

WTRIS - OPERATIONS



FLIGHT CONTROLS PANEL (P5-3)
A

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WTRIS - OPERATIONS

WTRIS - OPERATIONS - ENGAGE INTERLOCKS

General

Stall Management Yaw Damper (SMYD) 2 operates the Wheel-to-Rudder Interconnect System (WTRIS) and standby yaw damping during standby operations. To enable the WTRIS and standby yaw damper functions, the FLT CONTROL A and B switches must be in the correct positions. One of these switches must be in the STBY RUD position. The other switch can be in the STBY RUD position or the OFF position.

Engage Switch and Warning Light

To engage the WTRIS and standby yaw damper, move the YAW DAMPER switch on the flight controls panel to the ON position. Two seconds later, the YAW DAMPER light goes out to show that these systems are operating. The YAW DAMPER switch is held in the ON position with power from SMYD 2.

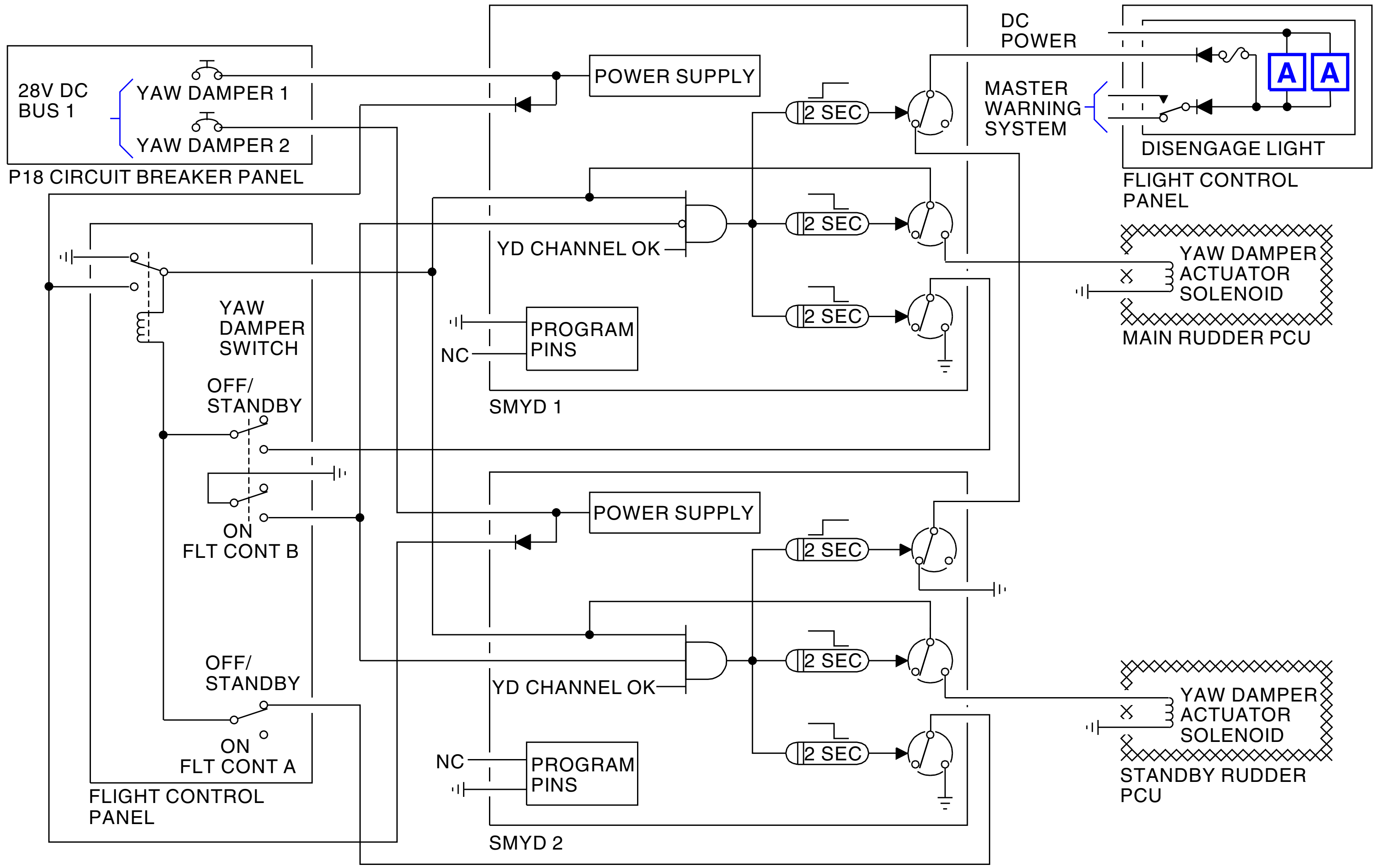
Move the YAW DAMPER switch to the OFF position to disengage the WTRIS and standby yaw damper. The yaw damper actuator solenoid deenergizes and the YAW DAMPER light comes on immediately to show that the system is disengaged.

During a system fault, The YAW DAMPER light comes on immediately. SMYD 2 removes power from the YAW DAMPER switch solenoid and actuator solenoid after 2 seconds. The switch moves to the OFF position.

SMYD

When a SMYD computer is in the number 2 position, it operates the WTRIS and standby yaw damper. These systems only operate when in flight control manual reversion mode. This is when flight control hydraulic system A and B are OFF and the standby system is ON.

WTRIS - OPERATIONS - ENGAGE INTERLOCKS



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WTRIS - OPERATIONS - ENGAGE INTERLOCKS

WTRIS - SMYD 2 - SYSTEM SUMMARY

General

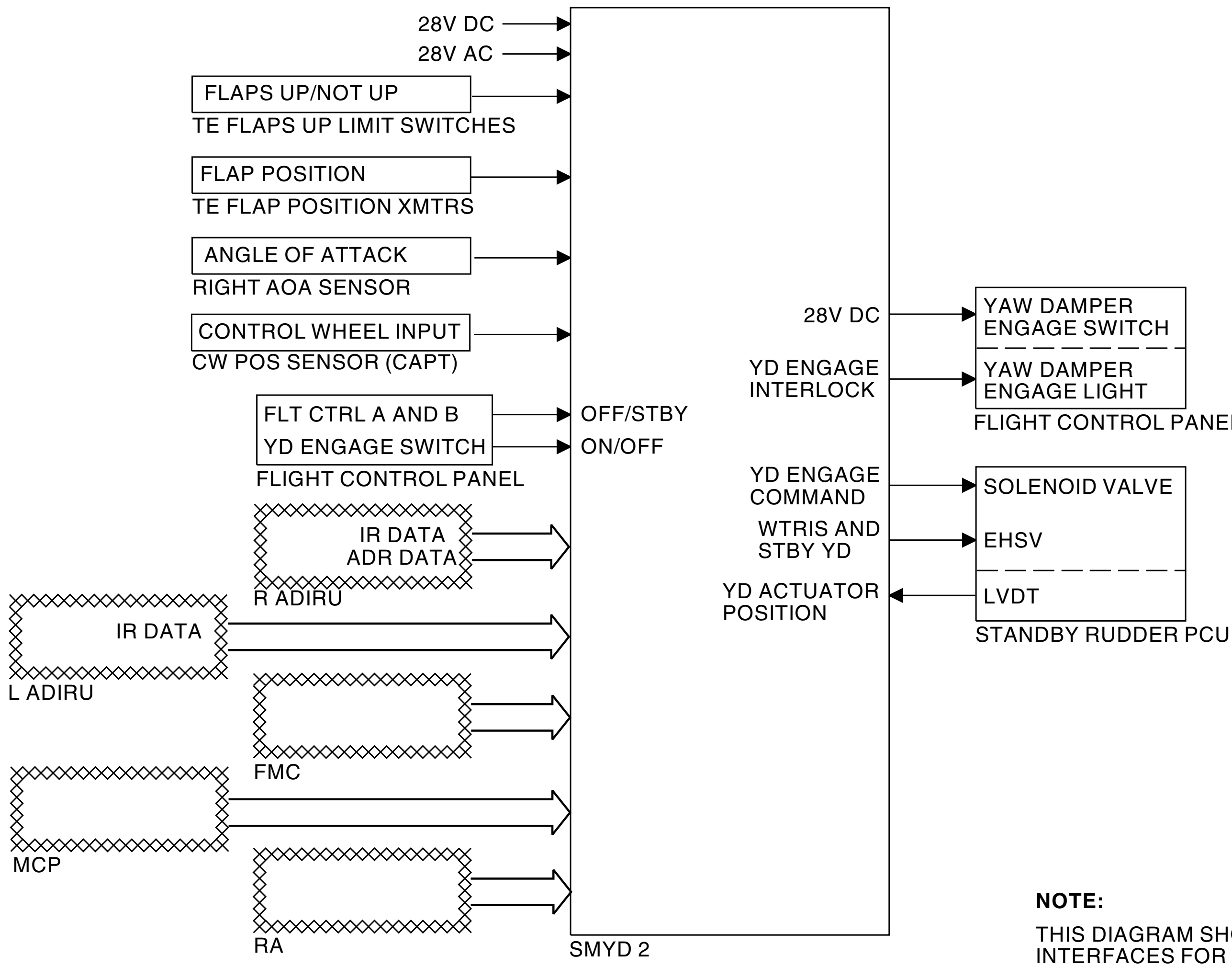
The Wheel-to-Rudder Interconnect System (WTRIS) moves the rudder to help turns during flight control manual reversion when on standby hydraulics. For the WTRIS function, SMYD 2 has interfaces with these components:

- Control wheel position sensor (captain)
- Yaw damper engage switch
- Yaw damper disengage light
- Flight control panel switches
- Standby yaw damper solenoid valve
- Standby Electro-Hydraulic Servo Valve (EHSV)
- Standby Linear Variable Differential Transformer (LVDT)
- Flight Management Computer (FMC)
- Trailing edge flaps up limit switches
- Left flap position transmitter.

Stall Management Yaw Damper

SMYD 2 commands rudder movement for WTRIS and standby yaw damping and turn coordination during flight control manual reversion when on standby hydraulics. SMYD 2 receives data from airplane sensors, switches and components, and uses the data to calculate and send commands to the standby rudder Power Control Unit (PCU) to move the rudder.

WTRIS - SMYD 2 - SYSTEM SUMMARY



NOTE:

THIS DIAGRAM SHOWS SMYD 2 INTERFACES FOR WTRIS AND STANDBY YAW DAMPING ONLY.

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WTRIS - SMYD 2 - SYSTEM SUMMARY

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ELEVATOR AND TAB CONTROL SYSTEM - INTRODUCTION

Purpose

The elevators control the pitch attitude of the airplane about the lateral axis.

Location

The elevators are on the trailing edge of the horizontal stabilizer.

Pitch control

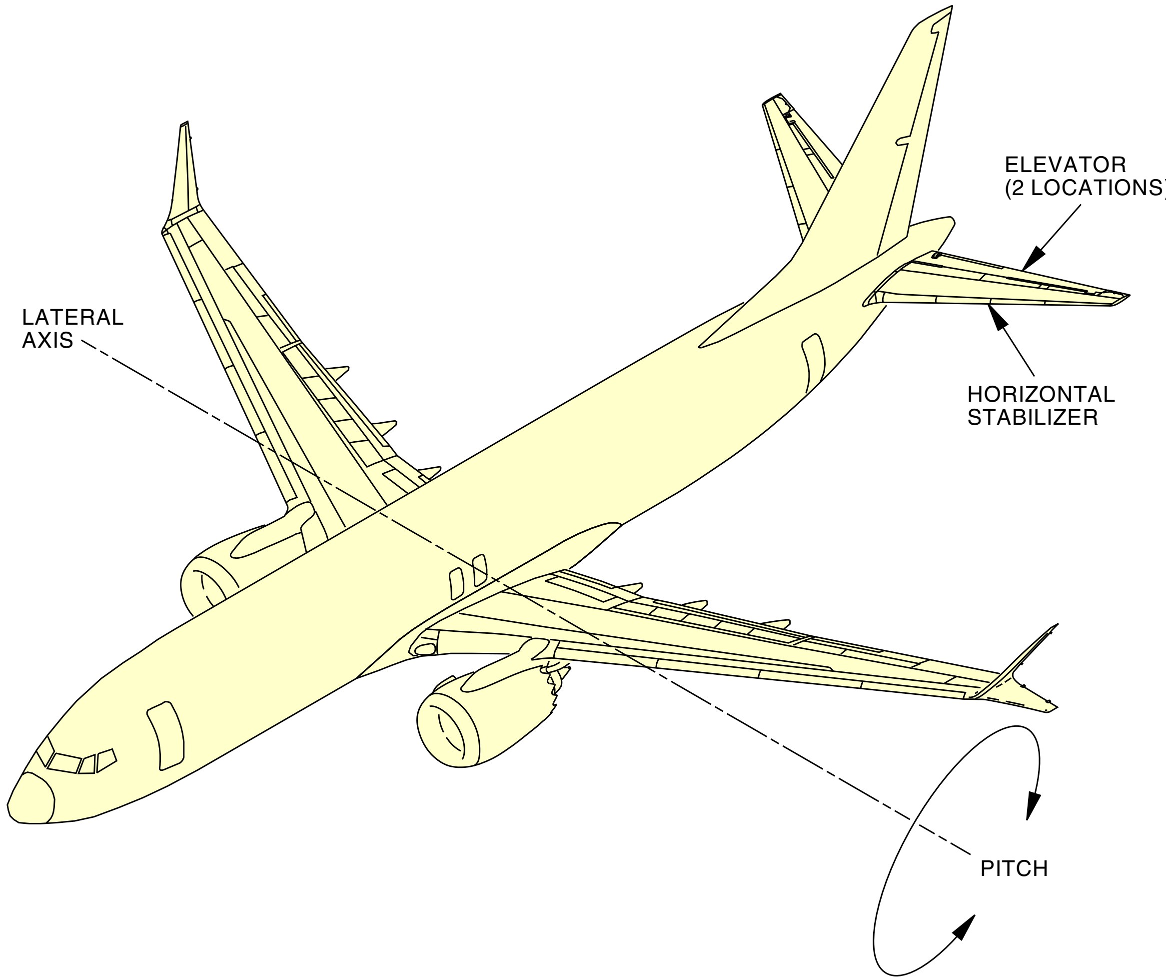
The pilots manually control the position of the elevators with forward and aft movement of the control column.

When the autopilot engages, it automatically controls the position of the elevators. During autopilot operation, inputs from the autopilot actuators backdrive the control columns through the elevator control system.

Abbreviations and Acronyms

- A/P - autopilot
- A/S - airspeed
- C/W - control wheel
- CWS - control wheel steering
- cntrl - control
- EFSM - elevator feel shift module
- FCC - flight control computer
- FDAU - flight data acquisition unit
- gnd - ground
- LE - leading edge
- MLG - main landing gear
- NLG - nose landing gear
- PCU - power control unit
- S/B - speedbrake
- sec - section
- SOV - shutoff valve
- stab - stabilizer
- SW - switch
- TE - trailing edge
- vlv - valve
- xfer - transfer

ELEVATOR AND TAB CONTROL SYSTEM - INTRODUCTION



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ELEVATOR AND TAB CONTROL SYSTEM - INTRODUCTION

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ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 1

General

The pilot controls the elevators manually. The autopilot system controls them automatically.

Manual Operation - Control Columns

The pilot moves the control column forward or aft to control the pitch attitude of the airplane. The control column gives a mechanical input to the elevator power control unit (PCU) through cables and linkages to the input torque tube. The input torque tube gives input to the elevator pogos. The pogos give input to the elevator PCUs that use hydraulic pressure to mechanically move the elevator through the output torque tube.

When the control column moves, it also gives an input to the pitch control wheel steering (CWS) force transducers, and control column position sensors. The pitch CWS force transducers send signals to the flight control computers proportional to control column forces. The control column sensors send control column position to the flight data acquisition unit (FDAU).

Movement of the feel and centering unit also gives an input to the elevator neutral shift sensor. The elevator neutral shift sensor sends signals to the flight control computers (FCC) proportional to the relative position of the elevator and stabilizer.

Movement of the elevators also gives an input to the elevator surface position sensor and position transmitters. The elevator surface position sensor sends signals to the FCCs proportional to the elevator position. The elevator position transmitters send elevator position to the FDAU.

See the digital flight control system section for more information about the pitch CWS force transducers, the elevator neutral shift sensor, the elevator surface position sensor, and FCCs. (SECTION 22-11)

See the flight data recorder section for more information about the control column sensors, elevator position transmitters, and the FDAU. (SECTION 31-31)

Autopilot Operation

When you engage the autopilot, the autopilot system uses FCC inputs to control the autopilot actuators. When the autopilot actuators move, they give a mechanical input to the elevator PCUs.

See the digital flight control system section for more information about the autopilot. (SECTION 22-11)

Autopilot Operation - Mach Trim Actuator

The mach trim actuator moves the elevators to prevent nose down forces at high air speeds. The FCCs control the mach trim actuator. When the mach trim actuator moves, it gives a mechanical input to the elevator PCUs through the feel and centering unit.

See the digital flight control system section for more information about the mach trim actuator. (SECTION 22-11)

FCC Operation - Neutral Shift

The FCC controlled neutral shift function uses the mach trim actuator, through the feel and centering unit to move the elevator to a new neutral position. This gives more airplane nose up control during takeoff and landing.

Stabilizer Operation - Neutral Shift

The stabilizer neutral shift function causes the elevators to move when the stabilizer moves. When the stabilizer moves, it gives a mechanical input to the elevator PCUs through the mach trim actuator, and the feel and centering unit.

See the horizontal stabilizer trim control section for more information about the elevator neutral shift functional description. (SECTION 27-41)

Elevator Feel Computer Inputs

The elevator feel computer receives pressure from hydraulic system A and system B, pitot pressure from the pitot tubes, and mechanical input from the stabilizer.

ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 1

The elevator feel computer uses pitot pressure and stabilizer input to control hydraulic pressure to the dual feel actuator in the feel and centering unit. The feel force of the feel and centering unit increases as the airspeed increases.

Elevator Feel Shift Module

During a stall, the elevator feel shift module (EFSM) provides 850 psi system A pressure to the elevator feel computer and the dual feel actuator. This causes the feel force of the control column and the feel and centering unit to increase.

See the stall warning system section for more information about the elevator feel shift module operation. (SECTION 27-32)

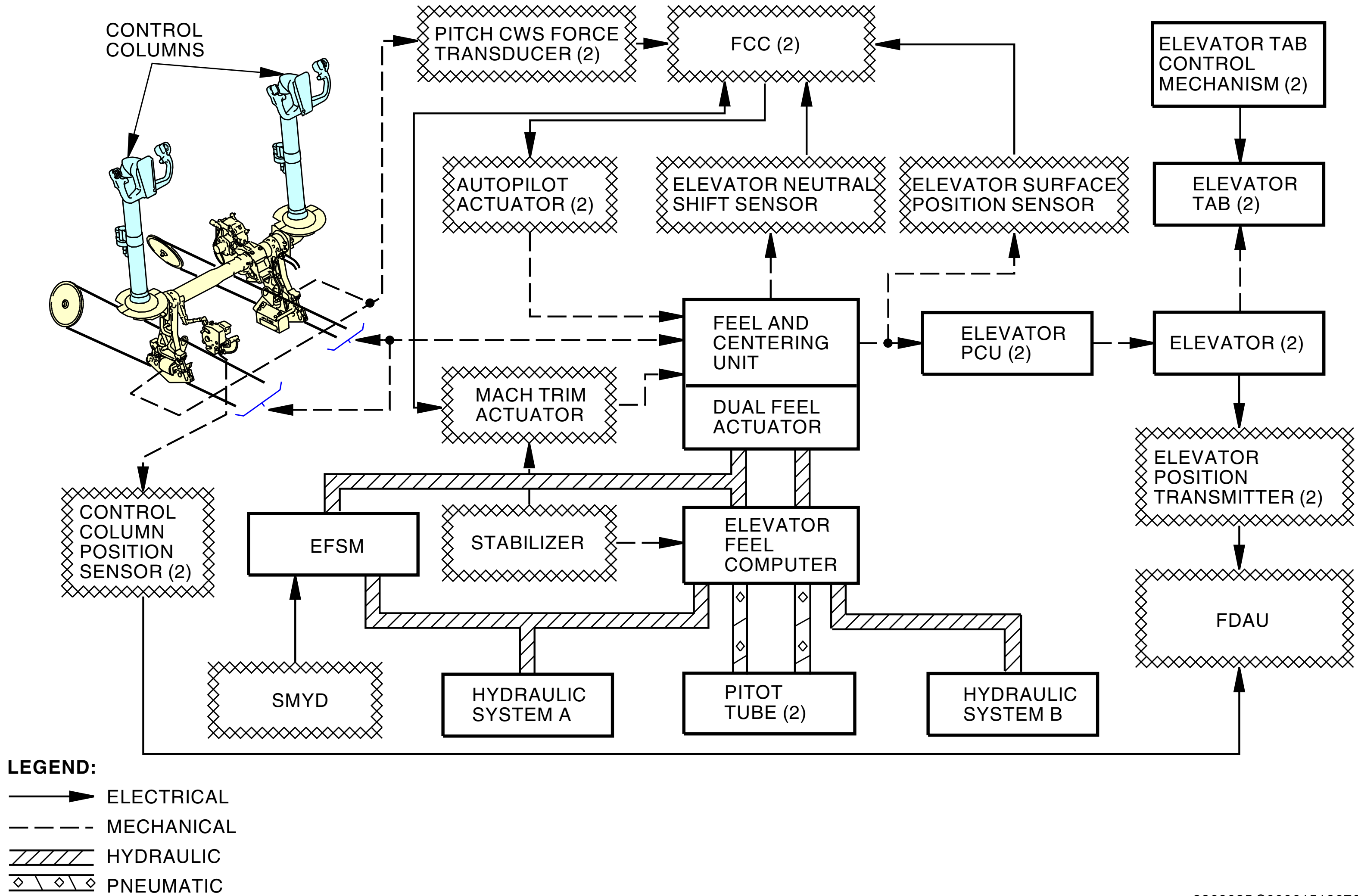
Elevator Tab

When the TE flaps are up, the elevator tab balances the elevator. As the elevator moves, the tab moves in a direction that is opposite to the elevator direction.

Elevator Tab Control Mechanism

When the TE flaps are not up, the elevator tab control mechanism changes the function of the elevator tab. This causes the elevator tab to move in the same direction that the elevator moves.

ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 1



ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 1

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ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 2

General

These are the components of the elevator and tab control system:

- Control columns (2)
- Elevator forward control quadrants (2)
- EA and EB; left and right body cables
- Elevator aft control quadrants (2)
- Elevator input torque tube
- Elevator power control units (2)
- Elevator output torque tube
- Elevators (2)
- Elevator feel computer
- Elevator feel and centering unit
- Balance panels (6) and tabs (2)
- Elevator tab control mechanism
- Neutral shift rods (2).

Control Columns

The control columns move the elevator forward quadrant and the elevator control cables.

If a jam occurs in one column, a breakout mechanism allows elevator input by the other column.

During stabilizer electric trim operation, if the pilot moves the control column in the opposite direction, the column cutout switches make the stabilizer electric trim stop.

Elevator Forward Control Quadrants

The elevator forward control quadrants connect to the control columns and transmit pilot forces through control cables to the elevator input torque tube.

Elevator Control Cables

The elevator left and right body control cables EA and EB move the elevator aft control quadrant, which provides an input to the elevator input torque tube.

Elevator Input Torque Tube

Pilot, autopilot, and flight control computer inputs move the elevator input torque tube. The elevator input torque tube moves the elevator PCU input pogos.

Elevator Power Control Units

The two elevator power control units (PCUs) move the elevator output torque tube. The PCU rod end is fixed and the housing moves the elevator output torque tube. Input from the input torque tube is transmitted through input pogos to the PCUs.

Elevator Output Torque Tube

The output torque tube moves the elevators through the elevator control rods.

Elevators

The elevators attach to the rear spar of the horizontal stabilizer. They control the pitch attitude of the airplane by up or down movement.

Elevator Feel Computer

The elevator feel computer controls hydraulic pressure to the elevator dual feel actuator. The feel computer gets inputs from the horizontal stabilizer, pitot tubes, and hydraulic system A and B.

ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 2

Elevator Feel and Centering Unit

Feel force is provided by the feel and centering unit and the dual feel actuator. Inputs to the feel and centering unit are provided by the stabilizer, the flight control computers, and elevator feel computer. The stabilizer inputs go through the elevator neutral shift rods. The flight control computer inputs go through the mach trim actuator. The elevator feel computer inputs go through the dual feel actuator. The dual feel actuator adds a variable feel force to the spring force in the feel and centering unit.

Balance Panels and Tabs

The elevator balance panels and tabs use aerodynamic forces to help decrease the force necessary to move the elevators in flight.

Elevator Tab Control Mechanism

The elevator tab mechanism changes the function of the elevator tab. When the TE flaps are up, the elevator tab operates in the balance mode. When the TE flaps are not up, the elevator tab operates in the anti-balance mode.

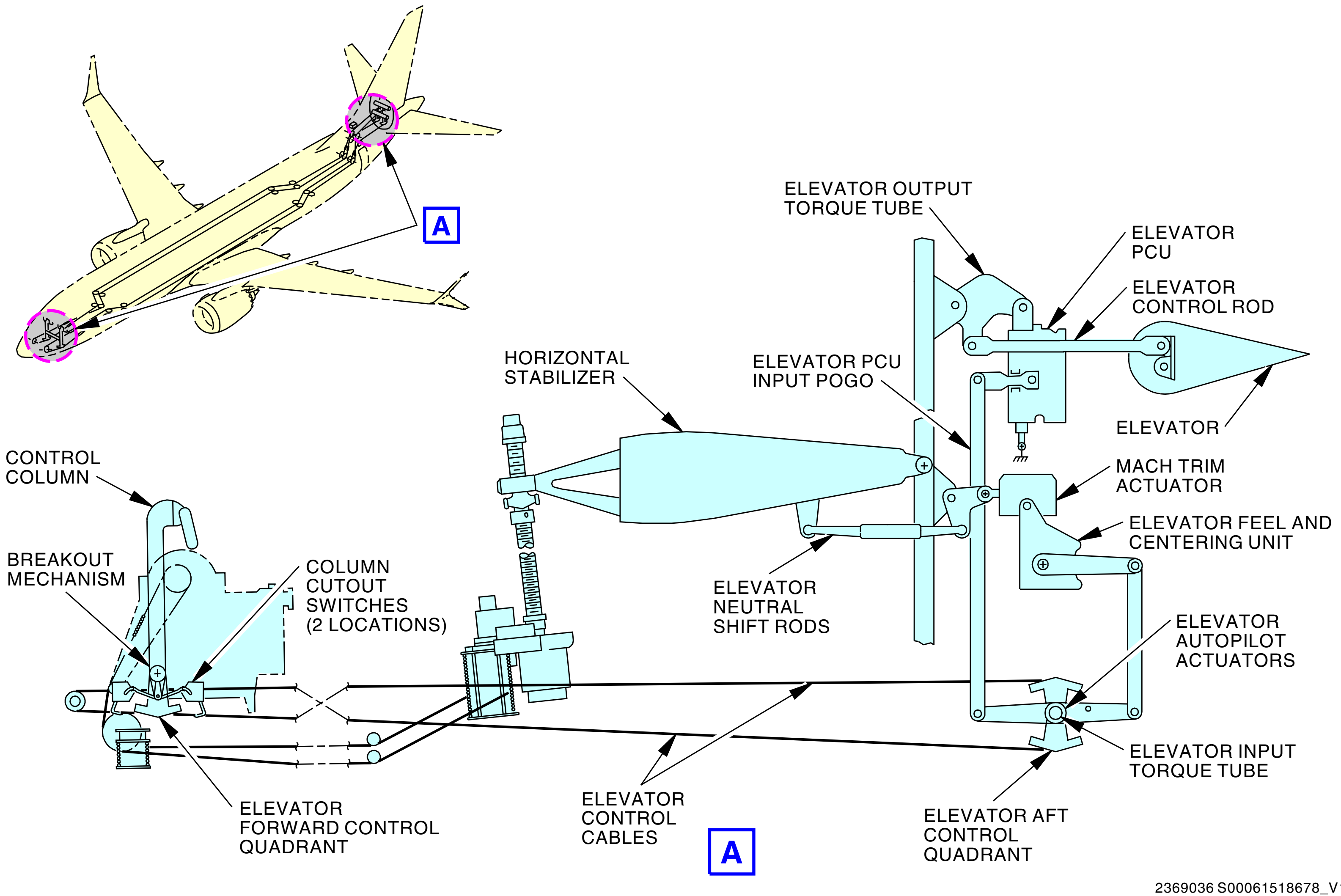
Elevator Neutral Shift - Stabilizer Input

The stabilizer moves two elevator neutral shift rods. The neutral shift rods provide an input to the elevators through the mach trim actuator, the feel and centering unit, and the elevator input torque tube to the PCUs. When the elevator input torque tube moves, it also backdrives the control cables which move the control columns to their new neutral position.

Elevator Neutral Shift - Flight Control Computer Input

The flight control computers send signals to the mach trim actuator. When the mach trim actuator moves, a mechanical input goes through the feel and centering unit to the input torque tube and PCUs. When the elevator input torque tube moves, it also backdrives the control cables which move the control columns to their new neutral position.

ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 2



ELEVATOR AND TAB CONTROL SYSTEM - GENERAL DESCRIPTION 2

ELEVATOR AND TAB CONTROL SYSTEM - COMPONENT LOCATION

General

The elevator components are in these six locations:

- Flight compartment
- Forward equipment compartment
- Empennage
- Vertical stabilizer
- Stabilizer jackscrew compartment
- Horizontal stabilizer.

Flight Compartment Components

These are the elevator components in the flight compartment:

- Control columns (2)
- FEEL DIFF PRESS light on the P5 forward overhead panel.

Forward Equipment Compartment Components

These are the elevator components in the forward equipment compartment:

- Elevator forward control quadrants (2)
- Balance weights (2)
- Breakout mechanism.

Empennage Components

These are the elevator components in the empennage:

- Elevator aft control quadrants (2)
- Elevator input torque tube
- Elevator PCUs (2)
- Elevator output torque tube
- Elevator feel and centering unit
- Tab mechanism solenoid control valves (2).

Vertical Stabilizer Components

The feel system pitot tubes are in the vertical stabilizer.

Stabilizer Jackscrew Compartment Components

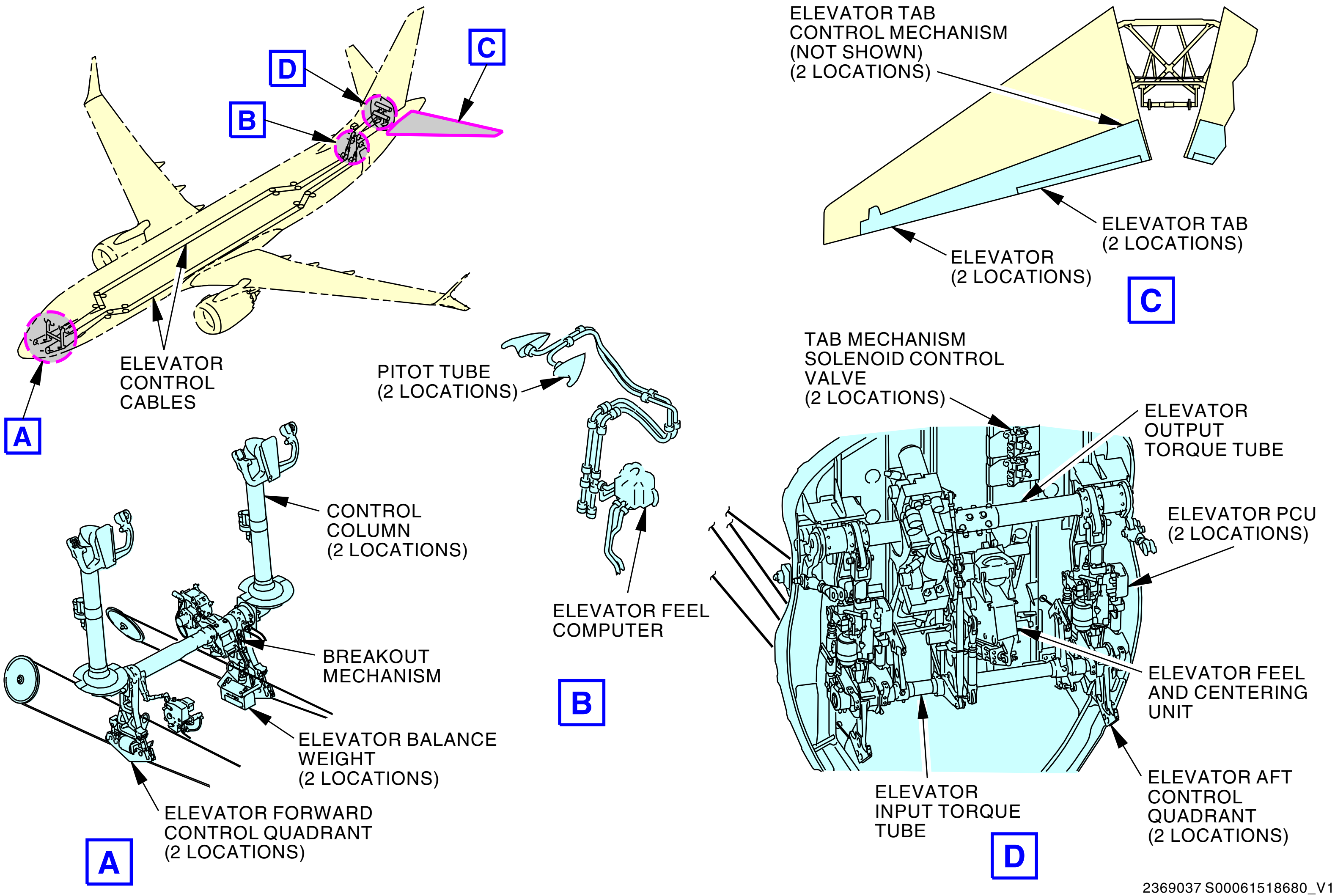
The elevator feel computer is in the stabilizer jackscrew compartment.

Horizontal Stabilizer Components

These are the elevator components on the horizontal stabilizer:

- Elevators (2)
- Balance panels (6)
- Elevator tab control mechanisms (2)
- Elevator tabs (2).

ELEVATOR AND TAB CONTROL SYSTEM - COMPONENT LOCATION



ELEVATOR AND TAB CONTROL SYSTEM - COMPONENT LOCATION

ELEVATOR AND TAB CONTROL SYSTEM - CONTROL COLUMN AND ELEVATOR FORWARD CONTROL QUADRANT

Purpose

Each pilot uses a control column for pitch control through the elevator forward control quadrants.

Location

The two control columns are in the flight compartment. The elevator forward control quadrants are under the flight compartment.

Physical Description

The control columns extend through the flight compartment floor and attach to the elevator forward control quadrants. The balance weights attach on each forward control quadrant. There is a pitch force transducer in each forward control quadrant.

See the digital flight control system section for more information on the pitch force transducer. (SECTION 22-11)

The elevator control cables attach at the lower surface of the quadrants. Each cable attaches to the quadrant. Elevator up cables (EB) go directly aft. Elevator down cables (EA) go forward around the turnaround pulley and then go aft.

Functional Description

The control columns move the forward input torque tube. This moves the elevator forward control quadrants and the cables to control the elevator position.

The column balance weights balance out the weight of the upper part of the control column. This prevents elevator input from the weight of the control column when the pilot does not make a control input.

When the forward input torque tube moves, it gives a mechanical input to the column cutout switch modules.

See the horizontal stabilizer trim control section for more information on the column cutout switch modules. (SECTION 27-41)

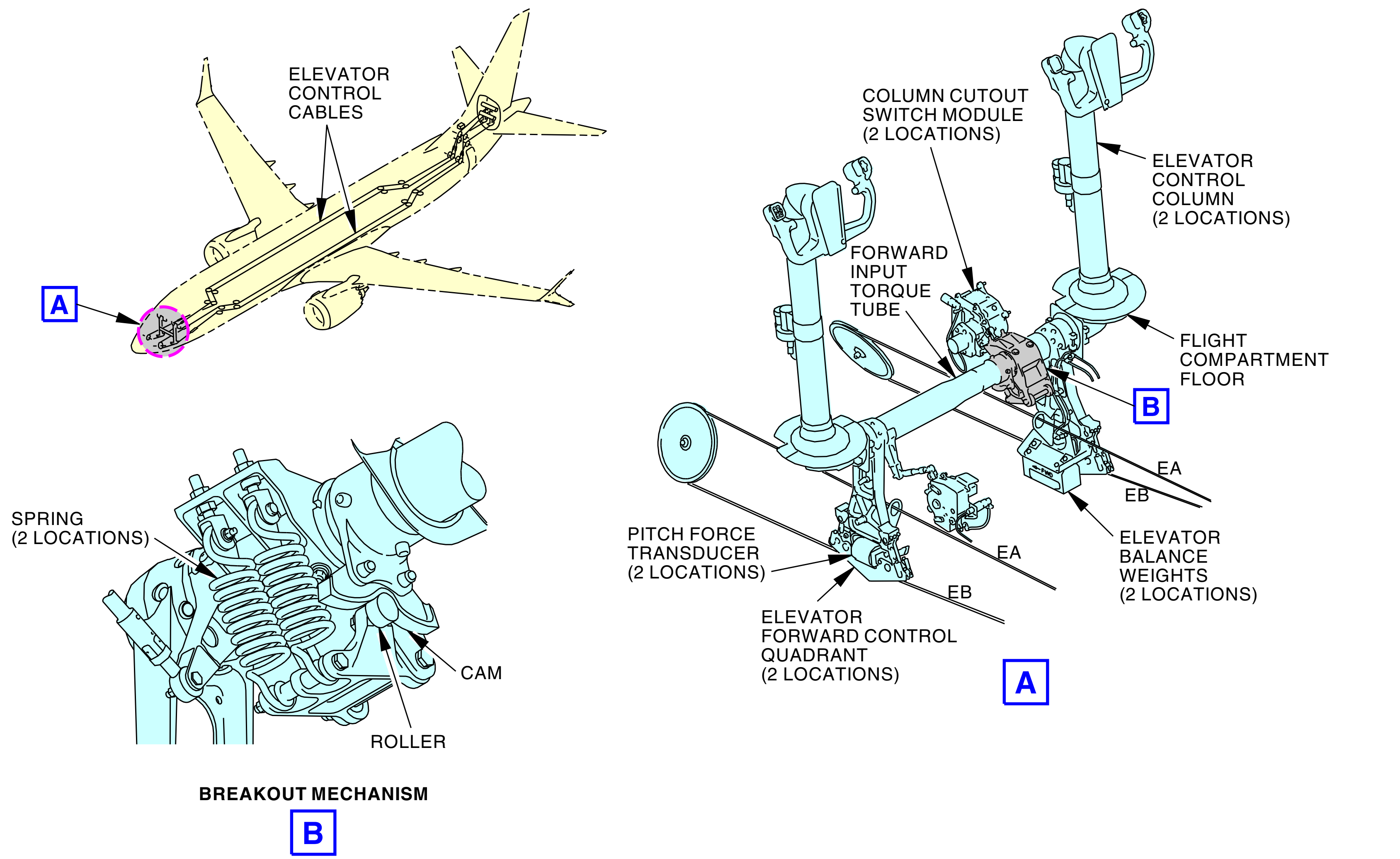
Elevator Breakout Mechanism

The elevator breakout mechanism attaches to the forward input torque tube. The breakout mechanism separates the left and right sides of the input torque tube. This allows elevator control if one column has a jam.

The breakout mechanism is a cam-roller type. The cam connects to the captain torque tube. The roller connects to an arm of the first officer torque tube. The two springs hold the roller at the detent position. The pilot must supply 31 pounds of additional force to extend the springs during a jam. When 100 pounds is applied, the elevator moves 4 degrees.

During normal operation, a control column moves and operates both torque tubes together. If one column has a jam, the other column can still move after the pilot overcomes the breakout force of the two springs.

ELEVATOR AND TAB CONTROL SYSTEM - CONTROL COLUMN AND ELEVATOR FORWARD CONTROL QUADRANT



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ELEVATOR AND TAB CONTROL SYSTEM - CONTROL COLUMN AND ELEVATOR FORWARD CONTROL QUADRANT

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR CABLE SYSTEM

Purpose

The elevator cables transmit the pilot force to the elevator PCUs.

Location

The elevator cables are under the floor. They start at the elevator forward control quadrants in the forward equipment compartment and end at the aft control quadrants in the empennage.

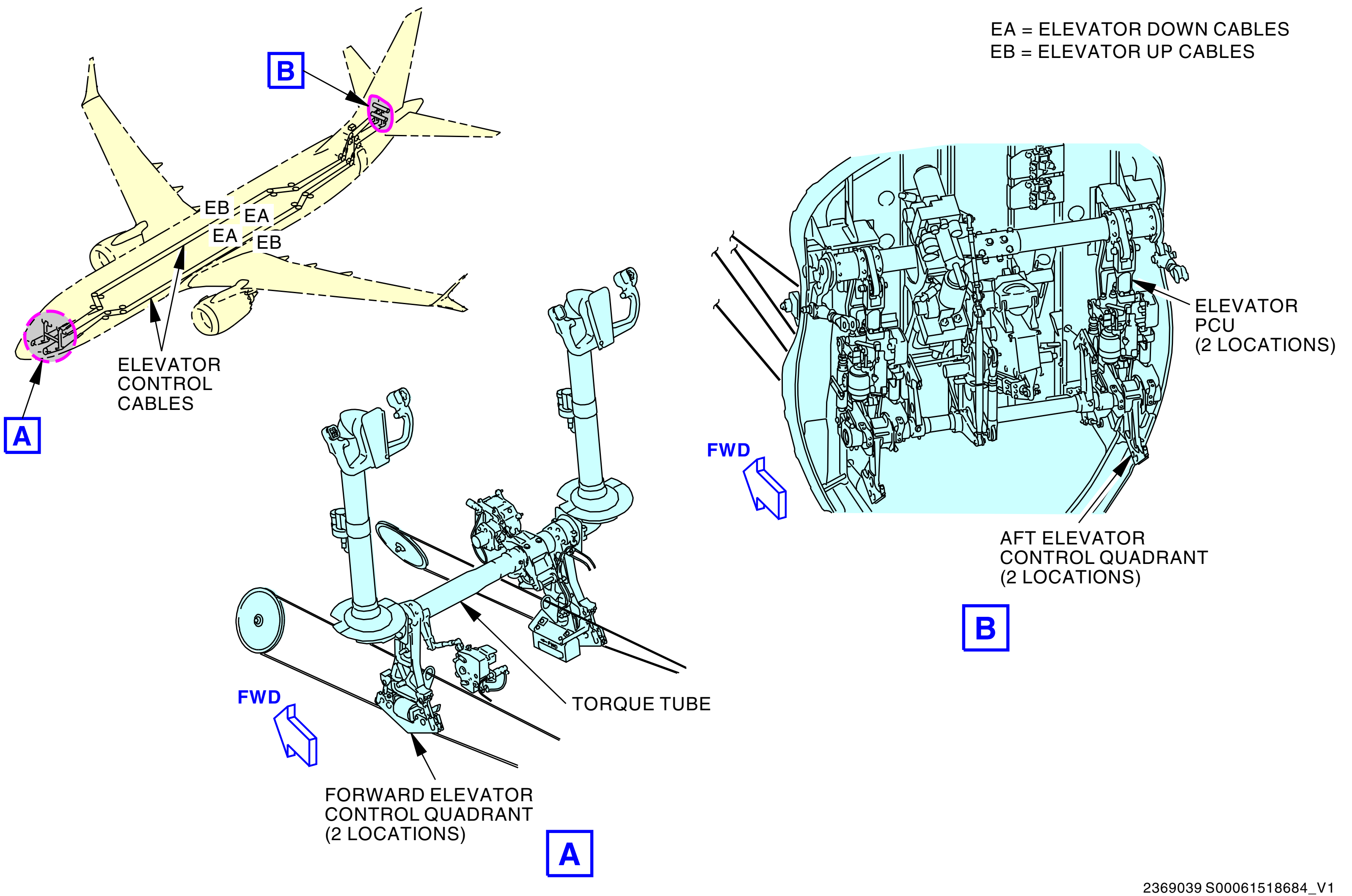
Physical Description

The elevator control cables are in the grooves at the lower surface of the quadrants. Each cable attaches to the quadrant. Elevator up cables (EB) go directly aft. Elevator down cables (EA) go forward around the turnaround pulley and then go aft.

Functional Description

The pilot moves the control columns to control the forward input torque tube. This moves the elevator forward control quadrants and the attached cables. The cables move and control the position of the input torque tube through the elevator aft control quadrants. When the input torque tube moves, it gives an input to the PCUs. The PCU housing moves and controls the elevator position.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR CABLE SYSTEM



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR CABLE SYSTEM

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR INPUT TORQUE TUBE

Purpose

The elevator input torque tube transmits elevator inputs to the elevator PCUs.

Location

The elevator input torque tube is the bottom of the two elevator torque tubes in the empennage.

Physical Description

The elevator input torque tube has these components:

- Elevator aft control quadrants (2)
- Autopilot input crank
- Elevator feel and centering unit crank
- Elevator PCU input cranks (4).

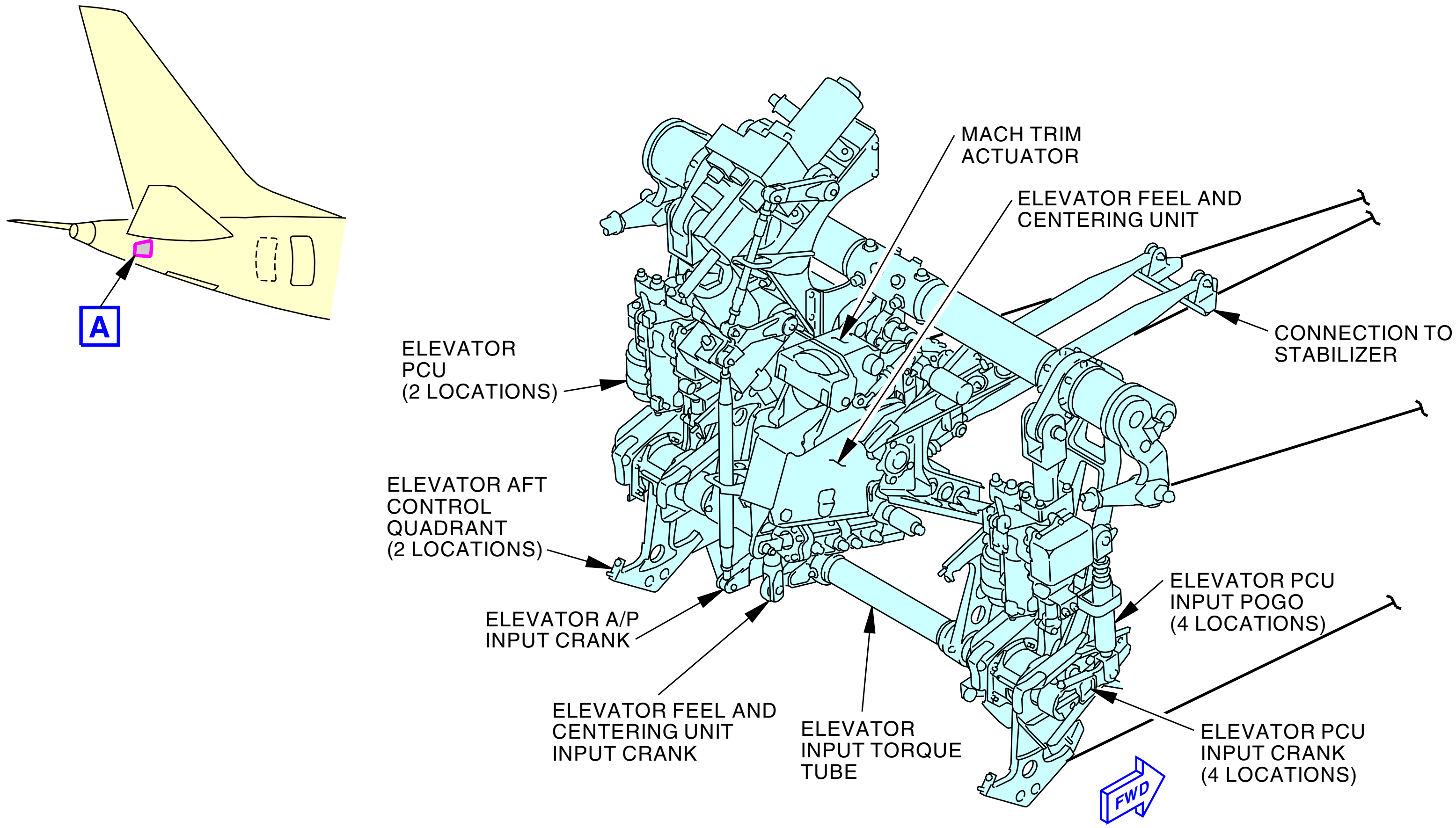
Functional Description

The elevator input torque tube receives these inputs:

- Pilot inputs through the elevator aft control quadrants
- Autopilot inputs through the elevator autopilot actuator input crank
- Stabilizer position through the elevator feel and centering unit
- Mach trim actuator position through the elevator feel and centering unit.

When the elevator aft control quadrants move, they move the elevator input torque tube. This moves the elevator PCU input pogos.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR INPUT TORQUE TUBE



ELEVATOR INPUT TORQUE TUBE
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ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR INPUT TORQUE TUBE

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ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR POWER CONTROL UNIT

Purpose

The elevator power control units (PCUs) use hydraulic power to move the elevators.

Location

The two elevator PCUs are on the empennage wall. The right PCU gets system B pressure and the left PCU gets system A pressure.

Physical Description

The elevator PCU has these parts:

- Movable housing connected to the output torque tube
- Fixed piston connected to structure.

The elevator PCU housing contains:

- Main Actuator
- Filter
- Bypass valve
- Main Control valve
- Primary and a secondary input cranks
- External mechanical stops (2).

Functional Description

The elevators move when any of the these conditions occur:

- Normal operation
- System pressure failure
- Rate jam
- Manual reversion.

Normal Operation

During normal operation, an elevator input goes through the input torque tube and to the input pogos of each PCU. Left and right input cranks on the PCU move slides in the control valve and supply hydraulic pressure to the actuator.

The left input crank connects to the primary slide and the right input crank connects to the secondary slide. A torsion spring inside the PCU connects the two input cranks. Movement of the primary slide supplies one-half the total flow rate, and movement of the secondary slide supplies the other half. The primary slide moves to its full effective stroke before the secondary crank starts to move the secondary slide.

When the primary and secondary slides move, hydraulic pressure goes through the control valve to one side of the actuator. The other side of the actuator is connected to return. This moves the actuator housing and the output torque tube to the commanded position.

System Pressure Failure

If one PCU cannot supply hydraulic pressure, then its bypass valve moves to the bypass position. This connects the two sides of the actuator, and prevents a hydraulic lock condition. When the pilot moves the elevator control column, the ON side PCU still moves to its commanded position normally. As the ON side PCU moves the output torque tube, it also back drives the OFF side PCU actuator housing. When the OFF side housing moves, hydraulic fluid is pushed from one side to the other through the bypass valve.

Rate Jam

If one PCU input pogo cannot move freely, then the pilot must supply approximately 30 pounds of additional force to compress or extend a spring inside the pogo. The other PCU input pogo still moves its respective input crank and slide to the commanded position. This equalizes pressure on both sides of the actuator and prevents a hydraulic lock condition. Now the other PCU can move the output torque tube normally. As the ON side PCU moves the output torque tube, it also back drives the OFF side PCU actuator housing. When the OFF side housing moves, hydraulic fluid is pushed from one side to the other through the control valve.

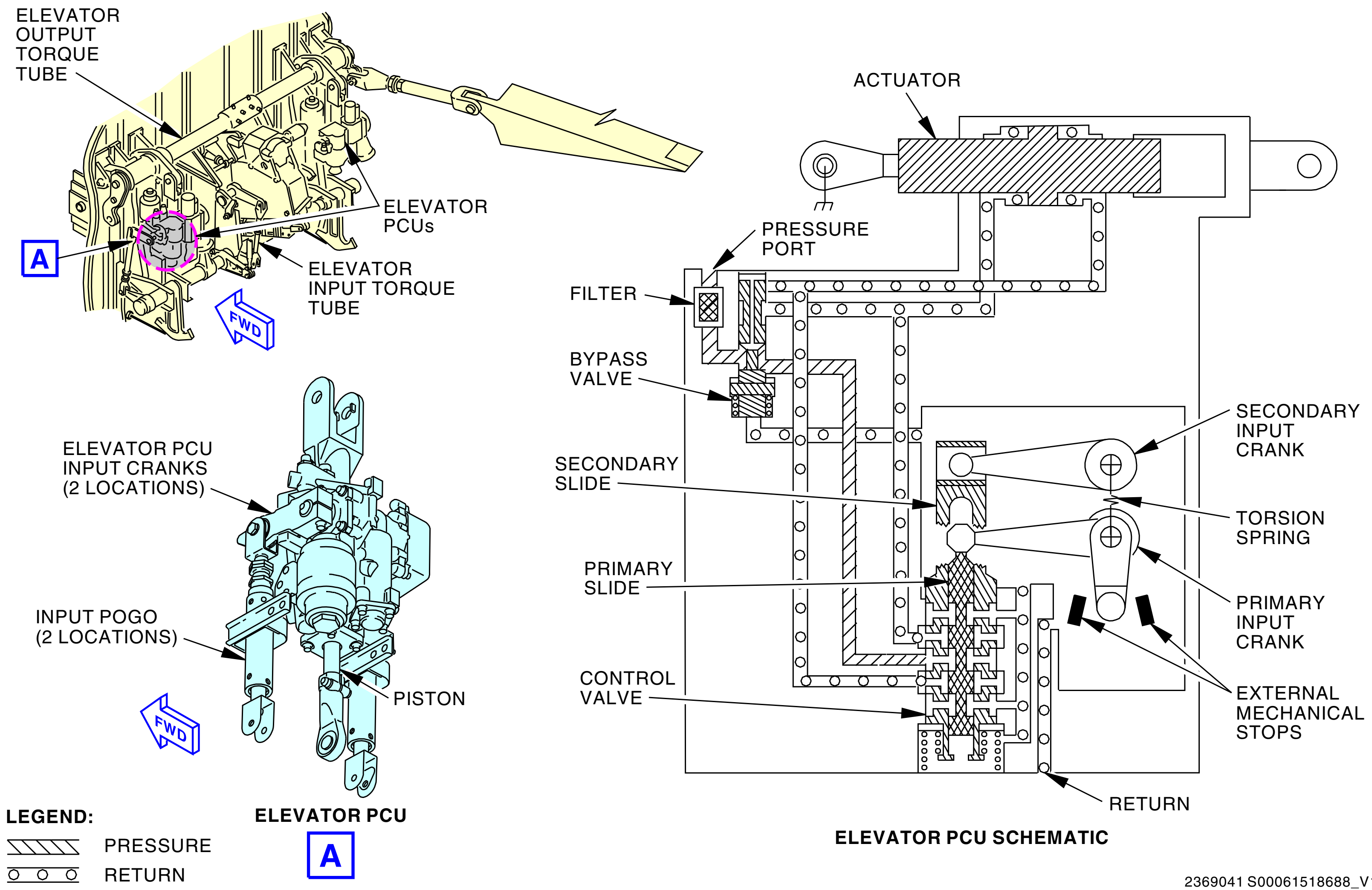
Manual Reversion

During a manual reversion, the bypass valve receives no hydraulic pressure and moves to the bypass position. This connects the two sides of the actuator and prevents a hydraulic lock condition. When the pilot moves the elevator control column more than one degree, the primary and secondary input cranks hit mechanical stops on the outside of the actuator housing. As the housing moves, hydraulic fluid in the actuator is pushed from one side to the other through the bypass valve. Movement of the housing also moves the output torque tube to the commanded position.

Training Information Point

The elevator PCUs are interchangeable with each other and with the aileron PCUs.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR POWER CONTROL UNIT



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR POWER CONTROL UNIT

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR OUTPUT TORQUE TUBE

Purpose

The elevator output torque tube transmits the motion of the elevator PCUs to the elevators.

Location

The elevator output torque tube is the torque tube at the top of the elevator components in the empennage.

Physical Description

The elevator output torque tube has these components:

- Outer torque tube
- Inner torque tubes (2)
- Elevator bus crank.

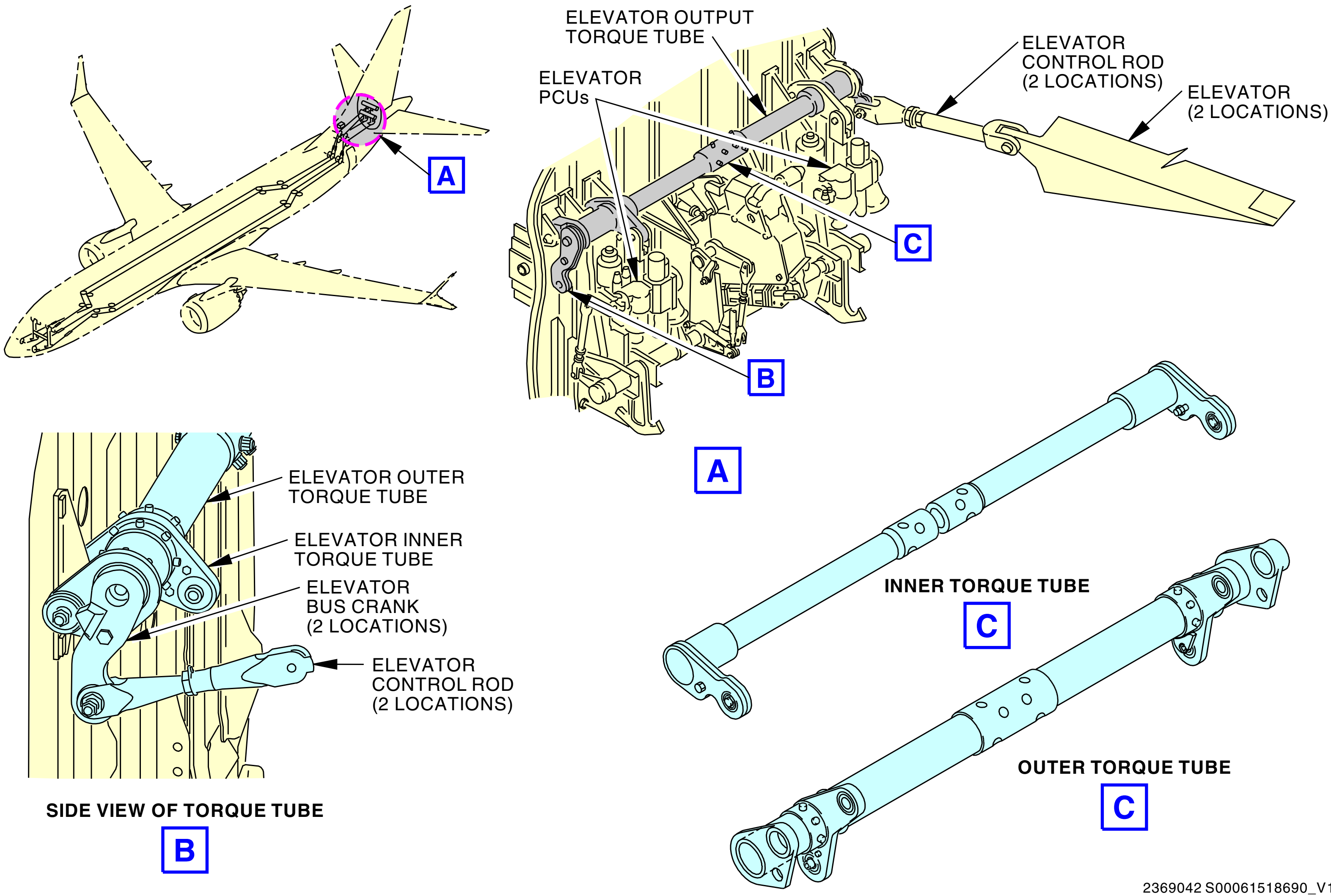
The elevator output torque tube connects with the two elevator PCUs. It also connects to both elevators through elevator control rods.

Functional Description

The elevator output torque tube receives inputs from the two elevator PCUs. When one or both of the PCUs move, they move the torque tube and both elevators.

The elevator bus crank operates the elevators if an inner torque tube breaks.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR OUTPUT TORQUE TUBE



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR OUTPUT TORQUE TUBE

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATORS

Purpose

The elevators control the pitch attitude of the airplane around the lateral axis.

Location

The elevators attach to the rear spar of the horizontal stabilizer.

Physical Description

The elevator assembly contains these components:

- Elevator
- Elevator balance panels (3)
- Elevator balance weights
- Elevator tab rods
- Elevator tab
- Elevator tab control mechanism.

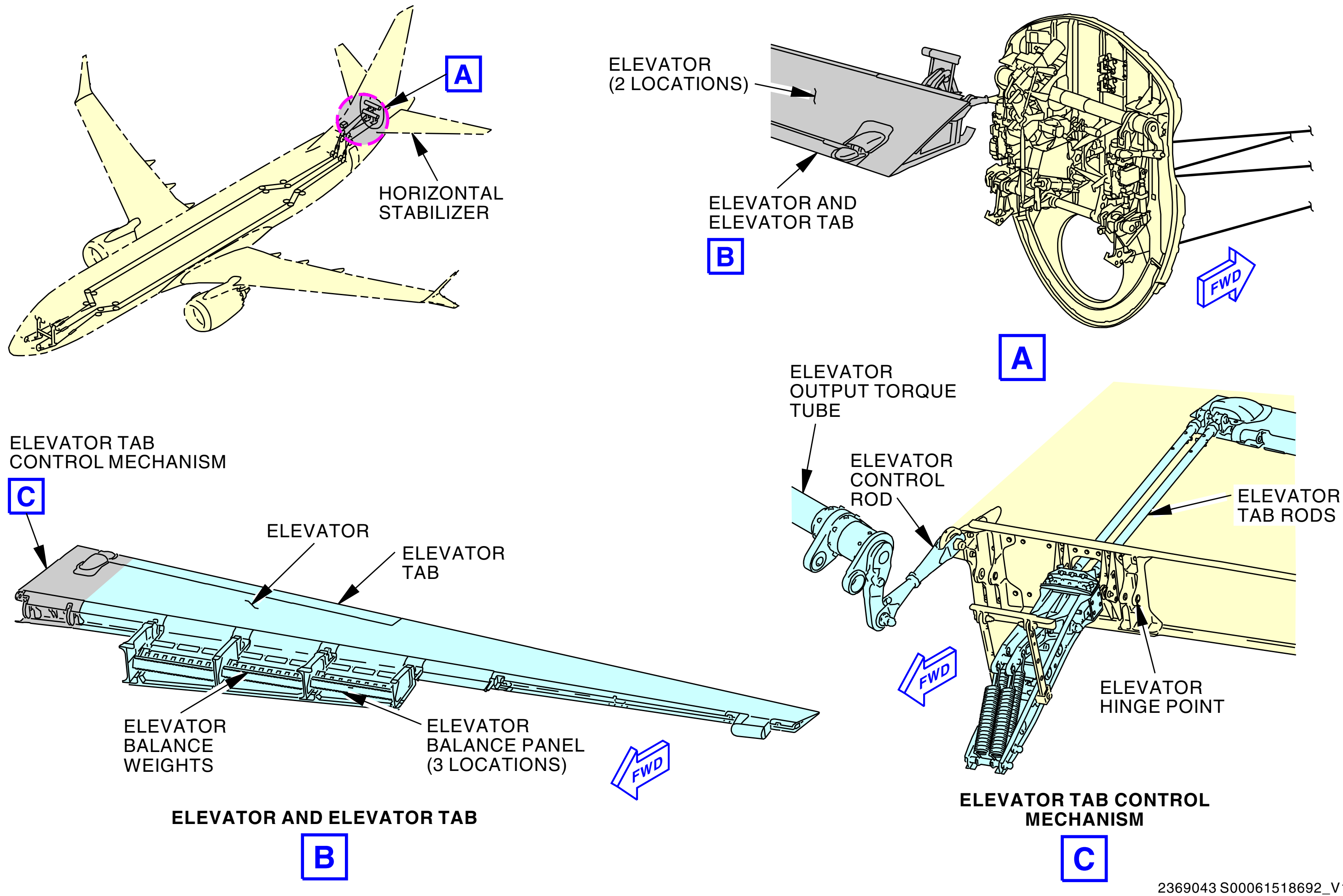
The elevators connect with hinges to the aft right and left sections of the horizontal stabilizer. Each elevator has a tab and three balance panels. The forward side of the elevator connects to the three balance panels. The balance weights attach to the lower surface of the balance panel. The tab attaches to the aft edge of each elevator.

Functional Description

When the output torque tube moves, it moves the elevator control rods. This moves the elevators and the elevator tab rods. The elevator tab rods normally move the elevator tab in a direction opposite to the elevator movement.

Elevator travel is limited by the stroke of the elevator power control units. The stabilizer neutral position is four units of trim. When the stabilizer is neutral (and no FCC input to the mach trim actuator), the elevator is downrigged four degrees from the stabilizer cord line. From this position, the elevator can move 24.3 degrees up and 18.1 degrees down.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATORS



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATORS

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR BALANCE PANEL

Purpose

The elevator balance panel and tab mechanism decreases the force necessary to move the elevator in flight.

Location

The elevator balance panels are between the trailing edge rib 1 and 14 of the horizontal stabilizer.

Physical Description

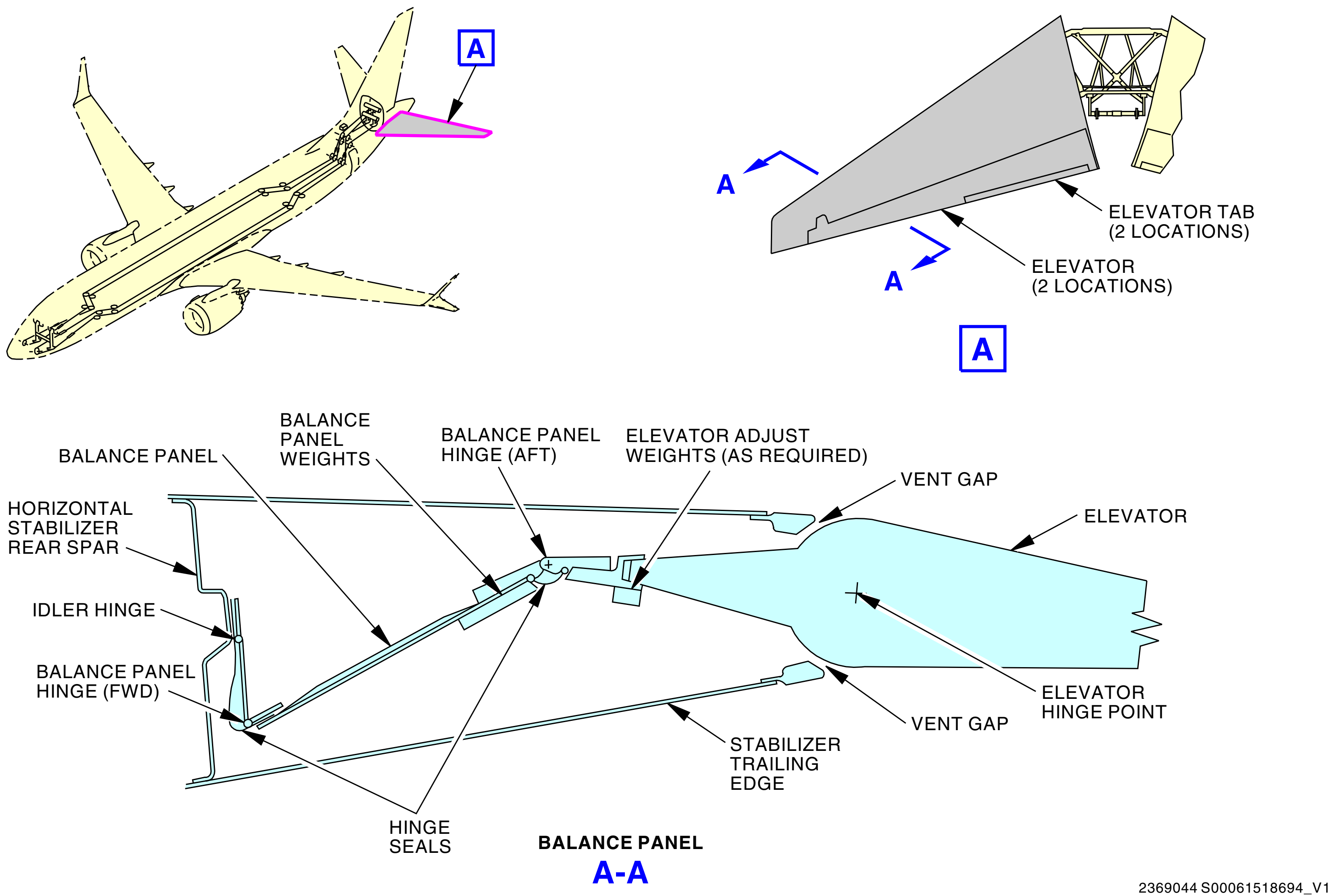
The forward edge of the elevator balance panel attaches to the horizontal stabilizer rear spar through an idler hinge. The aft edge attaches to the elevator.

Seals connect the hinge assemblies along the two sides of the balance panel. This makes two separate chambers. The upper chamber vents to the airstream over the horizontal stabilizer and the lower chamber to the airstream under the horizontal stabilizer.

Functional Description

When there is no elevator control input, the pressure forces across the elevator balance panel keep the elevator in the neutral position. When the elevator moves, the pressure forces cause the balance panels to move in the opposite direction of the elevator movement. This effect is necessary during manual reversion control.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR BALANCE PANEL



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR BALANCE PANEL

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER

Purpose

The elevator feel computer changes the control column forces as the airspeed changes and the horizontal stabilizer moves.

Location

The elevator feel computer is on the aft right wall of the stabilizer compartment.

Physical Description

The elevator feel computer is a dual unit. The housing has identical components for system A and for system B.

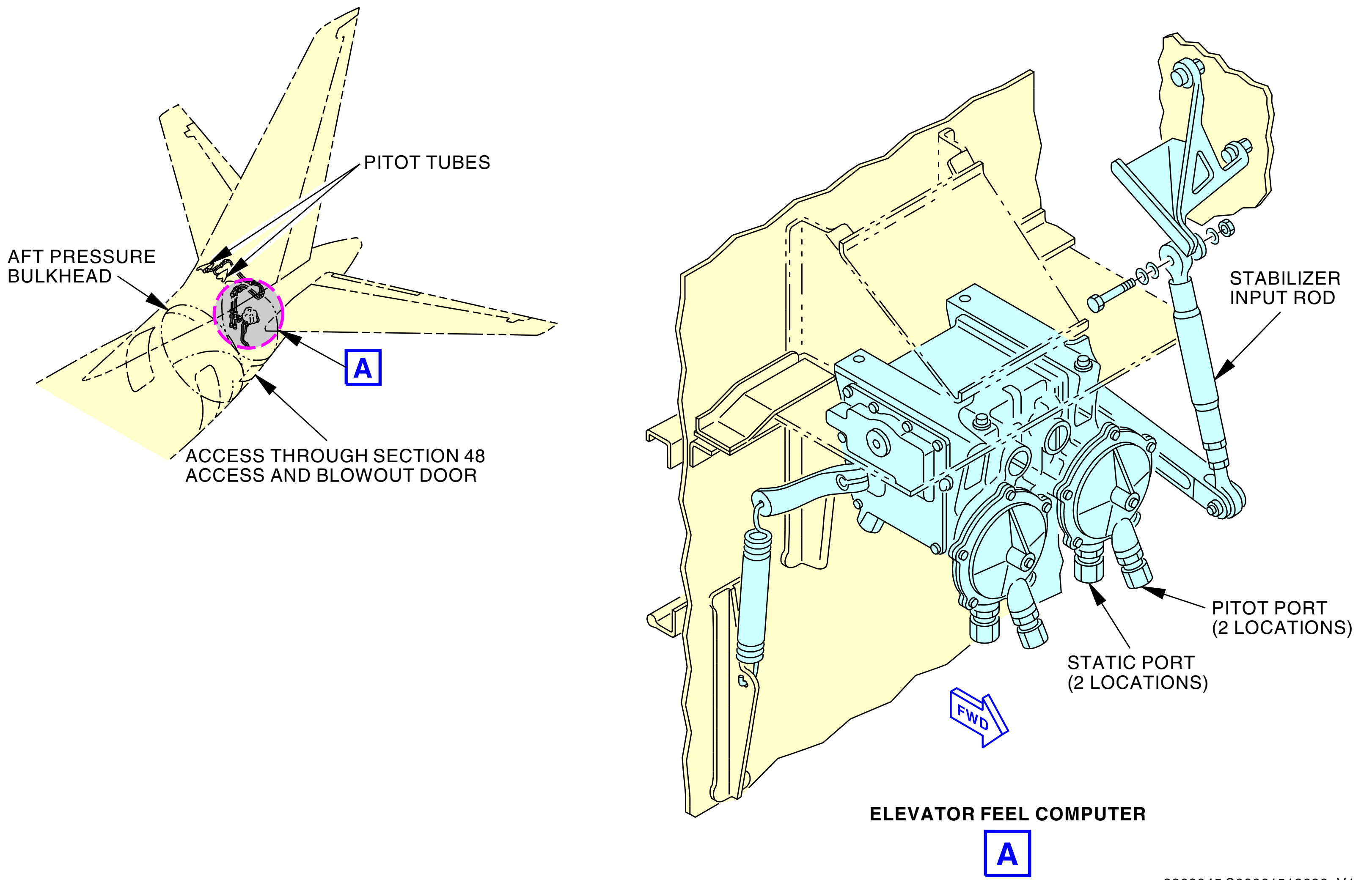
Functional Description

The elevator feel computer receives inputs from these items:

- Pitot tubes through the pitot ports
- Hydraulic system A and B
- Elevator feel shift module
- Horizontal stabilizer through the input rod.

The elevator feel computer uses these inputs to control the hydraulic pressure to the dual feel actuator on the elevator feel and centering unit.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER



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ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER

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ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER - FUNCTIONAL DESCRIPTION

General

The elevator feel computer receives pitot pressure, hydraulic pressure, and mechanical inputs. The elevator feel computer sends metered hydraulic pressure output to the dual feel actuator on the elevator feel and centering unit.

Physical Description

The elevator feel computer has these components:

- Stabilizer actuated cam (2)
- Q diaphragm (2)
- Droop spring (2)
- Relief valve (2)
- Force balance valve (2)
- Differential pressure switch
- Solenoid operated valve (2)
- Limiter piston (2)
- Feel pressure limit valve switch (2).

The elevator feel computer has these ports:

- Pneumatic pitot port (2)
- Pneumatic static port (2)
- Hydraulic pressure port (2)
- Hydraulic return port (2)
- Hydraulic computed pressure port (2).

Functional Description

Feel hydraulic pressure in the elevator feel computer changes between 180 psi (base feel) and 1400 psi (maximum). The feel pressure to the dual feel actuator is set by:

- The hydraulic pressure from system A and system B
- Pitot pressure
- Horizontal stabilizer mechanical inputs.

Hydraulic pressure from the system A and B flight control modules go to the hydraulic pressure ports.

When the airspeed increases, pitot pressure goes through the pitot port and pushes on the Q diaphragm. The Q diaphragm pushes and moves the relief valve. This movement is in proportion to the airspeed. When the relief valve moves, it pushes the force balance valve. The force balance valve controls hydraulic pressure that goes to the dual feel actuator. When the airspeed increases, the feel force increases.

The stabilizer adjusts the cam position. The cam position has an effect on the range that the Q diaphragm can move because of the pitot pressure. When the stabilizer moves from 0 to 17 units of trim, the cam turns. This puts a limit on how much the feel force can increase because of increased airspeed. If the stabilizer input to the elevator feel computer disconnects, the spring moves the cam to the maximum feel pressure position.

The elevator feel shift module (EFSM) operates during a stall. It supplies 850 psi system A pressure to the elevator feel computer and dual feel actuator. See the stall warning system section for more information about the elevator feel shift module operation (SECTION 27-32).

Elevator Feel Computer

The airplane has a fast airspeed at takeoff. There is a change to the elevator feel computer to lower the effect of the increased airspeed. The system uses hydraulic limiter pistons controlled by solenoids to decrease feedback from the elevator feel computer. The system uses the droop springs usually operated by the stabilizer actuated cams.

The solenoid operated valves energize when the airplane is on the ground. This sends pressure to the limiter pistons and moves the droop springs and the feel pressure limit valve switch. This decreases the force on the diaphragms caused by speed related air pressure. When the airplane is in the air for 7 seconds the solenoids de-energize. When the solenoids de-energize, the elevator feel goes back to normal feedback in proportion to airspeed. The feel pressure limit valve switches moniters the limiter pistons. The FEEL DIFF PRESS light on the P5 panel will come on when only one piston moves.

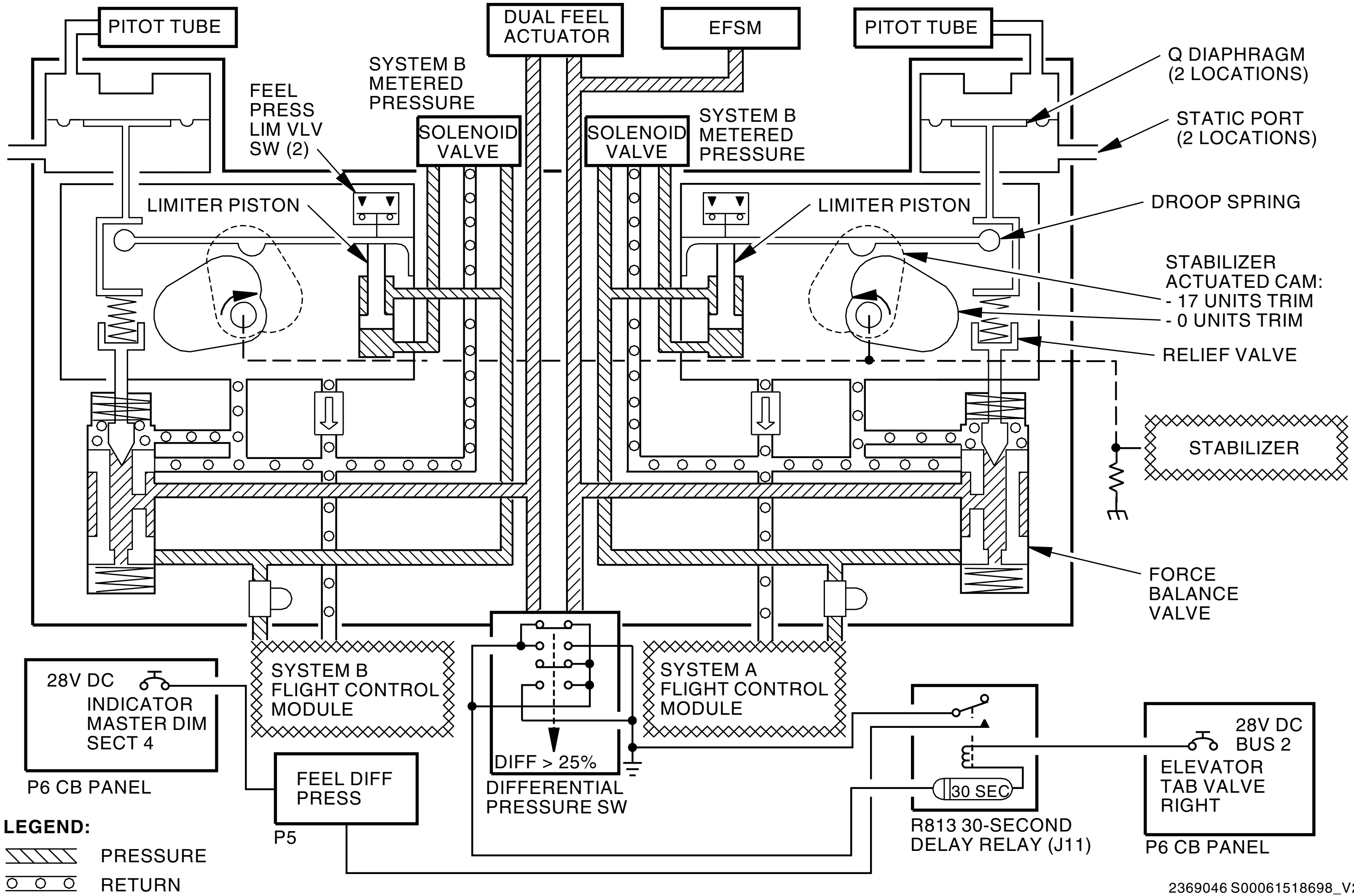
ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER - FUNCTIONAL DESCRIPTION

Indication

The feel differential pressure switch monitors the metered pressure from the elevator feel computer. The switch closes when there is a difference of 25 percent between the system A and system B metered pressure.

The FEEL DIFF PRESS light on the P5 panel comes on when the differential pressure switch closes for more than 30 seconds.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER - FUNCTIONAL DESCRIPTION



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL COMPUTER - FUNCTIONAL DESCRIPTION

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL AND CENTERING UNIT

Purpose

The elevator feel and centering unit gives variable feel force to the pilot. It also moves the control column to a neutral position when there is no input.

Location

The elevator feel and centering unit attaches to structure on the empennage.

Physical Description

The elevator feel and centering unit has these components:

- Housing
- Centering spring (2)
- Centering cam
- Roller
- Centering linkage
- Dual feel actuator.

The mach trim actuator attaches on the top of the housing.

The horizontal stabilizer connects with the housing through the neutral shift rods and the mach trim actuator.

Functional Description

The centering springs hold the roller in the center of the cam. When the control column moves, the cam turns with the shaft and moves the roller up on the cam. This extends the springs and supplies a feel force to the pilot.

When the pilot releases the control column, the spring force causes the roller to move to the cam detent. The system moves to the neutral position.

Functional Description - Dual Feel Actuator

At high airspeeds, the elevator feel computer increases the metered pressure to the dual feel actuator. The system A and system B metered pressures are not equal. This moves the housing of the dual feel actuator to the end of travel.

When the centering cam rotates, the centering linkage pulls against the highest of the two computed pressures. This adds an adjustable extra feel force to the feel and centering spring. This changes the feel force to the pilot.

During a stall, the EFSM operates and provides 850 psi system A pressure to the A side of the dual feel actuator. This increases the feel force to the pilot. See the stall warning system section for more information about the elevator feel shift module operation. (SECTION 27-32)

Digital Flight Control System Operation - Mach Trim

At high air speeds, the flight control computers (FCCs) send inputs to the mach trim actuator. The actuator retracts and turns the elevator feel and centering unit housing and centering cam. This gives a mechanical input to move the elevators through the input torque tube.

At low air speeds, the FCCs send inputs to the mach trim actuator to change the amount of elevator movement through the neutral shift operation. The neutral shift sensor sends signals to both FCCs for the relative position between the stabilizer and the elevator.

See the elevator tab control system - elevator neutral shift section for more information about the mach trim and neutral shift operation. (SECTION 27-31)

See the digital flight control system section for more information about the FCCs and the mach trim actuator operation. (SECTION 22-11)

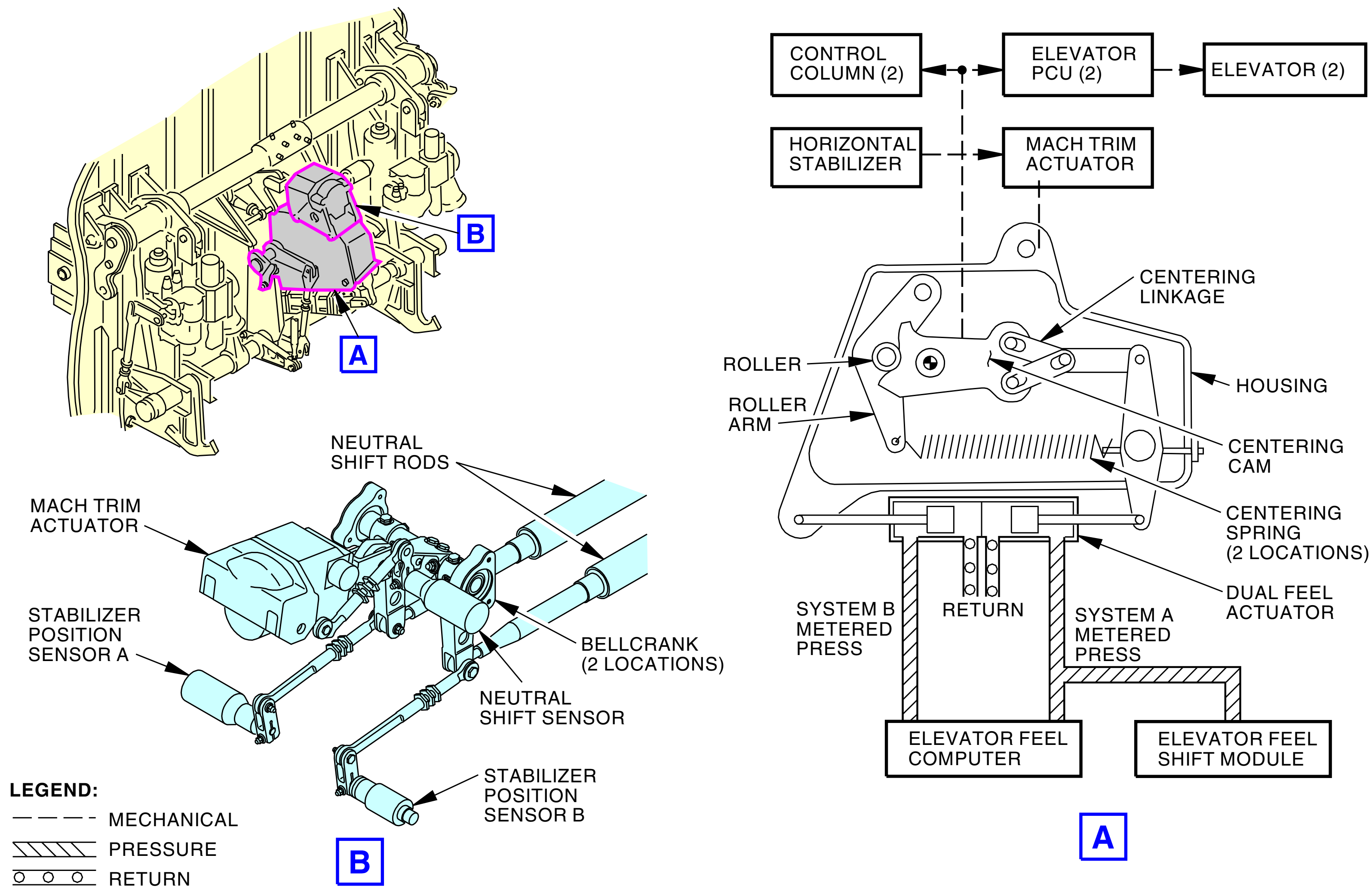
Stabilizer Trim

During stabilizer trim movement, the neutral shift rods move and give mechanical input to the elevator feel and centering unit housing through the mach trim actuator. This moves the elevators to a new neutral position.

The stabilizer position sensors A and B send signals to the FCCs for the new neutral position. Sensor A also sends signals to the flight data acquisition unit.

See the horizontal stabilizer trim control system section for more information on the stabilizer operation. (SECTION 27-41)

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL AND CENTERING UNIT



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ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR FEEL AND CENTERING UNIT

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM

Purpose

The elevator tab control mechanism changes the function of the elevator tab. This helps increase the nose up control of the airplane.

Location

The elevator tab control mechanism attaches to the rear spar on each side of the stabilizer. The solenoid control valves attach to a bracket on the station 1156 bulkhead.

Physical Description

Each elevator tab control mechanism contains these components:

- Actuator
- Crank (2)
- Spring (4)
- Frame
- Up stop.

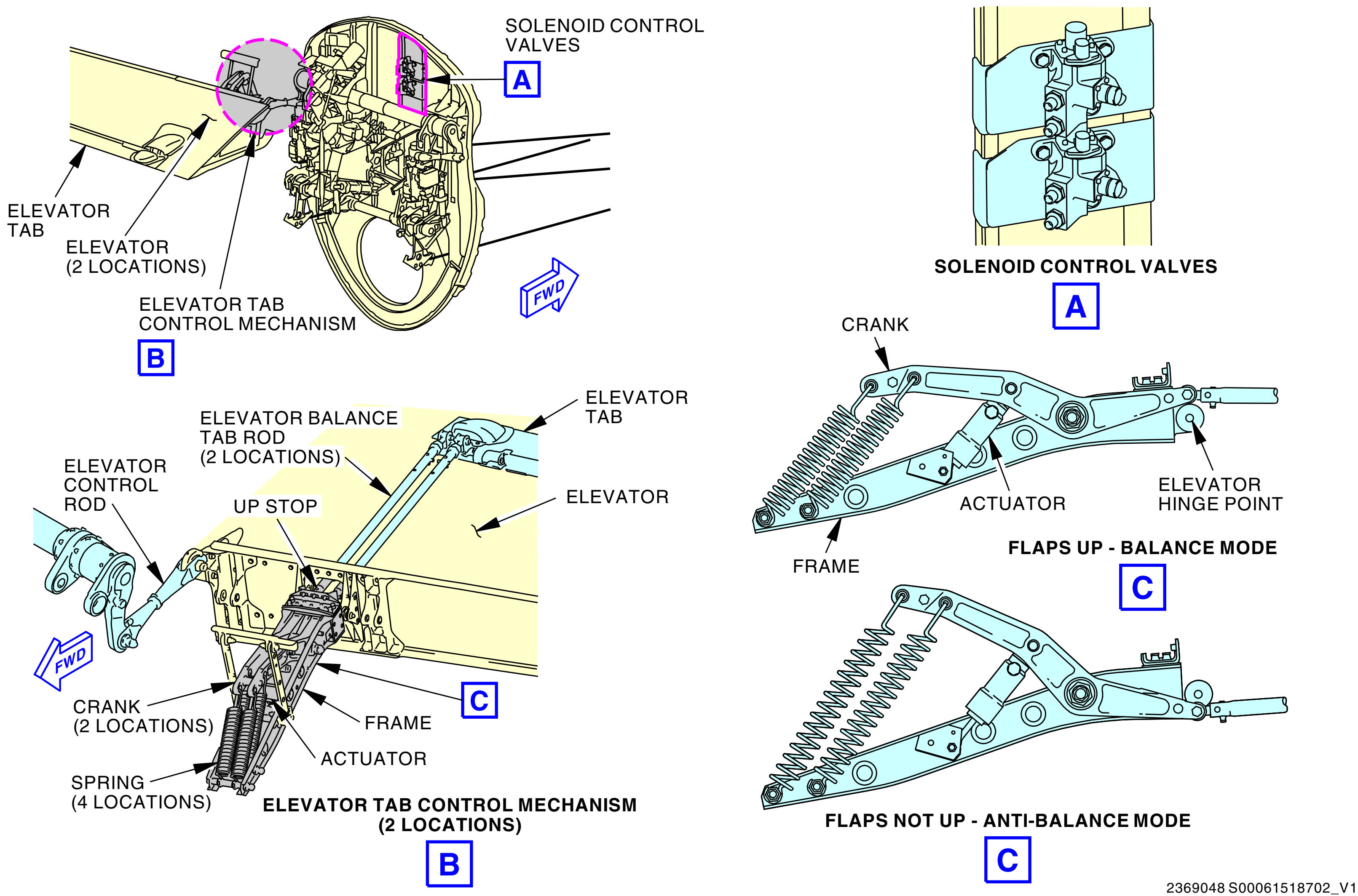
The elevator tab control mechanism attaches to the aft edge of each elevator. The elevator tab control mechanism frame attaches to the stabilizer structure. The cranks attach to the two tab control rods. The actuator housing attaches to a pin that connects the two cranks. The piston of the actuator attaches the fixed support structure of the frame. The four springs connect to the crank and to the fixed support structure.

Functional Description

When the flaps are up, the elevator tab operates in the balance mode. As the elevator moves, the tab moves in a direction that is opposite to the direction of elevator movement. In the balance mode, the tab moves 0.75 degrees for each degree of elevator movement.

When the flaps are not up and hydraulic power is on, the elevator tab operates in the anti-balance mode. The actuator extends, moves the crank and repositions the elevator balance tab rods. When the elevator moves, the elevator tab moves in the same direction that the elevator moves. In the anti-balance mode, the tab moves 0.50 degrees for each degree of elevator movement.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM - FUNCTIONAL DESCRIPTION

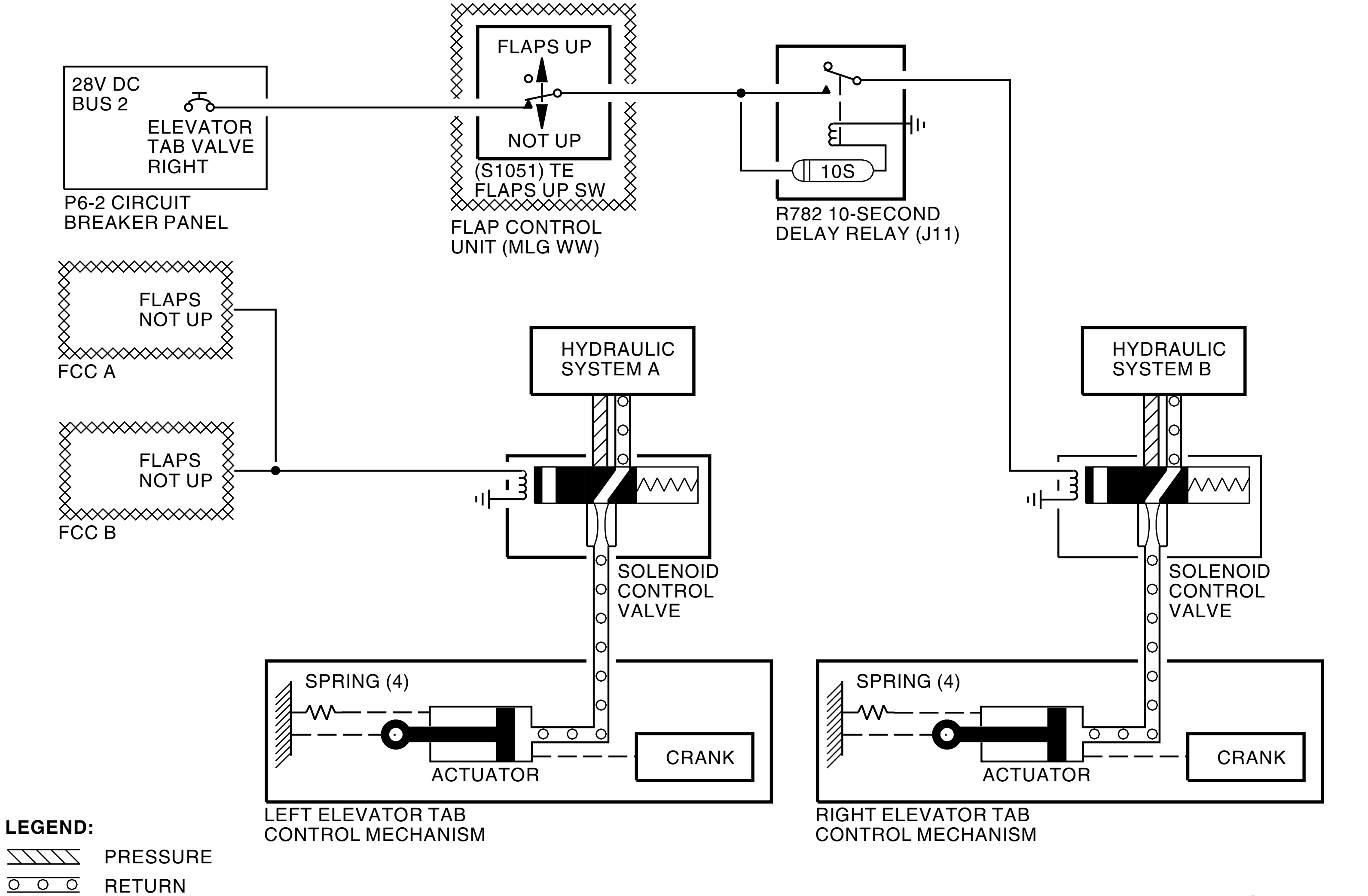
Functional Description

In the balance mode (TE flaps up), the solenoid control valves de-energize. When the control valve is de-energized, four springs move the elevator tab actuator to the retract position. This lets the elevator tab move in the opposite direction from the elevator movement.

The left solenoid control valve energizes when the TE flaps are not up, and the FCCs send signals to the left solenoid control valve. This connects system A pressure to the actuator. Because the rod end of the actuator attaches to the fixed frame, the actuator housing moves. This causes the crank to move and lets the elevator tab move in the same direction as the elevator, or the anti-balance mode of operation.

The right solenoid control valve energizes when the TE flaps are not up, and a ground goes to the 10-second delay relay. The purpose of the 10-second delay relay is to improve autopilot performance. When the relay energizes, power goes to operate the solenoid control valve. The solenoid control valve connects system B pressure to the right actuator. This causes the crank to move and lets the elevator tab move in the same direction as the elevator, or the anti-balance mode of operation.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM - FUNCTIONAL DESCRIPTION



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR TAB CONTROL MECHANISM - FUNCTIONAL DESCRIPTION

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR NEUTRAL SHIFT

Stabilizer Controlled Neutral Shift Functional Description

The stabilizer controlled elevator neutral shift function changes the neutral position of the elevators during stabilizer movement.

The neutral shift function causes the elevators to move when the stabilizer moves. The stabilizer neutral position is at 4 units of trim.

The elevator is downrigged 4 degrees when the stabilizer is at the neutral position (4 units of trim). When the stabilizer moves in either directions from neutral position, it moves the elevator neutral shift rods and gives a mechanical input to the elevator PCUs. The elevator moves up as the stabilizer moves either direction from the stabilizer neutral position. The amount of elevator movement due to stabilizer movement is shown by the stabilizer controlled neutral shift (not including FCC input) line.

FCC Controlled Neutral Shift Functional Description

The primary function of the flight control computer (FCC) controlled neutral shift is to reduce the pilot column force necessary to trim the airplane during initial climbout after takeoff with a forward CG and both engines operating.

The FCCs provide inputs to the mach trim actuator when these conditions occur:

- TE flaps not up
- Either engine N1 more than 18%.

FCC controlled neutral shift changes the elevator neutral position based on stabilizer and flap position. When active, the FCCs command a neutral shift when any of these occurs:

- Captain or F/O stabilizer trim switches operated
- Flap setting is changed.

Manual trim wheel inputs, autopilot, and speed trim system will not command elevator movement by the FCC controlled neutral shift function.

The incremental elevator input commanded by the FCC controlled neutral shift varies with flap position and stabilizer position. The amount of elevator movement due to FCC controlled neutral shift at flap position from 1 unit to 25 units is shown by the FCC controlled neutral shift (F1-F25) line. The input is slightly different at flap positions of 30 units and 40 units.

The elevator input commanded by the FCC controlled neutral shift varies in a very different manner as a function of stabilizer setting.

FCC Controlled Neutral Shift Operation During Forward CG Takeoffs

During forward CG takeoffs and the stabilizer at 7.0 to 10.5 units, the FCCs input some elevator downrig. The increased airplane nose up takeoff stabilizer settings give increased control during takeoff.

FCC Controlled Neutral Shift Operation During Aft CG Operations

During aft CG operations, as more airplane nose down stabilizer trim is necessary, less elevator downrig is commanded. This occurs as the stabilizer moves from 7 to 0 units of trim. Removal of the elevator downrig allows more nose down control.

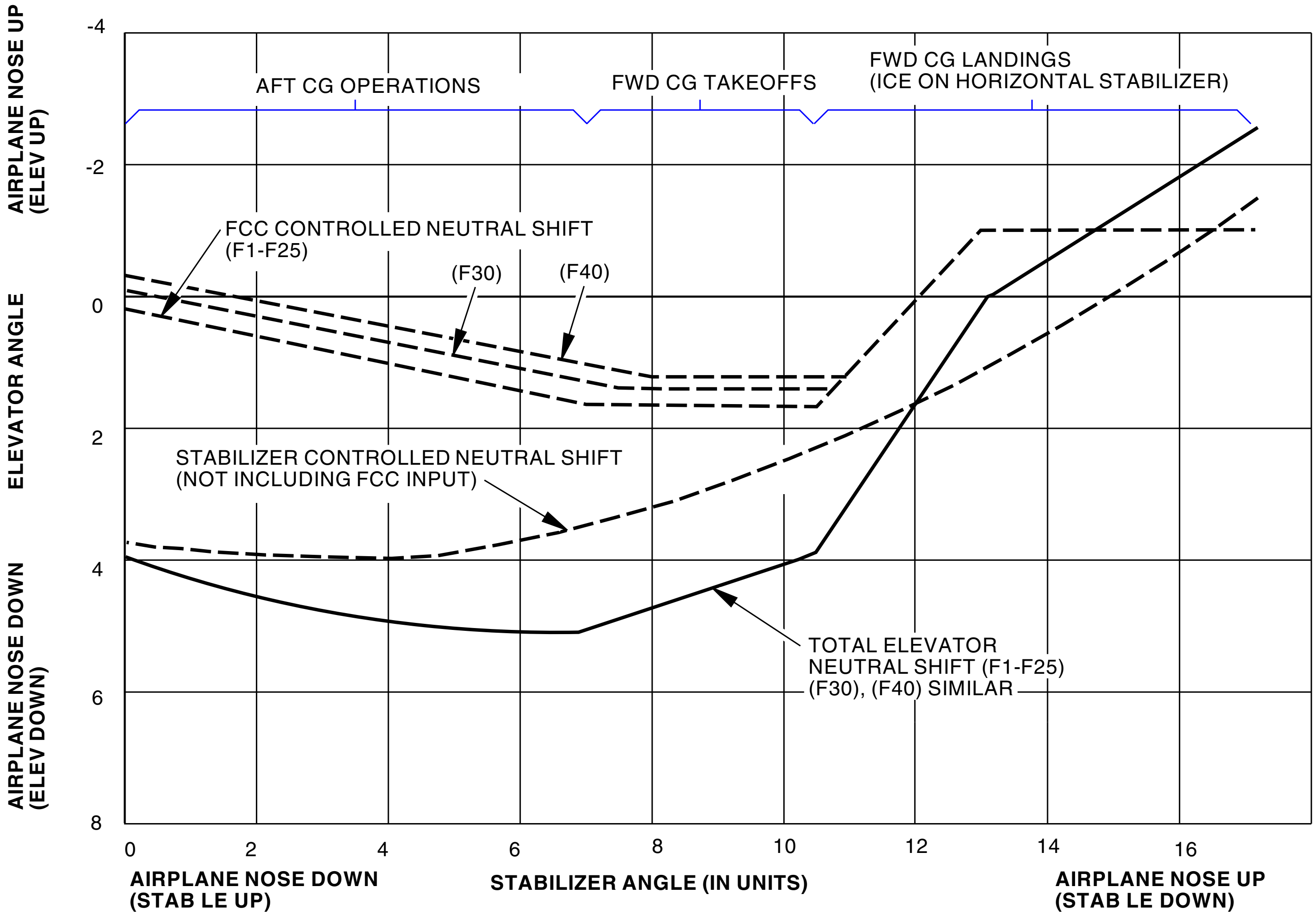
FCC Controlled Neutral Shift Operation During Forward CG Landings

During forward CG landings, as the stabilizer moves from 10.5 to 17.0 units, the FCCs remove the elevator downrig and add some uprig. By removal of the downrig and the addition of uprig, not as much airplane nose up stabilizer is necessary to trim. This decreases the stabilizer angle of attack and decreases the potential for tail buffet if there is ice on the stabilizer.

Combined Effect of Stabilizer Controlled Neutral Shift and FCC Controlled Neutral Shift.

The elevator movement due to stabilizer position and the FCC controlled neutral shift function add together. The total amount of elevator movement due to stabilizer controlled neutral shift and FCC controlled neutral shift is shown at flap positions from 1 unit to 25 units is shown by the total elevator neutral shift (F1-F25) line.

ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR NEUTRAL SHIFT



ELEVATOR AND TAB CONTROL SYSTEM - ELEVATOR NEUTRAL SHIFT

ELEVATOR AND TAB CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

General

The pilots manually control the position of the elevators with forward and aft movement of the control columns.

The stabilizer mechanically controls the position of the elevators during stabilizer neutral shift.

The autopilot controls the position of the elevators automatically when it is engaged.

The digital flight control system (DFCS) automatically controls the elevators during FCC controlled neutral shift.

Manual Operation - Elevator

The pilots use the control column to operate the elevator for pitch control. When the control column moves, it moves the elevator forward quadrant and the elevator control cables. The control cables move the elevator aft control quadrant. This provides an input to the elevator input torque tube. Feel force is provided by the feel and centering unit and dual feel actuator. The elevator input torque tube moves the elevator PCU input pogos. The pogos provide inputs to the PCUs. The PCU rod end is fixed and the housing moves the elevator output torque tube. The output torque tube moves the elevators through the control rods.

Autopilot - Elevator

The DFCS uses the autopilot actuators to mechanically give an input to the elevator input torque tube. The output from the input torque tube to the elevator PCUs is the same as in the manual operation.

During autopilot operation, the autopilot actuator input also backdrives the control columns to the DFCS commanded position.

See the DFCS section for more information about the autopilot system. (SECTION 22-11)

Elevator Neutral Shift - Stabilizer Input

When the stabilizer moves, it moves the two elevator neutral shift rods. The neutral shift rods provide an input to the elevators through the mach trim actuator, the feel and centering unit, and the elevator input torque tube to the PCUs. When the elevator input torque tube moves, it also backdrives the control cables which move the control columns to their new neutral position.

During stabilizer electric trim operation, if the pilot gives an opposite direction to elevator control input, the column cutout switches make the stabilizer electric trim stop.

Elevator Neutral Shift - Flight Control Computer Input

The flight control computers provide an input to the mach trim actuator when the TE flaps are not up and these conditions occur:

- The stabilizer trim switches are operated
- TE flap setting changed.

Manual trim, autopilot, speed trim system, and control column inputs do not command the elevators to move by the FCC controlled neutral shift function.

When the mach trim actuator moves, a mechanical input goes through the feel and centering unit to the PCUs.

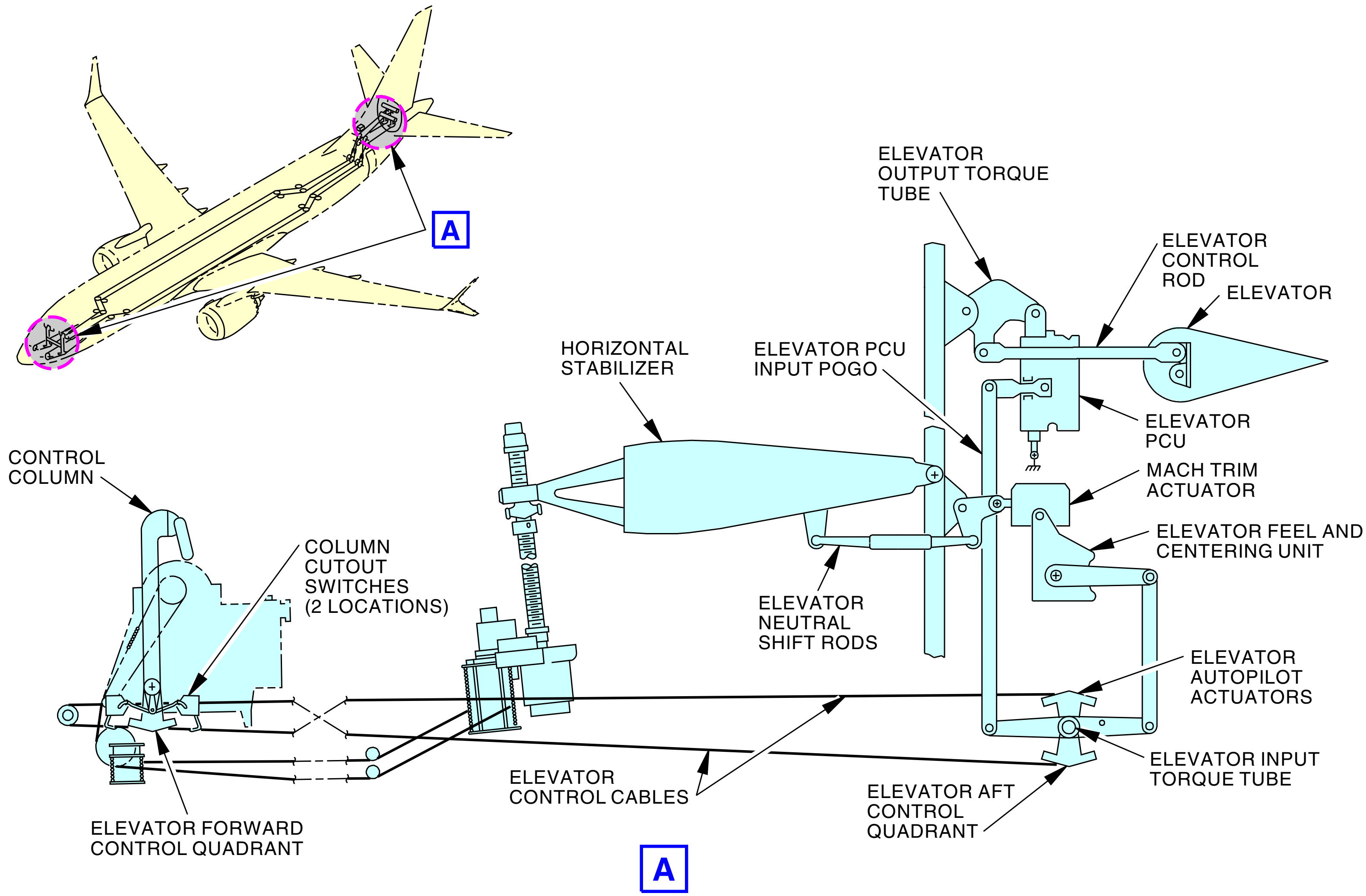
See the elevator neutral shift section for more information about the FCC controlled neutral shift function. (SECTION 27-31)

Elevator Tab Control

The elevator tab mechanism changes the function of the elevator tab. When the TE flaps are up, the elevator tab operates in the balance mode. When the TE flaps are not up, the elevator tab operates in the anti-balance mode.

See the elevator and tab control system section for more information on the elevator operation. (SECTION 27-31)

ELEVATOR AND TAB CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



ELEVATOR AND TAB CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

STALL WARNING SYSTEM - INTRODUCTION

Purpose

The stall warning system shakes the control column when the airplane gets close to a stall.

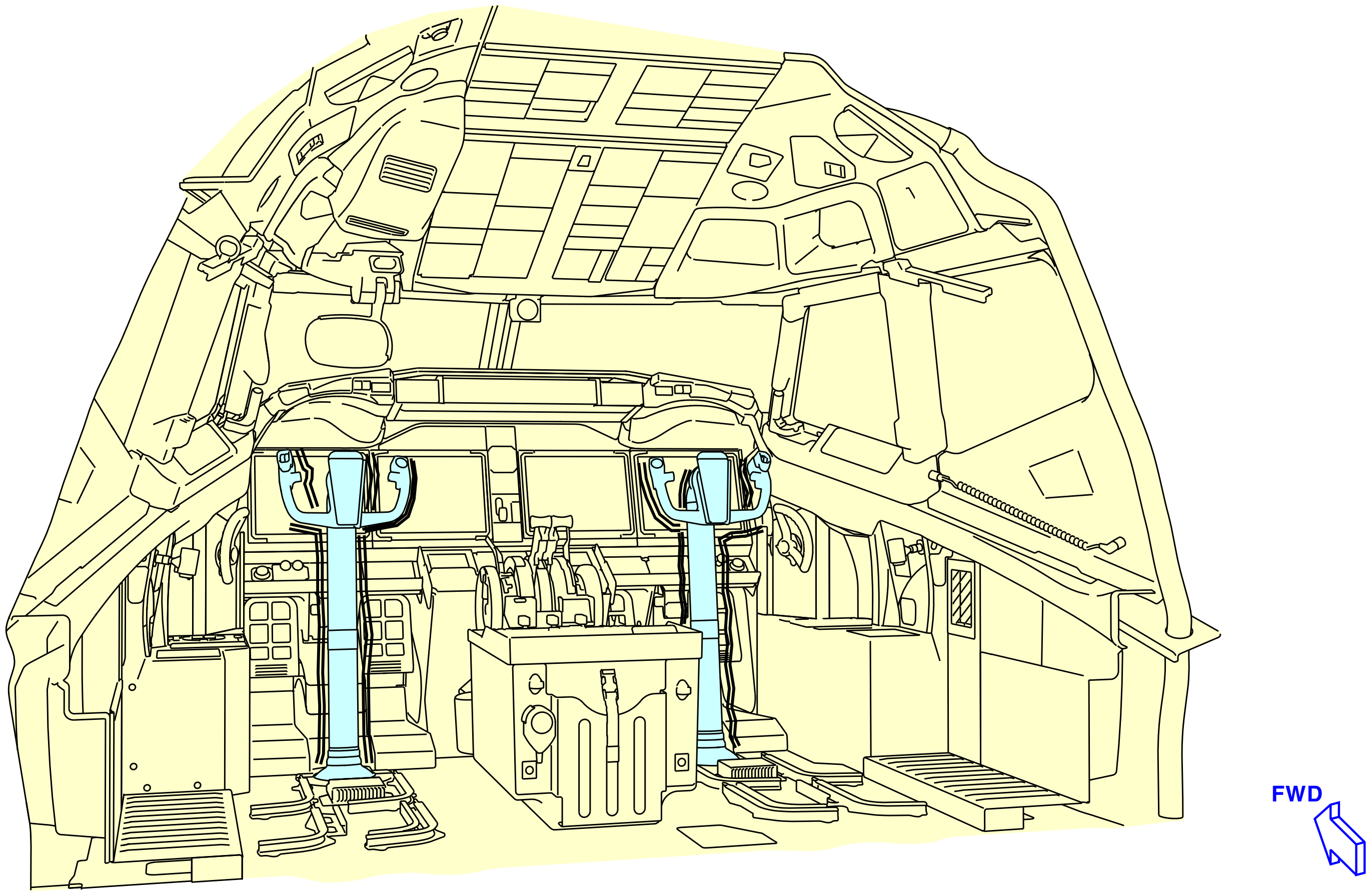
Stall ID increases control column feel forces during a stall.

Abbreviations and Acronyms

- AC - alternating current
- ADIRS - air data inertial reference system
- ADIRU - air data inertial reference unit
- ADR - air data reference
- AOA - angle of attack
- ARINC - Aeronautical Radio Inc.
- asym - asymmetry
- ATR - Austin Trumbull Radio
- BITE - built-in Test equipment
- CAA - Civil Aviation Authority
- capt - captain
- CB - circuit breaker
- CMD - command
- com - common
- CPC - cabin pressure controller
- DC - direct current
- deg - degree
- DPC - display processing computer
- EFS - elevator feel shift
- EFSM - elevator feel shift module
- eng - engine
- F/O - first officer
- FCC - flight control computer
- FDAU - flight data acquisition unit
- ft - feet
- FMCS - flight management computer system
- FSEU - flap slat electronics unit
- gnd - ground
- GPWC - ground proximity warning computer
- IR - inertial reference
- k - knot
- L - left
- LE - leading edge
- MCP - mode control panel
- MDS - MAX display system
- MMO - mach maximum operating
- No. - number
- norm - normal
- PLI - pitch limit indication
- POS - position
- PSEU - proximity switch electronics unit
- R - right
- RA - radio altitude
- sec - second
- SMYD - stall management yaw damper
- SS - stick shaker
- stall ID - stall identification
- sws - stall warning system
- TAI - thermal anti-ice
- TE - trailing edge
- TOGA - takeoff/go-around
- UCM - uncommanded motion
- v - volt
- Vcas - computed airspeed

- VMO - velocity maximum operating
- Vsf - speed floor velocity
- warn - warning
- WTRIS - wheel-to-rudder interconnect system

STALL WARNING SYSTEM - INTRODUCTION



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STALL WARNING SYSTEM - INTRODUCTION

SWS - GENERAL DESCRIPTION

General

The stall warning system shakes the control column when the airplane gets close to a stall.

The stall ID system makes sure the pilot cannot easily overcome automatic nose down trim of the airplane during a stall. During a stall, the stall warning system increases control column feel forces.

These are the components of the stall warning system:

- Stall management yaw dampers (SMYDs)
- Control column shakers
- Elevator feel shift module (EFSM)
- Stall warning test panel

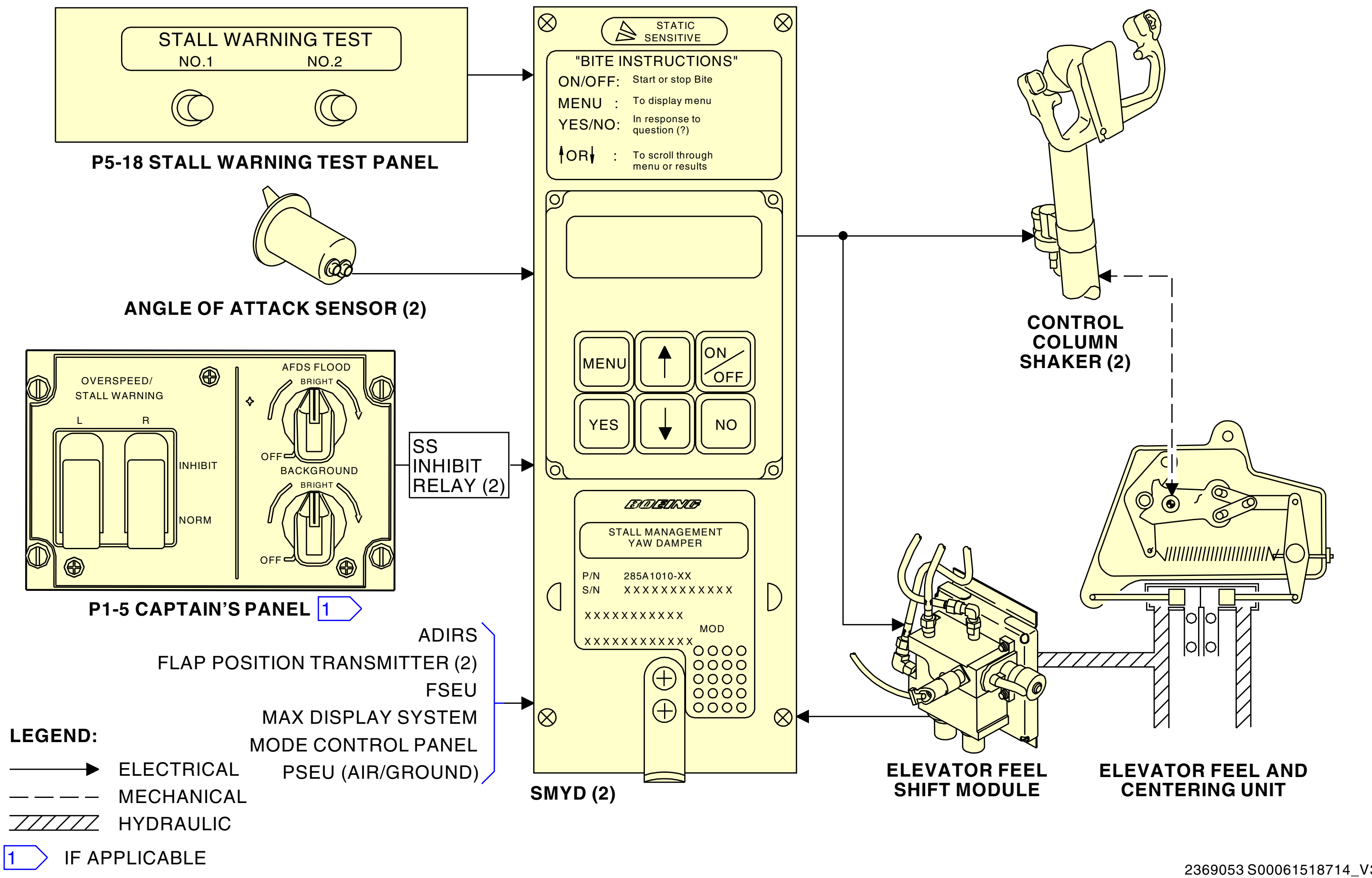
During a stall, the FCCs command the stabilizer to trim the airplane nose down. The EFSM and column cut-out switch modules operate to make sure the pilot cannot easily stop this automatic stabilizer movement with the elevator control column nose up input.

These are the components and systems that supply data to the stall warning system:

- Angle of attack sensors
- Air data inertial reference system (ADIRS)
- Flap position transmitters
- Flap slat electronics unit (FSEU)
- MAX display system (MDS)
- Mode control panel (MCP)
- Proximity switch electronic unit (PSEU)

The EFSM and the control column shakers receive discrete signals from the stall warning system.

SWS - GENERAL DESCRIPTION



SWS - GENERAL DESCRIPTION

SWS - COMPONENT LOCATION

General

The components of the stall warning system are in these compartments:

- Flight compartment
- Section 48 stabilizer compartment
- Electronic equipment compartment.

Flight Compartment

The stall warning test panel is on the P5 aft overhead panel. The control column shakers are on the forward side of the control columns.

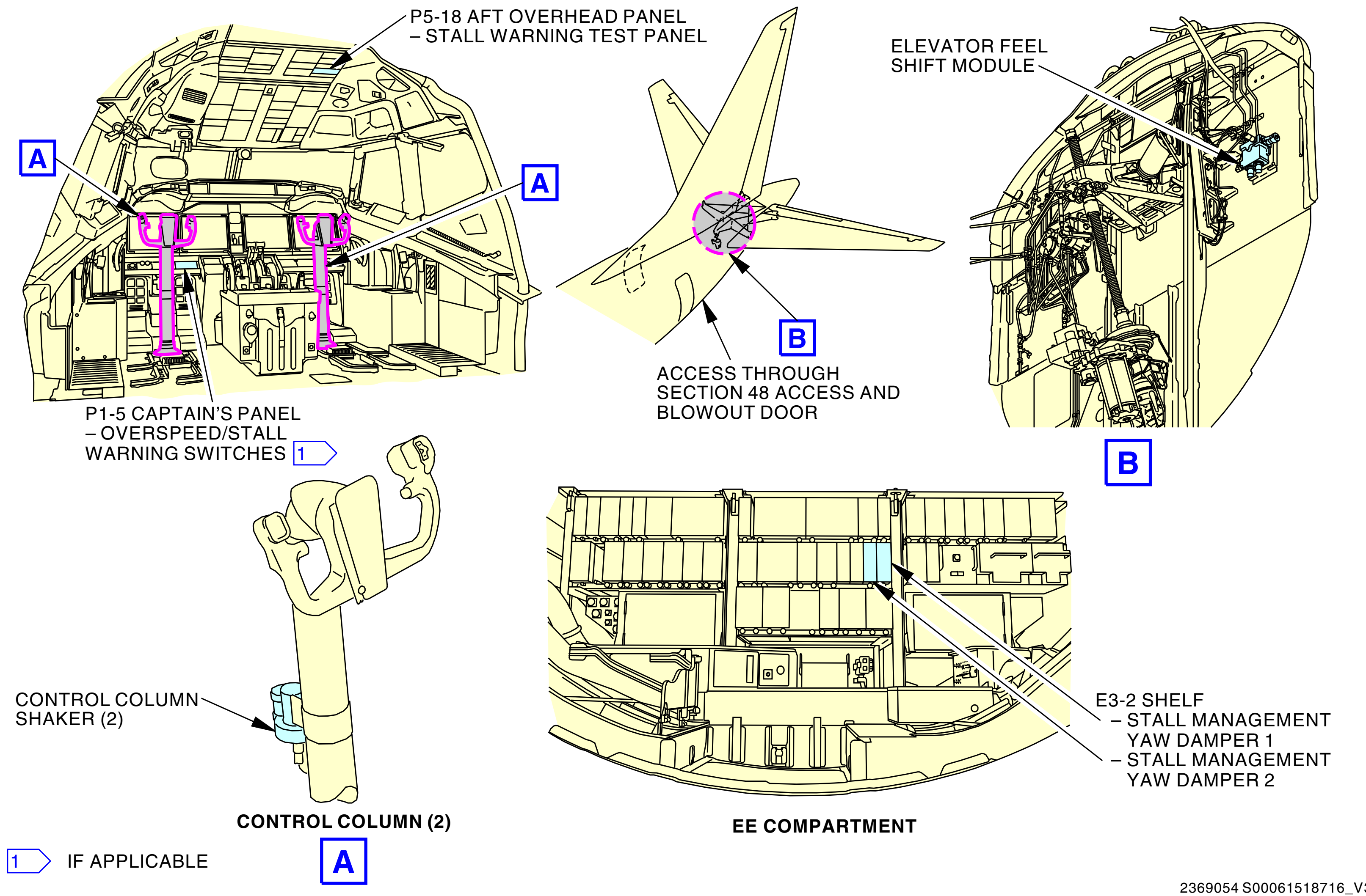
Electronic Equipment Compartment

The stall management yaw dampers (SMYDs) are on the E3-2 shelf.

Section 48 Stabilizer Compartment

The elevator feel shift module (EFSM) is on the left side of the aft bulkhead in the stabilizer compartment.

SWS - COMPONENT LOCATION



SWS - COMPONENT LOCATION

SWS - SMYD - STALL MANAGEMENT YAW DAMPER

General

The SMYD is a 1/4 ATR short unit. It uses 10 watts of power. The SMYD has a standard Boeing six keypad BITE module on the front of the unit. The BITE module has these features:

- BITE instructions
- Display
- Keypad.

BITE Instructions

BITE instructions show how to do a BITE test of the SMYD and move through the BITE sequence.

Display

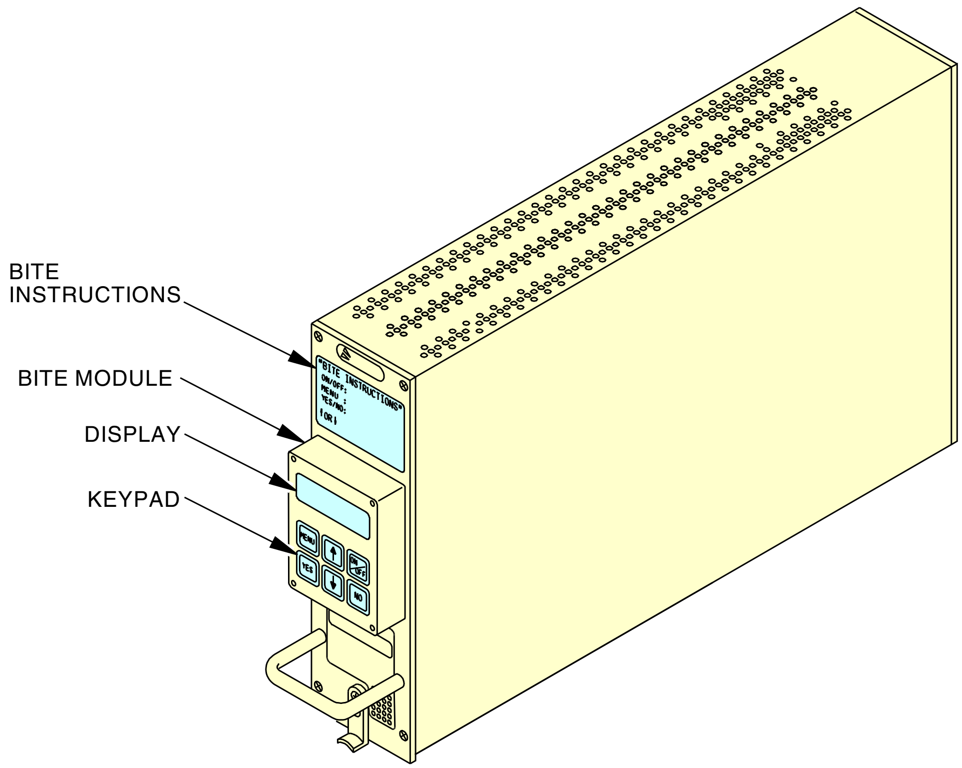
The BITE display shows the status of the SMYD BITE tests and results. The display has two lines. Each line can show eight amber alphanumeric characters.

Keypad

The BITE keypad has these six switches that allow interaction with the SMYD for faults recorded:

- ON/OFF
- MENU
- YES
- NO
- Up arrow
- Down arrow.

SWS - SMYD - STALL MANAGEMENT YAW DAMPER



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SWS - SMYD - STALL MANAGEMENT YAW DAMPER

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SWS - STALL MANAGEMENT YAW DAMPER - INTRODUCTION

General

The stall management yaw damper (SMYD) computer calculates and sends commands for stall management and yaw damping functions for these systems:

- Stall warning system (SWS)
- Autoslat system
- Performance data for display on MDS
- Primary yaw damping system
- WTRIS and standby yaw damping system.

Stall Warning System

The stall warning system operates the control column stick shakers to alert the crew when airspeed is at a minimum operating speed and is close to a wing stall condition.

When close to stall, the SMYD operates the elevator feel shift (EFS) function to increase elevator feel pressure to counteract control column elevator up movement.

Autoslat System

The autoslat system commands the leading edge slats to extend from the mid-extended to the full-extended position for flaps 1, 2, 5, 10, 15 and 25 when the speed is less than a safe margin above stall. Autoslat operates at an angle-of-attack that is less than for stick shaker speed.

Performance Data

The SMYD calculates airplane performance data for display on the MDS. These include the pitch limit indicator (PLI) symbol and minimum and maximum safe operating speed symbols.

Primary Yaw Damping and WTRIS/Standby Yaw Damping

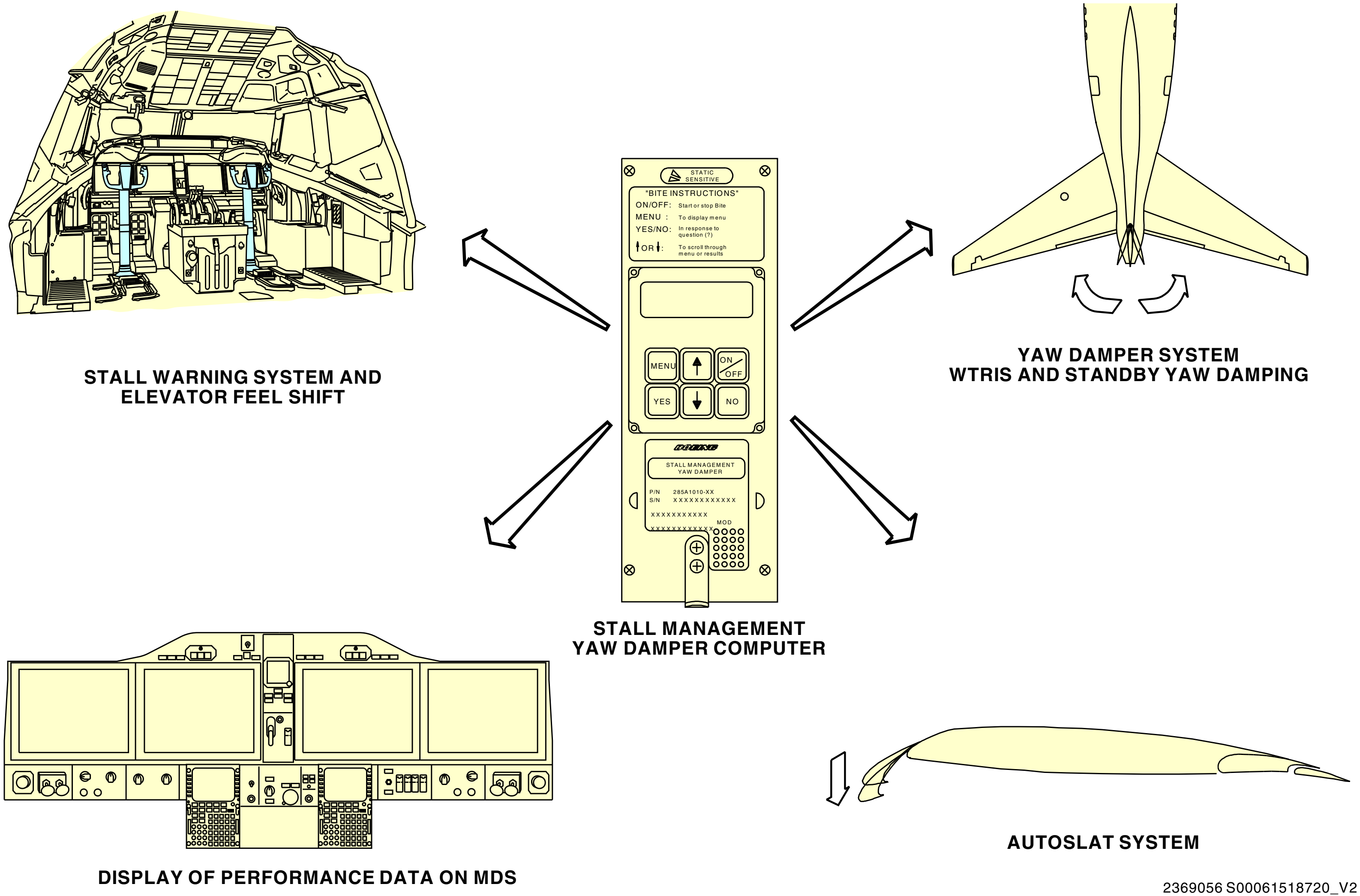
The yaw damping function of the SMYD does primary yaw damping, standby yaw damping, and WTRIS.

Abbreviations and Acronyms

- AC - alternating current
- actr - actuator
- ADI - attitude direction indicator
- ADIRU - air data inertial reference unit
- ADR - air data reference
- AOA - angle of attack
- ARINC - Aeronautical Radio, Inc.
- asym - asymmetry
- A/T - autothrottle
- ATR - austin trumbull radio
- BITE - built-in Test equipment
- CAA - civil aviation authority
- CAS - computed airspeed
- capt - captain
- CDU - control display unit
- cmd - command
- cmptr - computer
- com - common
- cos - cosine
- CPC - cabin pressure controller
- CPU - central processing unit
- CW - control wheel
- DC - direct current
- DFCS - digital flight control system
- DPC - display processing computer
- DU - display unit
- EFS - Elevator Feel Shift
- EFSM - Elevator Feel Shift Module
- elex - electronic

- eng - engage
- exc - excitation
- FAA - federal aviation administration
- FCC - flight control computer
- FDAU - flight data acquisition unit
- FMC - flight management computer
- FMCS - flight management computer system
- f/o - first officer
- FSEU - flap slat electronics unit
- fwd - forward
- gnd - ground
- GPWC - ground proximity warning computer
- ind - indicator
- I/O - input/output
- IR - inertial reference
- L - left
- LE - leading edge
- LRU - line replaceable unit
- lt - light
- LVDT - linear variable differential transformer
- MCP - mode control panel
- MDS - MAX display system
- mgt - management
- MLG - main landing gear
- NLG - nose landing gear
- NVM - non-volatile memory
- N1 - engine low pressure rotor (fan) speed
- N2 - engine high pressure rotor speed
- PCU - power control unit
- perf - performance
- PLI - pitch limit indicator
- pos - position
- PSEU - proximity switch electronics unit
- R - right
- req - request
- sin - sine
- SMYD - stall management yaw damper
- snsr - sensor
- stby - standby
- sw - switch
- SWS - stall warning system
- TE - trailing edge
- T/O - takeoff
- TO/GA - takeoff/go-around
- UCM - uncommanded motion
- V - volt
- Vmin - minimum safe airspeed
- Vmax - maximum safe airspeed
- Vmvr - min/max safe maneuvering speeds
- warn - warning
- WTRIS - wheel to rudder interconnect system
- xfr - transfer
- xmtr - transmitter
- YD - yaw damper

SWS - STALL MANAGEMENT YAW DAMPER - INTRODUCTION



SWS - STALL MANAGEMENT YAW DAMPER - INTRODUCTION

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SWS - SMYD - GENERAL DESCRIPTION

General

The stall management yaw damper computer (SMYD) uses analog and digital inputs signals from airplane systems and sensors to calculate commands for these systems:

- Stall warning system and elevator feel shift (EFS)
- Autoslat system
- Performance data for display on MDS
- Primary yaw damping and turn coordination
- WTRIS and standby yaw damping/turn coordination.

Stall warning, EFS, autoslat, and performance data are part of the stall management function of the SMYD.

Yaw damping, turn coordination, and WTRIS are part of the yaw damper function of the SMYD. SMYD 1 does primary yaw damping/turn coordination during normal operations. SMYD 2 does WTRIS and standby yaw damping/turn coordination during standby operations.

SMYD Input Data

These are the components and sensors that send data to the SMYDs. Some of these components also receive data from the SMYDs:

- DFCS mode control panel (MCP)
- Air data inertial reference unit (ADIRU)
- Flight management computer system (FMCS)
- MAX display system (MDS) DPCs
- LVDTs on the rudder power control units (PCU)
- Angle of airflow (AOA) sensors
- Takeoff/go-around (TO/GA) switches
- Stall warning test panel
- Flight control panel
- Flap slat electronics unit (FSEU)
- Proximity switch electronics unit (PSEU)
- Trailing edge flap up switches
- Flap position transmitters
- Control wheel position sensor (Capt's side only)
- Opposite SMYD.

SMYD Output Data

These are the systems that receive data from the SMYD:

- Flight control computers (FCC)
- Autothrottle computer (A/T)
- Ground proximity warning computer (GPWC)
- MAX display system (MDS) DPCs
- Cabin pressure controllers (CPC)
- Flight data acquisition unit (FDAU)
- Flight control panel
- Flap slat electronics unit (FSEU)
- Proximity switch electronics unit (PSEU)
- Elevator Feel Shift Module (EFSM).

ADIRU

The ADIRUs send air data and inertial data to the SMYD to use for stall management and yaw damping functions. These are discussed under SMYD - Digital Interfaces.

DFCS MCP

The MCP sends autopilot engage status to the SMYD.

FMC

The FMC sends gross weight to the SMYD to use to calculate airplane performance data such as Vmin, Vmax, and the PLI, and for stall management, yaw damping, and WTRIS. The FMC also provides buffet margin speeds and landing flap information to the SMYD.

SWS - SMYD - GENERAL DESCRIPTION

DPC

The SMYD calculates this airplane performance data and sends the data to the DPCs to show on the MDS:

- Vmin and Vmax speeds (red/black barber poles and amber band speed ranges) for airspeed indicators
- PLI symbol (amber) for display on ADI.

The DPCs send this data to the SMYD on ARINC high speed buses:

- Engine N1 and N2 RPM
- Radio altitude
- Wing and engine anti-ice switches.

Rudder PCU LVDT

The rudder PCU LVDT sends analog data to the SMYD about commanded rudder movement for yaw damping or WTRIS, for feedback in the SMYD servo loop.

AOA Sensor

The AOA sensor sends analog angle of airflow vane data to the on-side SMYD. This data is used to determine airplane pitch attitude to set the stall warnings and to calculate performance data.

TO/GA Switches

The TO/GA switches send DFCS and A/T engage status to the SMYD during takeoff when on the ground, or during go-around when in the air.

Stall Warning Test Panel

The stall warning panel test switches send analog discretes to their on-side SMYD to start a test of the control column shaker motors.

Flight Control Panel

The flight control panel sends analog switch position signals to the SMYD for the yaw damper engage switch and the flight control switches. When these switches are engaged on the flight control panel, the SMYD monitors yaw damper or WTRIS operation. If there are no faults, the SMYD sends a signal to this panel to turn off the yaw damper engage light and provides engage power to hold the yaw damper engage switch in the ON position.

FSEU

The FSEU sends analog discrete data to the SMYD for leading edge device asymmetry and uncommanded motion. This data enables the SMYD to bias the stall warnings so that the warnings occur earlier if there is asymmetry or uncommanded motion of these devices.

The SMYD sends analog discrete signals to the FSEU for the autoslat command function.

PSEU

The PSEU sends an air/ground discrete to the SMYD to set the AIR MODE and flight leg count for faults recorded in non-volatile memory (NVM). These are analog discretes sent from the nose gear, main gear and gear handle position.

The SMYD sends analog discrete data to the PSEU to use as part of the takeoff warning function. The SMYD sends a ground to the PSEU whenever the flaps are not in a valid takeoff range, and an open discrete if they are.

Flaps Up Switches

The trailing edge flaps up limit switches send a signal to the SMYD for flaps up logic. The SMYD uses this to limit rudder travel for yaw damping and WTRIS when the flaps are up.

Flap Position Transmitter

The flap position transmitters send analog flap position data to the SMYD when the flaps are not up.

SWS - SMYD - GENERAL DESCRIPTION

Control Wheel Position Sensor

The captain control wheel (CW) position sensor sends an analog signal to SMYD 2. This is used for the WTRIS function so that SMYD 2 will command rudder movement in proportion to pilot aileron input to assist turns during flight control manual reversion when operating on standby hydraulics.

Opposite SMYD

The opposite SMYD provides data to the other SMYD for these parameters:

- Mach
- TAS
- Impact pressure
- Autoslat extend signal.

FCC

The SMYD sends minimum operating speeds and flap position data to the FCC computers as part of the system engage logic. DFCS uses the flight control minimum operating speeds for its minimum speed calculations to change modes when the speed is near a margin above stall.

A/T

The SMYD sends minimum operating speeds and flap position data to the A/T computer. The A/T uses these data for its minimum speed calculations.

GPWC

The SMYD sends minimum operation speeds, flap, and AOA data to the GPWC for windshear alert calculations.

CPC

The DPCs send engine N1 and N2 RPM data to the SMYD. The SMYD sends this data to the CPC to use as part of the takeoff logic to adjust cabin pressure during the takeoff roll to prevent a pressure bump at rotation.

FDAU

The SMYD sends AOA data and other discrete data to the FDAU to record stall management and yaw damper status.

Stall Warning and Elevator Feel Shift

The SMYD sends a 28v DC discrete to its on-side control column shaker motor to operate the stick shaker when airspeed is close to stall, as calculated by the SMYD.

The SMYD activates the EFSM for the EFS function. EFS operates through the elevator feel system to increase elevator feel pressure to counteract or resist control column elevator up movement when close to a stall.

Performance Data Displayed on MDS

SMYD calculates these performance data to show on MDS:

- Pitch limit indicator (PLI) symbol
- Minimum and maximum operating speed symbols.

Autoslat

Each SMYD sends a signal to the autoslat solenoid valve to move the autoslats. The autoslat system extends the leading edge slats from the mid-extend to the full-extend position for trailing edge flap positions 1, 2, and 5 when the speed is less than a minimum safe margin more than stall speed. The autoslat system increases lift and improves airplane control and maneuverability at lower speeds. The autoslat system operates at lower AOA values than normal stall warning.

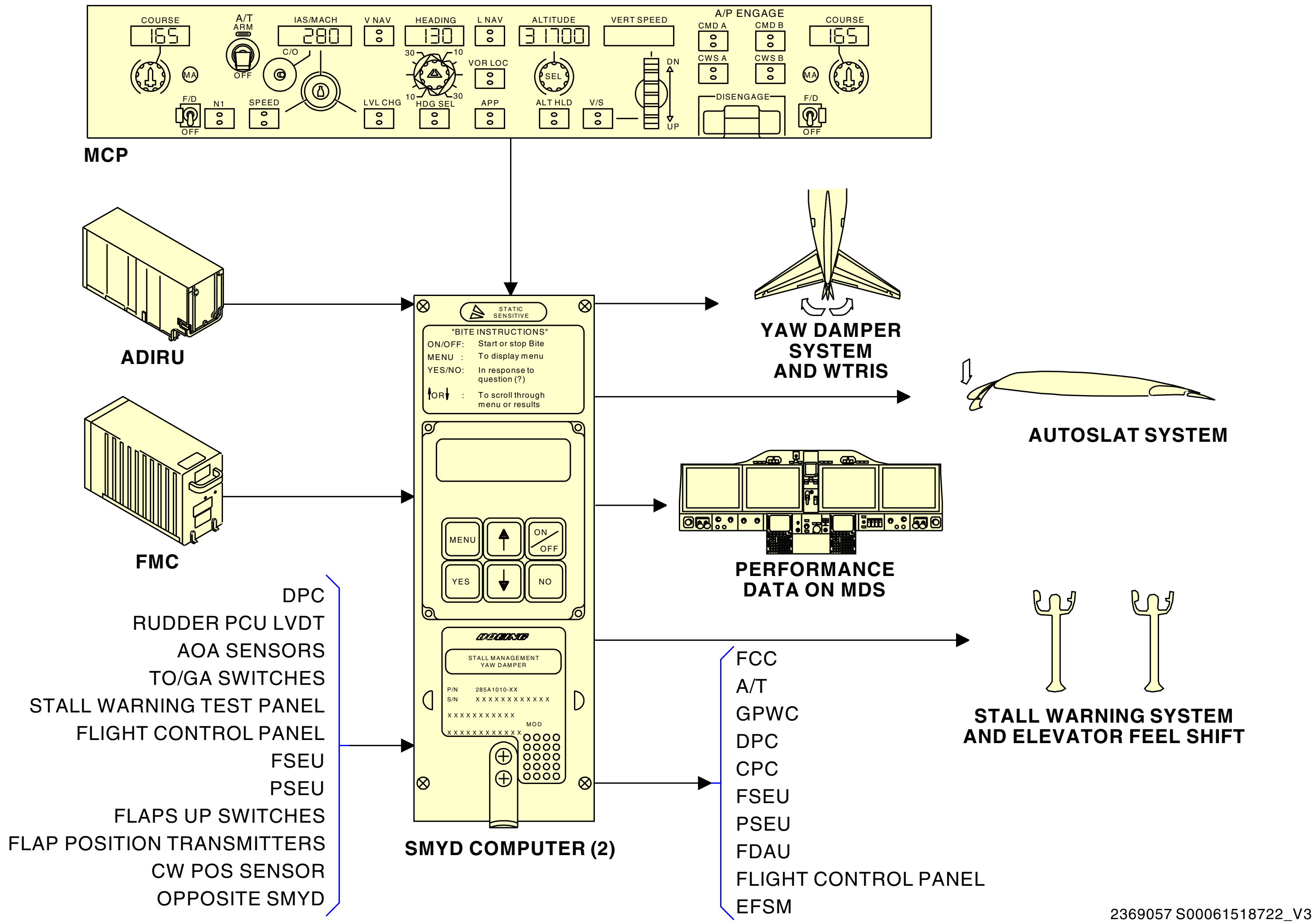
Primary Yaw Damping

SMYD 1 sends analog command signals to the main rudder PCU to engage primary yaw damping and move the rudder to reduce unwanted yaw motion. Primary yaw damping requires hydraulic system B pressure.

WTRIS and Standby Yaw Damping

SMYD 2 commands the standby rudder PCU to move the rudder for WTRIS/standby yaw damping during non-normal operations. This is only during manual reversion when both flight control systems A and B switches are in OFF or STBY RUD. At least one switch must be in STBY RUD.

SWS - SMYD - GENERAL DESCRIPTION



SWS - SMYD - GENERAL DESCRIPTION

SWS - SMYD - POWER INTERFACE

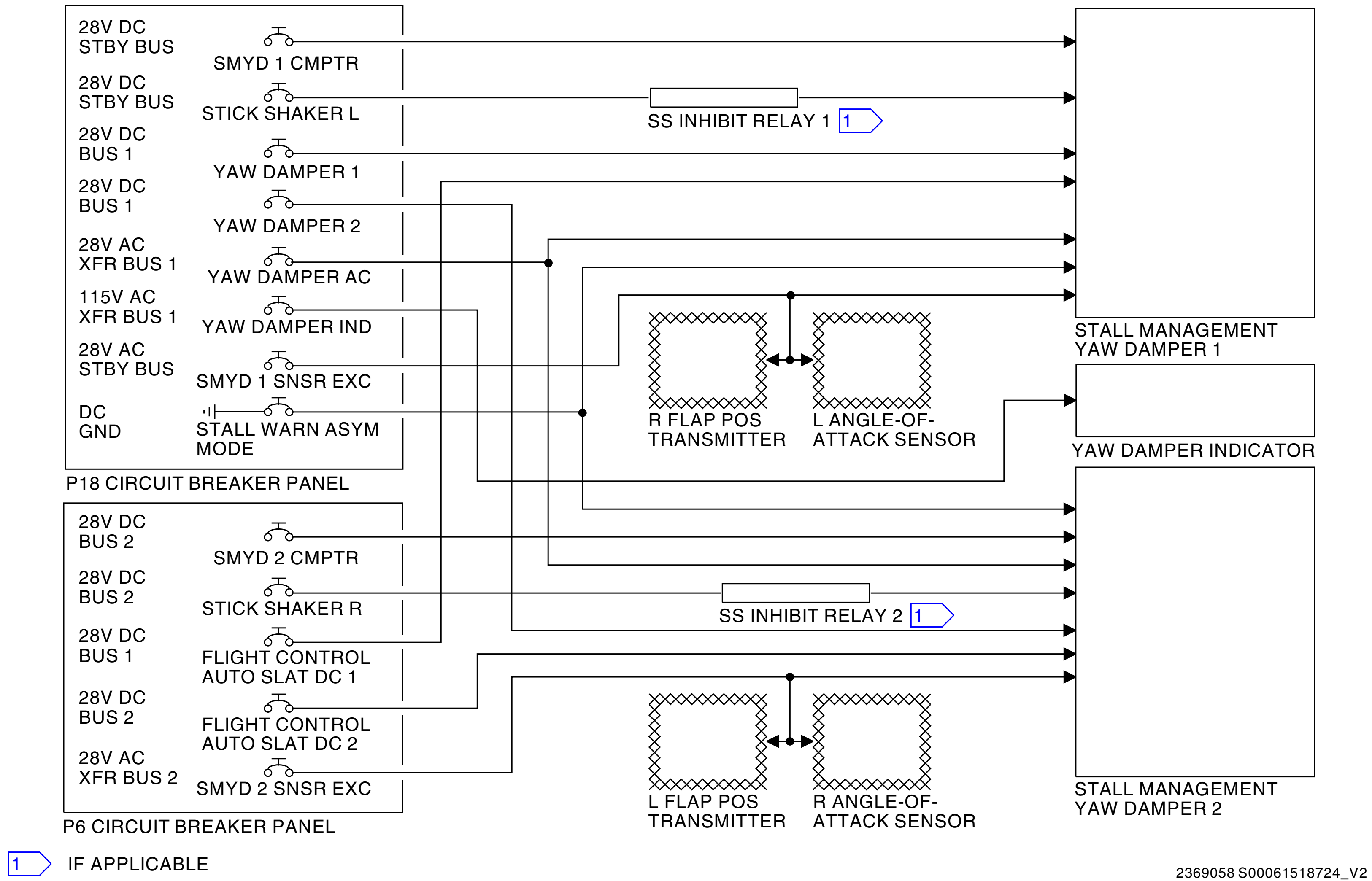
General

The SMYDs use electrical power from these sources:

- 28v DC standby bus
- 28v DC bus 1
- 28v DC bus 2
- 28v AC standby bus
- 28v AC transfer bus 1
- 28v AC transfer bus 2
- 115v AC transfer bus 1.

Each SMYD gets a DC ground through the STALL WARN ASYM MODE circuit breaker (CB). For the stall warning function (stick shakers), the SMYD adds a bias to provide the stick shaker warning sooner than normal when there is a LE asymmetry indication. This CB provides a ground which enables this early stall warning function of the SMYD. The CB may be used to disable the early warning function and does not affect normal stall warning.

SWS - SMYD - POWER INTERFACE



SWS - SMYD - POWER INTERFACE

SWS - SMYD - ANALOG INTERFACES - SMYD 1

General

These are the analog signals that the SMYD 1 receives from other components and sensors:

- Left angle of attack sensor (AOA)
- Right TE flap position transmitter
- Trailing edge flaps up switch
- Leading edge devices asymmetry (FSEU)
- Leading edge devices uncommanded motion (FSEU)
- Main landing gear air/ground position (PSEU)
- Nose landing gear air/ground position (PSEU)
- Landing gear down and locked (PSEU)
- Stall warning panel self test
- Takeoff/go-around (TO/GA) switches
- Flight control B switch
- Yaw damper engage light
- Yaw damper engage switch
- Yaw damper actuator position (LVDT).

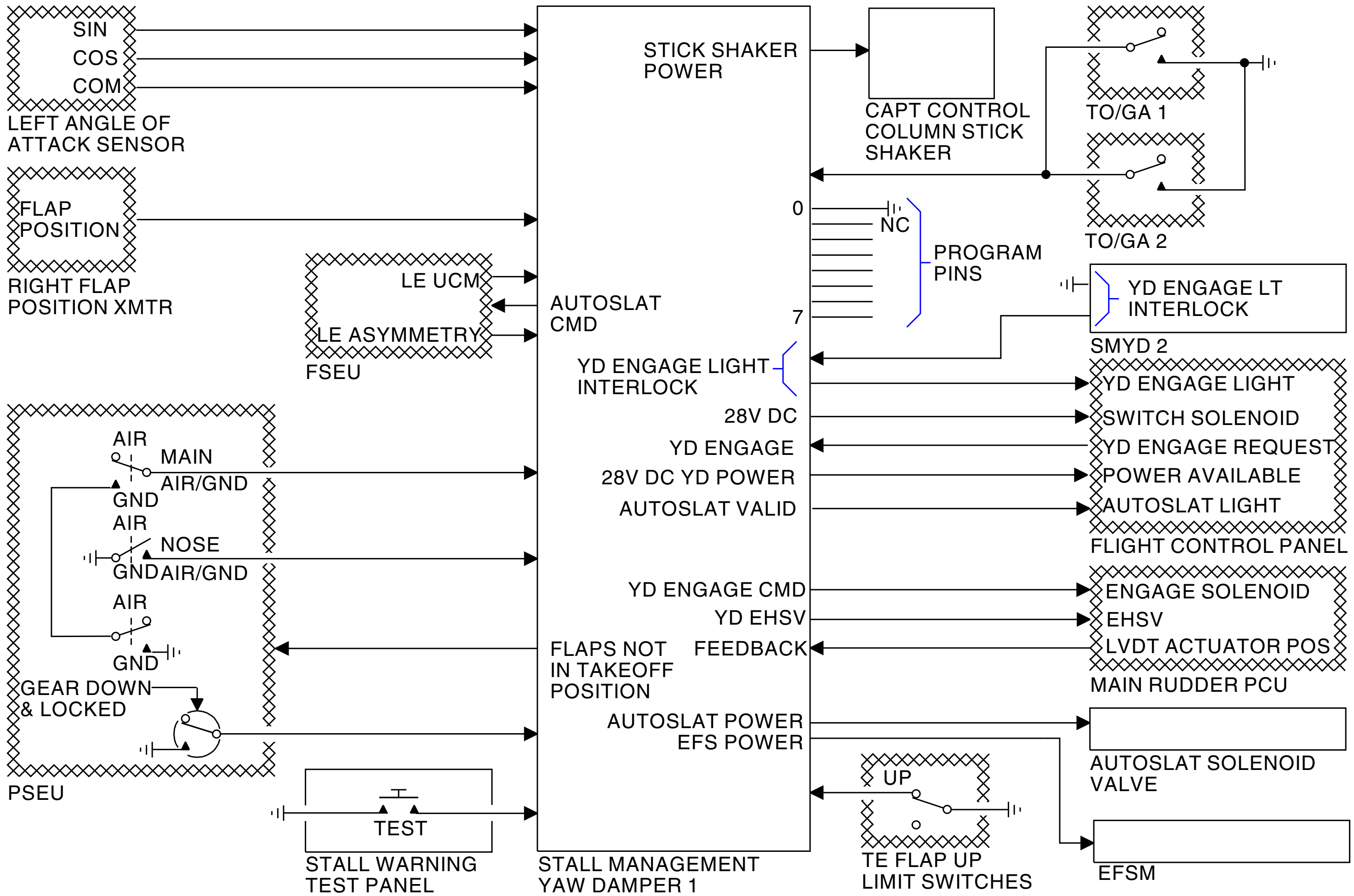
These are the eight program pins and options for each SMYD computer:

- 0 - stall management yaw damper 1
- 1 - stall management yaw damper 2
- 2 - alternate flap
- 3 - FAA or CAA/FAA
- 4 - 737-600
- 5 - 737-800
- 6 - 737-700
- 7 - parity pin.

SMYD 1 calculates stall management functions and primary yaw damping functions and sends analog signals and commands for these systems and sensors:

- 28v dc autoslat solenoid valve power
- Autoslat valid signal
- Autoslat command
- Autoslat commanding logic (FSEU)
- Flaps not in takeoff range warning (PSEU)
- Captain control column stick shaker
- 28v dc yaw damper power
- Elevator feel shift module (EFSM)
- Yaw damper solenoid valve (main rudder PCU)
- Yaw damper EHSV command (main rudder PCU)
- Yaw damper engage switch solenoid.

SWS - SMYD - ANALOG INTERFACES - SMYD 1



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SWS - SMYD - ANALOG INTERFACES - SMYD 1

SWS - SMYD - ANALOG INTERFACES - SMYD 2

General

These are the analog signals that SMYD 2 receives from other components and sensors:

- Control wheel position sensor (Captain)
- Right angle of attack (AOA) sensor
- Left TE flap position transmitter
- Trailing edge flaps up position
- Leading edge devices asymmetry (FSEU)
- Leading edge devices uncommanded motion (FSEU)
- Main landing gear air/ground position (PSEU)
- Nose landing gear air/ground position (PSEU)
- Landing gear down and locked (PSEU)
- Stall warning panel self test
- Takeoff/go-around (TO/GA) switches
- Flight control A and B switches (OFF/STBY RUD)
- Yaw damper engage light
- Yaw damper engage switch
- Yaw damper actuator position (LVDT).

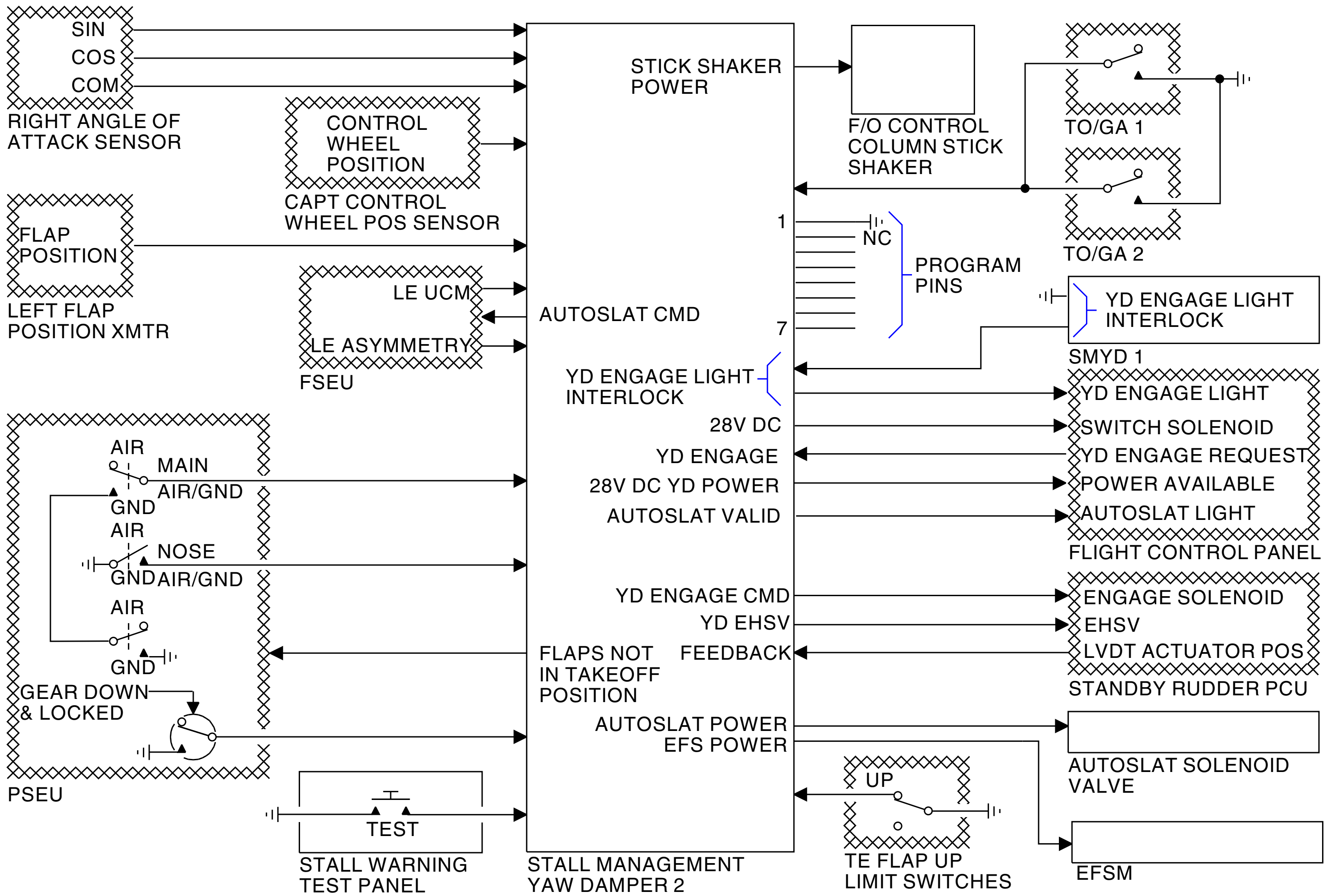
These are the eight program pins that connect to each SMYD computer:

- 0 - stall management yaw damper 1
- 1 - stall management yaw damper 2
- 2 - alternate flap
- 3 - FAA or CAA/FAA
- 4 - 737-600
- 5 - 737-800
- 6 - 737-700
- 7 - parity pin.

SMYD 2 calculates stall management functions and WTRIS and standby yaw damping functions and sends analog signals and commands for these systems and sensors:

- 28v dc autoslat solenoid valve power
- Autoslat valid signal
- Autoslat command
- Autoslat command logic (FSEU)
- Flaps not in takeoff range warning (PSEU)
- First officer control column stick shaker
- 28v dc yaw damper power
- Elevator Feel Shift Module
- Yaw damper solenoid valve (standby rudder PCU)
- Yaw damper EHSV command (standby rudder PCU)
- Yaw damper engage switch solenoid.

SWS - SMYD - ANALOG INTERFACES - SMYD 2



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SWS - SMYD - ANALOG INTERFACES - SMYD 2

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SWS - SMYD - DIGITAL INTERFACES

Digital Data Input to SMYD 1

SMYD 1 receives digital data from these systems:

- FMC 1
- FMC 2
- Left ADIRU (inertial data and air data)
- Right ADIRU (inertial data only)
- DFCS MCP
- DPC 1
- SMYD 2.

The FMC sends airplane gross weight and buffet margin speeds to the SMYD.

The on-side ADIRU sends these inertial data to the SMYD on ARINC high speed buses:

- Yaw rate
- Roll attitude
- Roll rate
- Lateral acceleration
- Pitch attitude
- Longitudinal acceleration
- Vertical speed.

The on-side ADIRU sends these air data to the SMYD on ARINC 429 low speed buses:

- Mach
- TAS
- CAS
- Impact pressure
- Static pressure
- Altitude
- Max operating speed.

The off-side ADIRU sends these inertial data to the SMYD on ARINC 429 high speed buses:

- Yaw rate
- Roll attitude
- Roll rate
- Lateral acceleration.

The MCP sends DFCS engage status to the SMYD.

The DPC sends these display values to the SMYD on ARINC high speed buses:

- Engine N1 and N2 RPM
- Radio altitude
- Position of the wing and engine anti-ice switches.

SMYD 2 sends this data to SMYD 1 on the cross-channel bus:

- Mach
- TAS
- Impact pressure
- Autoslat extend signal.

Digital Data Outputs From SMYD 1

SMYD 1 sends digital data to these systems:

- A/T computer
- FCC A
- GPWC
- DPC 1
- DPC 2
- CPC 1
- CPC 2

SWS - SMYD - DIGITAL INTERFACES

- FDAU
- SMYD 2.

The SMYD sends minimum operating speeds and flap position data to the A/T computer and on-side FCC. The FCC and A/T use this data for their minimum speed calculations.

The SMYD sends minimum operating speeds and flap and AOA data to the GPWC for windshear alert calculations.

The SMYD calculates the PLI symbol and minimum/maximum safe operating airspeeds and sends this data to the on-side DPC for display on the MDS.

The SMYD sends engine N1 and N2 RPM data (received from the DPC) to the CPC. The CPC uses this as part of the takeoff logic to detect throttle advance at the start of the takeoff roll for pressurization of the airplane to prevent a cabin pressure bump at rotation.

The SMYD sends on-side AOA data and other discrete data to the FDAU for data recording.

Digital Data Input to SMYD 2

The SMYD 2 interface is similar to SMYD 1. SMYD 2 receives digital data from these systems:

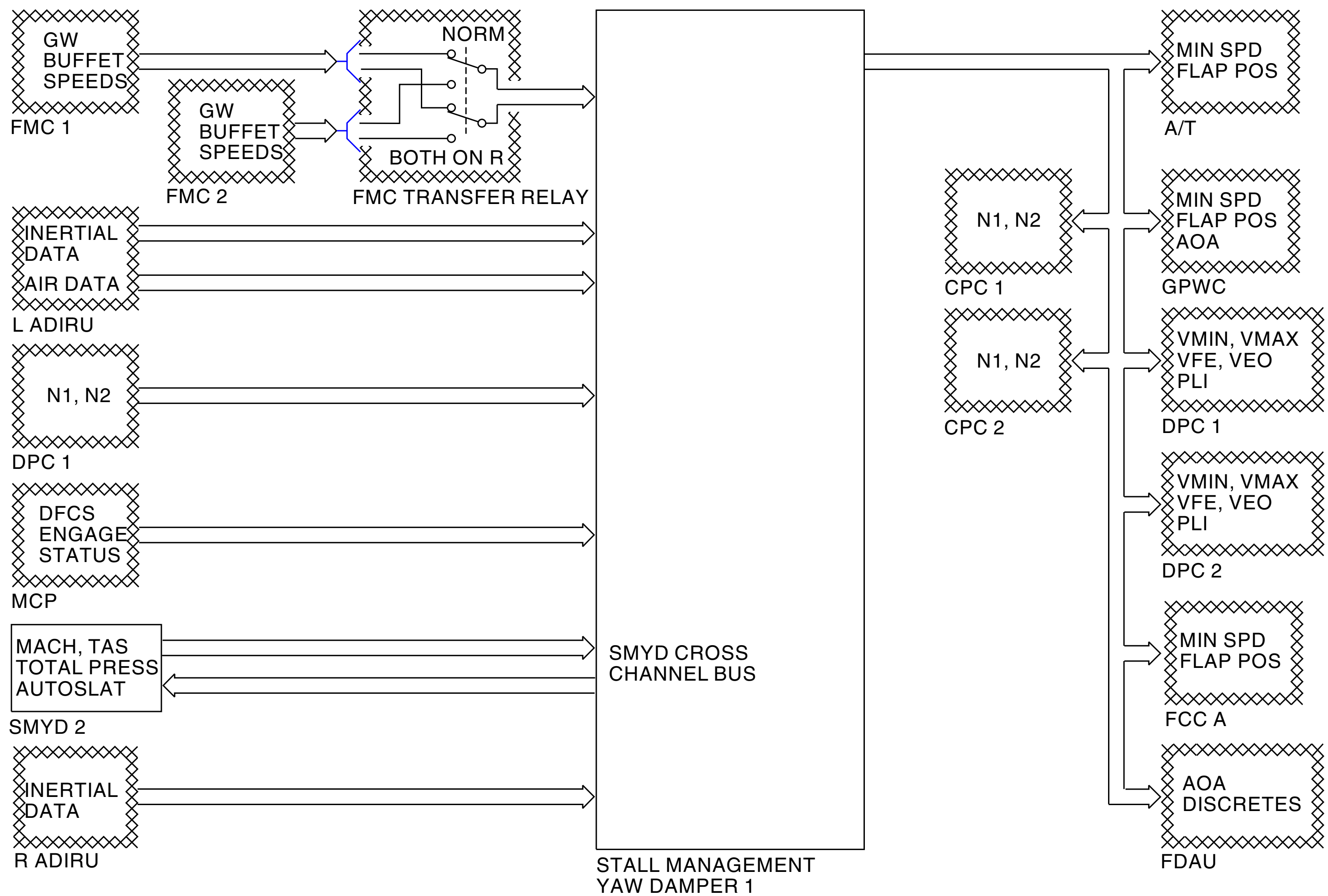
- FMC 1
- FMC 2
- Left ADIRU (inertial data only)
- Right ADIRU (inertial data and air data)
- DFCS MCP
- DPC 2
- SMYD 1.

Digital Data Outputs From SMYD 2

The SMYD 2 interface is similar to SMYD 1. SMYD 2 sends digital data to these systems:

- A/T computer
- FCC B
- GPWC
- DPC 1
- DPC 2
- CPC 1
- CPC 2
- FDAU
- SMYD 1.

SWS - SMYD - DIGITAL INTERFACES



SWS - SMYD - DIGITAL INTERFACES

SWS - SMYD - FUNCTIONAL DESCRIPTION

General

The stall management yaw damper (SMYD) calculates commands for stall management functions, yaw damping functions, and for the WTRIS.

There are two SMYD computers and they are interchangeable LRUs. Program pins and connections on the back of each LRU determine whether the SMYD will operate as SMYD 1 or SMYD 2.

Stall Management

For stall management functions, both SMYDs calculate commands for these functions:

- Stall warning
- Autoslat
- Performance data on MDS.

For stall management, both SMYDs calculate and send commands to their on-side systems for stall warning, autoslat, and for display of performance data on MDS. If one SMYD fails, the other SMYD continues to do the stall management functions.

Yaw Damping and WTRIS

For yaw damping, the SMYDs calculate commands for these functions:

- Primary yaw damping and turn coordination
- WTRIS and standby yaw damping/turn coordination.

SMYD 1 does primary yaw damping and turn coordination during normal operations with hydraulic system B, and uses the main rudder PCU to move the rudder.

SMYD 2 does WTRIS and standby yaw damping/turn coordination during non-normal operations during flight control manual reversion. It uses the standby hydraulic system and the standby rudder PCU.

This section provides a functional description of each SMYD system for stall management and yaw damping.

Stall Warning System and Elevator Feel Shift

The stall warning system is a stall management function that activates the control column stick shakers when airspeed is close to a stall. Each SMYD activates its on-side stick shaker motor.

When airspeed is close to a stall, the SMYDs do the EFS function by operating the EFSM which provides 850 psi hydraulic system A pressure to the elevator feel computer and the dual feel actuator. This causes the elevator feel force in the feel and centering unit to increase and to counteract or resist elevator up movement at the control column. Activation of the EFSM occurs at an AOA of 8 to 11 degrees depending on flap position. There are no other flight deck indications when this system operates.

Autoslat System

The autoslat system is a stall management function of the SMYD. Both SMYDs command the leading edge slats to extend from the sealed (mid-extend) to the gapped (full-extend) position when airspeed is less than a safe margin more than stall speed. This improves airplane control and handling characteristics. Hydraulic pressure to arm the autoslat function is available only for flaps 1, 2, 5, 10, 15 or 25. The autoslat system extends the slats at a less AOA value than where stall warning (stick shaker) occurs. Each SMYD can operate the autoslat system. See the leading edge autoslat system for more information about the autoslat operation. (SECTION 27-83)

Performance Data

The SMYD calculates performance data to show on the MDS. This is a stall management function. The SMYD calculates these performance data:

- Pitch limit indicator (PLI) symbol
- Minimum and maximum operating airspeeds.

The SMYD calculates and sends the pitch limit indicator (PLI) symbol to the MDS to show on the on-side ADI. The PLI symbol provides a visual indication for safe maneuver margins for pitch control during maximum performance climb and windshear escape maneuvers. The PLI is an amber symbol that shows on the ADI when the flaps are up or down.

SWS - SMYD - FUNCTIONAL DESCRIPTION

The SMYD calculates minimum and maximum safe operating speeds and sends this data to the airspeed indicator on the outboard EFIS displays of the MDS and to other airplane user systems. These are the speeds:

- Vmin/Vmax
- Vmvr
- Vf
- Veo.

Vmin is the minimum safe operating airspeed for a configuration of flaps and gear. The SMYD calculates Vmin with data such as flap position, Mach number and Angle of Attack. Vmin shows as an alternating red and black strip symbol at the bottom of the airspeed indicator. It is the speed at which the stick shaker operates for normal stall warning.

Vmax is the maximum safe design operating airspeed. The SMYD calculates Vmax as the least value of VMO/MMO, landing gear down, or flap placard limit speeds. Vmax shows as an alternating red and black strip symbol at the top of the airspeed display.

Vmvr speeds are the minimum and maximum safe airspeeds that provide a safe margin for maneuver in turbulence or with flaps extended and for low and high speed buffet margins. These speeds show as an amber band on the airspeed display and are an extension of the alternating red and black strips for Vmin and Vmax. The amber band becomes active on the display at first flap retraction after liftoff. The SMYD calculates these speeds as a function of gross weight, altitude, and other parameters. The SMYD also uses FMC calculated buffet speeds.

Vf is flap retraction speed. It is the minimum speed for flap retraction to the next operational flap setting. It is calculated from flap position and stick shaker speed and shows on the MDS only during flap retraction modes such as in climb-out or go-around.

Veo is the engine out speed. It is the flaps up engine out speed for the drift down procedure. It is calculated from gross weight and atmospheric pressure and only shows when flaps are up and in the air mode.

Primary Yaw Damping

SMYD 1 calculates commands for primary yaw damping and turn coordination. SMYD 1 sends analog command signals to the yaw damper components and actuator on the main rudder PCU to move the rudder to reduce unwanted airplane yaw motion. Primary yaw damping is used during normal operations and uses hydraulic system B pressure. To engage the primary yaw damper, turn ON hydraulic system B and do these steps on the flight control panel:

- Put the FLT CONTROL B switch to ON
- Put the YAW DAMPER switch to ON.

For primary yaw damping, rudder left/right movement is limited to 2 degrees with flaps up, and 3 degrees with flaps down.

For yaw damper operation see the Yaw Damper System. (SECTION 22-23)

WTRIS and Standby Yaw Damping

SMYD 2 calculates commands for WTRIS and standby yaw damping/turn coordination. SMYD 2 sends analog command signals to the standby yaw damper components to move the yaw damper actuator on the standby rudder PCU. This moves the rudder for the wheel to rudder interconnect system (WTRIS) and for standby yaw damping.

The purpose of WTRIS is to help turns during flight control manual reversion. During manual reversion with standby hydraulics ON, the WTRIS uses data from the control wheel sensor (Capt) to make a small command input to move the rudder in proportion to pilot control wheel (aileron) inputs during turns. WTRIS and standby yaw damping are not normal operations and standby hydraulic pressure is necessary. To engage WTRIS and standby yaw damping, do these steps on the flight control panel:

- Put both FLT CONTROL switches to OFF
- Put at least one FLT CONTROL switch to STBY RUD
- Put the yaw damper switch to ON.

SWS - SMYD - FUNCTIONAL DESCRIPTION

Both FLT CONTROL A and B switches must be off to enable SMYD 2, and one or both switches must be in the STBY RUD position to provide standby hydraulic pressure.

WTRIS only operates at Mach < 0.4. The gain schedule varies from 1 (full gain) at Mach < 0.3 to zero gain at Mach > 0.4.

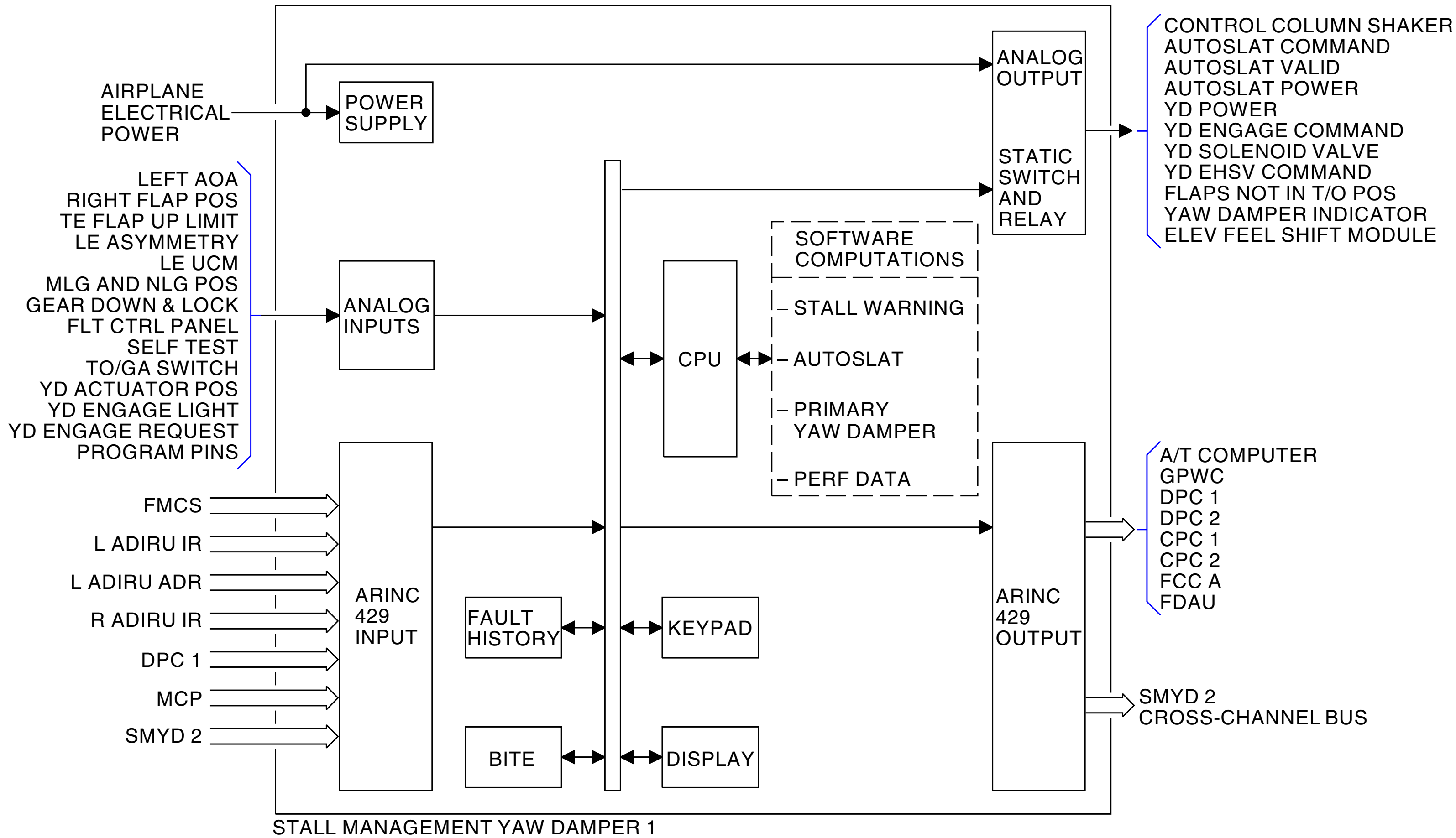
For WTRIS and standby yaw damping, rudder left/right travel limit is 2 deg with flaps up, and 2.5 deg with flaps down. See the WTRIS section for more information. (SECTION 27-32)

SMYD BITE

The SMYD has BITE functions for continuous monitoring of the SMYD LRU. The SMYD also has BITE tests to detect and record faults for the stall management and yaw damping functions.

The BITE module, keypad, and display on the front of the SMYD LRU are used for interaction with the SMYD BITE for servo tests, self-tests, and display of fault information for stall management functions and yaw damping functions.

SWS - SMYD - FUNCTIONAL DESCRIPTION



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SWS - SMYD - FUNCTIONAL DESCRIPTION

SWS - CONTROL COLUMN SHAKER

Purpose

The control column shakers shake the control columns to alert the pilots of a stall condition.

Location

The control column shakers attach to the control columns.

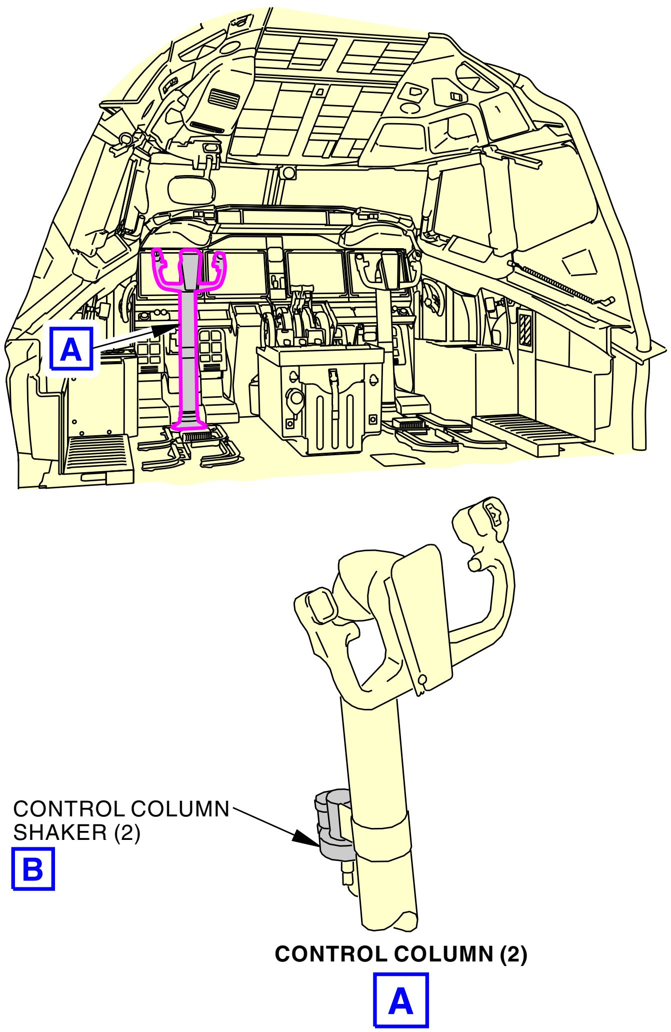
Physical Description

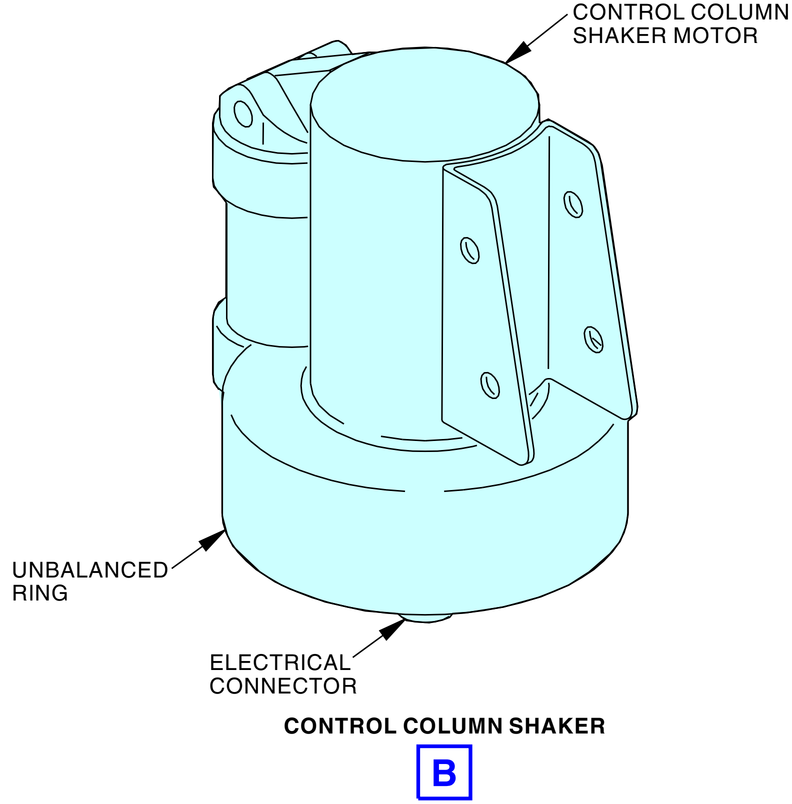
Each control column shaker has a 28v dc motor and an unbalanced ring. There is one electrical connector on each unit.

Functional Description

The motor drives an unbalanced ring. The ring shakes the control column.

SWS - CONTROL COLUMN SHAKER





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SWS - CONTROL COLUMN SHAKER

SWS - STALL WARNING TEST PANEL

Purpose

The test switches of stall warning test panel do a test of the stall warning system.

Location

The stall warning test panel is on the P5 aft overhead panel.

Physical Description

The stall warning test panel has two push button switches.

Functional Description

Each test switch lets you do a test of the stall warning system. When you push switch 1, you do a test of stall warning system 1 with operation of the control column shaker on the captain control column. When you push switch 2, you do a test of stall warning system 2 with operation of the control column shaker on the first officer control column.

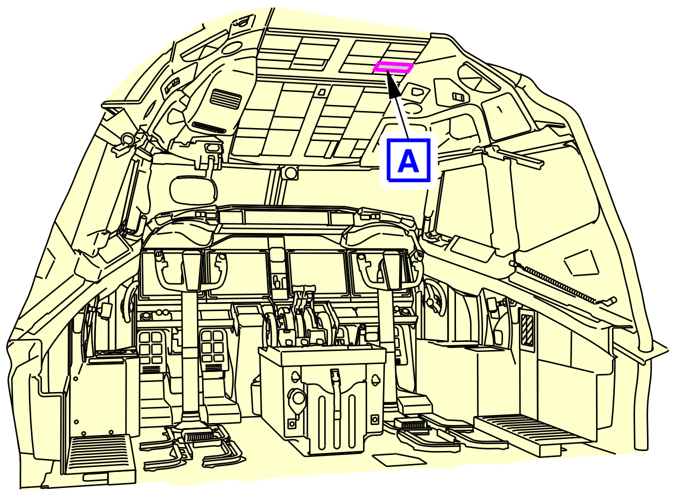
If there are no faults, the control column shaker operates. If there are faults, the control column shaker does not operate.

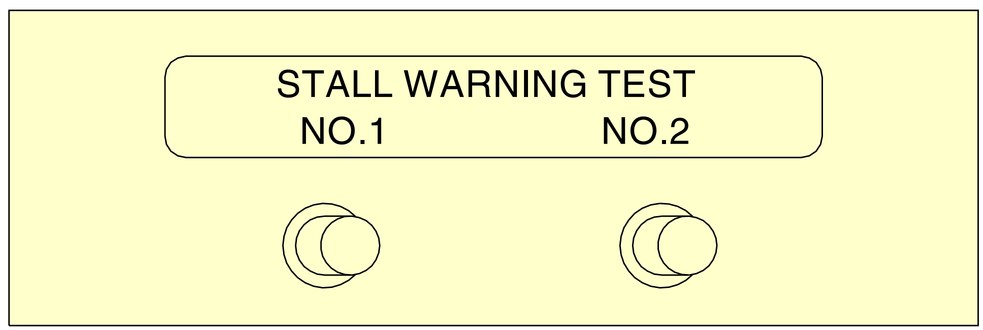
When you push the test switch, the stall warning system does a test of these:

- SWS software
- SWS hardware
- Test switches (electrical short)
- Air data bus valid (ADIRU)
- IR Bus valid (ADIRU)
- DPC data (TAI)
- AOA synchros
- Flap position transmitters
- LE Asymmetry
- LE UCM
- N1 and N2 status
- Program pins.

During the test, the control column shaker operates until you release the test switch, or a maximum of 20 seconds. The 20 second maximum time limit prevents damage to the control column shaker motor. The stall warning test is inhibited when the airplane is in the air.

SWS - STALL WARNING TEST PANEL





STALL WARNING TEST PANEL
A

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SWS - STALL WARNING TEST PANEL

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SWS - ELEVATOR FEEL SHIFT MODULE

Purpose

The elevator feel shift module (EFSM) supplies increased system A pressure to the dual feel actuator to increase control column feel forces during a stall.

Location

The elevator feel shift module is on the left side of the stabilizer compartment aft bulkhead in the 48 section. Open the section 48 access and blow out door to get access.

Physical Description

The elevator feel shift module has these components:

- Housing
- Dual coil solenoid valve
- Pressure reducer
- Pressure operated mode valve
- Relief valve
- Restrictor
- Internal filter.

The dual coil solenoid valve is a line replaceable unit (LRU) and is spring biased to the normal position.

The pressure reducer is a slide and sleeve assembly that is spring biased to the supply pressure position.

The mode valve is a slide assembly that is spring biased to the normal position.

The relief valve slide assembly is spring biased to the closed position. At 1300 psi it starts to open. An internal orifice limits the flow rate to 900 psi or less when the valve is open.

Normal Operation

During normal operation, there is no EFSM hydraulic output pressure to the dual feel actuator. The feel pressure is not changed by the EFSM. The EFSM receives 3000 psi nominal system A pressure. The pressure reducer provides 850 psi to the mode valve. The mode valve remains closed until SMYD 1 or SMYD 2 commands the dual coil solenoid valve to open during a stall.

EFSM Operation

At stall onset, either SMYD sends a signal to energize the dual coil solenoid valve on the EFSM. The EFSM operation occurs when all of these conditions occur:

- Stick shaker is active
- AOA is 8 to 11 degrees more than thermal anti-ice (TAI) biased stick shaker AOA
- EFSM is not inhibited due to low altitude or the airplane is on the ground.

When all of these conditions occur, the SMYDs energize the dual coil solenoid valve. The solenoid valve sends 3000 psi system A pressure to the pressure-operated mode valve.

The mode valve opens and sends pressure between 820 psi to 880 psi from the pressure reducer to the system A side of the dual feel actuator. This increases the control column feel forces up to four times nominal feel. The increased feel force makes sure the pilots cannot easily override automatic stabilizer movement to nose down pitch of the airplane.

Pressure Reducer Failure

If the pressure reducer fails, the relief valve opens at 1300 psi and provides a maximum output of 900 psi to the dual feel actuator. The elevator FEEL DIFF PRESS light comes on after 30 seconds.

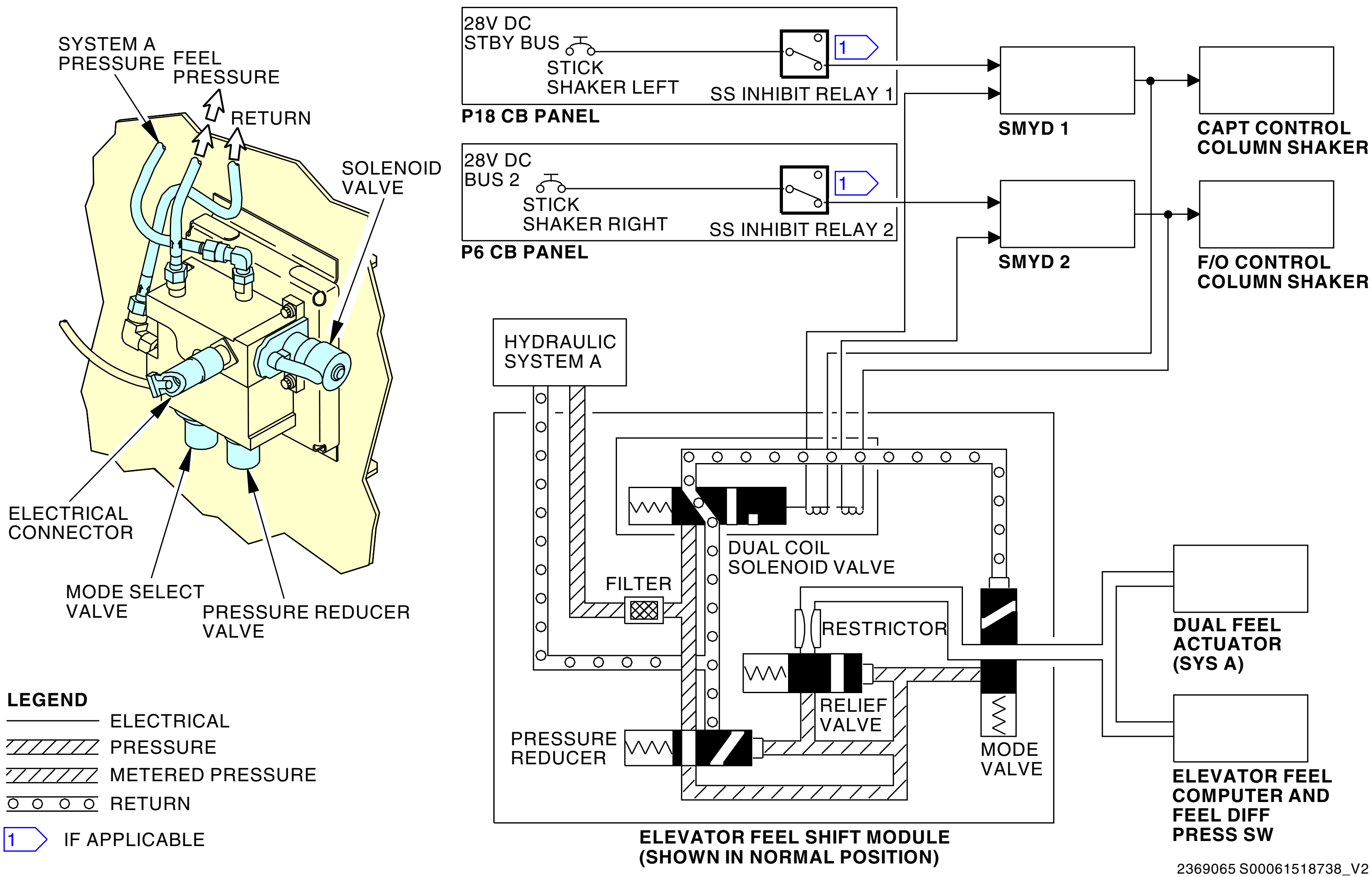
See the elevator and tab control system section for more information about the elevator FEEL DIFF PRESS light. (SECTION 27-31)

SWS - ELEVATOR FEEL SHIFT MODULE

Training Information Point

There is no flight deck annunciation that the EFSM is armed or operating during a stall.

SWS - ELEVATOR FEEL SHIFT MODULE



SWS - ELEVATOR FEEL SHIFT MODULE

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SWS - FUNCTIONAL DESCRIPTION

General

The SMYDs do two calculations for stall warning. These are the normal stall warning and the speed floor stall warning calculations. Either calculation can cause an SMYD to send a stall warning signal to a column shaker.

SMYD 1 controls the captain column shaker and SMYD 2 controls the first officer column shaker.

Stall warning is only available when the airplane is in the air.

Air Mode

During takeoff, the air mode latch is set when these conditions are true:

- AIR/GRD system (1 or 2) in air
- Nose landing gear (NLG) in air.

The latch is also set to the air mode when these conditions are true:

- AIR/GRD system (1 or 2) or NLG in air
- Airspeed more than 110 knots.

The air mode latch is reset when the initial set conditions are removed, the pitch angle is less than 5 degrees, and the airspeed is less than 105 knots.

Normal Stall Warning

Normal stall warning uses this data:

- Angle of attack (AOA)
- TE flap position
- LE flap and slat asymmetry information
- LE uncommanded motion (UCM) information
- Engine thrust settings (N1 and N2)
- Computed airspeed (VCAS)
- Wing and engine thermal anti-ice switch (TAI) status.

A normal stall warning schedule sets the AOA trip point for each TE flap position. The AOA trip point values change from 13.0 to 23.5 degrees depending on flap position. If the AOA is more than the trip point for a TE flap position, the SMYDs send a stall warning signal to the column stick shakers.

The SMYDs use the other data for bias calculations. If a bias is active, the SMYDs send a stall warning signal at a lower AOA. The SMYDs calculate all biases simultaneously and use the highest bias. The SMYDs subtract the highest active bias from the normal trip point schedule to decrease the trip point. These are the biases that the SMYD calculates:

- LE flap and slat asymmetry bias (10.2 - 15.0)
- High thrust bias (0 - 13.6)
- LE UCM bias (2.3 - 6.7)
- TAI bias (0.8 - 5.3).

The leading asymmetry bias is set if one or more LE devices are in a position that disagrees with the TE flaps.

The high thrust bias is enabled if the offside engine N2 is more than 75% and the onside engine N1 is valid. This bias prevents a pitch up stall tendency at low speeds and high thrust.

The high thrust bias does not change with each flap position. It uses a signal for TE flaps less than or equal to 15 and a signal for TE flaps more than 15. The maximum bias for flaps less than or equal to 15 is 6.7 degrees. The maximum bias for flaps more than 15 is 13.6 degrees.

The FSEU sends an uncommanded motion (UCM) signal during lead edge UCM.

The thermal anit-ice (TAI) bias decreases the trip point to account for 3.0 inches of rough ice on the LE devices. The TAI bias is set when either the WING ANTI-ICE or ENG ANTI-ICE switches are in the ON position. If the WING ANTI-ICE switch is moved to the ON position for greater than 5 seconds, a TAI bias latch is set for the remainder of the flight.

SWS - FUNCTIONAL DESCRIPTION

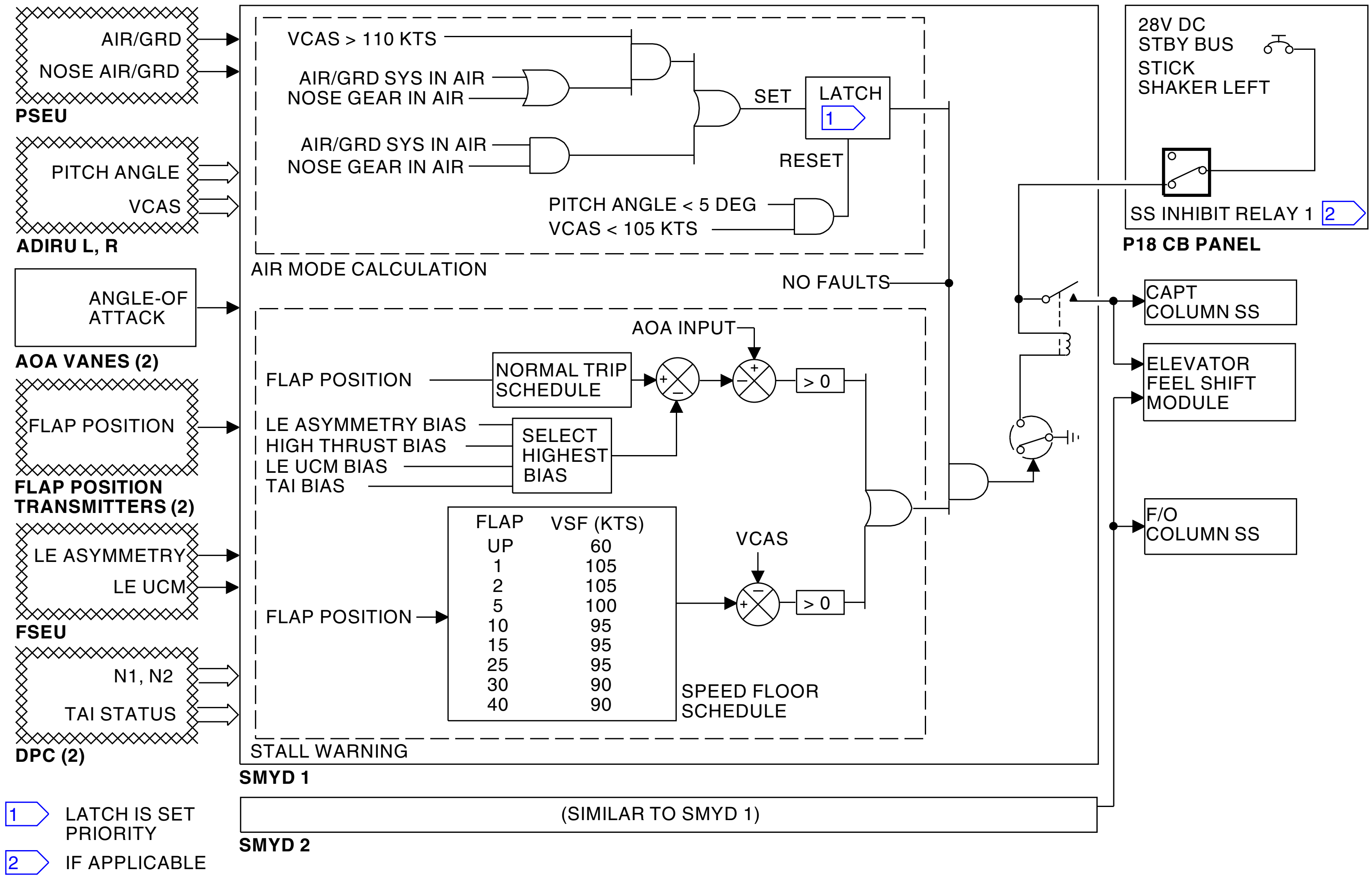
Speed Floor Stall Warning

The speed floor stall warning uses TE flap position data and airspeed data. If the airspeed is too low for a specific TE flap position, the SMYDs send a stall warning signal to the column shakers. AOA is not used for the speed floor stall warning calculation.

EFSM Power Output

The stick shaker 28v dc standby bus power is used for elevator feel shift module operation.

SWS - FUNCTIONAL DESCRIPTION



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SWS - FUNCTIONAL DESCRIPTION

SWS - ELEVATOR FEEL SHIFT - FUNCTIONAL DESCRIPTION

General

The stall warning software in the SMYDs make two calculations for the elevator feel shift module (EFSM) operation.

The first calculation provides 28v dc to operate the stick shakers and provide power to the EFSM.

The second calculation, called the elevator feel shift (EFS) command, provides an electrical ground to operate the EFSM.

The EFSM only operates if the AOA is 8 to 11 degrees above the TAI stick shaker AOA.

Inputs

The proximity switch electronic unit (PSEU) provides air/ground information for the air mode calculation.

The ADIRUs provide pitch angle and VCAS airplane speed.

The angle of attack sensors provide AOA input.

The flap position transmitters provide flap position for the Delta AOA calculation.

The mode control panel (MCP) is used for autopilot engage status.

The display processing computer (DPCs) are used to provide radio altimeter RA and thermal anti-ice status.

EFS Set and Arm

The air mode calculation is the same as the stall warning air mode calculation.

After takeoff, the EFS latch is set when the airplane is in the air and the radio altitude is more than 100 feet.

The EFS latch is also set when the airplane is in the air and the pitch attitude is more than 5 degrees.

The EFS is armed when the EFS latch is set and the autopilot is not engaged.

EFS Inhibit

The elevator feel shift is inhibited when the airplane is not in the air or when these conditions are true:

- Radio altitude is less than 100 feet
- EFS is not active.

If the EFS command is active as the airplane descends through 100 feet, the EFS stays armed until the EFS command goes away.

EFS Enabled

EFS is enabled when EFS is armed and there are none of the faults:

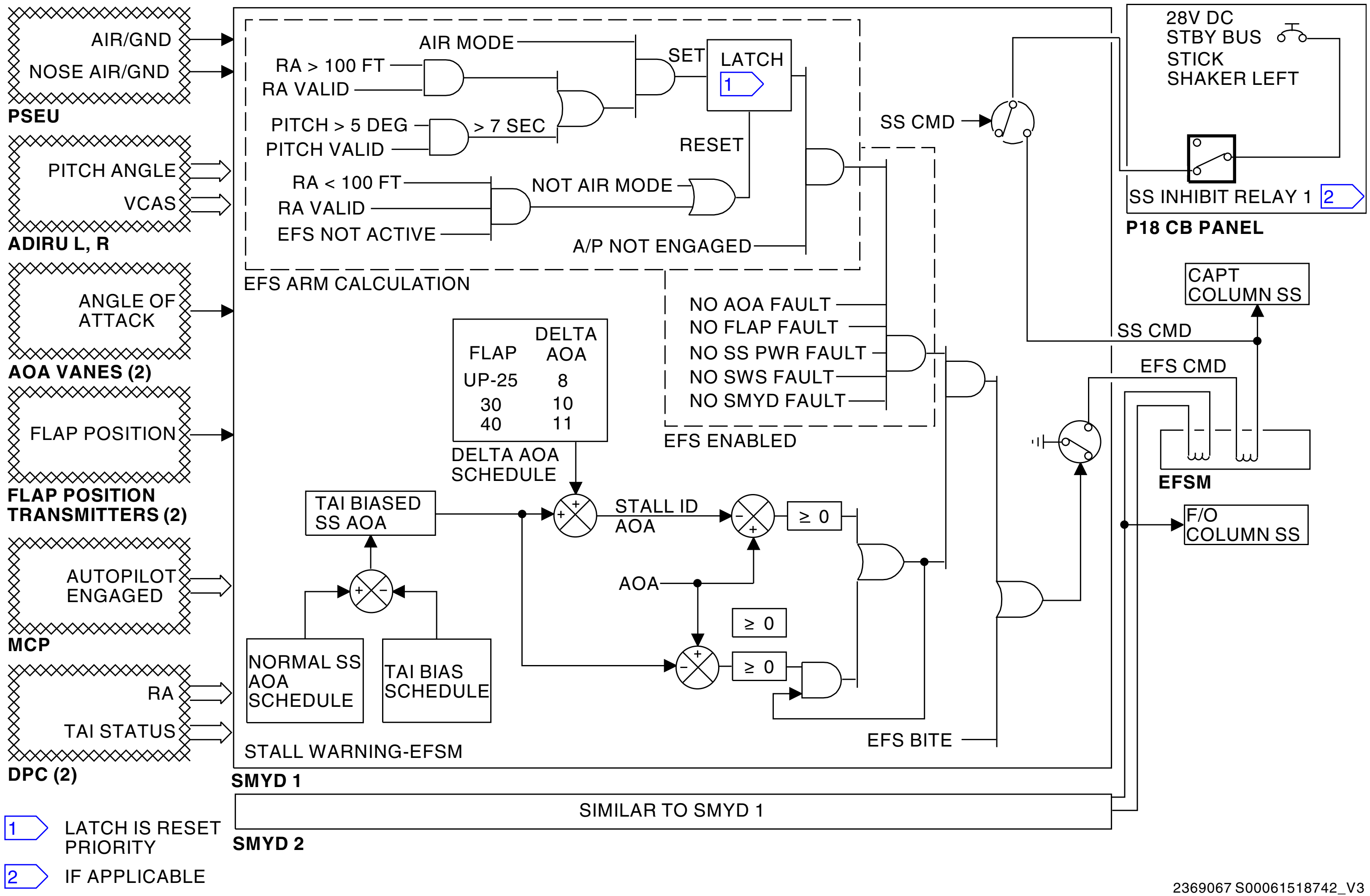
- AOA fault
- TE flap fault
- Stick shaker power fault
- Stall warning software fault
- SMYD hardware fault.

EFS Command

The SMYDs make a calculation called stall ID AOA. The flap position is used to determine the delta AOA value. The delta AOA is added to the TAI biased stick shaker AOA for the stall ID AOA calculation. This stall ID AOA value is compared to the airplane AOA. If the airplane AOA is more than or equal to the stall ID AOA, a EFS command operates the EFSM.

The EFS command stays as the AOA decreases until the stick shaker command is removed or the AOA is less than the TAI biased stick shaker AOA.

SWS - ELEVATOR FEEL SHIFT - FUNCTIONAL DESCRIPTION



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SWS - ELEVATOR FEEL SHIFT - FUNCTIONAL DESCRIPTION

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HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - INTRODUCTION

Purpose

The horizontal stabilizer controls the pitch trim of the airplane about the lateral axis.

Location

The horizontal stabilizer is on the aft section of the fuselage.

Trim Control

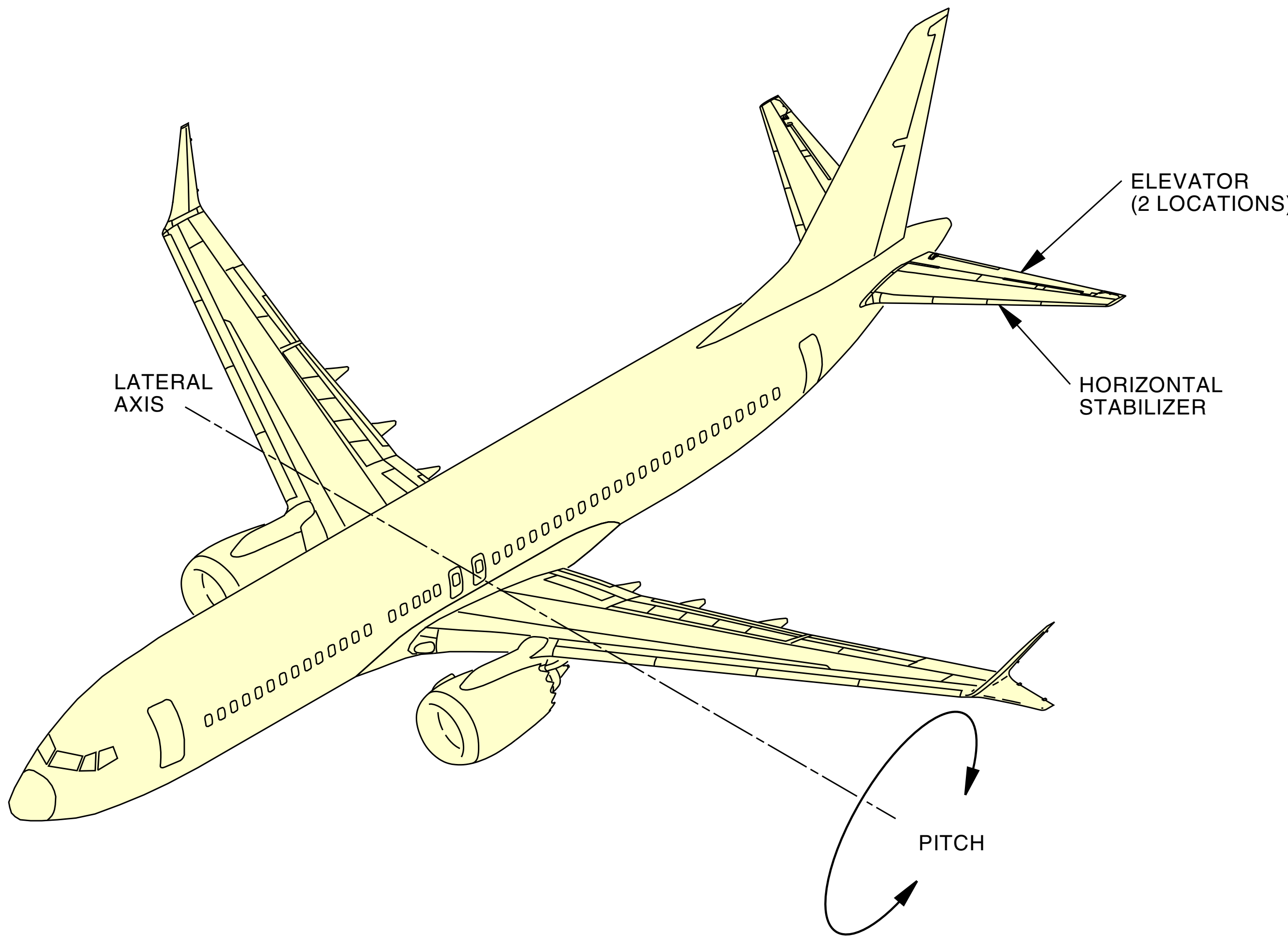
The pilots manually control the position of the horizontal stabilizer with the stabilizer trim switches. Also, the pilots can use the stabilizer trim wheels on each side of the control stand.

When the autopilot engages, it controls the position of the horizontal stabilizer. During autopilot or main electric operation, the actuator backdrives the stabilizer trim wheels.

Abbreviations and Acronyms

- apl - airplane
- actr - actuator
- A/P - autopilot
- A/S - airspeed
- C/W - control wheel
- cntl - control
- DFCS - digital flight control system
- FCC - flight control computer
- FDAU - flight data acquisition unit
- gnd - ground
- LE - leading edge
- MLG - main landing gear
- NLG - nose landing gear
- PCU - power control unit
- S/B - speedbrake
- sec - section
- SOV - shutoff valve
- sw - switch
- stab - stabilizer
- TE - trailing edge
- vlv - valve
- xfer - transfer

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - INTRODUCTION



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HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - INTRODUCTION

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

General

The pilots control the horizontal stabilizer manually by the stabilizer trim wheels or electrically by the stabilizer trim switches. The autopilot controls the stabilizer automatically through the Digital Flight Control System (DFCS).

Manual Operation - Stabilizer Trim Wheels

The pilots use the stabilizer trim wheels on the control stand to manually move the forward and aft cable drums. The aft cable drum moves the gearbox and jackscrew. When the jackscrew moves, the horizontal stabilizer moves. The stabilizer also gives a mechanical input to the elevator, through the neutral shift rods. Movement of the manual trim wheels also moves the stabilizer indicator pointer.

Electric Operation - Stabilizer Trim Switches

The pilots operate two stabilizer trim switches for main electric trim control. The switches are on the outboard side of each control wheel. The switches control electric input to the stabilizer trim actuator and send signals to the Flight Data Acquisition Unit (FDAU). When the trim actuator operates, it moves the stabilizer gearbox. When the stabilizer gearbox moves, it moves the stabilizer jackscrew which moves the horizontal stabilizer. The gearbox also back drives the stabilizer aft and forward cable drums. Movement of the forward cable drum moves the manual trim wheels and stabilizer indicator pointer. Limit switches control the main electric and autopilot movement of the stabilizer.

See the digital flight recorder system section for more information about the stabilizer position sensor A and the FDAU (SECTION 31-31).

Autopilot Operation

The DFCS gives electric input to the stabilizer trim actuator. During autopilot operation, the stabilizer trim actuator operates at different speeds than during manual electric operation. Stabilizer position sensors A and B send signals to the Flight Control Computer (FCC) in the DFCS. Stabilizer position sensor A sends stabilizer position to FCC A and the FDAU. Stabilizer position sensor B sends stabilizer position to FCC B.

See the digital flight control system section for more information on the stabilizer autopilot operation, the FCCs, and the stabilizer position sensors A and B (SECTION 22-11).

Column Cutout Switches

The column cutout switches stop the stabilizer trim actuator when the pilot moves the control column in a direction opposite to the trim direction.

Stabilizer Trim Override Switch

The pilots use the stabilizer trim override switch on the aisle stand to bypass the column cutout switches if one or both fail.

Stabilizer Trim Cutout Switches

The pilots use the stabilizer trim cutout switches on the control stand to stop the PRI and B/U runaway trim inputs to the stabilizer trim actuator.

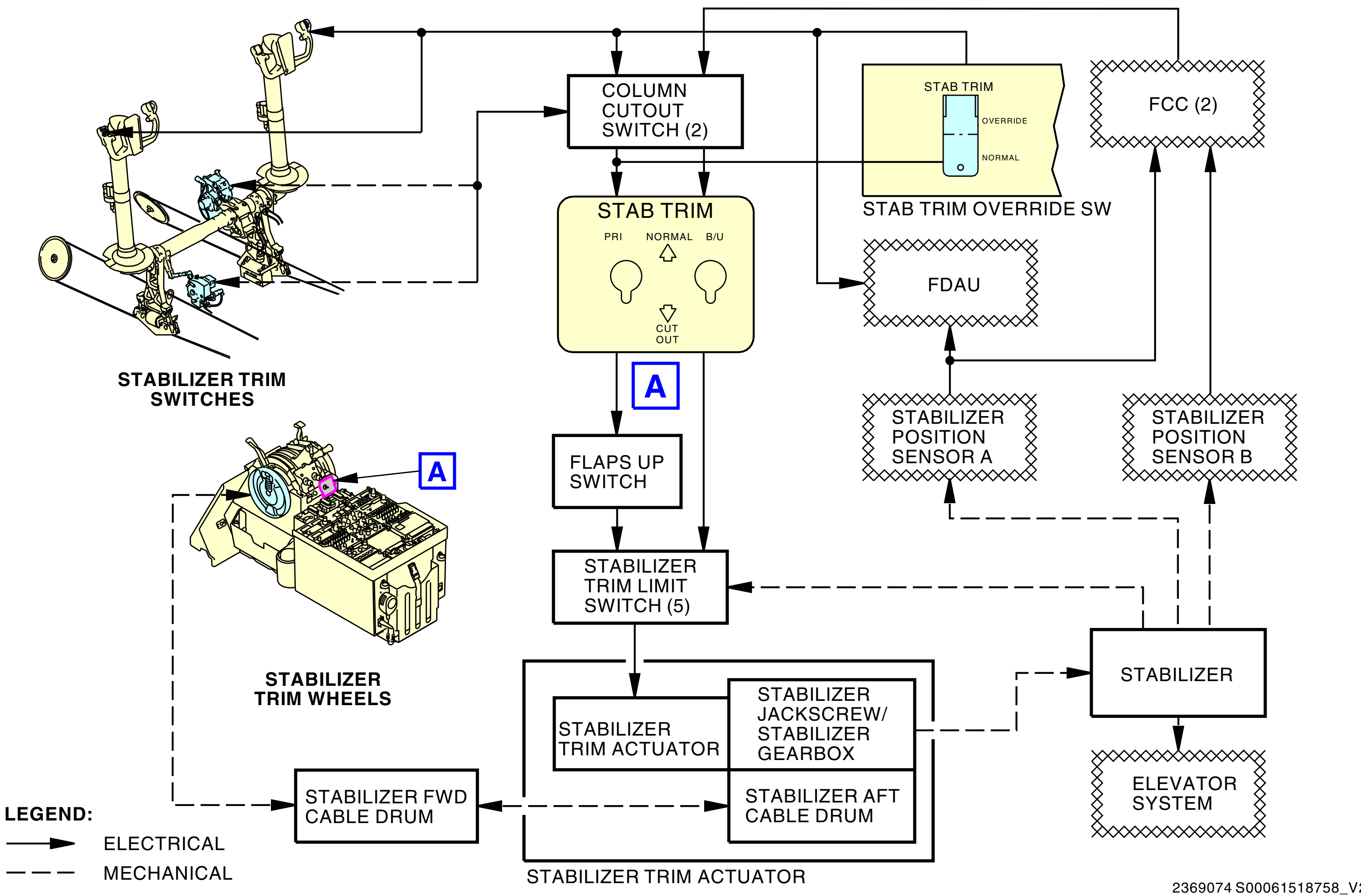
Flaps Up Switch

The flaps up switch controls the main electric operation speed of the stabilizer trim actuator. The autopilot electric control of the stabilizer trim actuator does not go through the flaps up switch.

Stabilizer Trim Limit Switches

The stabilizer trim limit switches limit the range of stabilizer motion.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 1

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

General

These are the components of the horizontal stabilizer trim control system:

- Stabilizer trim control switches (4)
- Stabilizer trim wheels (2)
- Stabilizer column cutout switches (2)
- Stabilizer forward cable drum
- Stabilizer trim control cables
- Stabilizer aft cable drum
- Stabilizer gearbox, jackscrew, and electric trim actuator
- Stabilizer
- Stabilizer trim limit switches (5)
- Stabilizer trim override switch.

Stabilizer Trim Control Switches

The pilots operate the stabilizer trim control switches for main electric pitch trim control. This gives electric input to the stabilizer trim actuator.

Stabilizer Trim Wheels

The pilots use the stabilizer trim wheels for manual pitch trim control. The stabilizer trim wheels move a chain that drives the forward cable drum.

Stabilizer Trim Cutout Switches

Pilots use the main electric or autopilot stabilizer trim cutout switches to stop the stabilizer trim actuator if there is an uncommanded motion or runaway of the trim actuator.

Stabilizer Column Cutout Switches

During electric trim operation, if the pilot gives an opposite direction to elevator control input, the column switching modules make the stabilizer electric trim stop. If either of the column cutout switches fail, the stabilizer trim override switch allows operation of the stabilizer trim control switches.

Stabilizer Forward Control Cable Drum

The forward cable drum moves the cables connected to the aft cable drum.

Stabilizer Trim Control Cables

The stabilizer trim control cables connect the forward control cable drum and aft cable drum together. Input from the electric trim operation moves the aft cable drum, which backdrives the forward control cable drum through the trim control cables. Manual input from the stabilizer trim wheels, moves the aft cable drum through the forward control cable drum and trim control cables.

Stabilizer Aft Cable Drum

The aft cable drum input moves the gearbox, jackscrew, stabilizer and forward control cable drum.

Stabilizer Gearbox, Jackscrew, and Electric Trim Actuator

Input from the stabilizer trim switches control the stabilizer trim actuator. The trim actuator input moves the stabilizer gearbox and stabilizer jackscrew. When the jackscrew turns, the leading edge of the stabilizer moves. The gearbox also backdrives the aft cable drum.

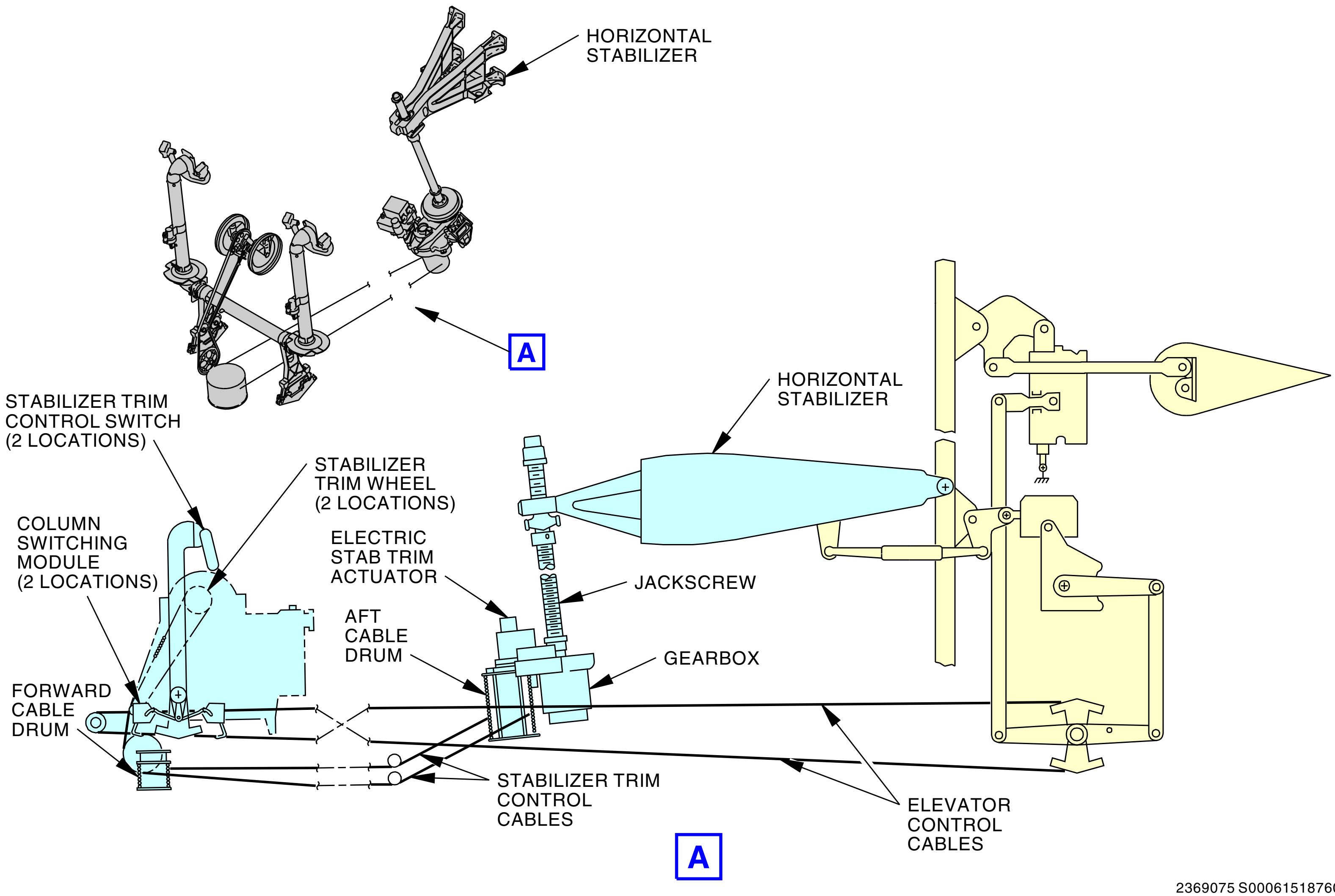
Stabilizer

The stabilizer consists of a left, right, and center section. It pivots at a hinge point located at the aft end of the center section. A ball nut is attached to the front spar fitting that connects to the jackscrew. The stabilizer moves to a maximum of 3.85 trim units (leading edge up/airplane nose down) and 14.0 trim units (leading edge down/airplane nose up).

Stabilizer Trim Limit Switches (5)

Cam operated trim limit switches control the stabilizer trim range. When the stabilizer moves, a cam operates five limit switches.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - GENERAL DESCRIPTION 2

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - COMPONENT LOCATION

General

The horizontal stabilizer trim control system components are in the flight compartment and in the tail:

Flight Deck Components

These are the flight compartment components:

- Stabilizer trim control switches on the control wheel (2)
- Stabilizer trim wheels on the control stand (2)
- Stabilizer trim cutout switches on the control stand (2)
- Stabilizer trim override switch on control stand
- Stabilizer trim indicators (2).

Forward Equipment Compartment Components

These are the forward equipment compartment components:

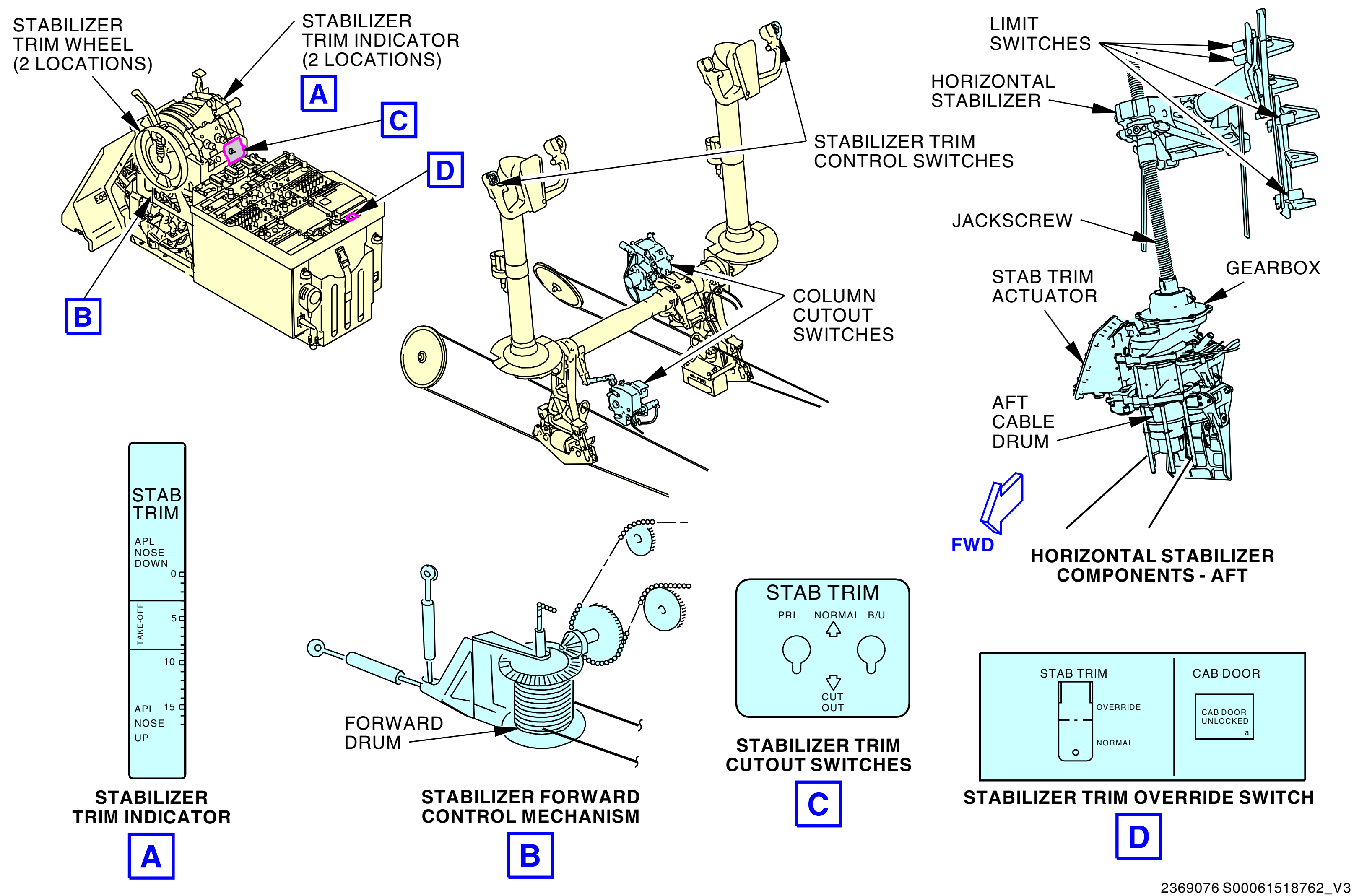
- Column cutout switch (2)
- Stabilizer forward control mechanism.

Tail Components

These are the horizontal stabilizer trim control system components in the tail area:

- Stabilizer trim actuator
- Aft cable drum
- Jackscrew
- Stabilizer ball nut and jackscrew gearbox
- Stabilizer trim limit switches
- Horizontal stabilizer.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - COMPONENT LOCATION



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - COMPONENT LOCATION

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - FORWARD CONTROL MECHANISM

Purpose

The pilot uses the stabilizer forward control mechanism for manual input.

Location

The forward control mechanism is in the flight deck and the forward equipment compartment.

Physical Description

The forward control mechanism has these components:

- Stabilizer trim wheels on control stand (2)
- Sprocket
- Chain assembly
- Forward cable drum.

The trim wheels and the sprocket are splined to a control wheel shaft.

Functional Description

When the pilot turns the trim wheels, this moves the sprocket and chain and drives the forward cable drum. This moves the cables that go to the aft cable drum. The aft cable drum moves and drives the gearbox and jackscrew and the stabilizer.

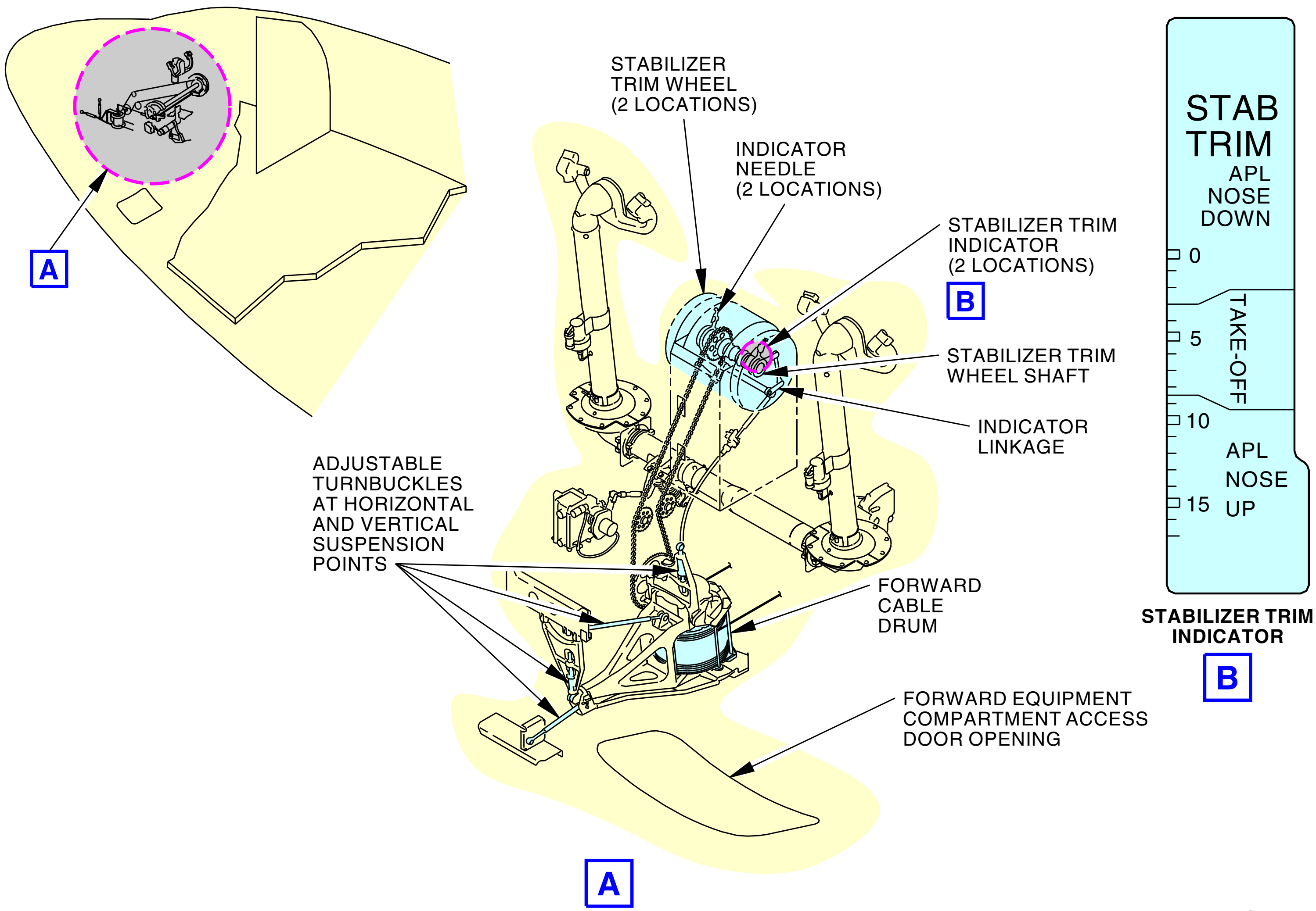
Indication

When the forward control mechanism moves, it drives a jackshaft through a flexible cable which transmits motion to a linkage that positions the indicator needle.

Training Information Point

The forward cable drum is on a housing attached to structure by two horizontal and two vertical suspension points. Use the adjustable turnbuckles at these points to align the forward mechanism and adjust the tension in the chain and cable.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - FORWARD CONTROL MECHANISM



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HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - FORWARD CONTROL MECHANISM

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - CUTOUT SWITCHES

Purpose

The stabilizer trim cutout and column cutout switches disable stabilizer electric trim. The stabilizer trim override switch lets you bypass the column cutout switches.

Location

The stabilizer trim cutout switches are on the control stand. The column cutout switches are in the forward equipment compartment. The stabilizer trim override switch is on the aisle stand.

Stabilizer Trim Cutout Switches

The pilot uses the stabilizer trim cutout switches to stop a runaway electric trim condition.

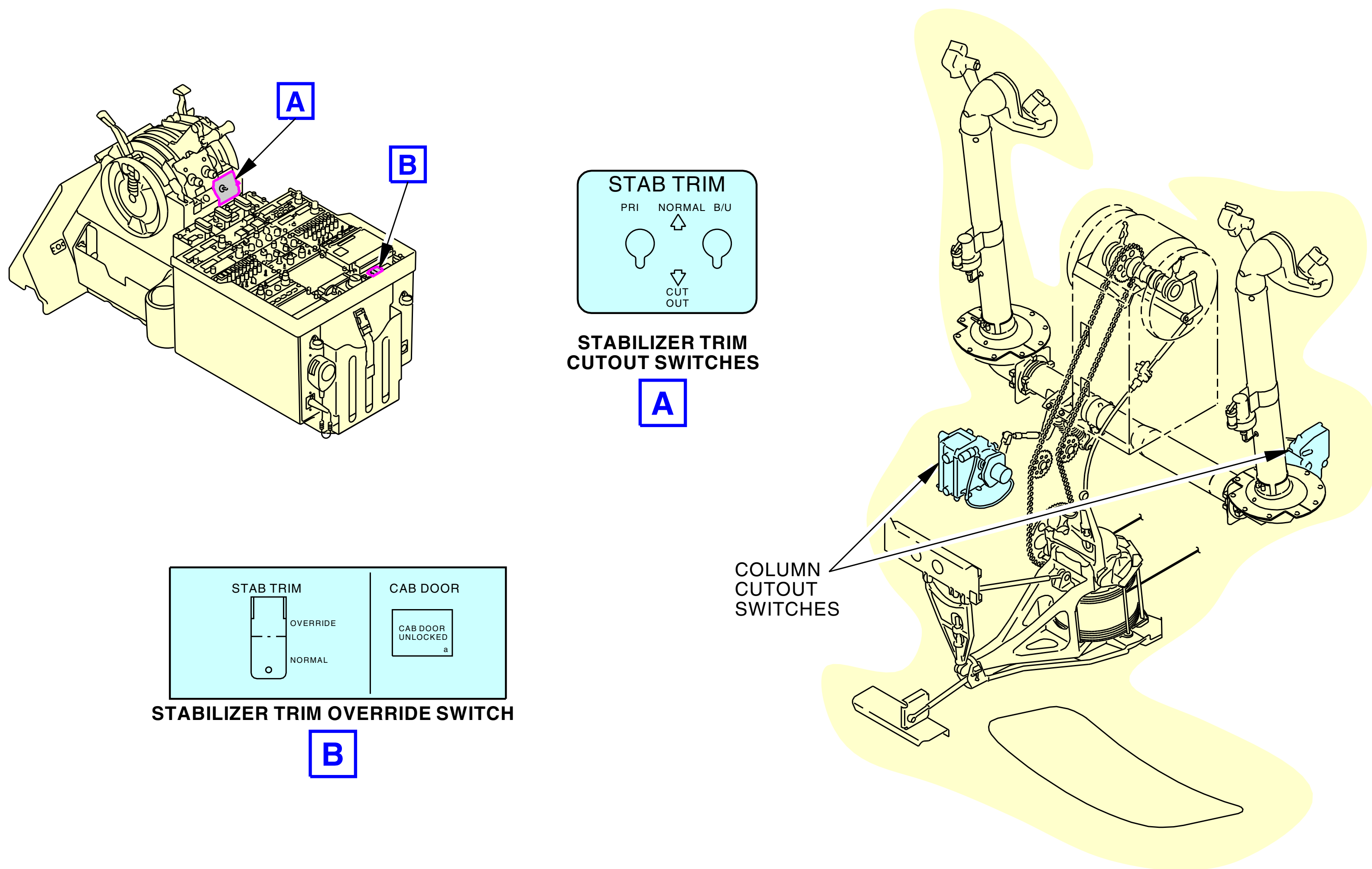
Column Cutout Switches

The column cutout switches contain a set of cam-operated switches. The cutout switches also contain two relays. When the control column moves in the opposite direction from the stabilizer trim direction, electric trim stops.

Stabilizer Trim Override Switch

The stabilizer trim override switch bypasses the column cutout switches. The pilot uses this switch to operate the electric trim if both column cutout switches fail.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - CUTOUT SWITCHES



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HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - CUTOUT SWITCHES

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - AFT COMPONENTS

Purpose

The horizontal stabilizer trim control system components in the aft section of the airplane move the leading edge of the stabilizer

Location

The horizontal stabilizer components are in section 48, aft of the rear pressure bulkhead.

Physical Description

The horizontal stabilizer components are:

- Aft cable drum
- Gimbal (2)
- Stabilizer trim actuator
- Ball nut
- Jackscrew
- Safety rod.

The gearbox connects to the bulkhead in the fuselage by the lower gimbal. The upper gimbal connects the ball nut to the stabilizer front spar fitting.

The stabilizer trim actuator is a multi-speed DC motor. It receives commands from the stab trim control switch or the autopilot.

Functional Description - Input

The pilot or autopilot controls the stabilizer trim actuator. The pilot also controls the aft cable drum position with the stabilizer trim wheels. This is the priority for control of the stabilizer:

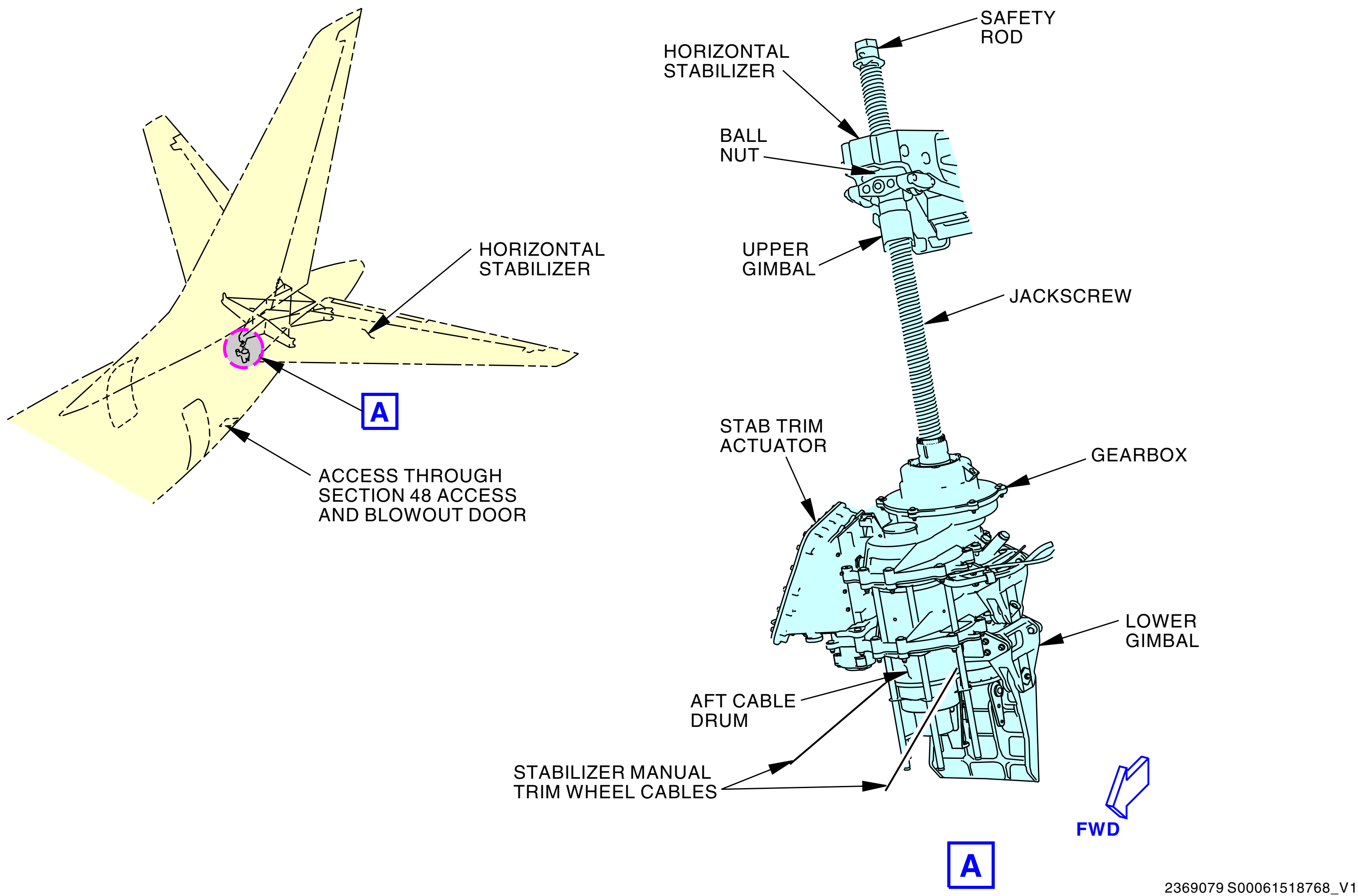
- Manual
- Electric
- Autopilot.

The jackscrew gearbox receives inputs from the stabilizer manual trim wheel cables and the stabilizer trim actuator. The stabilizer manual trim wheel cables turn the aft cable drum. The aft cable drum or the stabilizer trim actuator turns gears in the gearbox to turn the jackscrew. When the jackscrew turns, the leading edge of the stabilizer moves. The gimbals permit fore and aft motion of the jackscrew as the stabilizer moves.

Functional Description - Brakes

The gearbox has two internal brakes and a mechanical clutch. Both of the brakes are ratchet type brakes. The clutch lets the stabilizer manual trim wheel input override the stabilizer trim actuator input.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - AFT COMPONENTS



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - AFT COMPONENTS

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER TRIM LIMIT SWITCHES

Purpose

The stabilizer trim limit switches limit the range of horizontal stabilizer motion. There are different limits for manual, autopilot, and for flaps up and flaps down. The takeoff warning switches tell the pilot of incorrect stabilizer position at takeoff.

Location

The stabilizer trim limit switches are on the left side of the horizontal stabilizer jackscrew attach fitting.

Physical Description

The seven stabilizer trim limit switches mount on vertical brackets attached to structure. They are cam operated microswitches. The cam mounts to a support tube which connects to the stabilizer center section jackscrew attach fitting.

There are three limit switches (S144, S145, and S844) and four stabilizer takeoff warning switches (S132, S1184, S546 and S1183) on the brackets along the stabilizer jackscrew.

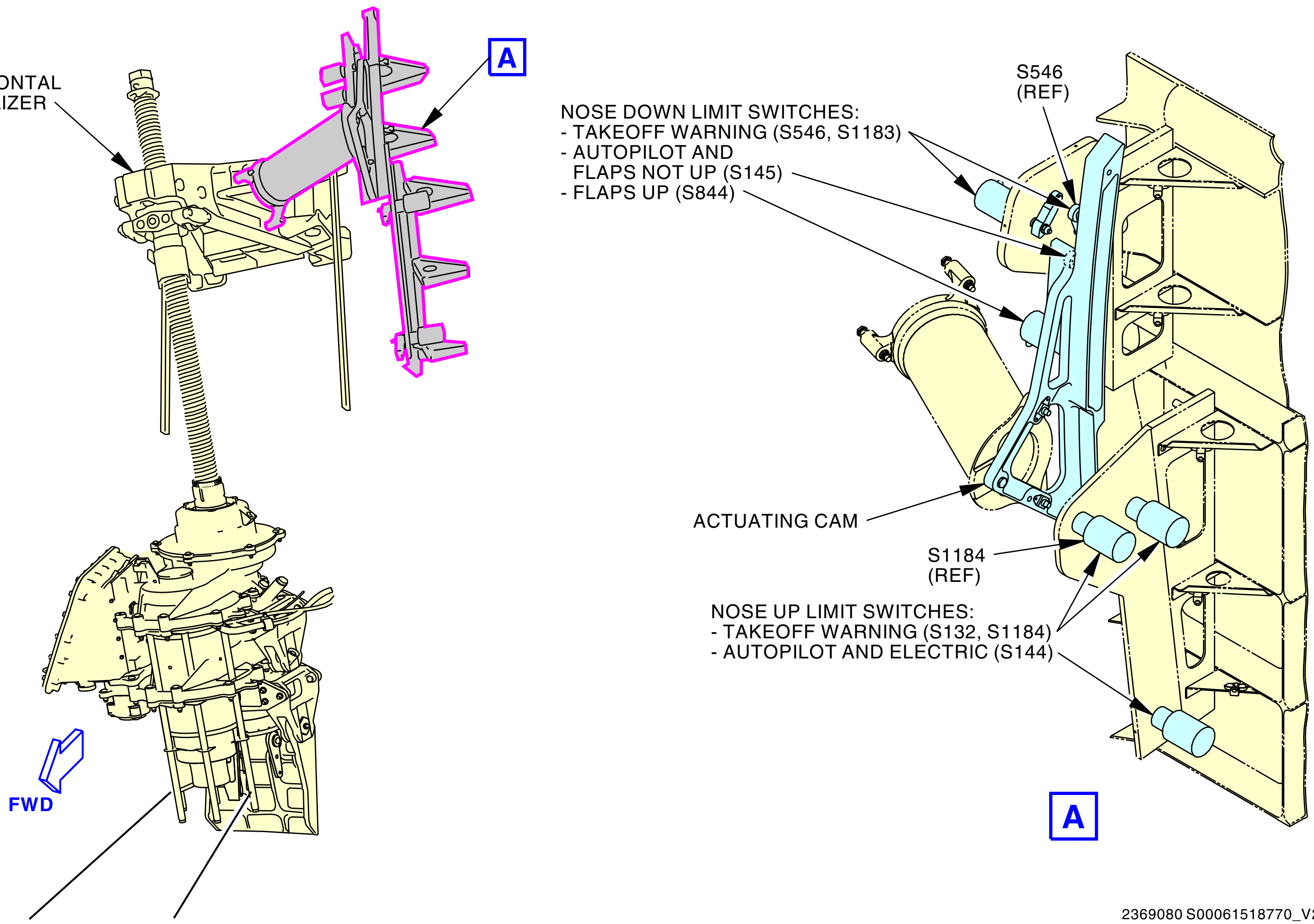
Functional Description

The cam moves with the horizontal stabilizer and operates the seven switches. The switches have these functions:

- S145 - Nose down autopilot and flaps not up electric limit switch, operates at –0.45 units when the “B” dimension is set to 45.48 ±0.05 in. (115.52 ±0.13 cm)
- S546 - Nose down takeoff warning switch, operates at 2.75 units when the “B” dimension is set to 40.95 ±0.03 in. (104.01 ±0.08 cm)
- S1183 - Nose down takeoff warning switch, operates at 2.75 units when the “B” dimension is set to 40.95 ±0.03 in. (104.01 ±0.08 cm)
- S844 - Nose down flaps up electric limit switch, operates at 3.85 units when the “B” dimension is set to 39.39 ±0.05 in. (100.05 ±0.13 cm)
- S132 - Nose up takeoff warning switch, operates at 8.75 units when “B” dimension is set to 32.38 ±0.03 in. (82.25 ±0.08 cm)
- S1184 - Nose up takeoff warning switch, operates at 8.75 units when “B” dimension is set to 32.38 ±0.03 in. (82.25 ±0.08 cm)
- S144 - Nose up autopilot limit switch, operates at 14.00 units when the “B” dimension is set to 24.80 ±0.05 in. (62.99 ±0.13 cm).

NOTE: The stabilizer trim limit switches are adjustable.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER TRIM LIMIT SWITCHES



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER TRIM LIMIT SWITCHES

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HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - ELECTRIC TRIM - FUNCTIONAL DESCRIPTION

General

The stabilizer trim motor gets 115v ac, three-phase, 400 Hz. Power comes from transfer bus 2. The stabilizer trim motor has an internal ac to dc converter that changes input power to the 270v dc necessary for the brushless dc motor. Control power is 28v dc from bus 2.

Normal Sequence

When the primary and backup cutout switches are in the NORMAL positions, control power goes through them to these:

- Captain stabilizer trim switch
- First officer stabilizer trim switch
- R1192 main trim flaps relay
- R64 stabilizer trim control relay.

R64 energizes and sends power to the electric stabilizer trim motor (STM).

When the pilots move the switches on one or the other control wheel in the NOSE UP position, power goes to the:

- Stabilizer trim override switch
- Captain column cutout switch module
- F/O column cutout switch module
- R1193 main trim arm relay.

R1193 energizes and these occur:

- A main electric trim interlock signal goes to the Flight Control Computer (FCC)
- Power signal goes to the main trim enable speed and direction function in the STM
- Power signal goes through the S144 stabilizer nose up limit switch to the main trim function in the STM.

When the pilots move the switches on one or the other control wheel in the NOSE DN position, power goes to the:

- Stabilizer trim override switch
- Captain column cutout switch module
- F/O column cutout switch module
- R1193 main trim arm relay.

R1193 energizes and these occur:

- A main electric trim interlock signal goes to the FCC
- Power signal goes to the main trim enable speed and direction function in the STM
- Power signal goes through the R1192 main trim flaps relay. The signal then goes through the S844 stabilizer electric actuator limit switch to the main trim function in the STM.

The range of stabilizer trim has a limit in the two directions by the stabilizer trim limit switches.

Trim Speed Change

R1192 controls the nose down rate of trim. When the flaps are down, the FCCs energize R1192 and these occur:

- A flaps not up signal goes to the main trim function in the STM
- A signal also goes to the speed change relay in the STM.

When the flaps are up, low speed trim is set. Low speed trim moves the stabilizer at 0.2 units per second. When the flaps are not up, high speed trim is set. High speed trim moves the stabilizer at 0.4 units per second.

During autopilot operation the stabilizer trim speed changes. When the flaps are up, the low speed trim is 0.09 units per second. When the flaps are not up, the high speed trim is 0.27 units per second.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - ELECTRIC TRIM - FUNCTIONAL DESCRIPTION

Trim Authority

Main Electric	737-7	737-8	737-9	737–10
Flaps Retracted	4.25 - 14.0 units	3.85 - 14.0 units	3.75 - 14.0 units	4.00 - 14.0 units
Flaps Extended	-0.45 - 14.0 units	-0.45 - 14.0 units	-0.45 - 14.0 units	-0.45 - 14.0 units
Autopilot Trim	-0.45 - 14.0 units	-0.45 - 14.0 units	-0.45 - 14.0 units	-0.45 - 14.0 units
Manual Trim (Stabilizer Trim Wheels)	-0.70 - 16.4 units	-0.70 - 16.4 units	-0.70 - 16.4 units	-0.70 - 16.4 units

Stabilizer Trim Cut Out Switch

If there is a stabilizer runaway condition, the pilots move the STAB TRIM PRI (primary) switch to the CUT OUT position. This removes power to the STAB TRIM B/U (backup) switch and these:

- Captain and F/O stabilizer trim switches
- R64 (de-energizes)
- R1192 contact
- Signals to the FCCs.

Column Cutout Switches and Column Input

The column cutout switches are in the column cutout switch module. There are two modules, captain and F/O. When the pilot moves the elevator column out of the neutral range, the column cutout switches open for trim in a direction opposite to the column movement. One other set of switches let the actuator operate the stabilizer in the same direction as the column movement.

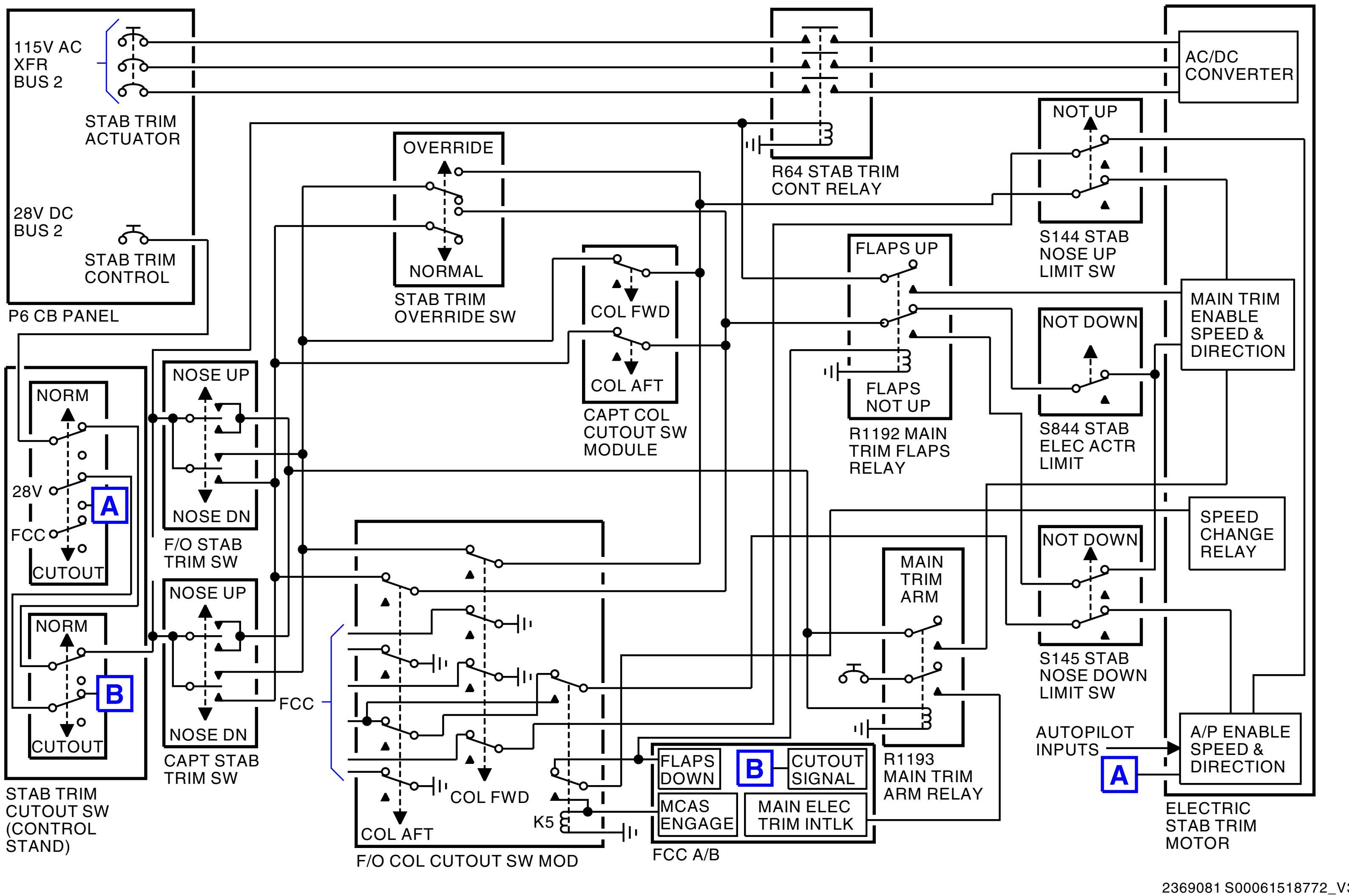
The pilot uses the STAB TRIM override switch to do a bypass of the column cutout switches if the two switches have internal failures.

Maneuvering Characteristic Augmentation System

The maneuvering characteristic augmentation system (MCAS) allows the stabilizer to move in the nose down direction when approaching high angles of attack at high speeds. This requires the stabilizer to move in the opposite direction in which the pilot is pulling the column for nose up pitch. The MCAS only operates at extreme high speed pitch up conditions that are outside the normal operating envelope.

Only the F/Os column cutout switch module is affected because it is the only module that interfaces with the FCCs.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - ELECTRIC TRIM - FUNCTIONAL DESCRIPTION



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - ELECTRIC TRIM - FUNCTIONAL DESCRIPTION

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER

Purpose

The horizontal stabilizer supplies long-term pitch control of the airplane.

Location

The horizontal stabilizer is at the aft section of the fuselage.

Physical Description

The horizontal stabilizer assembly consists of a left and right section attached to a center section.

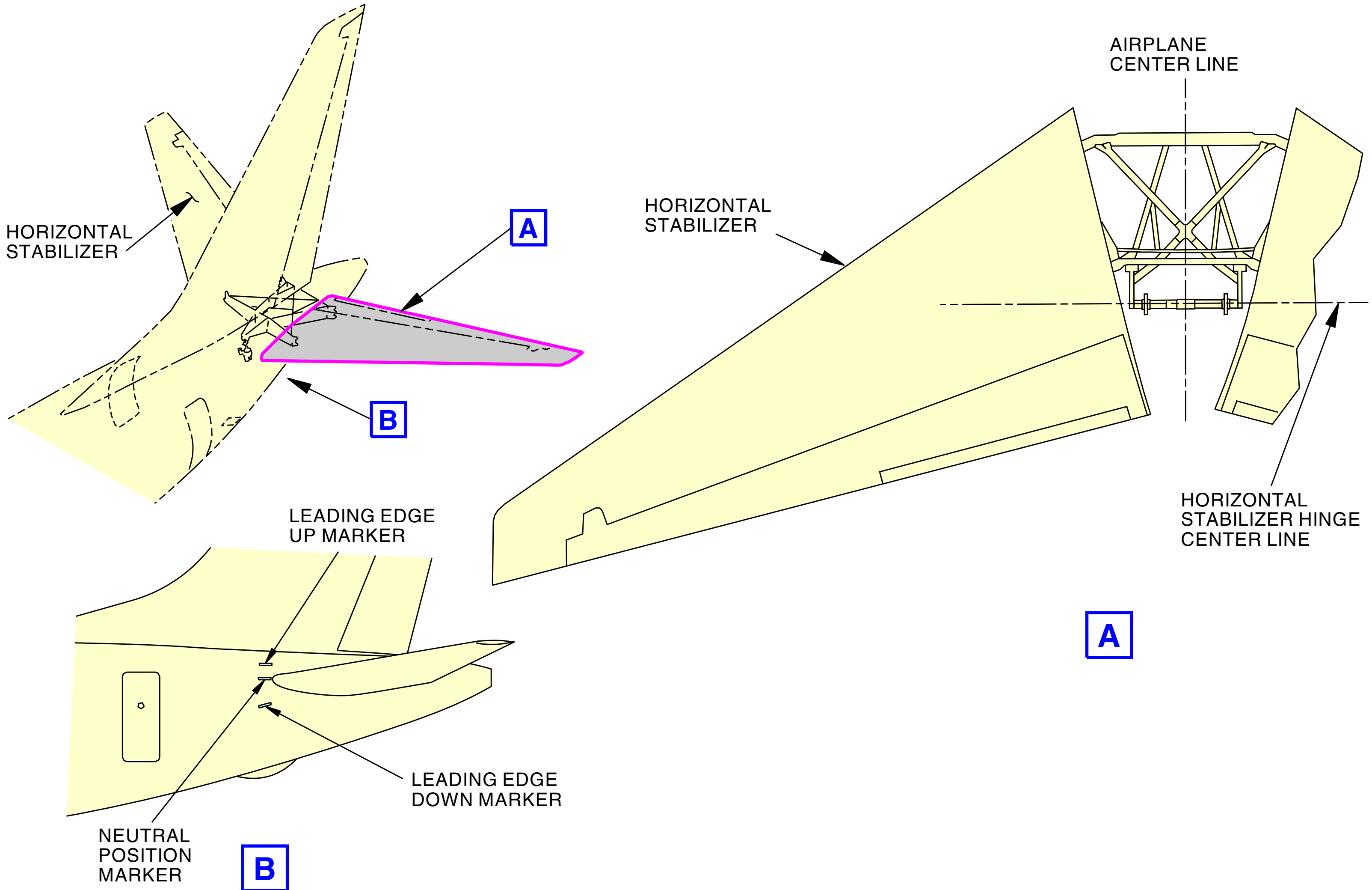
Functional Description

The horizontal stabilizer moves a total of 17.1 degrees in these directions:

- 4.2 degrees stabilizer leading edge up (airplane nose down trim)
- 12.9 degrees stabilizer leading edge down (airplane nose up trim).

NOTE: The maximum leading edge up and leading edge down positions are measured from the stabilizer neutral position (0.0 degrees or 4 units of trim). Markers on the fuselage show the maximum leading edge up, leading edge down, and the neutral positions.

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - STABILIZER

Manual Operation - Stabilizer Trim Switches

The pilots operate the stabilizer trim control switches for main electric pitch trim control. The switches are on the outboard side of each control wheel. This gives electric input to the stabilizer trim actuator. The motor operates and drives the gearbox and stabilizer jackscrew. The stabilizer pivots at each rear spar. A ball nut attached to the front spar moves the stabilizer to a maximum of:

- 3.85 trim units (leading edge up/airplane nose down) and 14.0 trim units (leading edge down/airplane nose up).

During electric trim operation, if the pilot gives an opposite direction elevator control input, the column switching modules make the stabilizer electric trim stop.

Manual Operation - Stabilizer Trim Wheels

The pilots use the stabilizer trim wheels for manual pitch trim control. The wheels are on each side of the control stand. Operation of the stabilizer trim wheels moves a chain that drives the forward cable drum. The forward cable drum moves the cables connected to the aft cable drum. When the aft cable drum moves, it drives the gearbox, jackscrew, and stabilizer.

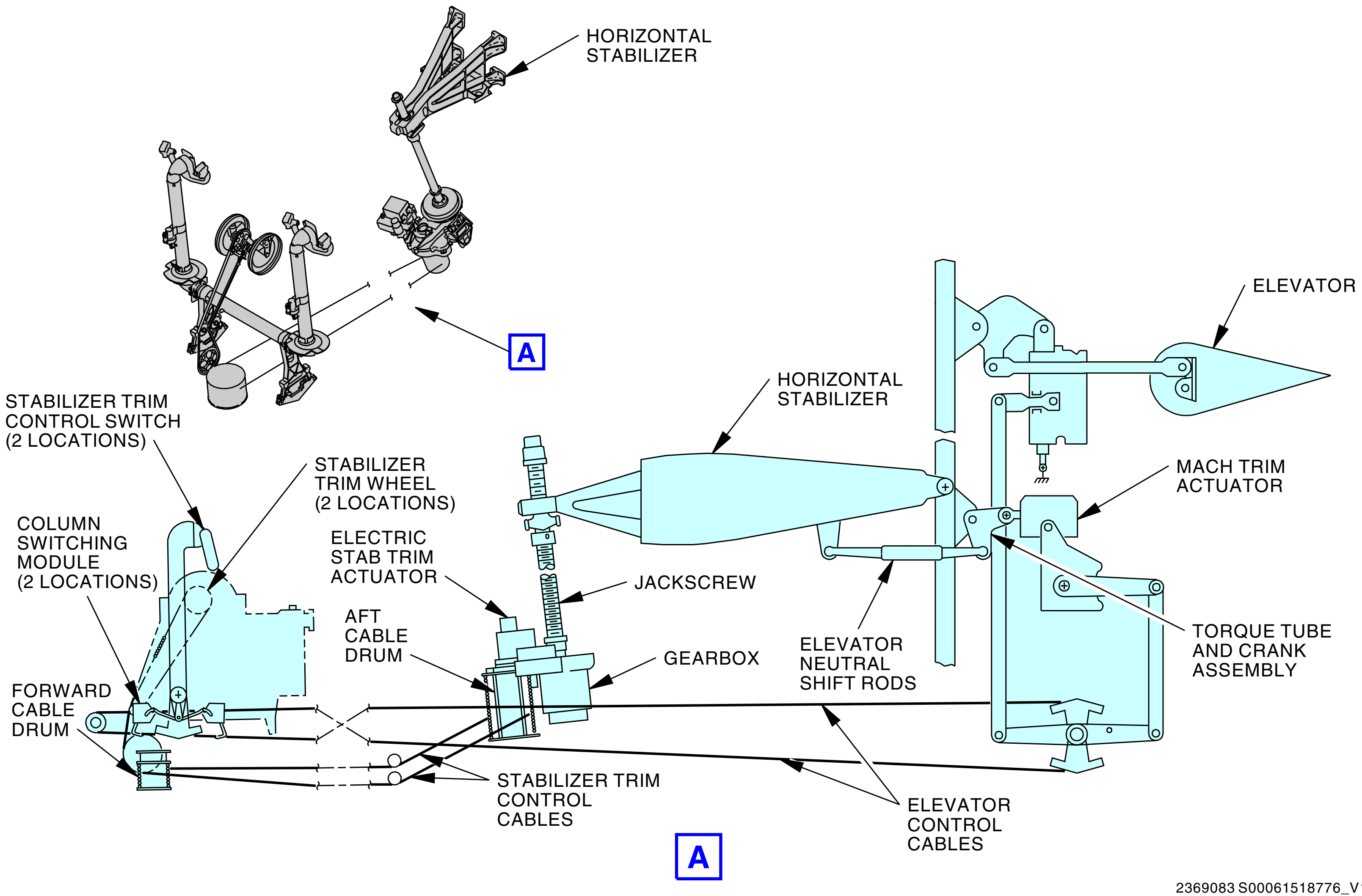
Elevator Neutral Shift Input

The elevator neutral shift rods are pogo type control rods with a spring inside. When the stabilizer moves, it moves the two elevator neutral shift rods. The neutral shift rods move a torque tube and crank assembly which moves the mach trim actuator. When the mach trim actuator moves because of the neutral shift rod input, it acts as a link and turns the elevator feel and centering unit housing. This creates a new neutral position for the elevators.

Each rod also provides protection, in both directions (push or pull) if there is jam between the stabilizer and the elevator feel and centering unit. The pilot must supply approximately 180 pounds of additional force to extend or compress the springs inside the rods. The breakout force of each rod is 90 pounds.

See the elevator and tab control system section for more information on the elevator operation. (SECTION 27-31)

HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



HORIZONTAL STABILIZER TRIM CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

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TE FLAP SYSTEM - INTRODUCTION

Purpose

The trailing edge (TE) flaps increase the wing area and the wing camber. This increases lift to help improve the takeoff and landing performance of the airplane.

General

Two double-slotted flaps on each wing extend during takeoff to increase lift. This permits slower speeds for airplane rotation during takeoff. During cruise, the TE flaps fully retract. During landing, the TE flaps fully extend to increase lift and increase drag to permit slower speeds at touchdown.

During the normal operation of the TE flaps, the TE flaps are mechanically controlled and hydraulically operated. During the alternate operation, the TE flaps are electrically controlled and electrically operated.

The flap load relief function retracts the TE flaps at high airspeeds to prevent structural damage to the TE flaps and wing structures.

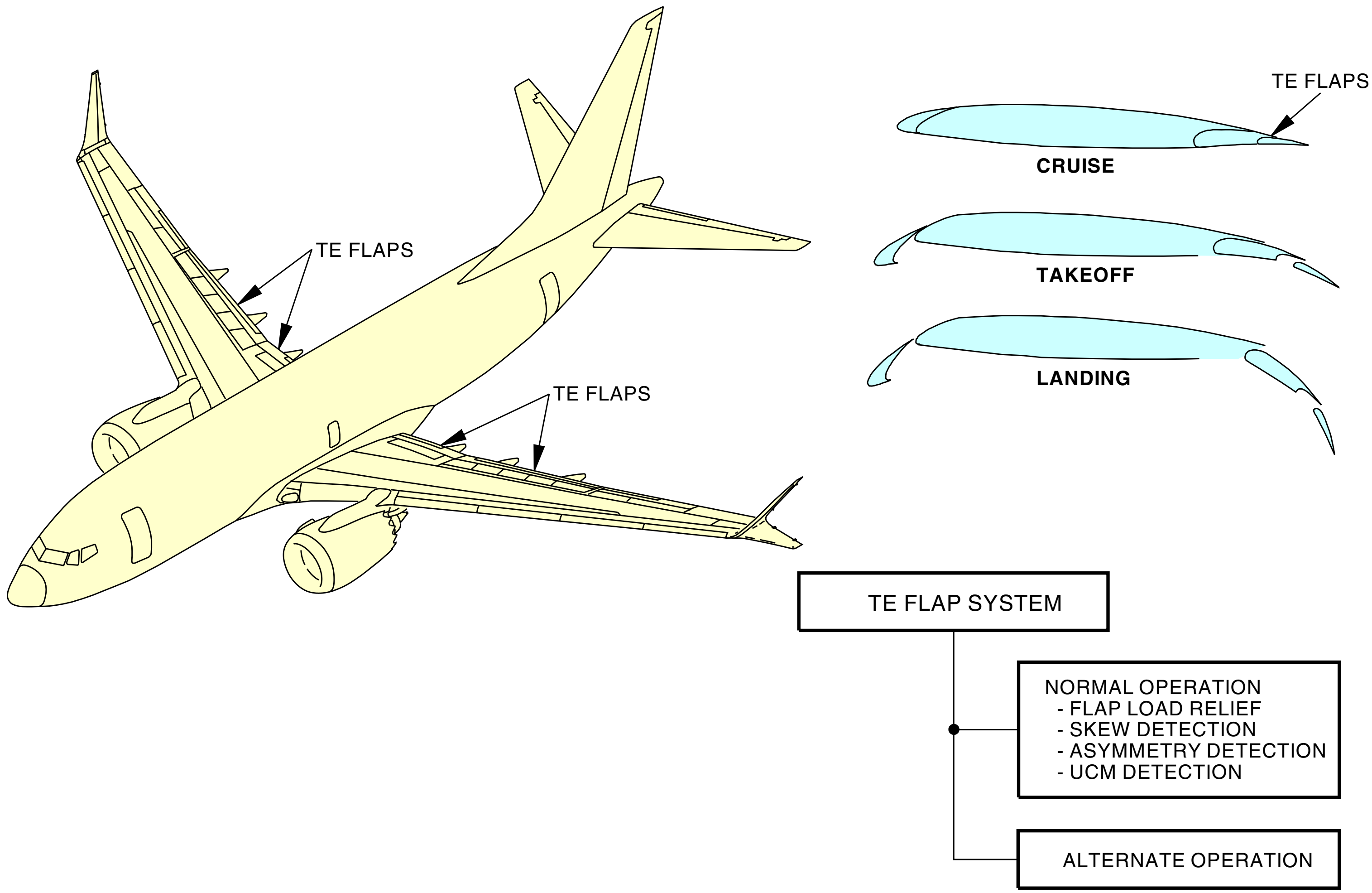
The TE flap skew and asymmetry detection functions stop the TE flap hydraulic operation if the TE flaps are not aligned. The TE flap uncommanded motion (UCM) detection function stops the TE flap hydraulic operation if the TE flaps move away from their commanded position.

You can do tests of the TE flaps with built-in test equipment (BITE) in the flap/slat electronics unit (FSEU). The FSEU BITE also lets you see other maintenance data.

Abbreviations and Acronyms

- alt - alternate
- BITE - built-in test equipment
- FCC - flight control computer
- FSEU - flap/slat electronics unit
- gnd - ground
- GPM - gallons per minute
- LE - leading edge
- lvr - lever
- MLG - main landing gear
- NWW - nose wheel well
- NVM - non-volatile memory
- PCU - power control unit
- PDU - power drive unit
- PSEU - proximity switch electronics unit
- rly - relay
- sect - section
- SMYD - stall management yaw damper
- snsr - sensor
- sw - switch
- TE - trailing edge
- UCM - uncommanded motion
- vlv - valve
- xmtr - transmitter
- WW - wheel well

TE FLAP SYSTEM - INTRODUCTION



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TE FLAP SYSTEM - INTRODUCTION

TE FLAP SYSTEM - GENERAL DESCRIPTION

General

For normal operation of the TE flaps, the flap lever makes the command to the flaps and hydraulic power moves them. If hydraulic power is not available, you can manually select alternate operation. During alternate operation, the alternate flaps switches make the command to the flaps and electrical power moves them.

Normal Operation

Hydraulic system B power goes through a priority valve and a flow limiter to the flap control unit. The priority valve gives priority of hydraulic system B power to the LE devices over the TE flaps. The flow limiter limits the speed of movement of the TE flaps.

The flap lever moves a cable system that supplies a mechanical input to the flap control valve through the FCU. The flap control valve sends system B hydraulic power through the TE flap bypass valve to the flap power drive unit (PDU). The flap PDU controls the flap drive system that moves the TE flaps.

Follow-up cables attached to the flap PDU and FCU supply mechanical feedback from the PDU to the FCU. The feedback does this:

- Moves the TE flap control valve to the null position and stops the TE flap drive system.
- Moves the LE flap and slat control valve to the commanded position.
- Operates the flap limit switches.

See the LE flap and slat control section for more information about the LE flap and slat control valve (SMTM 27-81).

The flap/slat electronics unit (FSEU) has these functions:

- Load relief
- Skew detection
- Asymmetry detection
- Uncommanded motion detection (UCM).

The flap load relief function uses data from one of the flap lever position switches and inputs from other systems. If the airspeed is more than a limit, the FSEU sends a signal to the load relief solenoid. The solenoid moves the TE flap and slat control valve and the TE flaps retract.

The TE flap skew and asymmetry detection functions monitor the alignment of the TE flaps. The FSEU uses data from the flap position transmitters and the flap skew sensors for this function. If the TE flaps are not aligned, the FSEU moves the TE flap bypass valve to the bypass position. The valve prevents hydraulic power to the flap PDU and the TE flaps stop.

The TE UCM detection function uses data from the flap skew sensors and the flap lever position sensor. If the TE flaps move from their commanded position, the FSEU moves the TE flap bypass valve to the bypass position. The valve prevents hydraulic power to the flap PDU and the TE flaps stop.

The flap position transmitters send signals to the FSEU. The FSEU sends this data to the flap position indicator in the flight compartment. The flap position transmitters also send signals to the flight control computers (FCCs) and stall management yaw dampers (SMYDs).

Alternate Operation

During alternate operation, the alternate flaps switches send a signal to move the bypass valve to the bypass position. The bypass valve prevents a hydraulic lock on the PDU.

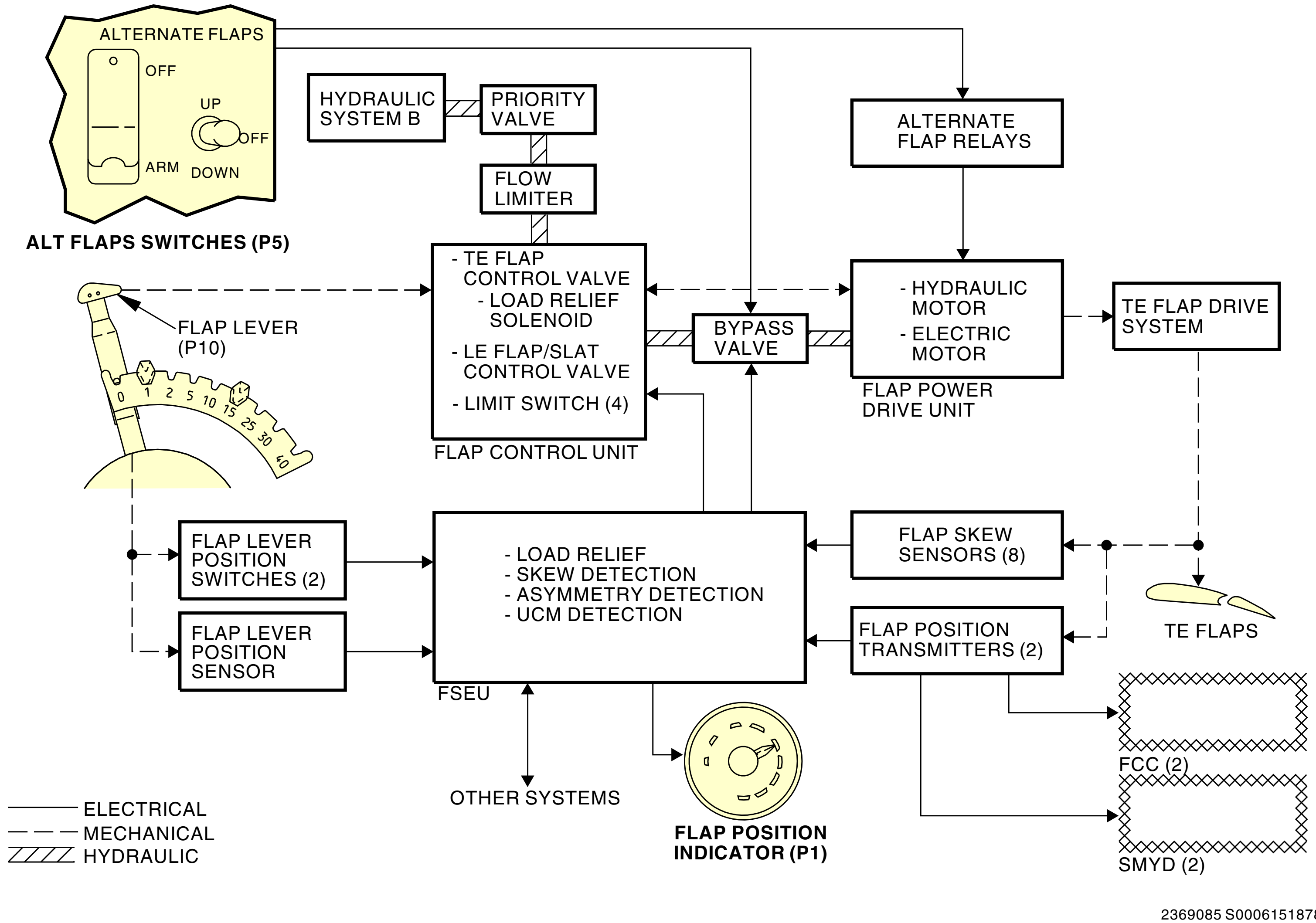
The alternate flaps control switch energizes the alternate flap relays. These relays supply electrical power to an electric motor on the flap PDU. The PDU moves the flap drive system to move the TE flaps.

The flap PDU supplies a mechanical feedback to the flap limit switches on the FCU. The flap limit switches remove electrical power from the relays when the flaps move to a limit. This stops the TE flaps.

During alternate operation, these functions are not available:

- Flap load relief
- Skew detection
- Asymmetry detection
- Uncommanded motion detection.

TE FLAP SYSTEM - GENERAL DESCRIPTION



TE FLAP SYSTEM - GENERAL DESCRIPTION

TE FLAP SYSTEM - GENERAL DESCRIPTION - FLAP DRIVE SYSTEM

General

These are the components of the TE flap drive system:

- Flap control unit
- Flap PDU
- Torque tubes
- Torque tube supports
- Angle gearboxes
- Transmissions
- Ballscrews
- Gimbals.

The flap drive system on the left wing is the same as the flap drive system on the right wing. Many of the components are interchangeable.

Flap Control Unit

There is one flap control unit. The flap control unit receives commands from the flap lever cables during normal operation and sends hydraulic power to the flap PDU. During alternate operation, switches in the flap control unit limit the operation of the electric motor in the flap PDU.

Flap PDU

There is one flap PDU. Hydraulic and electric motors on the PDU turn the flap torque tubes.

Torque Tubes

There are eight torque tubes on each wing. The torque tubes transmit power from the flap PDU to the transmissions.

Torque Tube Supports

There is one torque tube support on each wing. The torque tube supports hold the torque tubes in place.

Angle Gearboxes

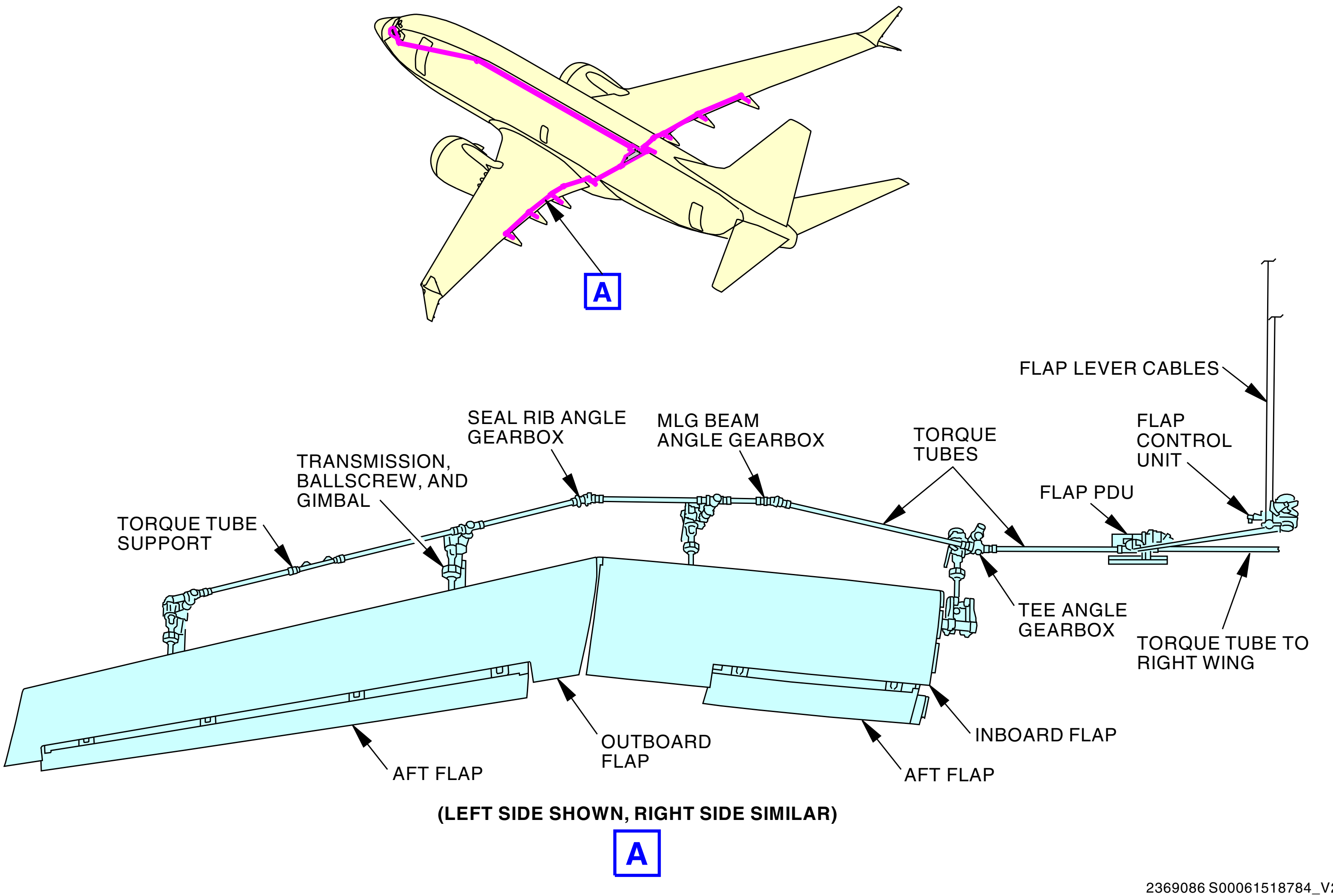
There are three angle gearboxes on each wing. The angle gearboxes connect torque tubes that are at different angles to each other. The three angle gearboxes are:

- Tee angle gearbox
- MLG beam angle gearbox
- Seal rib angle gearbox.

Transmissions, Ballscrews, and Gimbals

There are four transmissions, ballscrews, and gimbals on each wing, two for each flap surface. They receive power from the torque tubes to move the flap surfaces.

TE FLAP SYSTEM - GENERAL DESCRIPTION - FLAP DRIVE SYSTEM



TE FLAP SYSTEM - GENERAL DESCRIPTION - FLAP DRIVE SYSTEM

TE FLAP SYSTEM - COMPONENT LOCATIONS 1

General

The TE flap system components are in these areas:

- Flight deck
- Electronic equipment compartment
- Main landing gear (MLG) wheel well
- Wing.

Flight Deck Components

These are the TE flap system components in the flight deck:

- Flap lever
- Flap lever position sensor
- Flap lever position switches (2)
- Alternate flaps arm switch
- Alternate flaps control switch
- Flap load relief indication
- Flap position indicator.

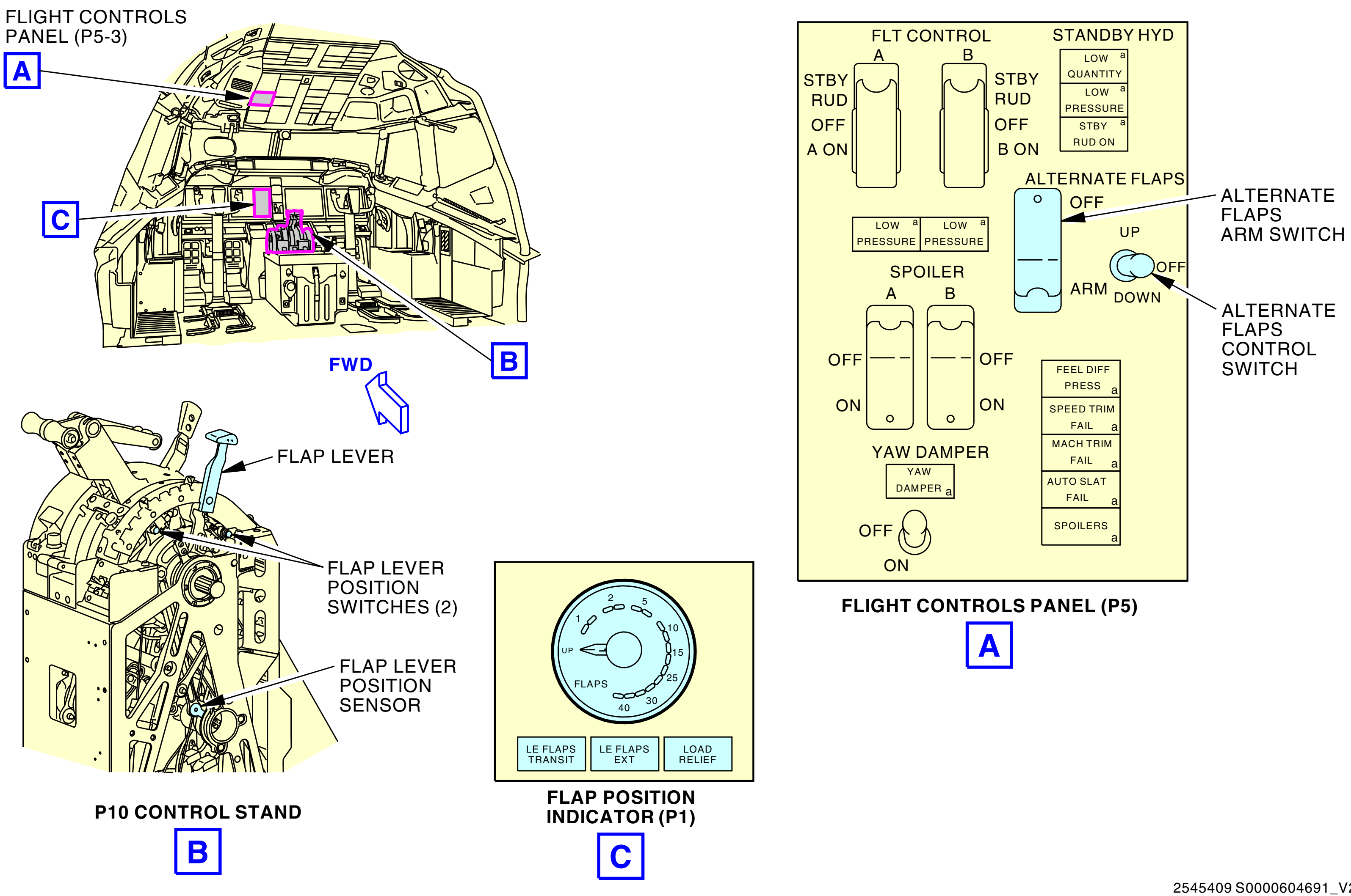
The flap lever is on the P10 control stand. The flap lever position sensor and the flap lever position switch are in the P10 control stand.

The alternate flaps arm switch and control switch are on the P5 flight control panel.

The flap LOAD RELIEF light is on the P1 captain's panel.

The flap position indicator is on the P1 captain's panel.

TE FLAP SYSTEM - COMPONENT LOCATIONS 1



TE FLAP SYSTEM - COMPONENT LOCATIONS 1

TE FLAP SYSTEM - COMPONENT LOCATIONS 2

General

The TE flap system components outside of the flight deck are in these areas:

- Electronic equipment compartment
- Main landing gear (MLG) wheel well
- Wing.

Electronic Equipment Compartment Components

The FSEU is on the E1-1 shelf.

MLG Wheel Well Components

These are the components in the MLG wheel well:

- Flap control unit
- Flap PDU
- TE flap bypass valve
- Torque tubes
- Tee angle gearboxes
- Flap priority valve (not shown)
- Flap flow limiter (not shown).

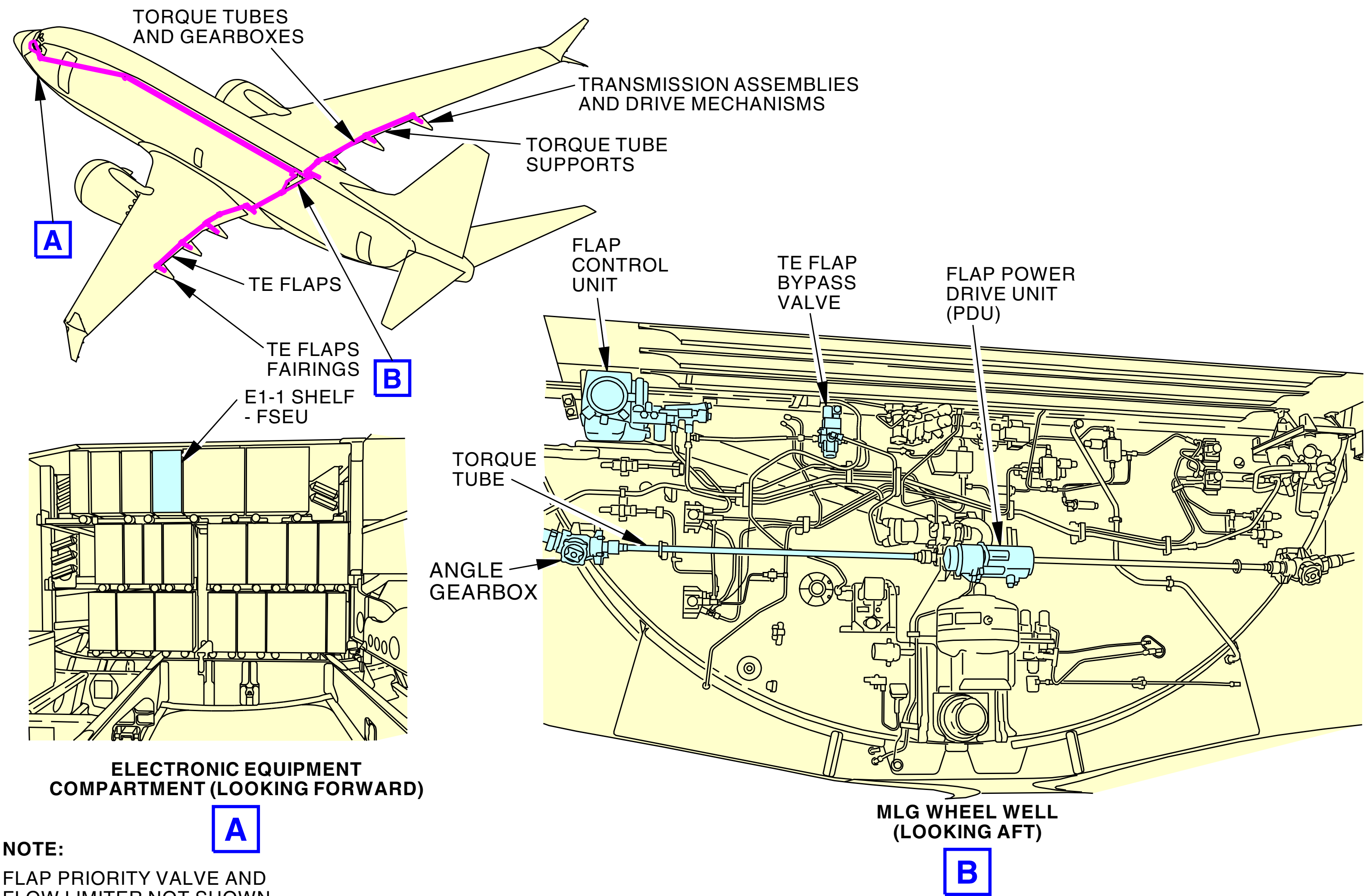
Wing Components

These are the components on the wings:

- Torque tubes
- Torque tube supports
- Tee angle gearboxes
- Beam angle gearboxes
- Seal rib angle gearboxes
- Transmission assemblies
- TE flap drive mechanisms
- TE flaps
- TE flap fairings.

Extend the TE flaps to get access to the torque tubes and gearboxes. Remove the TE flap fairings to get access to the transmission assemblies and drive mechanisms.

TE FLAP SYSTEM - COMPONENT LOCATIONS 2



NOTE:

FLAP PRIORITY VALVE AND
FLOW LIMITER NOT SHOWN.

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TE FLAP SYSTEM - COMPONENT LOCATIONS 2

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TE FLAP SYSTEM - FLAP/SLAT ELECTRONICS UNIT (FSEU)

Purpose

The flap/slat electronics unit (FSEU) supplies some control and monitor functions for the TE flaps and the LE devices.

The FSEU includes these functions for the TE flaps and LE devices:

- TE flap position indication
- TE flap load relief
- TE flap skew and asymmetry detection
- TE flap uncommanded motion detection (UCM)
- LE flap and slat position indication
- LE cruise depressurization
- LE flap and slat uncommanded motion detection (UCM)
- BITE.

There is more information on these functions later.

Location

The FSEU is on the E1-1 shelf in the electronic equipment compartment.

Physical Description

The FSEU has front panel BITE with an LED display. The FSEU weighs 13 lb (6 kg), and it is passively cooled.

Interfaces

The FSEU receives analog signals from these components:

- Alternate flaps arm switch for alternate operation
- Flap lever position sensor for monitoring, TE flap load relief, and LE cruise depressurization
- TE flap position transmitters for position indication, monitoring, and TE flap load relief
- TE flap skew sensors for monitoring
- LE flap and slat sensors for position indication, monitoring, and LE cruise depressurization
- Proximity switch electronics unit (PSEU) for a ground signal to reset a TE skew or asymmetry
- Stall management yaw damper (SMYD) 1 and 2 to inhibit the LE FLAPS TRANSIT light during an autoslat command.

The FSEU sends analog signals to these components/systems:

- TE flap load relief solenoid
- TE flap bypass valve
- TE flap position indicator
- Flap LOAD RELIEF light
- LE cruise depressurization valve
- LE UCM shutoff valve
- LE devices annunciator panel
- LE FLAPS EXT light
- LE FLAPS TRANSIT light
- Main rudder power control unit (PCU) for the rudder load limiter function
- Air conditioning system to operate the right ram air actuator
- Proximity sensor electronic unit (PSEU) for the takeoff warning system
- Ground proximity module for ground proximity warning
- SMYDs for takeoff warning.

The FSEU has ARINC 429 interfaces with these components:

- Air data inertial reference unit (ADIRU) for airspeed data for TE flap load relief, TE and LE UCM inhibit, reset of TE skew and asymmetry, and the rudder load limiter command
- Digital flight data acquisition unit (DFDAU) to send flap lever position, TE flap position, and LE flap and slat position to the flight data recorder
- Display processing computer (DPCs) 1 and 2 for flap lever position data for flap extension and retraction speed indications.

TE FLAP SYSTEM - FLAP/SLAT ELECTRONICS UNIT (FSEU)

TE Flap Position Indication

The FSEU receives inputs from the TE flap position transmitters to operate the TE flap position indicator. The FSEU also sends this data to other airplane systems.

See the TE flap position indication section for more information. (SECTION 27-58)

TE Flap Load Relief

The flap load relief function uses data from one of the flap lever position switches and inputs from other systems. If the airspeed is more than the limit, the FSEU sends a signal to the load relief solenoid. The solenoid then moves the TE flap and slat control valve and causes the TE flaps to retract.

When the FSEU sends a flap load relief command, the amber flap LOAD RELIEF light comes on.

TE Flap Skew and Asymmetry Detection

The FSEU receives inputs from the TE flap skew sensors and position transmitters to monitor the alignment of the TE flaps. If the TE flaps do not stay in alignment, the FSEU operates the bypass valve. This stops the hydraulic operation of the TE flaps.

During a flap skew, the FSEU also causes a change in the TE flap position indicator.

See the flap skew detection section for more information. (SECTION 27-59)

TE Flap Uncommanded Motion (UCM) Detection

The FSEU receives inputs from the flap lever position sensor and the TE flap skew sensors for UCM detection. If the TE flaps move away from their commanded position, then the FSEU operates the bypass valve. This stops the hydraulic operation of the TE flaps.

LE Flap and Slat Position Indication

The FSEU receives inputs from the LE flap and slat sensors to control the lights on the LE devices annunciator panel. The FSEU also sends this data to the FDAU.

See the LE flap and slat position indicating section for more information. (SECTION 27-88)

LE Cruise Depressurization

During cruise, the FSEU supplies a ground for the LE cruise depressurization valve to prevent movement of the LE flaps and slats.

See the LE flap and slat control section for more information about the LE cruise depressurization function. (SECTION 27-81)

LE Flap and Slat Uncommanded Motion (UCM) Detection

The FSEU receives inputs from these to monitor the position of the LE flaps and slats:

- Flap lever position sensor
- LE flap and slat sensors.

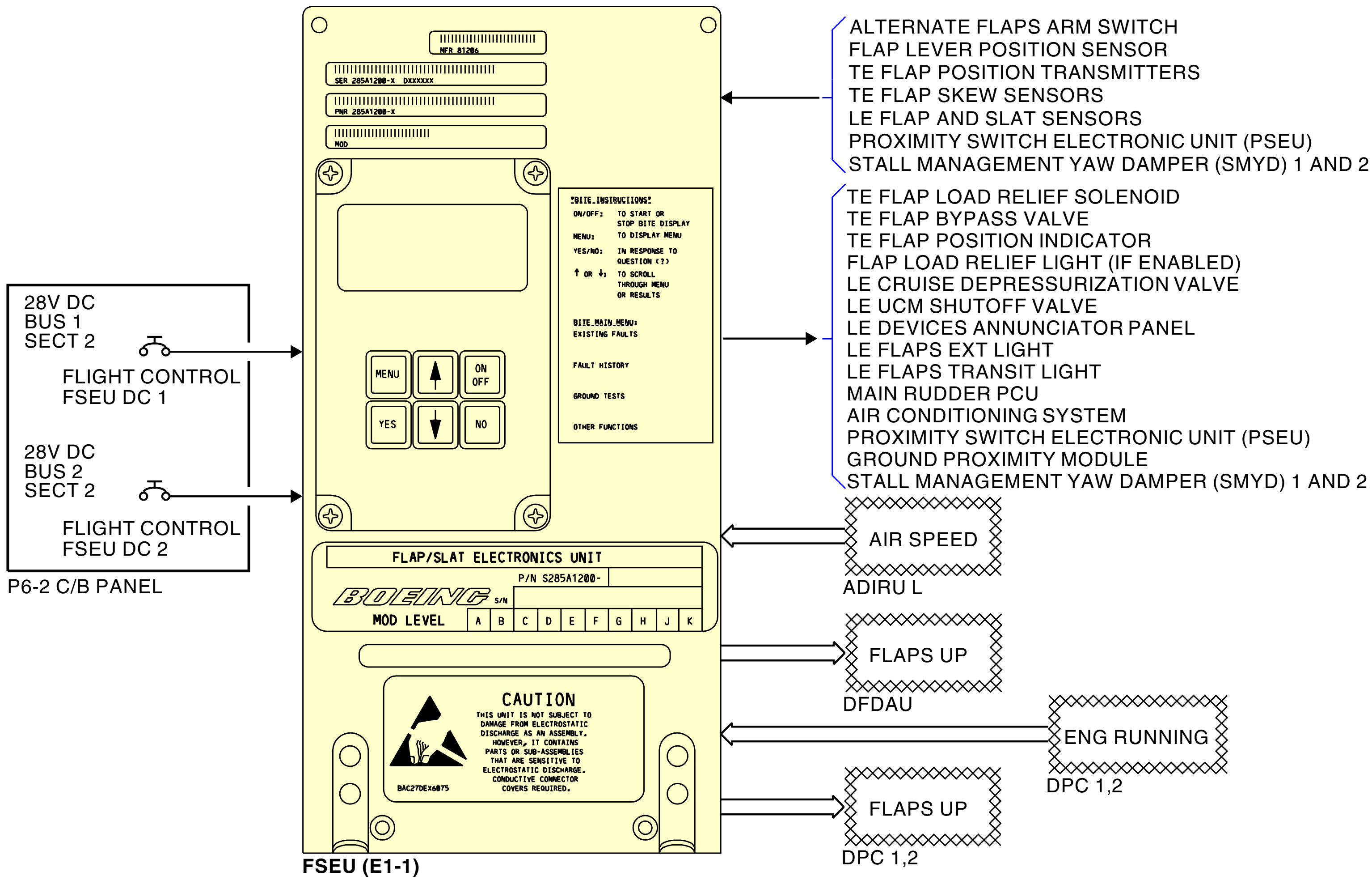
If two or more LE flaps or slats move away from the flap lever position, the FSEU operates the LE UCM shutoff valve. This stops the movement of all the LE flaps and slats.

See the LE flap and slat control section for more information about the LE flap and slat uncommanded motion detection. (SECTION 27-81)

BITE

The FSEU uses all of the electrical inputs that it receives to monitor for failures. The FSEU has front panel BITE interface to let you see this data and to do some tests of the TE flaps and LE devices.

TE FLAP SYSTEM - FLAP/SLAT ELECTRONICS UNIT (FSEU)



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TE FLAP SYSTEM - FLAP/SLAT ELECTRONICS UNIT (FSEU)

TE FLAP SYSTEM - FLAP LEVER, POSITION SENSOR, AND POSITION SWITCHES

Purpose

The flap lever controls the position of the TE flaps and LE devices. You use the flap lever during the normal operation of the TE flaps. During the alternate operation, you do not use the flap lever.

The flap lever position sensor sends flap lever position data to the FSEU for the TE flaps UCM detection function. The FSEU also sends this data to other airplane systems.

The flap lever position switches monitor flap lever position for the LE cruise depressurization function (UP) and the flap load relief function (10).

Location

The flap lever is on the right side of the P10 control stand. The flap lever position sensor and switches are below the flap lever, in the control stand. To get access to the flap lever position sensor, remove the lower panel on the right side of the control stand. To get access to the flap lever position switches, remove the stabilizer trim indicator panel and cover.

Physical Description

The flap lever is a spring-loaded, telescoping handle. It attaches to the flap lever quadrant in the control stand. The quadrant moves the flap cables that supply inputs to the flap control unit in the MLG wheel well. Springs in the flap control unit supply a resistant force on the flap lever.

The flap lever has an index pin that holds the flap lever in detents in the detent plate. The detent plate has these detent positions:

- 0
- 1
- 2
- 5
- 10
- 15
- 25
- 30
- 40.

Gates at detents 1 and 15 help the flight crew identify these positions during go-arounds.

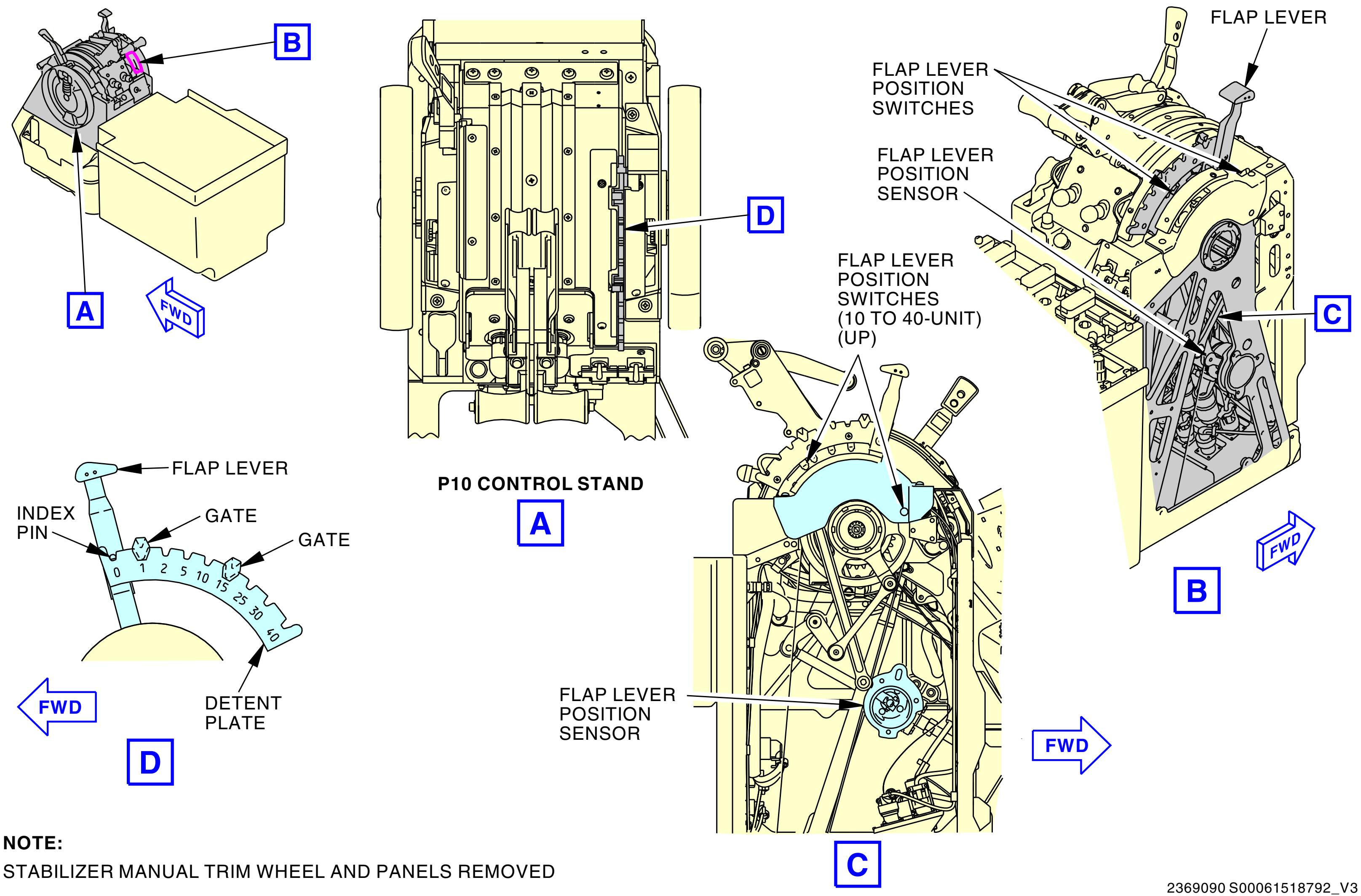
The flap lever position sensor has one synchro that uses 28v ac excitation. The flap lever position sensor is at 0 resolver degrees when the flap lever is up and is at 108 resolver degrees when the flap lever is at 40-unit position.

One of the flap lever position switches operates when the flap lever moves to the UP position. The other flap lever switch operates when the flap lever between 5 and 10-unit position.

Operation

To move the flap lever to a new position, you must lift the flap lever so the index pin moves out of the detent.

TE FLAP SYSTEM - FLAP LEVER, POSITION SENSOR, AND POSITION SWITCHES



NOTE:
STABILIZER MANUAL TRIM WHEEL AND PANELS REMOVED

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TE FLAP SYSTEM - FLAP LEVER, POSITION SENSOR, AND POSITION SWITCHES

TE FLAP SYSTEM - ALTERNATE FLAPS SWITCHES

Purpose

The two alternate flaps switches control the TE flaps and LE devices during the alternate operation. These are the alternate flaps switches:

- Alternate flaps arm switch
- Alternate flaps control switch.

Location

The alternate flaps switches are on the flight control panel on the P5 overhead panel.

Physical Description

The alternate flaps arm switch is a two position, guarded, toggle switch. The positions are the arm position and the OFF position. When the guard is closed, the switch is in the OFF position.

The alternate flaps control switch is a three position toggle switch with these positions:

- UP
- OFF
- DOWN.

Functional Description

When you put the switch in the UP position, it stays. When you put it in the DOWN position, it returns to the OFF position when you release it.

The alternate flaps control switch operates only when the arm switch is in the arm position. The control switch controls the direction of movement of the TE flaps and LE devices.

NOTE: During alternate operation with system B hydraulic power applied, move the flap lever to the position that you will move the flaps to. This will decrease the load on the flap electric motor and it will make there is no movement of the flaps when alternate operation stops.

When the alternate flaps arm switch is in the arm position, this occurs:

- TE flap bypass valve moves to the bypass position
- Standby electric motor driven pump (EMDP) starts
- Electrical power goes to the alternate flaps control switch.

Extend

When you move the control switch to the DOWN position momentarily, the LE devices use pressure from the standby EMDP to fully extend. You can not stop the extension of the LE devices unless you move the alternate flaps arm switch to the OFF position.

When you hold the control switch in the DOWN position, the TE flaps use electric power to extend. To stop the extension of the TE flaps, move the control switch to the OFF position.

Retract

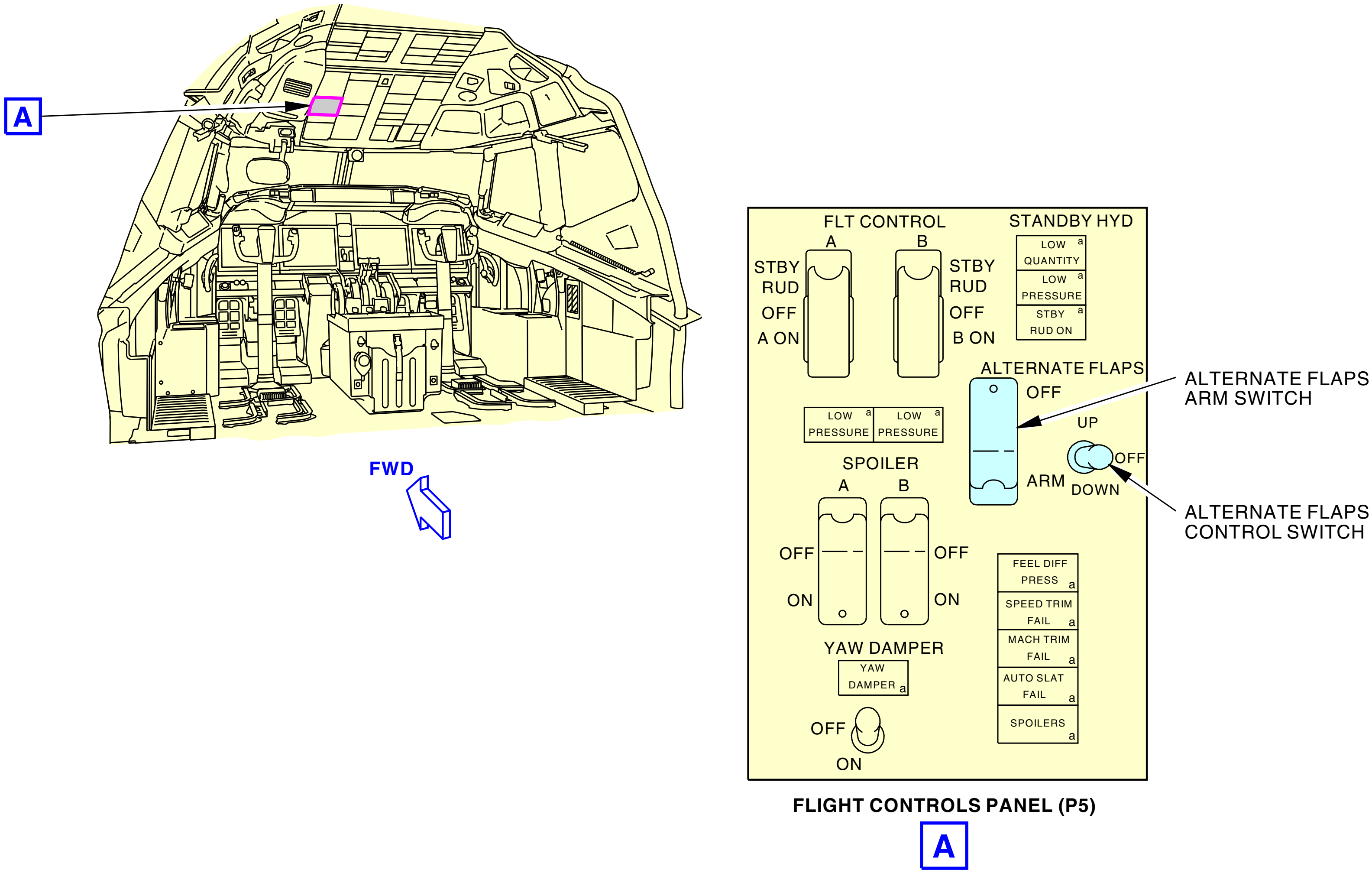
When the control switch is in the UP position, the TE flaps use electric power to retract and the LE devices stay in the full extend position. You can not retract the LE devices during the alternate operation. To retract the LE devices, use the normal operation with the flap lever.

Return To Normal Operation

To return to normal operation, move the arm switch from the ARM position to the OFF position. This stops the alternate operation and normal operation becomes active. Before you do this, obey this warning:

WARNING	MAKE SURE THAT THE POSITION OF THE TE FLAPS AGREES WITH THE POSITION OF THE FLAP CONTROL LEVER. WHEN YOU SUPPLY HYDRAULIC POWER, THE FLAPS AND SLATS WILL MOVE AUTOMATICALLY TO THE POSITION OF THE FLAP CONTROL LEVER. THIS CAN CAUSE INJURY TO PERSONS AND DAMAGE TO EQUIPMENT.

TE FLAP SYSTEM - ALTERNATE FLAPS SWITCHES



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TE FLAP SYSTEM - ALTERNATE FLAPS SWITCHES

TE FLAP SYSTEM - FLAP CONTROL QUADRANT

Purpose

The flap control quadrant transmits pilot inputs from the flap lever to the flap control unit.

Location

The flap control quadrant is above the MLG wheel well. To get access, remove a floor panel in the passenger cabin.

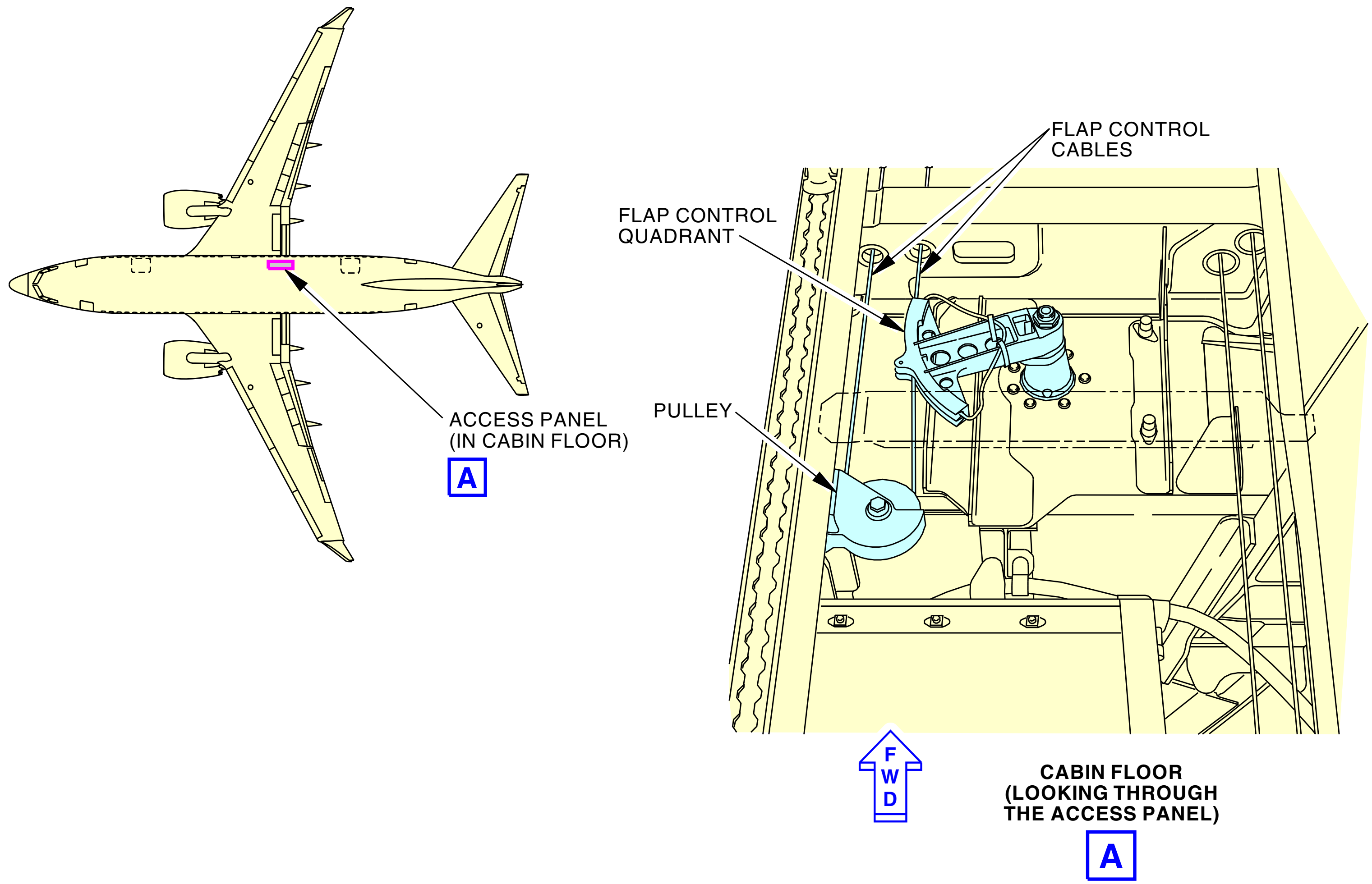
Physical Description

A cable assembly from the flap lever attaches to the flap control quadrant and a pulley.

Functional Description

Flap lever movement causes the cable assembly to move the flap control quadrant. The quadrant turns an input shaft to operate the flap control unit in the MLG wheel well.

TE FLAP SYSTEM - FLAP CONTROL QUADRANT



TE FLAP SYSTEM - FLAP CONTROL QUADRANT

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TE FLAP SYSTEM - FLAP CONTROL UNIT

Purpose

The flap control unit receives mechanical inputs from the pilots and sends hydraulic power to the flap PDU and the slat actuators. The flap control unit also causes the TE flaps to retract during load relief operation.

Location

The flap control unit is in the MLG wheel well on the right side of the ceiling, near the aft bulkhead.

Physical Description

The flap control unit has these components:

- Input rod
- Summing lever
- TE flap control valve link
- TE flap control valve
- LE flap control valve link
- LE flap control valve
- Follow-up drum
- Cam rollers
- Flap position switches.

See the leading edge (LE) flap and slat control system section for more information on the LE flap control valve and the LE flap control valve link. (SECTION 27-81)

The TE flap control valve receives mechanical and electrical inputs and sends hydraulic power to the flap PDU. The flap load relief solenoid is on the TE flap control valve. When this solenoid energizes, the TE flaps retract from the flaps 40 or 30 unit positions to the next lower position, or from the flaps 40, 30, 25, 15, or 10 unit position to the next lower position for SFP aircraft.

These are the four TE flap position switches:

- TE flap up switch (S245)
- TE flap down switch (S246)
- TE flap switch (S1051)
- Flap landing warning switch (S138).

TE Flap Position Switches Interfaces

The TE flap up switch (S245) operates at the up position and interfaces with these components/systems:

- Alternate TE flap system to limit the position of the TE flaps during alternate operation
- Stabilizer system for stab trim speed control
- SMYDs to limit yaw damper authority
- Passenger cabin signs control.

The TE flap down switch (S246) operates at the 40 unit position and interfaces with the alternate TE flap system to limit the position of the TE flaps during alternate operation.

The TE flap switch (S1051) operates at the up position and interfaces with these components/systems:

- Right elevator tab solenoid valve
- Standby hydraulic system to enable the automatic operation
- Power transfer unit (PTU) system to enable the automatic operation
- Air conditioning system to operate the left ram air actuator.

The flap landing warning switch (S138) operates at the 15 unit position and interfaces with these components/systems:

- PSEU for landing gear red lights and aural warning
- PSEU for SPEEDBRAKES EXTENDED light
- PTU system to disable the automatic operation.

NOTE: The TE flap up switch (S245) and the TE flap switch (S1051) close when the TE flaps move to the up position, but they are rigged differently. Because of this, the TE flap up switch (S245) operates closer to the up stop than the TE flap switch (S1051).

TE FLAP SYSTEM - FLAP CONTROL UNIT

Functional Description

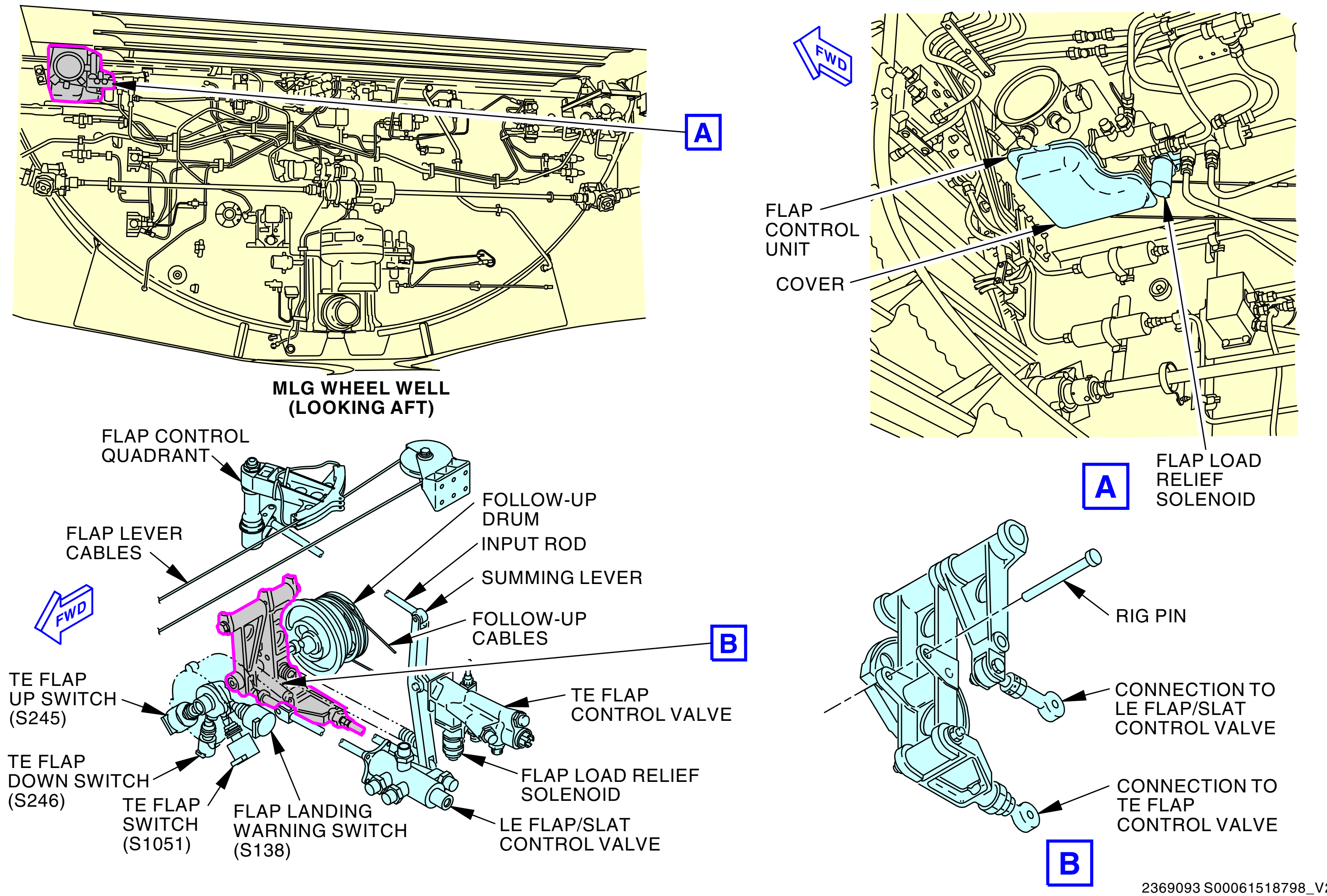
The flap lever moves the flap control quadrant, which moves the input rod and summing lever. The summing lever moves the TE flap control valve, which sends hydraulic power to the TE flap PDU. As the TE flaps move, the follow-up cables move the follow-up drum. The follow-up drum moves three cam rollers.

One of the cam rollers causes the TE flap control valve link to move. This link moves the summing lever in the opposite direction to cause the TE flap control valve to move to the neutral position. This stops the hydraulic power to the TE flap PDU.

A second cam roller operates the TE flap position switches.

The third cam roller causes the LE flap control valve link to move, which moves the LE flap control valve.

TE FLAP SYSTEM - FLAP CONTROL UNIT



TE FLAP SYSTEM - FLAP CONTROL UNIT

TE FLAP SYSTEM - FLAP POWER DRIVE UNIT

Purpose

The TE flap power drive unit (PDU) uses hydraulic or electric power to turn the TE flap torque tubes and the follow-up cables.

Location

The flap PDU is on the aft bulkhead of the MLG wheel well.

Physical Description

The flap PDU has these components:

- Gearbox
- Hydraulic motor
- Electric motor.

The gearbox transfers power from the hydraulic and electric motors to the flap torque tubes. As the torque tubes turn, the gearbox moves the follow-up cables that attach to the flap control unit. The gearbox is oil- filled.

There is a 3/8-inch manual drive connection on the flap PDU that lets you manually move the TE flaps. Remove the manual drive cover to get access to the manual drive input shaft.

The hydraulic motor is a reversible, nine cylinder piston-type motor. Case drain hydraulic fluid lubricates the hydraulic motor. A check valve attaches to the case drain hydraulic port.

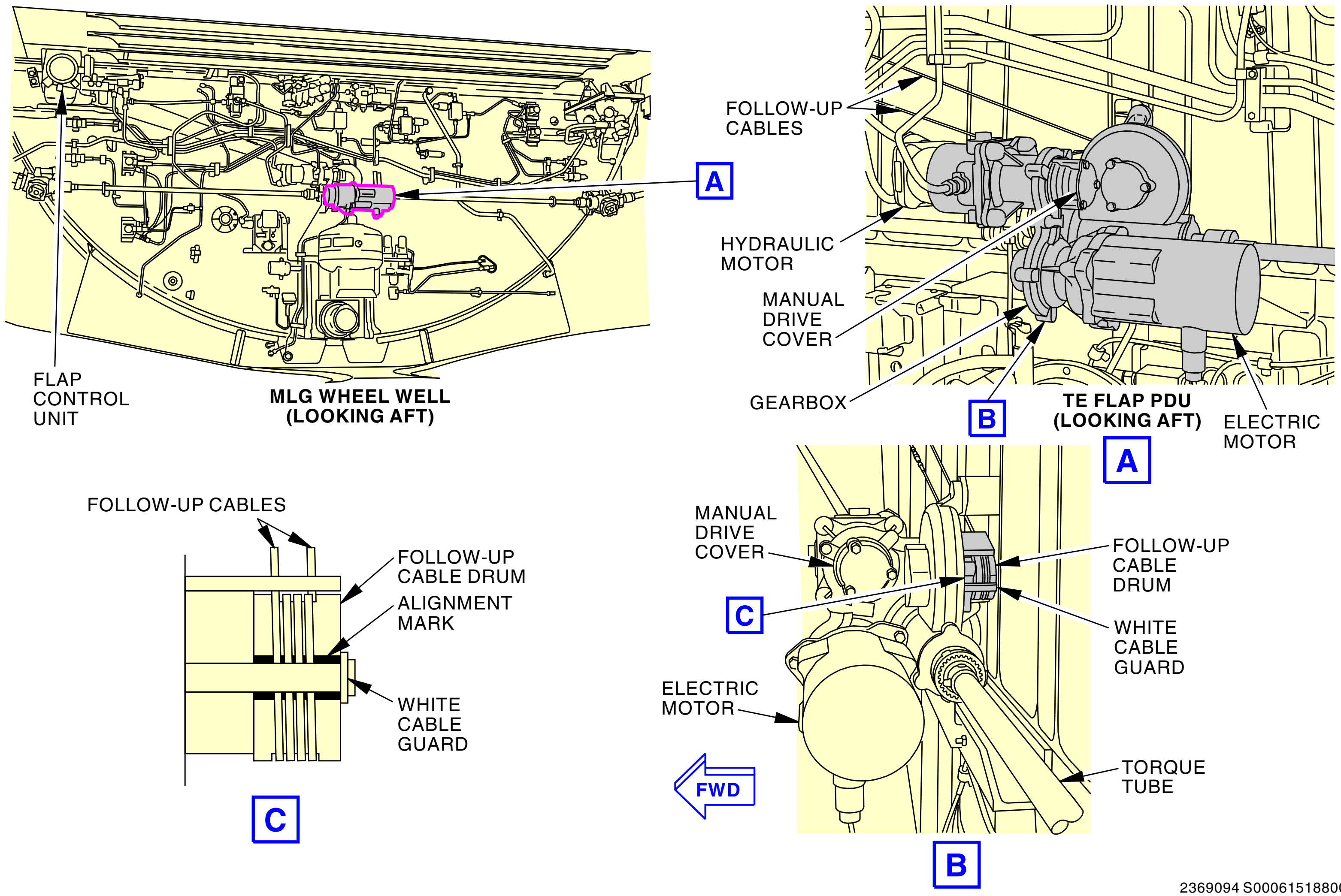
The electric motor is a three-phase, 400 Hz, 115v ac motor with these components:

- Clutch
- Solenoid
- Overload mechanism.

During hydraulic operation of the TE flaps, the clutch disengages. This helps prevent damage to the electric motor. When the electric motor receives electric power, the solenoid engages the clutch. This lets the electric motor turn the PDU gears.

The overload mechanism in the electric motor disengages the clutch if a jam occurs in the PDU gearbox or the flap torque tubes.

TE FLAP SYSTEM - FLAP POWER DRIVE UNIT



TE FLAP SYSTEM - FLAP POWER DRIVE UNIT

TE FLAP SYSTEM - FLAP PRIORITY VALVE AND FLOW LIMITER

Purpose

The TE flap priority valve and the flow limiter control the flow of hydraulic fluid to the TE flap hydraulic components. The priority valve gives priority of system B hydraulic power to the LE devices over the TE flaps. The flow limiter limits the speed of movement of the TE flaps.

Location

The TE flap priority valve and the flow limiter are on the ceiling of the MLG wheel well.

Physical Description

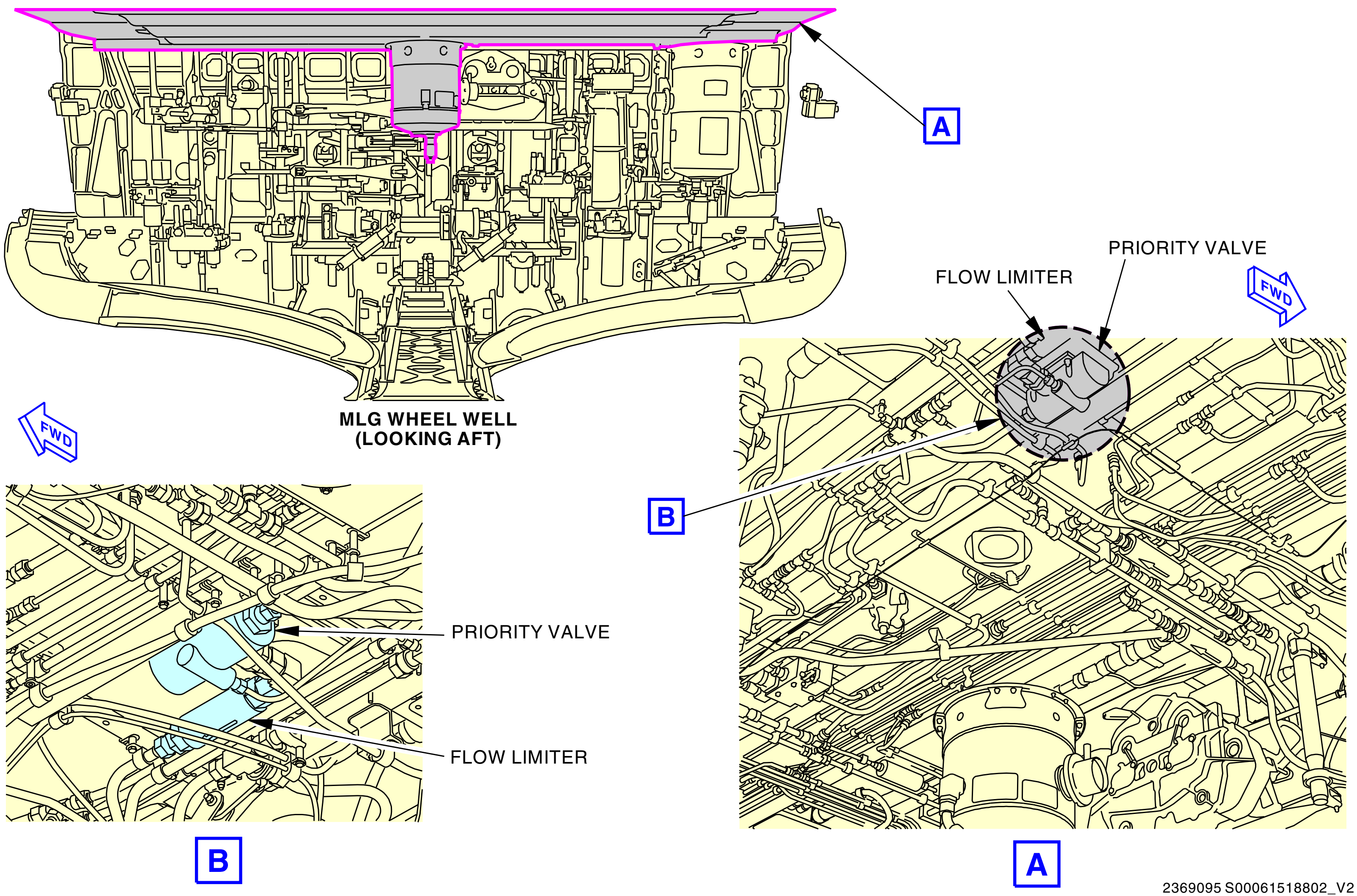
The priority valve is a pressure-operated valve with two positions.

The flow limiter limits the hydraulic fluid flow to 14 gpm.

Functional Description

If the system B hydraulic pressure is less than 2400 psi, the priority valve moves to the reduced flow position. This reduces the hydraulic flow to the TE flap components.

TE FLAP SYSTEM - FLAP PRIORITY VALVE AND FLOW LIMITER



TE FLAP SYSTEM - FLAP PRIORITY VALVE AND FLOW LIMITER

TE FLAP SYSTEM - TE FLAP BYPASS VALVE

Purpose

The TE flap bypass valve prevents the hydraulic operation of the TE flaps during these conditions:

- Alternate flap operation (arm switch in arm position)
- TE flap skew
- TE flaps asymmetry
- TE flaps uncommanded motion (UCM).

There is more information on these conditions later in this section.

Location

The bypass valve is on the aft bulkhead of the MLG wheel well.

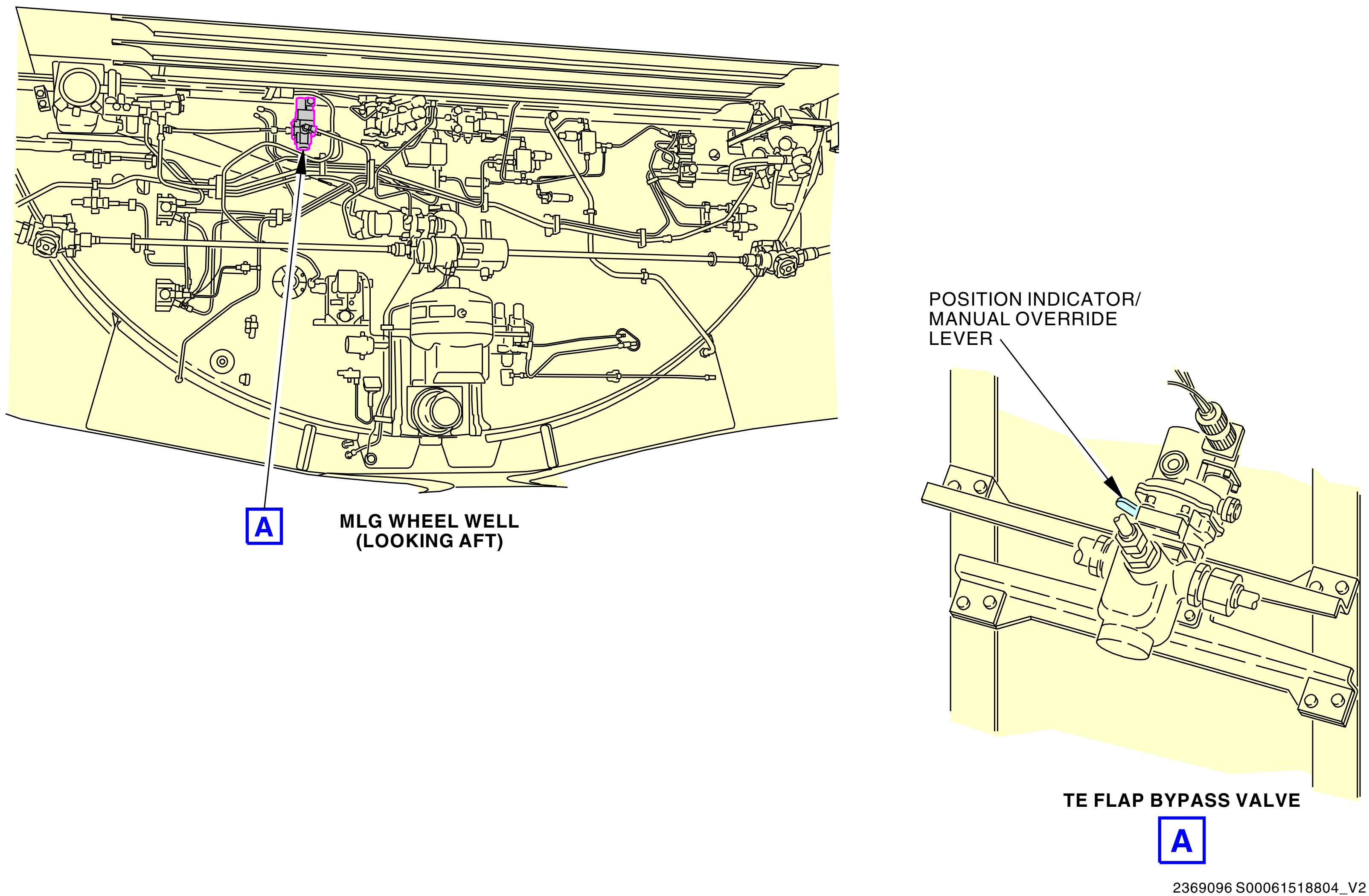
Physical Description

The bypass valve is a two position valve that uses 28v dc power from bus 1. The valve has a manual override lever that shows the position of the valve. The lever also lets you move the valve manually.

Functional Description

When the bypass valve is in the normal position, it lets hydraulic power from the flap control valve go to the TE flap hydraulic motor. When the bypass valve is in the bypass position, it connects the hydraulic lines on both sides of the hydraulic motor to each other. This stops operation of the hydraulic motor, prevents a hydraulic lock, and lets alternate flaps operation backdrive the hydraulic motor.

TE FLAP SYSTEM - TE FLAP BYPASS VALVE



TE FLAP SYSTEM - TE FLAP BYPASS VALVE

TE FLAP SYSTEM - TORQUE TUBES AND TORQUE TUBE SUPPORTS

Purpose

The flap torque tubes transmit power from the TE flap PDU, through the angle gearboxes, to the flap transmissions. The torque tube supports transmit power between two torque tubes in areas where stronger torque tubes are necessary.

Location

There are 16 torque tubes of different lengths for the flap drive system. These torque tubes are in the MLG wheel well, along the MLG beams, and along the rear spar of both wings. To get access, go through the MLG wheel well, go through removable access panels under the wings, or extend the TE flaps.

There is one torque tube support between the two outboard flap transmissions on each wing. To get access, go through removable access panels under the wings or extend the TE flaps.

Torque Tubes

There are two types of torque tubes. The torque tubes that connect the flap PDU to the flap transmissions 4 and 5 are steel tubes that are bolted to steel end fittings. All the other torque tubes are aluminum tubes that are magneformed to steel end fittings.

The magneforming process forms the ends of the torque tubes around the end fittings electro-magnetically. The torque tubes are magneformed instead of riveted to help prevent disconnects.

Torque Tube Supports

The torque tube supports have these parts:

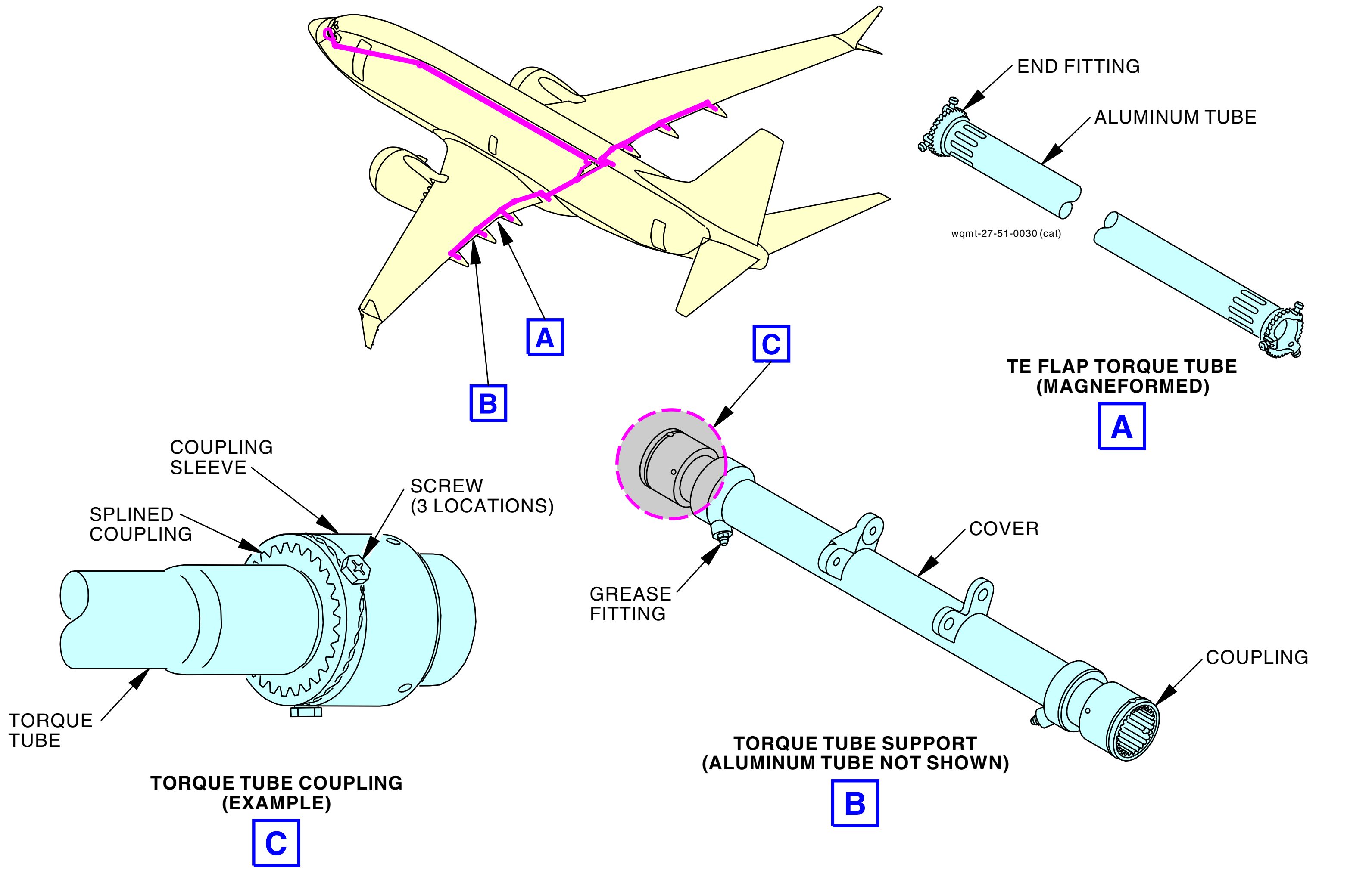
- Coupling
- Torque tube cover
- Aluminum tube.

The coupling moves the aluminum tube. The aluminum tube is inside the torque tube cover.

The torque tube support is one line replaceable unit (LRU).

The torque tube supports have grease fittings for lubrication.

TE FLAP SYSTEM - TORQUE TUBES AND TORQUE TUBE SUPPORTS



TE FLAP SYSTEM - TORQUE TUBES AND TORQUE TUBE SUPPORTS

TE FLAP SYSTEM - ANGLE GEARBOXES

Purpose

The angle gearboxes connect torque tubes that are at different angles to each other.

Location

There are six angle gearboxes, three on each wing. These are the angle gearboxes:

- Tee angle gearbox (2)
- MLG beam angle gearbox (2)
- Seal rib angle gearbox (2).

To get access to the tee angle gearboxes, go through the MLG wheel well. To get access to the other angle gearboxes, extend the TE flaps.

Physical Description

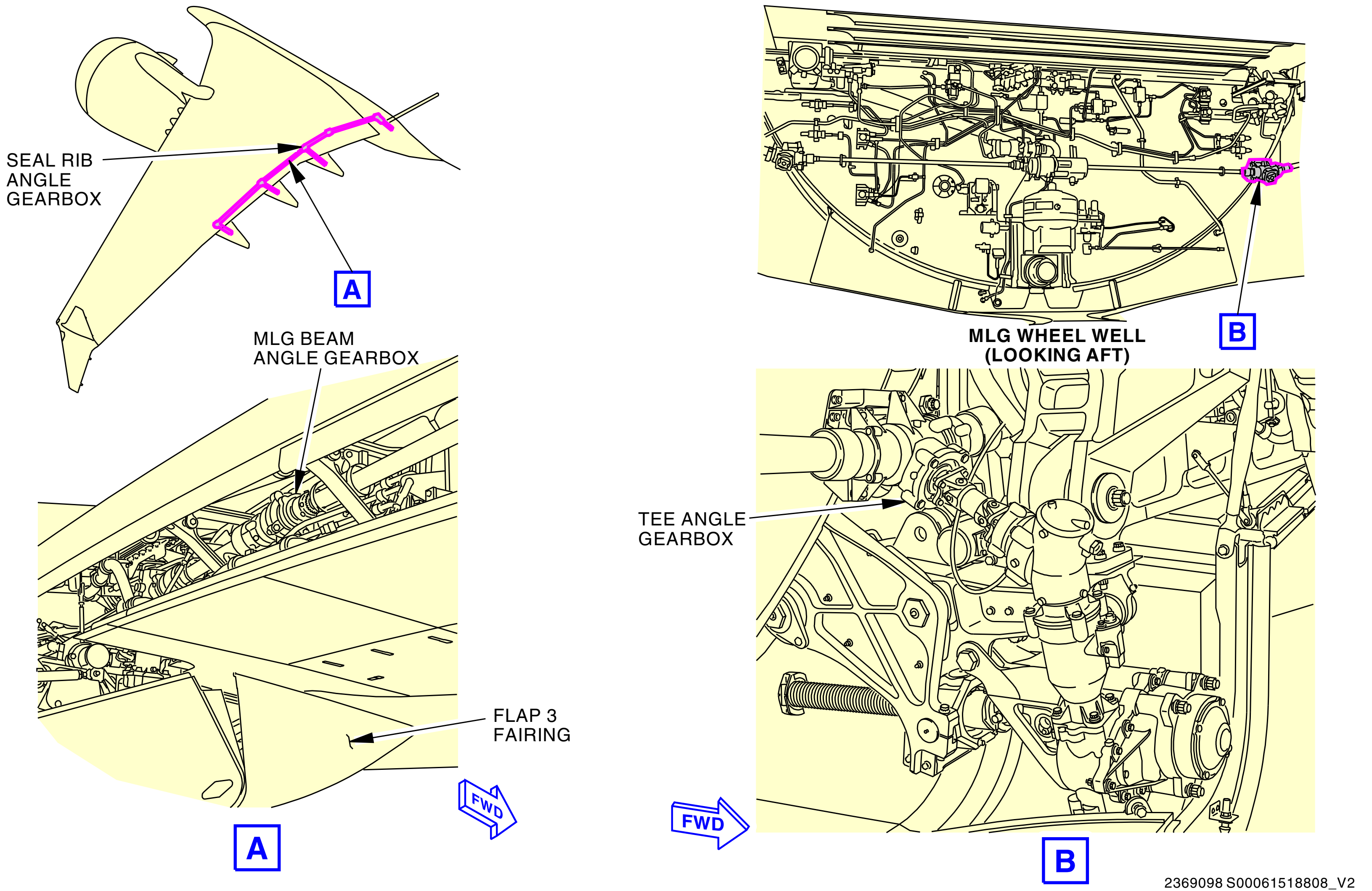
The angle gearboxes contain grease (BMS 3-33). The angle gearboxes contain bevel gears with ball bearings in an aluminum housing.

- MLG beam angle gearbox (7.2 lb (3.3 kg))
- Seal rib angle gearbox (7.6 lb (3.4 kg))
- Tee angle gearbox (30 lb (13.6 kg))

Functional Description

The angle gearboxes change the direction of the torque tube drive line and transmit power to TE flap drive system components.

TE FLAP SYSTEM - ANGLE GEARBOXES



TE FLAP SYSTEM - ANGLE GEARBOXES

TE FLAP SYSTEM - FLAP TRANSMISSIONS, BALLSCREWS, AND GIMBALS

Purpose

Each TE flap transmission transmits the power from the torque tubes to the universal joint and ballscrew. When the ballscrew moves, the gimbal moves. This causes the TE flap to move.

Location

There are eight TE flap transmissions, two transmissions for each TE flap. There is one ballscrew and gimbal for each transmission. The transmissions are on the rear spar of the wing. Access to the transmissions, ballscrews, and gimbals is through the TE flap fairings or through the MLG wheel well.

Transmissions

Each transmission has a torque brake that prevents excessive loads on the ballscrew if the flap does not move freely. The torque brake is a ball ramp type brake with a torque trip indicator. If the TE flap does not move freely, the torque brake stops the movement of the torque tubes. This causes the hydraulic motor to stop. The torque brake operates in either direction of flap movement. The trip indicator must be manually reset if it activates.

Each transmission also has two no-back brakes. The no-back brakes are skewed-roller type brakes. They prevent TE flaps retraction and extension if a torque tube breaks or because of airloads.

Each transmission contains oil and weighs approximately 45 lb (20 kg).

Ballscrews

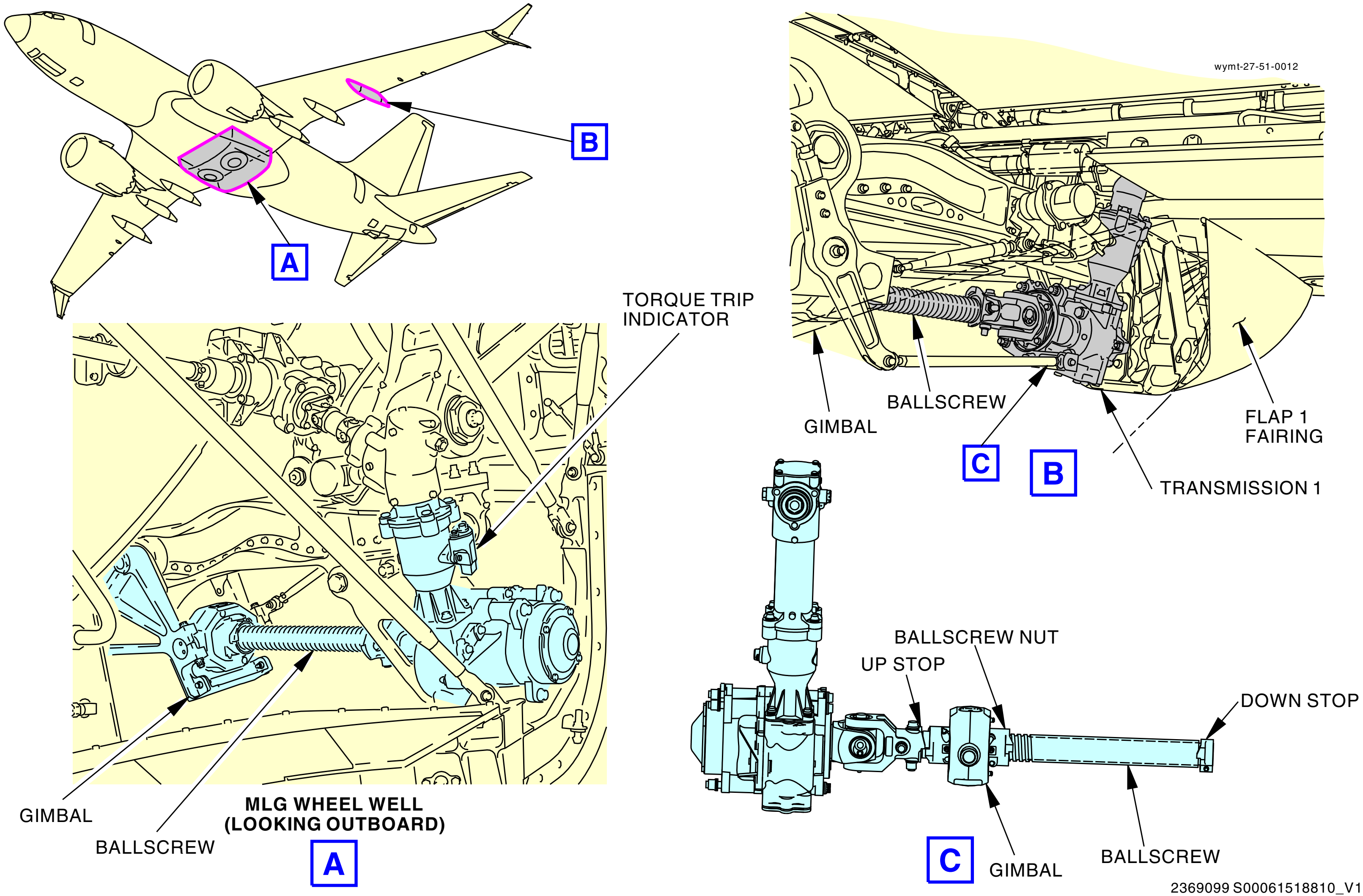
The transmission turns the ballscrew through the universal joint. The ballscrew has a ballscrew nut which connects to the gimbal. As the ballscrew turns, the ballscrew nut moves the gimbal.

The ballscrew has stops at both ends. The ballscrew nut does not touch the stops during the usual operation of the TE flaps. The ballscrew nut is lubricated with grease.

Gimbal

The gimbal moves the TE flap surface. The gimbal connects to the ballscrew nut and moves as the ballscrew turns.

TE FLAP SYSTEM - FLAP TRANSMISSIONS, BALLSCREWS, AND GIMBALS



TE FLAP SYSTEM - FLAP TRANSMISSIONS, BALLSCREWS, AND GIMBALS

TE FLAP SYSTEM - FLAP DRIVE MECHANISMS AND FAIRINGS

Purpose

Each flap drive mechanism transmits power from the transmission, ballscrew, and gimbal to move the TE flap. The flap fairings cover the drive mechanisms and reduce aerodynamic drag.

Location

There are two drive mechanisms for each TE flap. There are three flap fairings on the bottom of each wing.

Two of the flap drive mechanisms are in the MLG wheel well. To get access to the flap drive mechanisms on the wings, extend the TE flaps or remove the flap fairings.

Physical Description

These are the components that connect to the carriage and move as the carriage moves:

- Gimbal
- Main flap
- Aft flap pushrods (outboard flaps only)
- Flap fairing links (outboard flaps only)
- Flap skew sensor control rod.

The flap fairings are made of composite materials. The fairings have these three sections:

- Forward section (Fiberglass)
- Aft section (Fiberglass/Carbon)
- Tailcone (Fiberglass).

Flap Drive Mechanisms

During extension, the ballscrew moves the carriage along the main flap track. The rollers in the carriage stay in the main flap track.

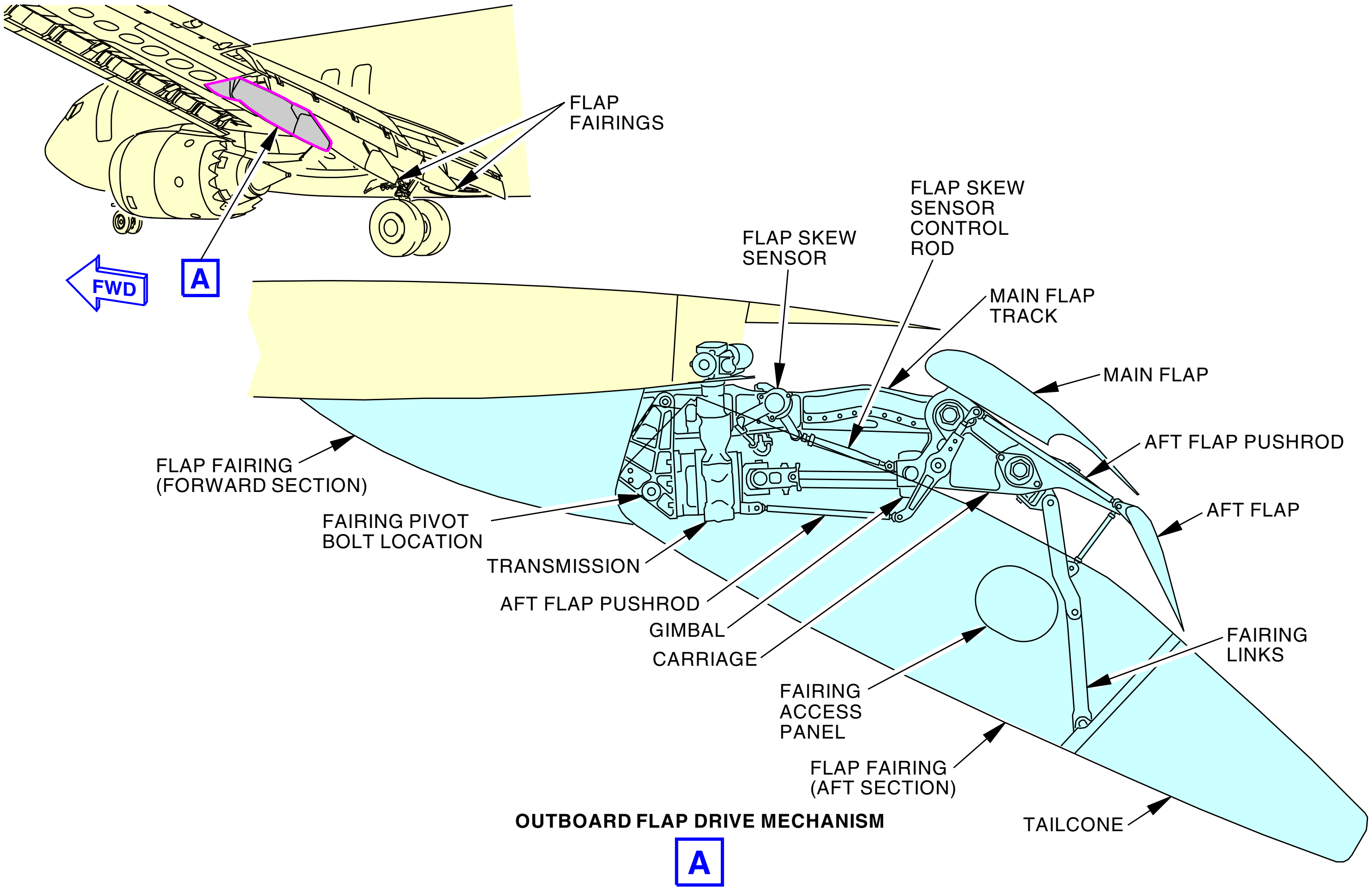
The aft flap pushrods move the aft flap. The outboard flaps have 4 aft flap tracks to help support the aft flap. The inboard flaps have 2 aft flap tracks.

Flap Fairings

The flap fairing links move the flap fairing. The flap skew sensor control rod moves the flap skew sensor input shaft.

The forward section attaches to the bottom of the wing. The aft section turns about a pivot bolt and is controlled by the fairing links. The tailcone attaches to the aft section.

TE FLAP SYSTEM - FLAP DRIVE MECHANISMS AND FAIRINGS



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TE FLAP SYSTEM - FLAP DRIVE MECHANISMS AND FAIRINGS

TE FLAP SYSTEM - INBOARD AND OUTBOARD FLAPS

Purpose

The inboard and outboard flaps increase the wing area and the wing camber. This helps improve the airplane performance during takeoff and landing.

Location

The inboard and outboard flaps are on the trailing edge of the wings.

Physical Description

The flaps have aluminum stiffeners and aluminum skins. The trailing edge wedge of the main flap is fiberglass skin bonded to a core of Nomex honeycomb.

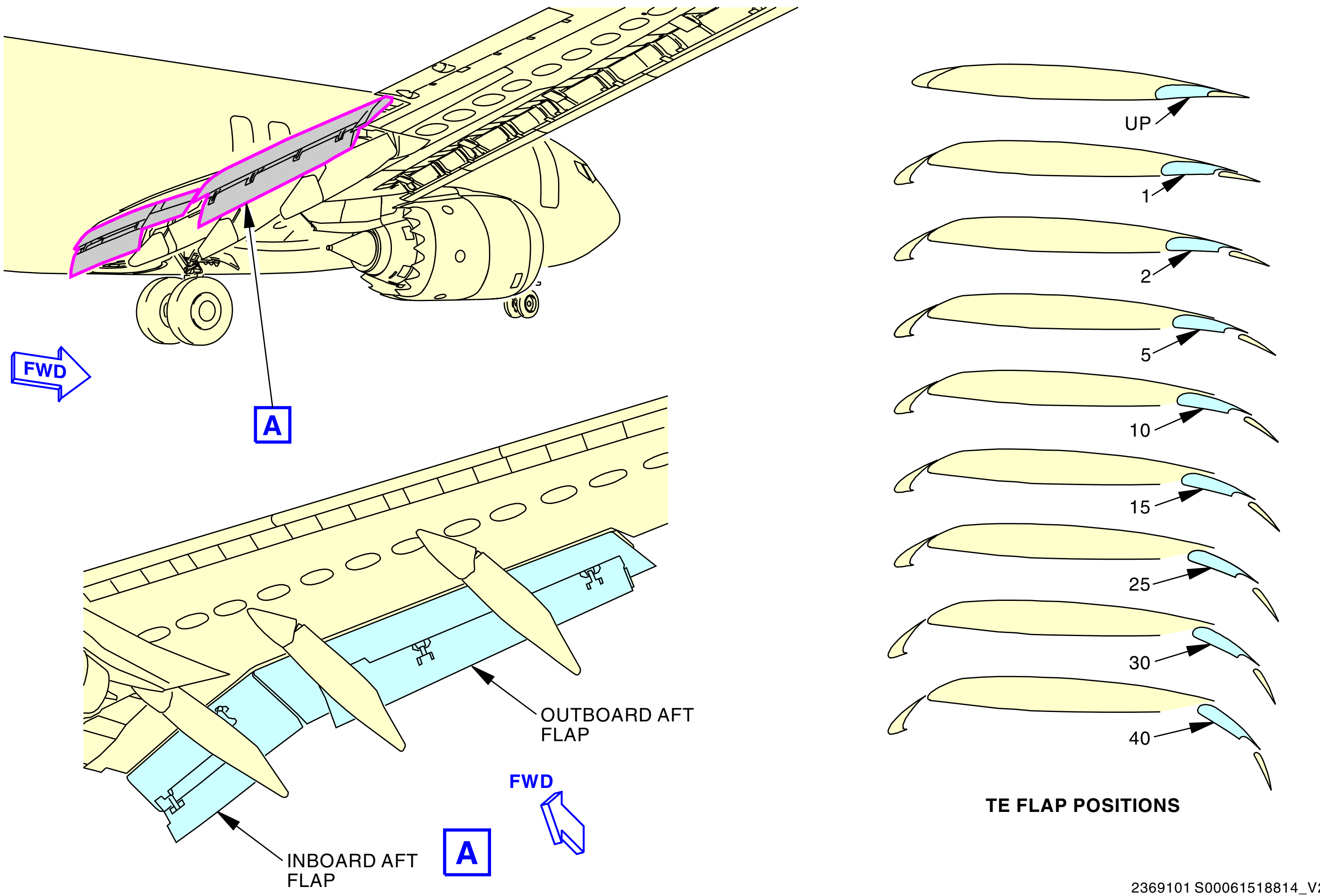
The dimensions of the inboard main flap are approximately 127 in. (3.2 m) by 44 in. (1.1 m). The dimensions of the inboard aft flap are approximately 84 in. (2.1 m) by 20 in. (0.5 m). The dimensions of the outboard main flap are approximately 223 in. (5.7 m) by 43 in. (1.1 m). The dimensions of the outboard aft flap are approximately 191 in. (4.9 m) by 19 in. (0.5 m).

The inboard main and aft flaps weigh approximately 270 lb (122.5 kg). The outboard main and aft flaps weigh approximately 300 lb (136.1 kg).

Functional Description

The TE flaps have nine positions. The TE flaps are fully extended when the flap lever is at the 40 detent position.

TE FLAP SYSTEM - INBOARD AND OUTBOARD FLAPS



TE FLAP SYSTEM - INBOARD AND OUTBOARD FLAPS

TE FLAP SYSTEM - OPERATION

Normal Operation

You use the flap lever to operate the TE flaps during normal operation. The normal operation requires system B hydraulic power.

The TE flaps move to nine different positions. The flap position indicator in the flight deck shows the position of the TE flaps.

During normal operation of the TE flaps, the LE devices move also.

Flap load relief is available during normal operation. If the airspeed increases more than the flap placard limit for the flap position, the flaps automatically retract to the next lower flap position. This occurs at flap position 30 and 40. The flap position indicator shows the actual position of the TE flaps, except during a flap skew condition.

If the TE flaps do not stay in alignment or if they move away from their commanded position, the TE flaps stop automatically. If this occurs, you can not operate the TE flaps again until the airplane lands and you correct the problem. The flap position indicator gives you indication that the TE flaps are out of alignment.

It takes approximately 38 seconds for the TE flaps to fully extend or fully retract during the normal operation.

Alternate Operation

You use the alternate flaps switches to operate the TE flaps during alternate operation. The alternate operation uses electric power instead of hydraulic power.

When you move the alternate flaps arm switch to the ARM position, this occurs:

- TE flap bypass valve moves to the bypass position
- Standby hydraulic pump starts
- Electrical power goes to the alternate flaps control switch.

The alternate flaps control switch operates only when you move the arm switch to the ARM position. When you move and hold the control switch in the DOWN position, the TE flaps and LE devices extend. To stop the extension of the TE flaps, move the control switch to the OFF position. To stop the extension of the LE devices, move the arm switch to the OFF position.

During alternate operation, the TE flaps can extend to the 40 unit position. It takes approximately 2 minutes and 39 seconds for the TE flaps to fully extend or fully retract during alternate operation.

NOTE: During alternate operation with system B hydraulic power applied, move the flap lever to the position that you will move the flaps to. This will decrease the load on the flap electric motor.

To retract the TE flaps, move the control switch to the UP position. The control switch has a detent at the UP position, thus, you do not have to hold the switch in the UP position. There are limit switches in the flap control unit that stop the flaps at the up and down limits. You cannot retract the LE devices using the alternate operation.

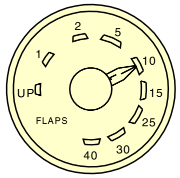
During alternate operation, load relief does not operate. Also, TE flap skew detection, asymmetry detection, and UCM detection are not available.

When you move the arm switch from the ARM position to the OFF position, alternate operation stops and normal operation becomes active. Before you do this, obey this warning:

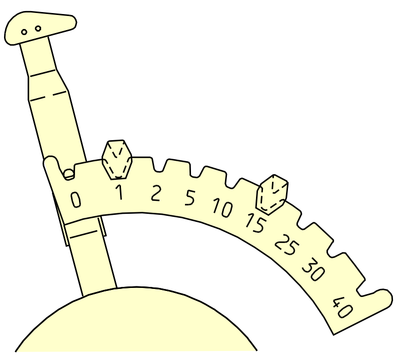
WARNING

MAKE SURE THAT THE POSITION OF THE TE FLAPS AGREES WITH THE POSITION OF THE FLAP CONTROL LEVER. WHEN YOU SUPPLY HYDRAULIC POWER, THE FLAPS AND SLATS WILL MOVE AUTOMATICALLY TO THE POSITION OF THE FLAP CONTROL LEVER. THIS CAN CAUSE INJURY TO PERSONS AND DAMAGE TO EQUIPMENT.

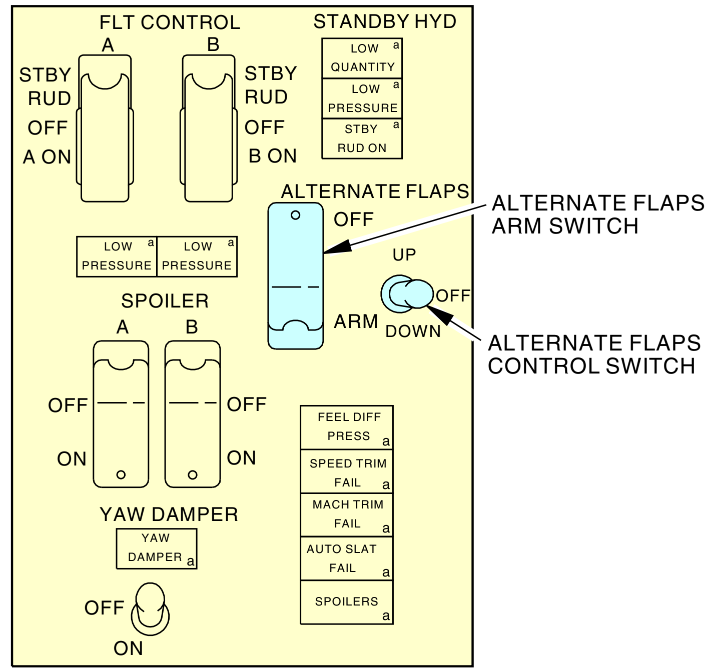
TE FLAP SYSTEM - OPERATION



FLAP POSITION INDICATOR (P1) (SHOWN WITH THE TE FLAPS AT 10)



FLAP LEVER (P10)



FLIGHT CONTROLS PANEL (P5)

2369102 S00061518816_V2

TE FLAP SYSTEM - OPERATION

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC OPERATION

General

These are the TE flap hydraulic components that are LRUs:

- Flap priority valve
- Flap flow limiter
- Flap control valve
- Flap load relief solenoid valve
- Flap bypass valve
- Flap hydraulic motor.

Functional Description

Hydraulic fluid from system B flows through the flap priority valve. This valve reduces the flow of hydraulic fluid to the TE hydraulic motor to 0.7 gpm (2.6 l/min) if the system B pressure is less than 2400 psi (16,547 kPa). This gives priority of system B hydraulic power to the LE devices over the TE flaps.

The flow limiter then limits the flow of hydraulic fluid to 14 gpm (53.0 l/min). This controls the speed of movement of the TE flaps.

The flap control unit has a control valve and a flap load relief solenoid. The control valve uses mechanical inputs from the flap lever cables to control the hydraulic flow to the hydraulic motor.

During flap load relief, the flap load relief solenoid energizes and moves the sleeve in the control valve. This causes the control valve to send hydraulic power to the retract side of the hydraulic motor.

The hydraulic power from the flap control unit goes to the flap bypass valve. This valve stops the hydraulic power to the hydraulic motor during non-normal operations. When the bypass valve is in the normal position, it allows hydraulic power from the flap control valve to go to the TE flap hydraulic motor.

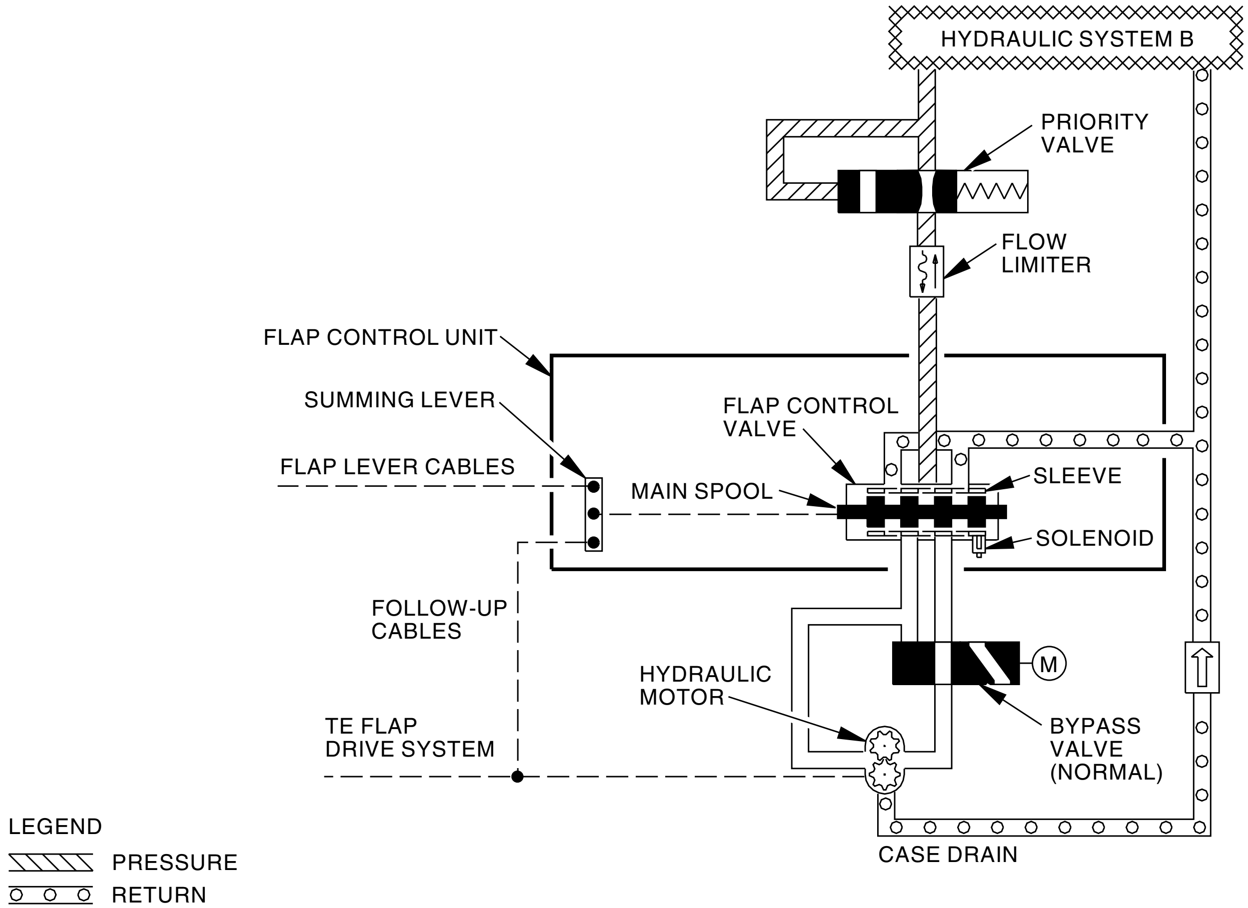
When the bypass valve moves to the bypass position, it connects the hydraulic lines on both sides of the hydraulic motor to each other. This does these:

- Stops operation of the hydraulic motor
- Prevents a hydraulic lock
- Lets alternate flaps operation backdrive the hydraulic motor.

The hydraulic motor is a reversible motor that moves the TE flap drive system to move the TE flaps. The TE flap drive system moves the follow-up cables, which move the summing lever. When the TE flaps move to the correct position, the main spool of the control valve moves to the center position. The control valve then stops the hydraulic power to the hydraulic motor.

It takes 22 to 27 seconds for the TE flaps to fully extend or fully retract during normal operation.

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC OPERATION



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TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC OPERATION

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC BYPASS

General

The alternate flaps arm switch and the FSEU control the position of the bypass valve. The bypass valve prevents the TE flap hydraulic motor operation during these conditions:

- Alternate flap operation
- TE flap skew
- TE flap asymmetry
- TE flap uncommanded motion (UCM).

The FSEU BITE also operates the bypass valve during the TE ASYM-SKW-IND test.

When the bypass valve is in the normal position, it lets hydraulic power from the TE flap control valve go to the TE flap hydraulic motor. When the bypass valve moves to the bypass position, it stops the hydraulic flow to the hydraulic motor.

Alternate Flap Operation

The bypass valve is in the normal position during the hydraulic operation of the TE flaps. When you move the alternate flaps arm switch to the ARM position, this switch supplies electrical power to move the bypass valve to the bypass position. This prevents a hydraulic lock on the hydraulic motor and lets the electric motor operate.

TE Flap Skew

The FSEU compares the data from symmetrical flap skew sensors to monitor the alignment of the TE flaps. If the FSEU finds a skew, it operates the bypass valve.

TE Flap Asymmetry

The FSEU compares the data from the left and right TE flap position transmitters to monitor the position of the TE flaps. If the FSEU detects a flap asymmetry, it energizes the bypass valve.

TE Flap Uncommanded Motion (UCM)

The FSEU compares the data from the TE flap skew sensors 1 and 8 to the data from the flap lever position sensor for the TE flap UCM detection. If the TE flaps move away from their commanded position, the FSEU operates the bypass valve.

The TE flap uncommanded motion function is inhibited at airspeeds below 60 knots. The FSEU gets airspeed data from the left ADIRU.

BITE

During the TE ASYM-SKW-IND test on the FSEU BITE, the bypass valve is commanded to the bypass position, then back to the normal position. If the bypass valve does not operate correctly, the BITE test fails.

DFDAU

The FSEU also sends disagree warning signals to the digital flight data acquisition unit (DFDAU).

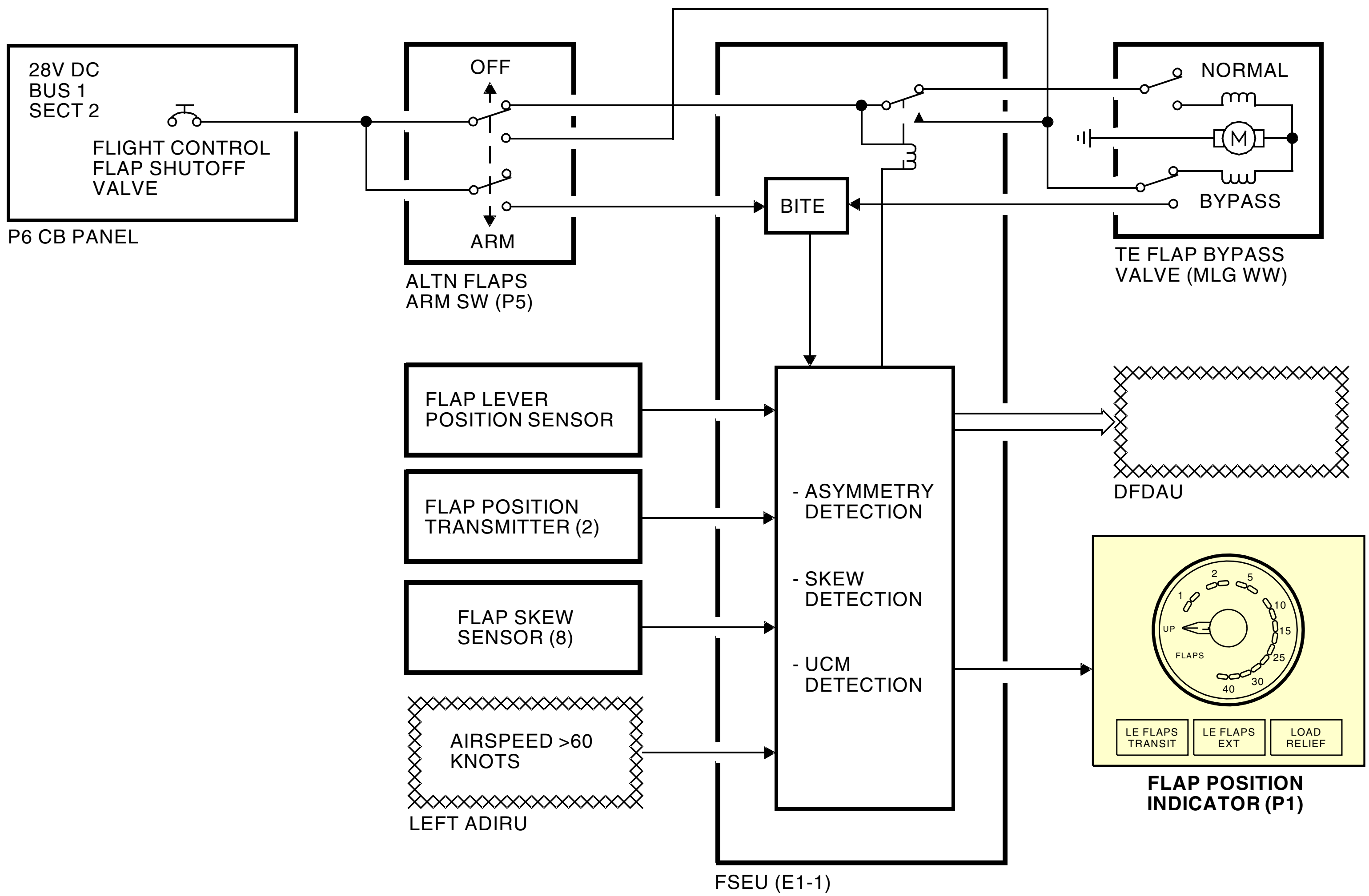
See the Flight Data Recorder System (FDRS) section for more information about the DFDAU (SECTION 31-31).

Position Indicator

The FSEU also sends signals to the position indicator.

See the TE Flap Position Indicating section for more information about the TE flap position indicator (SECTION 27-58).

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC BYPASS



2369104 S00061518820_V2

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC BYPASS

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ASYMMETRY DETECTION

General

Trailing edge flap asymmetry protection is provided in normal operation by the FSEU and the TE flaps bypass valve. No asymmetry protection is provided during alternate flaps operation.

Asymmetry Detection

When the FSEU detects a TE flap asymmetry, it sends a signal to the TE flaps bypass valve to move to the bypass position. In the bypass position, the bypass valve prevents TE flap hydraulic motor operation.

The FSEU compares the data from the left and right TE flap position transmitters to monitor the position of the TE flaps. If they are different by more than 9 resolver degrees, there is an asymmetry condition.

If the TE flaps are in an asymmetry condition, the FSEU sends electrical power to the bypass valve. This stops the hydraulic operation of the TE flaps.

During an asymmetry condition, the needles on the flap position indicator show the actual data from the flap position transmitters.

After a flap asymmetry, you must correct the asymmetry condition to permit normal operation again. The asymmetry condition resets when all of these conditions are true:

- The difference between left and right flap position transmitters is less than 7.5 degrees
- The airplane is on the ground
- The airspeed is less than 60 knots.

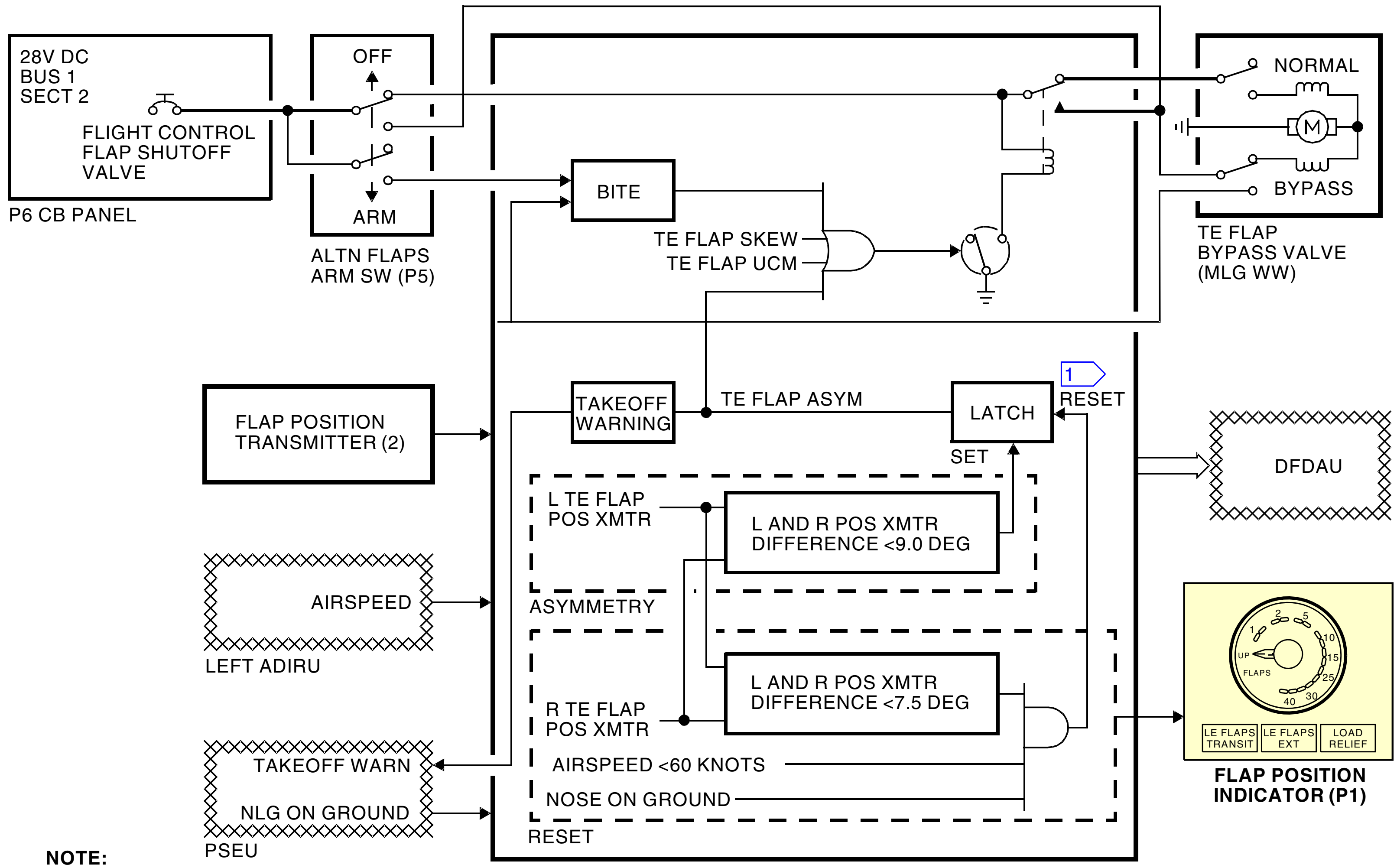
The FSEU also sends disagree warning signals to the digital flight data acquisition unit (DFDAU).

See the flight data recorder system (FDRS) section for more information about the DFDAU.

Test

The FSEU BITE TE ASYM-SKW-IND TEST? can also operate the TE flaps bypass valve.

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ASYMMETRY DETECTION



NOTE:
1 LATCH IS RESET PRIORITY

2369105 S00061518822_V2

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ASYMMETRY DETECTION

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - UNCOMMANDED MOTION DETECTION

General

These components supply uncommanded motion (UCM) protection for the trailing edge flap during normal operation:

- The flap slat electronics unit (FSEU)
- The bypass valve.

There is no UCM protection during alternate flaps operation.

TE Flap Uncommanded Motion (UCM) Detection

The FSEU finds and puts a limit on the TE flap travel if the flaps move without a pilot command. When the FSEU finds an uncommanded motion of the TE flap, it sends a signal to the TE flaps bypass valve. This causes the bypass valve to move to the bypass position. In the bypass position, the valve prevents TE flap hydraulic motor operation.

The FSEU compares the data from the TE flap skew sensors 1 and 8 to the data from the flap lever position sensor. The FSEU has retract and extend limits that change based on flap lever position and flap position. If the TE flaps move to less than the retract limit, or more than the extend limit, the FSEU detects an uncommanded motion.

The left ADIRU provides airplane speed input to the FSEU. The FSEU will detect a UCM at any airspeed. When a UCM is detected at an airspeed less than 60 knots, the FSEU sends a signal to the PSEU for the takeoff warning system. When a UCM is detected at an airspeed more than 60 knots, the FSEU also sends a signal to the TE flaps bypass valve to move to the bypass position.

During TE flap load relief operation, the FSEU changes the retract and extend limits to let the flaps move.

During an uncommanded movement, the needles on the flap position indicator show the actual data from the flap position transmitters.

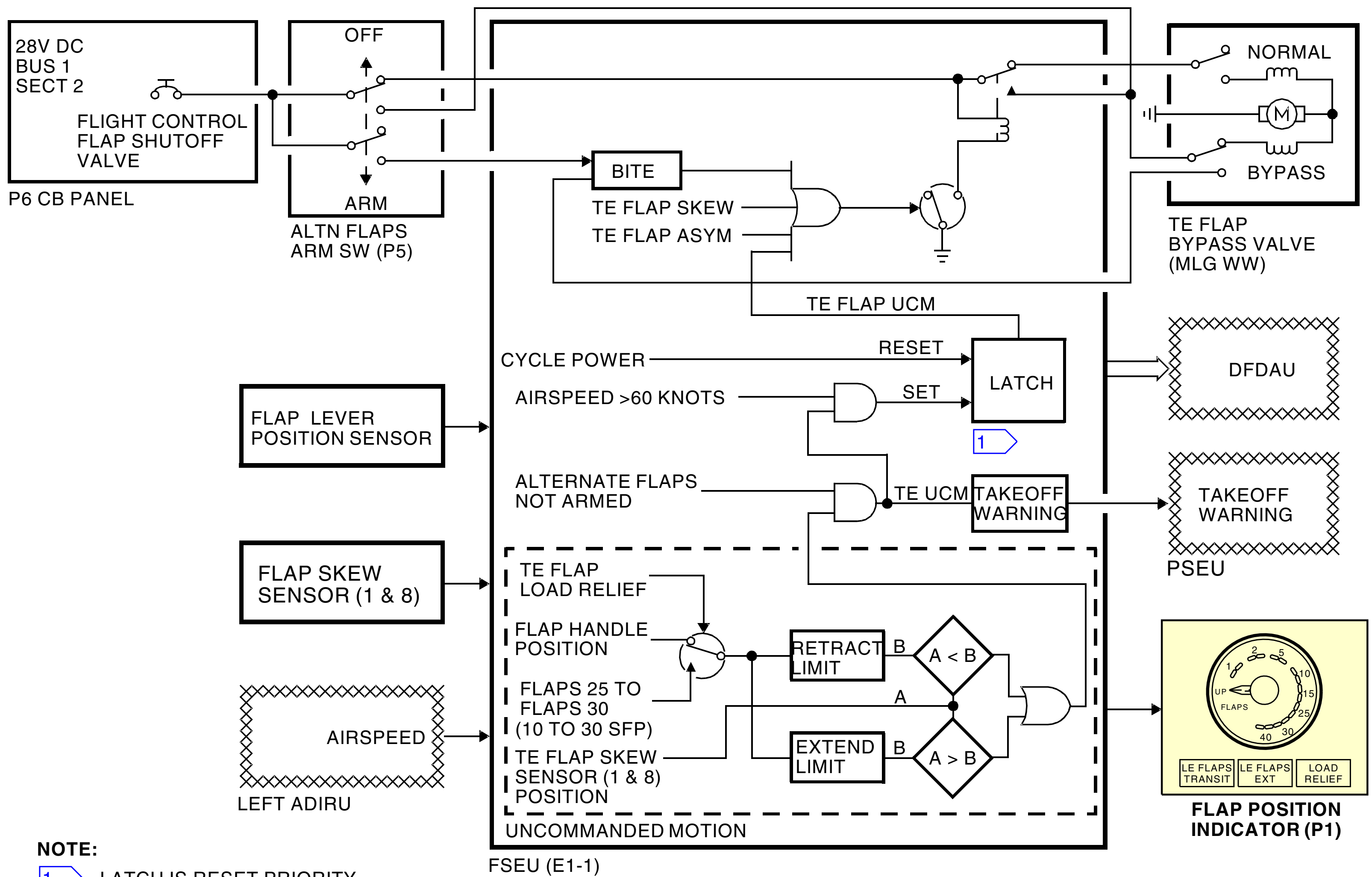
The FSEU also sends disagree warning signals to the digital flight data acquisition unit (DFDAU).

See the air ground system section for more information about the PSEU.

See the flight data recorder system (FDRS) section for more information about the DFDAU.

After a flap UCM, you must cycle the power to the FSEU on the ground to permit normal operation again.

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - UNCOMMANDED MOTION DETECTION



NOTE:
1 LATCH IS RESET PRIORITY

2369106 S00061518824_V2

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - UNCOMMANDED MOTION DETECTION

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - FLAP LOAD RELIEF

General

The flap load relief function prevents damage to the flaps and their support structures from large aerodynamic forces.

Flap load relief limits the positions of the TE flaps as a function of airspeed. Flap load relief operates only during normal operation of the TE flaps.

The FSEU also sends position signals to the digital flight data acquisition unit (DFDAU).

See the flight data recorder system (FDRS) section for more information about the DFDAU.

Load Relief - 40

The load relief solenoid energizes when the flap lever is at the 40 unit position and the airspeed increases to more than 167 knots. This causes the TE flaps to retract to the 30 position.

The load relief solenoid deenergizes when the pilot moves the flap lever to the 30 unit position or if the airspeed decreases to less than 162 knots.

Load Relief - 30

The load relief solenoid energizes when the flap lever is at the 30 unit position and the airspeed increases to more than 176 knots. This causes the TE flaps to retract to the 25 position.

The load relief solenoid deenergizes when the pilot moves the flap lever to the 25 unit position or if the airspeed decreases to less than 171 knots.

Load Relief - 25

The load relief solenoid energizes when the flap lever is at the 25 unit position and the airspeed increases to more than 191 knots. This causes the TE flaps to retract to the 15 position.

The load relief solenoid deenergizes when the pilot moves the flap lever to the 15 unit position or if the airspeed decreases to less than 186 knots.

Load Relief - 15

The load relief solenoid energizes when the flap lever is at the 15 unit position and the airspeed increases to more than 201 knots. This causes the TE flaps to retract to the 10 position.

The load relief solenoid deenergizes when the pilot moves the flap lever to the 10 unit position or if the airspeed decreases to less than 196 knots.

Load Relief - 10

The load relief solenoid energizes when the flap lever is at the 10 unit position and the airspeed increases to more than 211 knots. This causes the TE flaps to retract to the 5 position.

The load relief solenoid deenergizes when the pilot moves the flap lever to the 5 unit position or if the airspeed decreases to less than 206 knots.

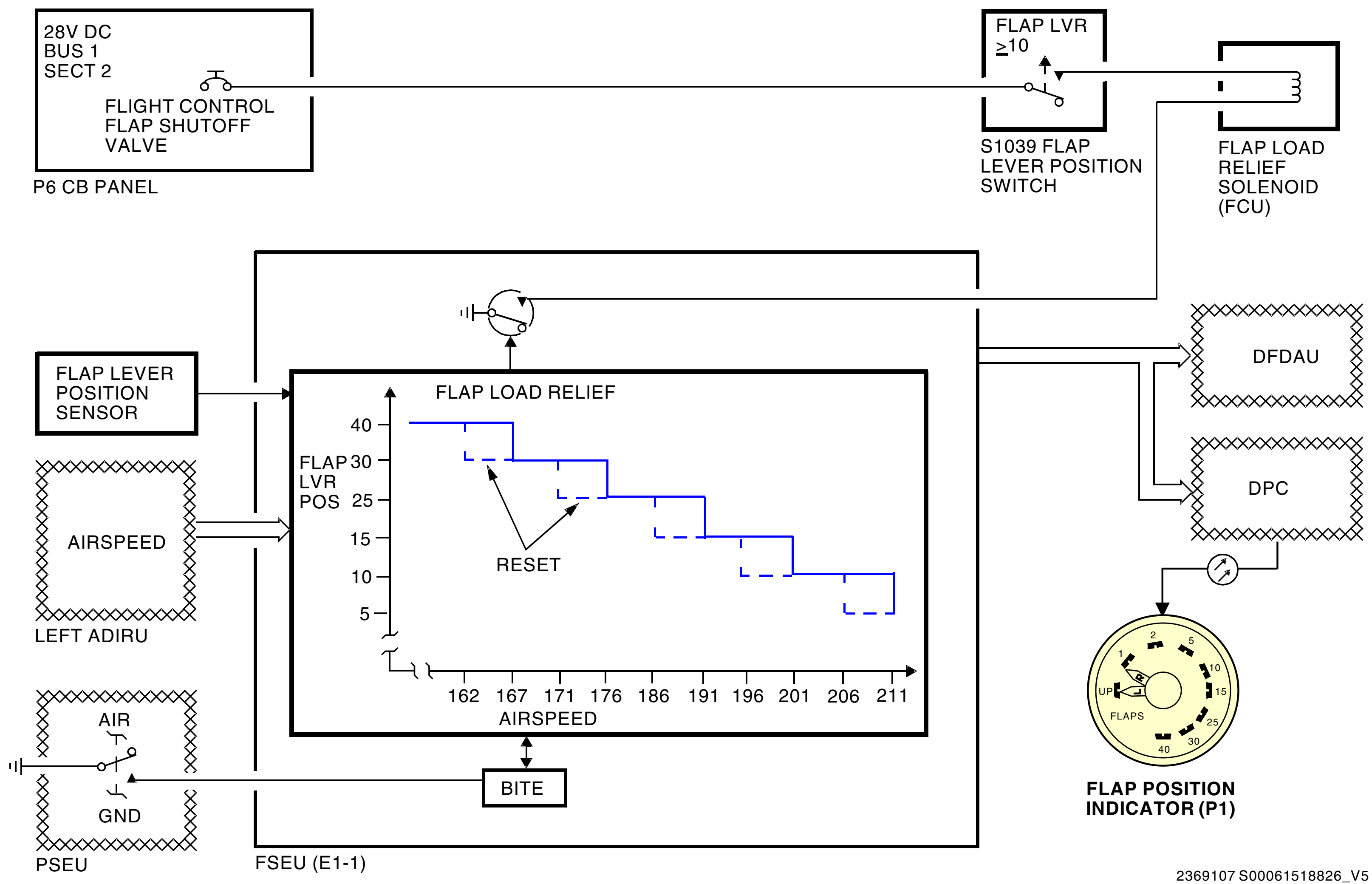
Indication

When the FSEU sends a command to energize the flap load relief solenoid, the flap LOAD RELIEF amber light shows on the P1 captain's panel.

Test

You can do a test of the flap load relief function when the airplane is on the ground. Use the BITE panel on the FSEU to do this test. During this test, the TE flaps move.

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - FLAP LOAD RELIEF



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TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - FLAP LOAD RELIEF

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ALTERNATE OPERATION

General

During the alternate operation, the alternate flaps switches control the Trailing Edge (TE) flap electric motor and flap bypass valve.

Arm

When you move the alternate flaps arm switch to the ARM position, electrical power becomes available to the alternate flaps control switch. The arm switch also supplies power to move the flap bypass motor-operated valve to the bypass position. This prevents a hydraulic lock on the hydraulic motor and permits the electric motor to operate.

Extend

When you move and hold the alternate flaps control switch in the DOWN position, the alternate flap down relay energizes. This lets the TE flap electric motor receive electrical power. The electric motor moves the TE flaps until you release the switch or move it to the OFF position. This stops the operation of the electric motor.

When the TE flaps move to the down position limit, the flap down switch deenergizes the alternate flap down relay. This also stops the operation of the electric motor. The flap down limit is at the flap 40 position.

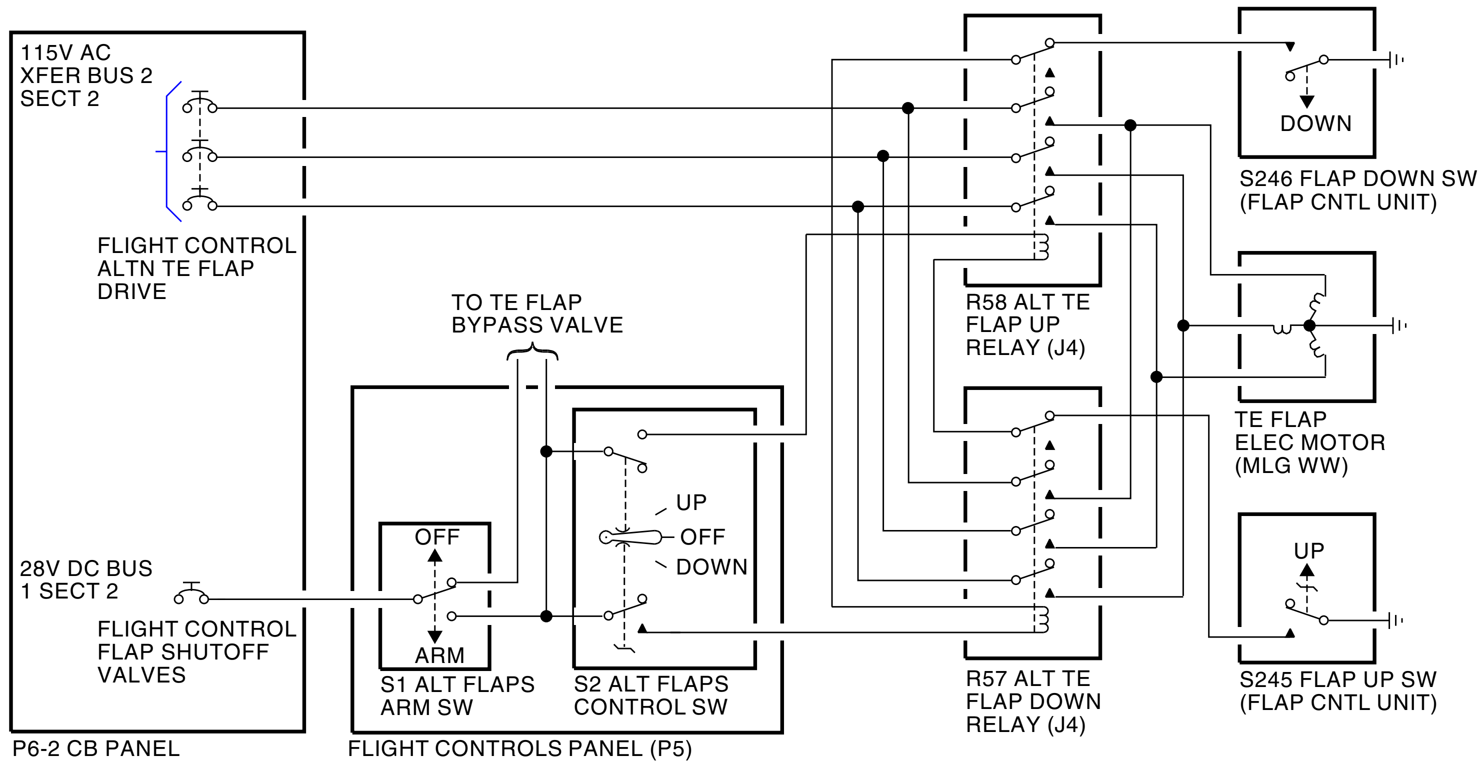
It takes approximately 2 minutes and 39 seconds for the TE flaps to fully extend during the alternate operation.

Retract

Retraction of the TE flaps is almost the same as extension, except you do not need to hold the control switch in the UP position. The flap up limit is at the flap up position.

It takes approximately 2 minutes and 39 seconds for the TE flaps to fully retract during the alternate operation.

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ALTERNATE OPERATION



2369109 S00061518829_V2

TE FLAP SYSTEM - FUNCTIONAL DESCRIPTION - ALTERNATE OPERATION

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TE FLAP POSITION INDICATING SYSTEM - INTRODUCTION

Purpose

The Trailing Edge (TE) flaps position indicating system shows position of the TE flaps during normal and alternate operations and during asymmetry and skew conditions.

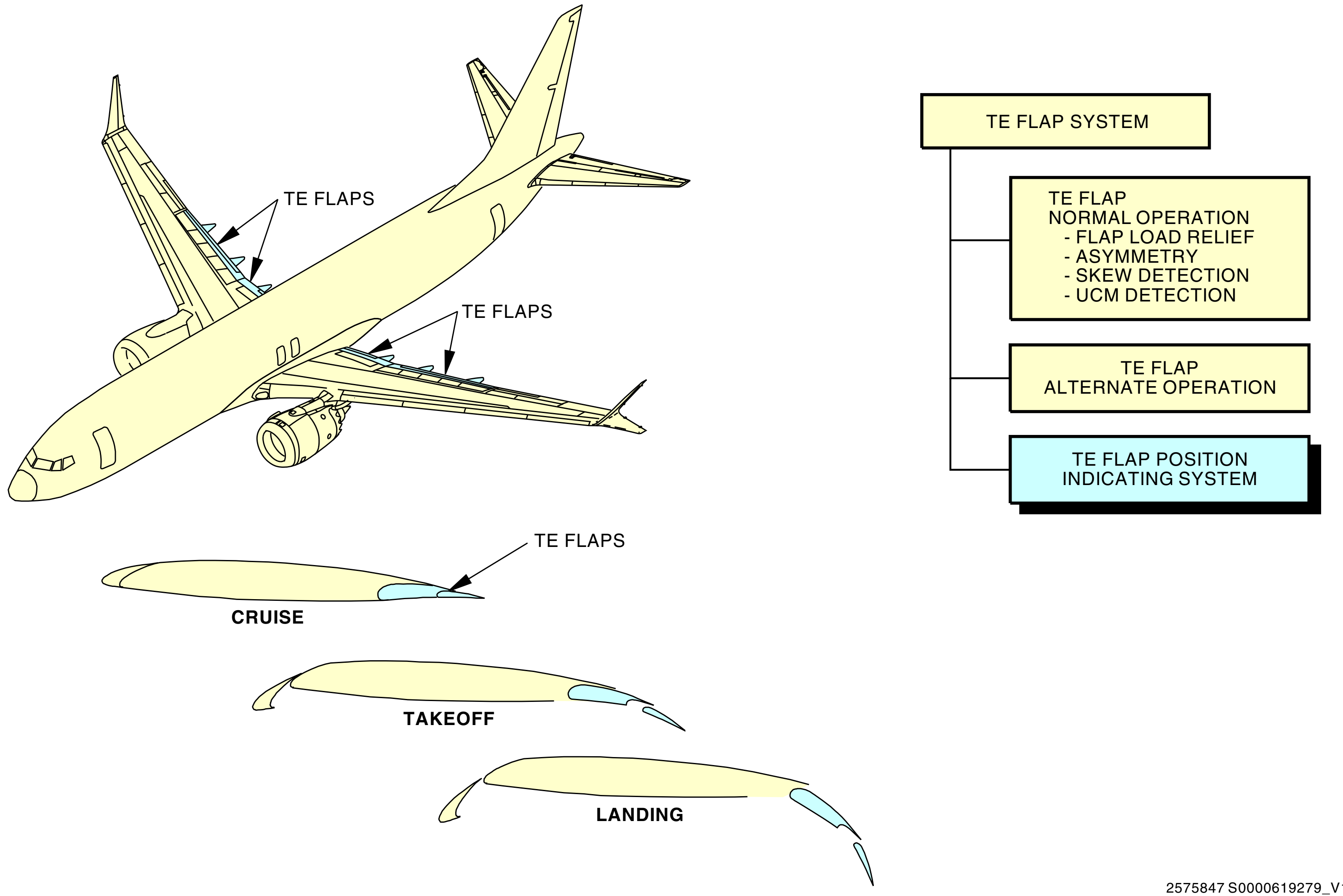
General

You can do tests of the TE flaps position indication with Built-In-Test Equipment (BITE) in the Flap/Slat Electronics Unit (FSEU). The FSEU BITE also lets you see other maintenance data. The TE flaps position also shows on the Flight Controls page in the MAINT DATA PGS screen on the MAX Display System (MDS).

Abbreviations and Acronyms

- ac - alternating current
- alt - alternate
- AMM - aircraft maintenance manual
- BITE - built-in test equipment
- CB - circuit breaker
- FCC - flight control computer
- FSEU - flap/slat electronics unit
- IFSAU - integrated flight systems accessory unit
- Hz - Hertz
- IND - indicator
- LE - leading edge
- NVM - non-volatile memory
- POS - position
- SMYD - stall management yaw damper
- sect - section
- snsr - sensor
- sw - switch
- TE - trailing edge
- UCM - uncommanded motion
- v - volts
- XFR - transfer
- xmtr - transmitter

TE FLAP POSITION INDICATING SYSTEM - INTRODUCTION



TE FLAP POSITION INDICATING SYSTEM - INTRODUCTION

TE FLAP POSITION INDICATING SYSTEM - GENERAL DESCRIPTION

General

The Trailing Edge (TE) flap position indicating system uses the flap position transmitters to measure the position of the TE flaps. This data shows on the flap position indicator in the flight deck and also goes to other user systems.

Interfaces with Other Components

The flap position transmitters send flap position data to these components:

- Flap/Slat Electronics Unit (FSEU)
- Flight Control Computer (FCC) (2). Left transmitter to FCC A and the right transmitter to FCC B
- Stall Management Yaw Dampers (SMYD) (2). Left transmitter to SMYD 2 and the right transmitter to SMYD 1.

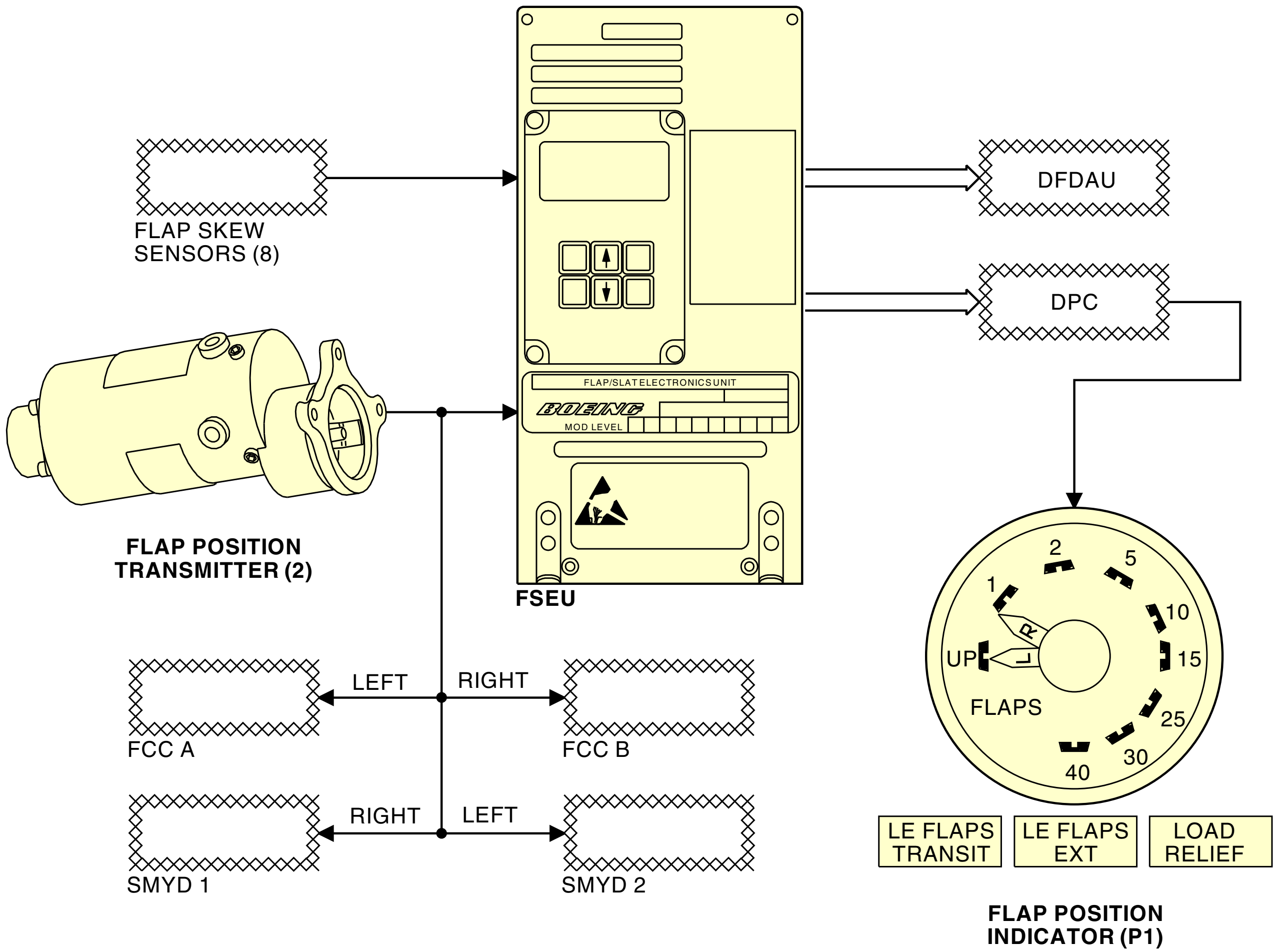
The FSEU uses this data to control the flap position indicator and to monitor the alignment of the TE flaps. The FSEU also sends this data to other systems.

The FSEU uses data from the flap skew sensors to monitor for a flap skew. During a flap skew, the FSEU tells the Display Processing Computer (DPC) to change the indication on the flap position indicator to show this condition.

The FSEU also sends disagree warning signals to the Digital Flight Data Acquisition Unit (DFDAU).

See the Flight Data Recorder System (FDRS) section for more information about the DFDAU (SECTION 31-31).

TE FLAP POSITION INDICATING SYSTEM - GENERAL DESCRIPTION



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TE FLAP POSITION INDICATING SYSTEM - GENERAL DESCRIPTION

TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION TRANSMITTER

Purpose

The flap position transmitters send flap position data to these components:

- Flap/Slat Electronics Unit (FSEU)
- Flight Control Computer (FCC) (2)
- Stall Management Yaw Dampers (SMYD) (2).

Location

There are two flap position transmitters. The position transmitters are at the left and right ends of the flap drive system, on transmissions 1 and 8. To get access, extend the Trailing Edge (TE) flaps.

Physical Description

Each flap position transmitter is a shaft driven unit consisting of a gear reducer driving three cam operated resolvers. Each resolver uses 28v ac, 400 Hz excitation. The excitation power for each resolver comes from a different computer. The unit is brushless, has no internal stops, and is capable of continuous rotation.

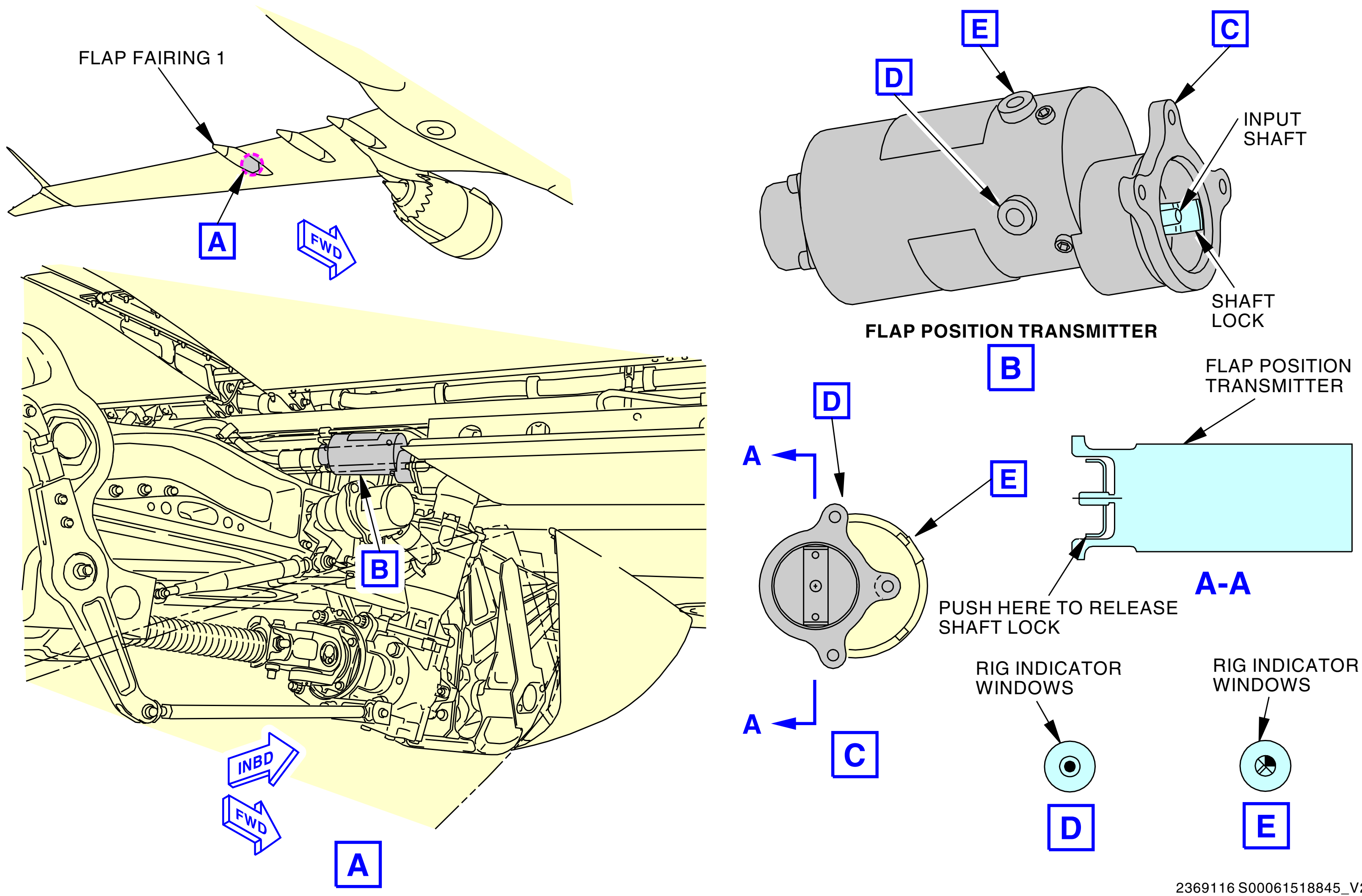
Each flap position transmitter has a locking device to keep the input shaft at the rig position. It also has two rig indicator windows. When the transmitter is installed, the locking device is disengaged.

Each flap position transmitter weighs 1.8 lb (0.8 kg).

Functional Description

The flap position transmitter outputs are 0 resolver degrees when the TE flaps are up and 270 resolver degrees when the TE flaps are at 40. The resolver degrees increase as the TE flaps extend.

TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION TRANSMITTER



TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION TRANSMITTER

TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION INDICATOR

Purpose

The flap position indicator shows the position of the left and right wing Trailing Edge (TE) flaps independently.

Location

The flap position indicator is on the first officer instrument panel.

Physical Description

The flap position indicator is driven by the Display Processing Computer (DPC) using inputs from the Flap/Slat Electronics Unit (FSEU). There are two concentric needles to show the position of the left and right wing TE flaps.

The left and right needles are independent. The indicator also has reference marks to show the flap lever detent positions.

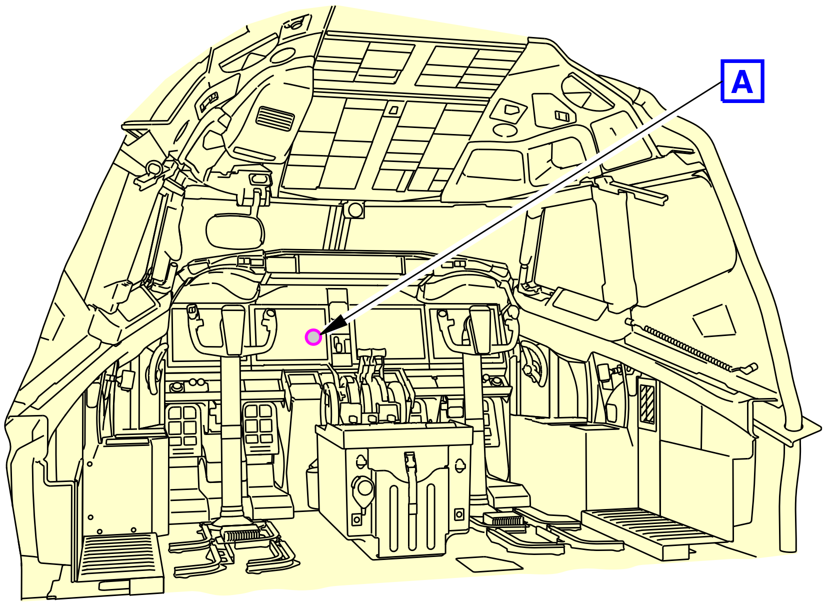
Functional Description

The DPC receives inputs from the FSEU, which receive inputs from the flap position transmitters.

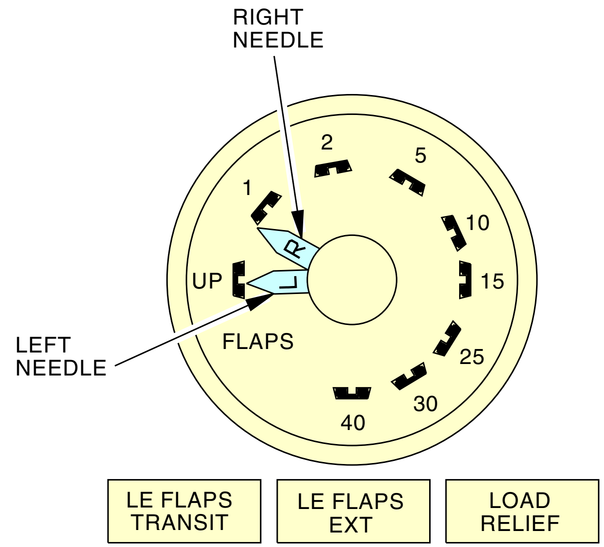
During an assymmetry, uncommanded motion, or skew condition the needles on the flap position indicator show the actual data from the flap position transmitters:

- Assymmetry - Needles split approximately 9 degrees and stop. When the flaps extend, the trailing needle is the problem side. When the flaps retract, the trailing needle is the problem side. When an assymmetry and skew condition occur at the same time, the needles bias to the assymmetry condition.
- Uncommanded motion - Both needles stop at the uncommanded position.
- Skew - Needles split approximately 15 degrees and stop. When the flaps extend, the trailing needle is the problem side. When the flaps retract, the trailing needle is the problem side.

TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION INDICATOR



FLIGHT COMPARTMENT



FLAP POSITION INDICATOR

A

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TE FLAP POSITION INDICATING SYSTEM - FLAP POSITION INDICATOR

TE FLAP POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION

General

There are two flap position transmitters. Each has three internal resolvers. The resolvers have interfaces with these components:

- Flap/Slat Electronics Unit (FSEU)
- Stall Management Yaw Dampers (SMYD) 1 and 2
- Flight Control Computer (FCC) A and B
- Integrated Flight System Accessory Unit (IFSAU).

Functional Description

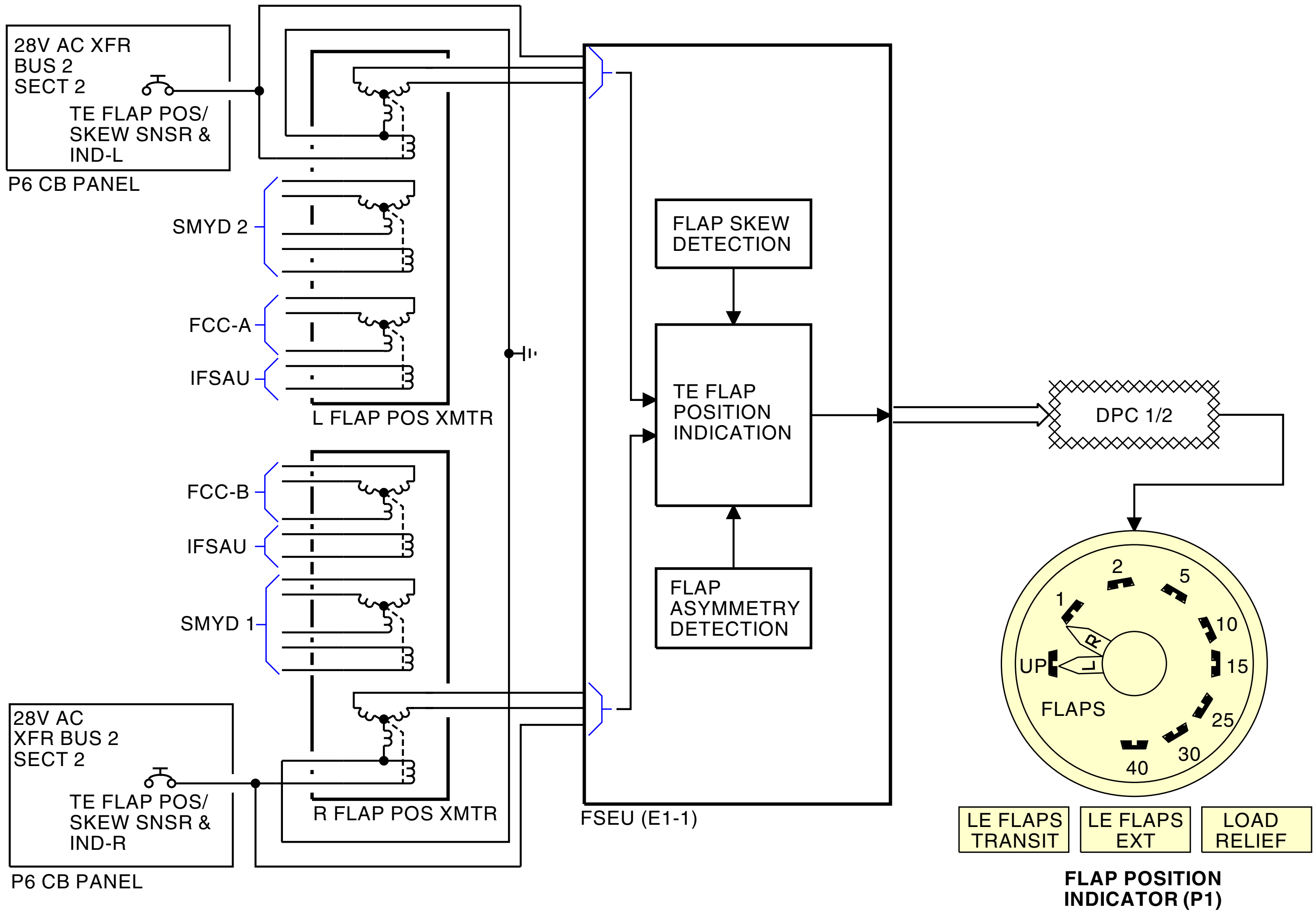
The FSEU uses flap position data from the flap position transmitters to send to the Display Processing Computer (DPC) for positioning the left and right pointers in the flap position indicator. The FSEU uses inputs from the asymmetry detection monitor. If the TE flaps are in an asymmetry condition, the FSEU changes the signals to one of the pointers in the flap position indicator. This causes the pointers to be 9 degrees apart during a TE flap asymmetry.

The FSEU also uses inputs from the flap skew monitor. If the TE flaps are in a skew condition, the FSEU changes the signals to one of the pointers in the flap position indicator. This causes the pointers to be 15 degrees apart during a TE flap skew.

The position transmitters receive excitation power from the IFSAU.

See the stall warning system for more information about the SMYDs (SECTION 27-32). See the autoflight chapter for more information about the FCCs and the IFSAU (SECTION 22-11).

TE FLAP POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION



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TE FLAP POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION

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TE FLAP SKEW DETECTION SYSTEM - INTRODUCTION

Purpose

The Trailing Edge (TE) flaps skew detection system shows position of the TE flaps during a skew condition.

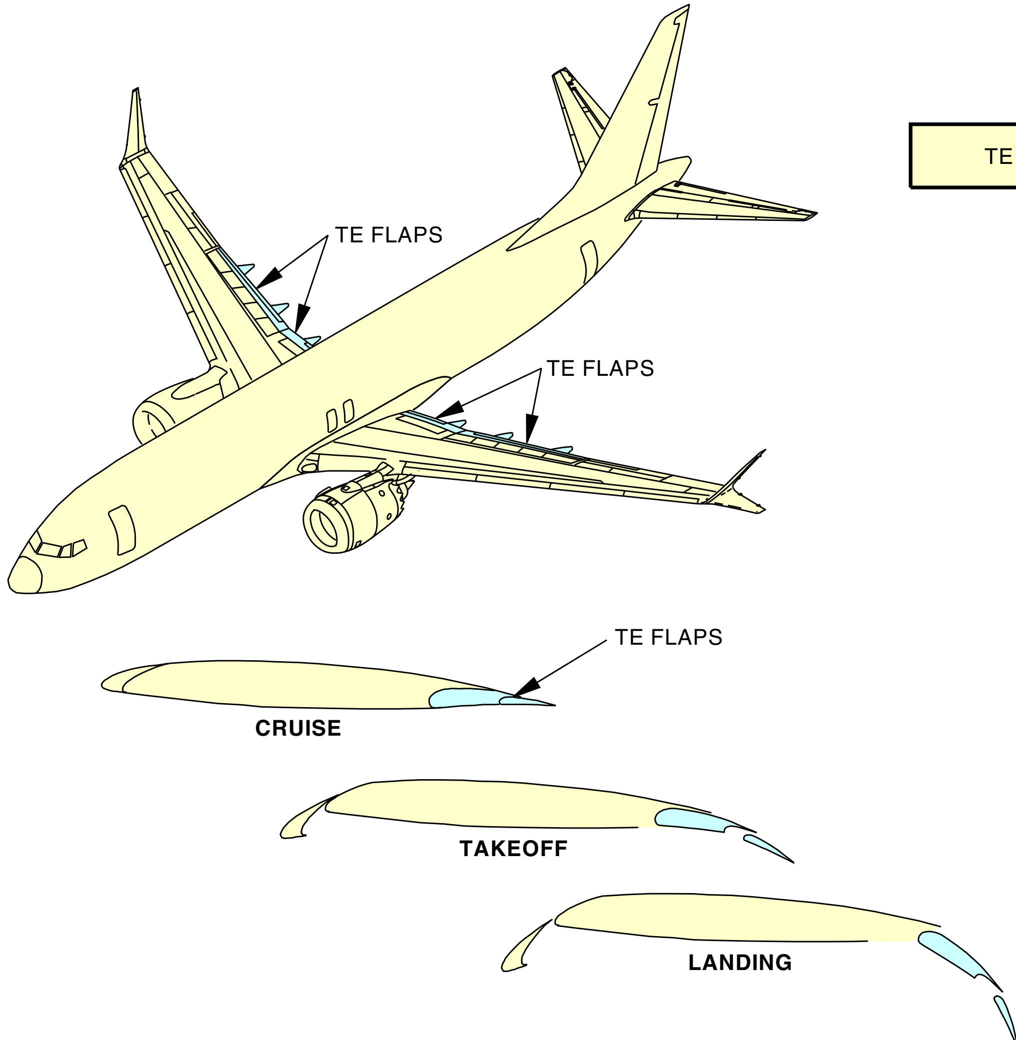
General

You can do tests of the TE flaps position indication with Built-In-Test Equipment (BITE) in the Flap/Slat Electronics Unit (FSEU). The FSEU BITE also lets you see other maintenance data.

Abbreviations and Acronyms

- alt - alternate
- AMM - aircraft maintenance manual
- BITE - built-in test equipment
- C/B - circuit breaker
- FCC - flight control computer
- FSEU - flap/slat electronics unit
- IFSAU - integrated flight systems accessory unit
- Hz - Hertz
- IND - indicator
- LE - leading edge
- NVM - non-volatile memory
- POS - position
- SMYD - stall management yaw damper
- sect - section
- snsr - sensor
- sw - switch
- TE - trailing edge
- UCM - uncommanded motion
- v - volts
- xfr - transfer
- xmtr - transmitter

TE FLAP SKEW DETECTION SYSTEM - INTRODUCTION



- TE FLAP SYSTEM
  - TE FLAP NORMAL OPERATION
    - FLAP LOAD RELIEF
    - ASYMMETRY
    - SKEW DETECTION
    - UCM DETECTION
  - TE FLAP ALTERNATE OPERATION
  - TE FLAP POSITION INDICATING SYSTEM
  - TE FLAP SKEW DETECTION SYSTEM

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TE FLAP SKEW DETECTION SYSTEM - INTRODUCTION

TE FLAP SKEW DETECTION SYSTEM - GENERAL DESCRIPTION

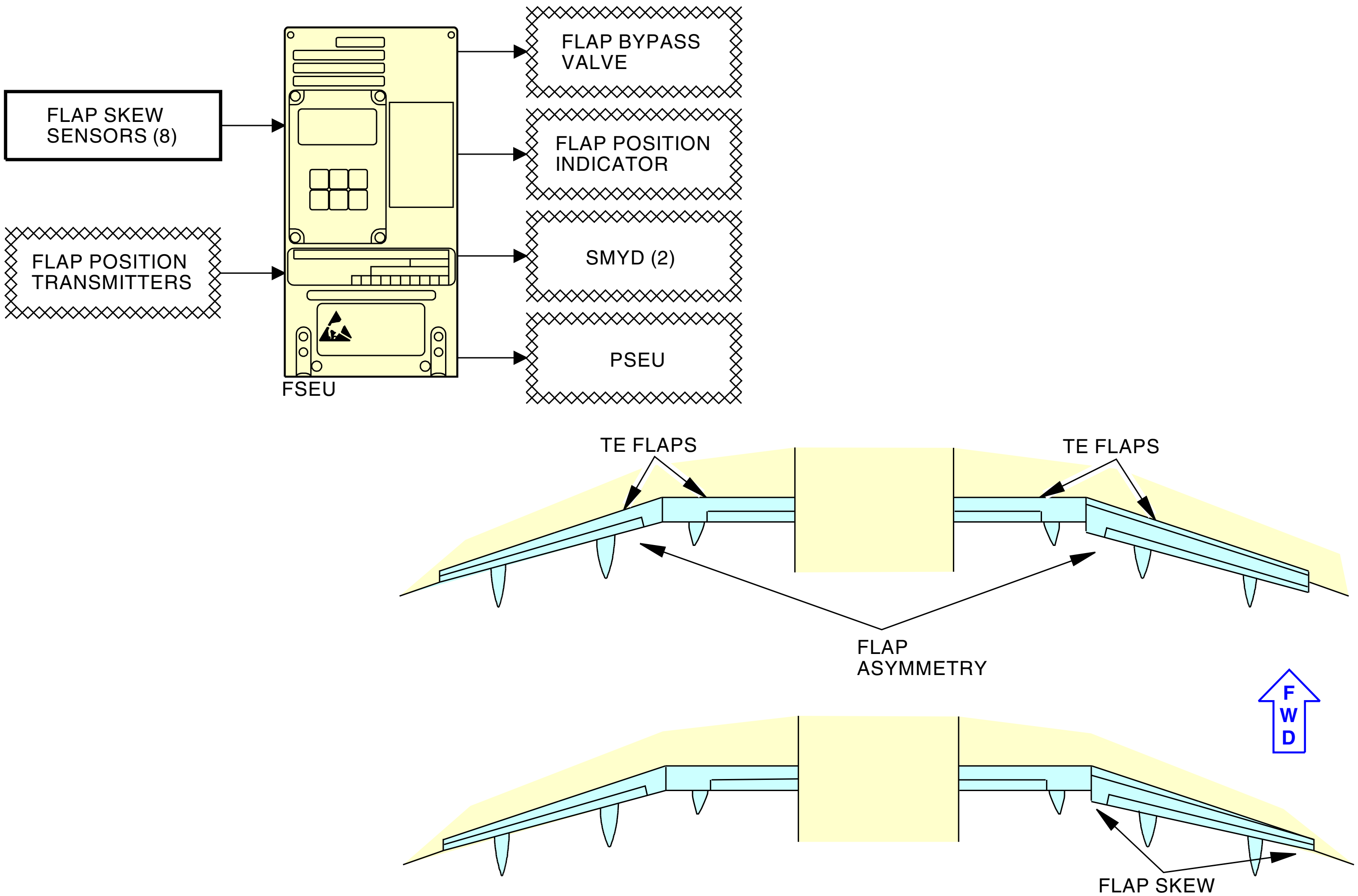
General

The flap skew detection system uses the Flap/Slat Electronics Unit (FSEU) to monitor the alignment of the Trailing Edge (TE) flaps. The FSEU uses data from the flap skew sensors and the flap position transmitters. If the TE flaps do not stay in alignment, the FSEU does these functions:

- Operates the flap bypass valve
- Changes the flap position indicator
- Sends data to the Stall Management Yaw Dampers (SMYDs) for stall warning
- Sends data to the Proximity Switch Electronic Unit (PSEU) for takeoff warning.

The FSEU monitors for a flap asymmetry condition and a flap skew condition. There is a flap asymmetry condition if a flap on one wing does not align with the symmetrical flap on the other wing. There is a flap skew condition if the inboard end of a flap does not align with the outboard end.

TE FLAP SKEW DETECTION SYSTEM - GENERAL DESCRIPTION



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TE FLAP SKEW DETECTION SYSTEM - GENERAL DESCRIPTION

TE FLAP SKEW DETECTION SYSTEM - FLAP SKEW SENSORS

Purpose

The flap skew sensors send flap position data to the Flap/Slat Electronics Unit (FSEU). The FSEU uses this data to monitor the alignment of the Trailing Edge (TE) flaps.

Location

There are eight flap skew sensors. There is one sensor at each flap drive mechanism. To get access to the sensors at flap drive mechanism 4 or 5, go through the MLG wheel well. To get access to all the other sensors, extend the TE flaps.

Physical Description

The flap skew sensors have two parts. The parts are an input assembly and a sensor connected to the assembly.

The flap skew sensor has a shaft-driven gear ratio changer of 2.5:1 that moves one synchro. Each synchro uses 28v ac 400 Hz excitation. The excitation power for each synchro comes from the FSEU. The sensor has an internal stop to put a limit on the continuous turns of the input shaft.

To get the rig position, align the location with no tooth on the input shaft with a hole in the skew sensor assembly.

Each flap skew sensor weighs 1.3 lb (0.6 kg).

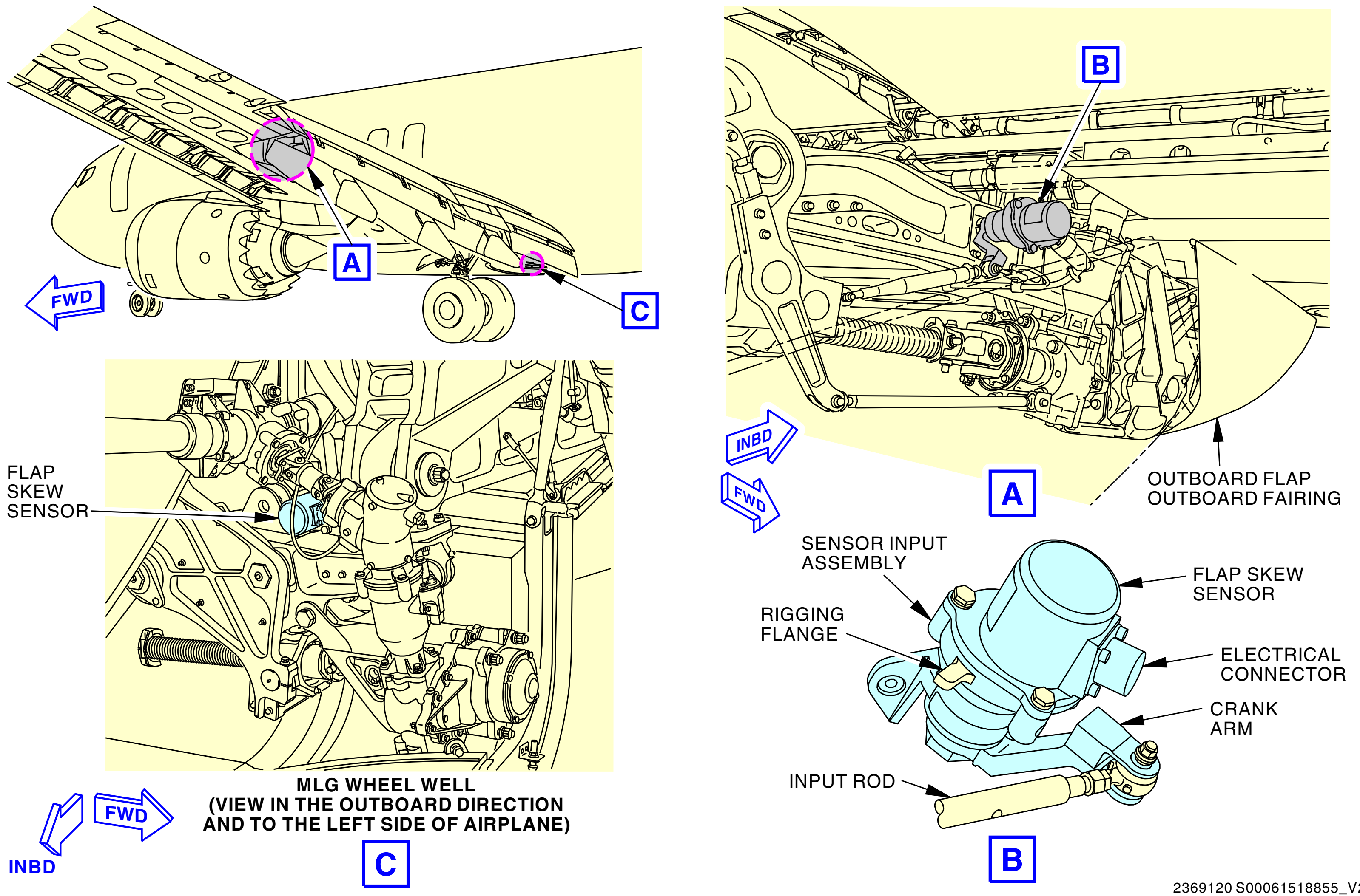
An input rod connects the skew sensor input assembly crank arm to the flap carriage.

Functional Description

When the input rod moves, a crank on the input assembly moves. This turns an internal shaft that turns the skew sensor resolver. The table below shows the resolver degrees when the TE flaps are at up and at 40. For sensors 1 thru 4, TE flap extension causes the resolver degrees to increase. For sensors 5 thru 8, TE flap extension causes the resolver degrees to decrease.

Flap Skew Sensor Outputs in Resolver Degrees								
	1	2	3	4	5	6	7	8
Up	303	338	6	340	20	354	22	57
40	233	288	297	274	86	63	72	127

TE FLAP SKEW DETECTION SYSTEM - FLAP SKEW SENSORS



TE FLAP SKEW DETECTION SYSTEM - FLAP SKEW SENSORS

TE FLAP SKEW DETECTION SYSTEM - FUNCTIONAL DESCRIPTION

General

There are eight flap skew sensors that interface with the Flap/Slat Electronics Unit (FSEU). The number in the name of each sensor relates to the flap drive mechanism that the sensor connects to.

The excitation power for the sensors on the left wing is independent from the excitation power for the sensors on the right wing. The wiring for the excitation power goes through each sensor.

Functional Description

The FSEU uses the data from the flap skew sensors to monitor the alignment of the Trailing Edge (TE) flaps. These monitoring functions are skew detection and asymmetry detection.

The skew detection and asymmetry detection functions can operate on the ground. Either condition can also cause the Proximity Switch Electronic Unit (PSEU) to command a takeoff warning.

The FSEU compares the data from symmetrical sensors. If the difference in the position of two symmetrical sensors is more than a limit, there is a skew condition. These are the resolver difference limits:

- 28 degrees between skew sensors 1 and 8
- 28 degrees between skew sensors 2 and 7
- 26 degrees between skew sensors 3 and 6
- 34 degrees between skew sensors 4 and 5.

The skew condition resets when the difference is less than 12.75 degrees and the aircraft is on the ground.

If the TE flaps are in a skew condition, the FSEU sends electrical power to the bypass valve. This stops the hydraulic operation of the TE flaps.

During the skew condition the FSEU sends an input to the flap position indication control. This causes the needles in the flap position indicator to be 15 degrees apart. To do this, the FSEU first finds which wing had the skew. Then it finds if the skew occurred during retraction or extension.

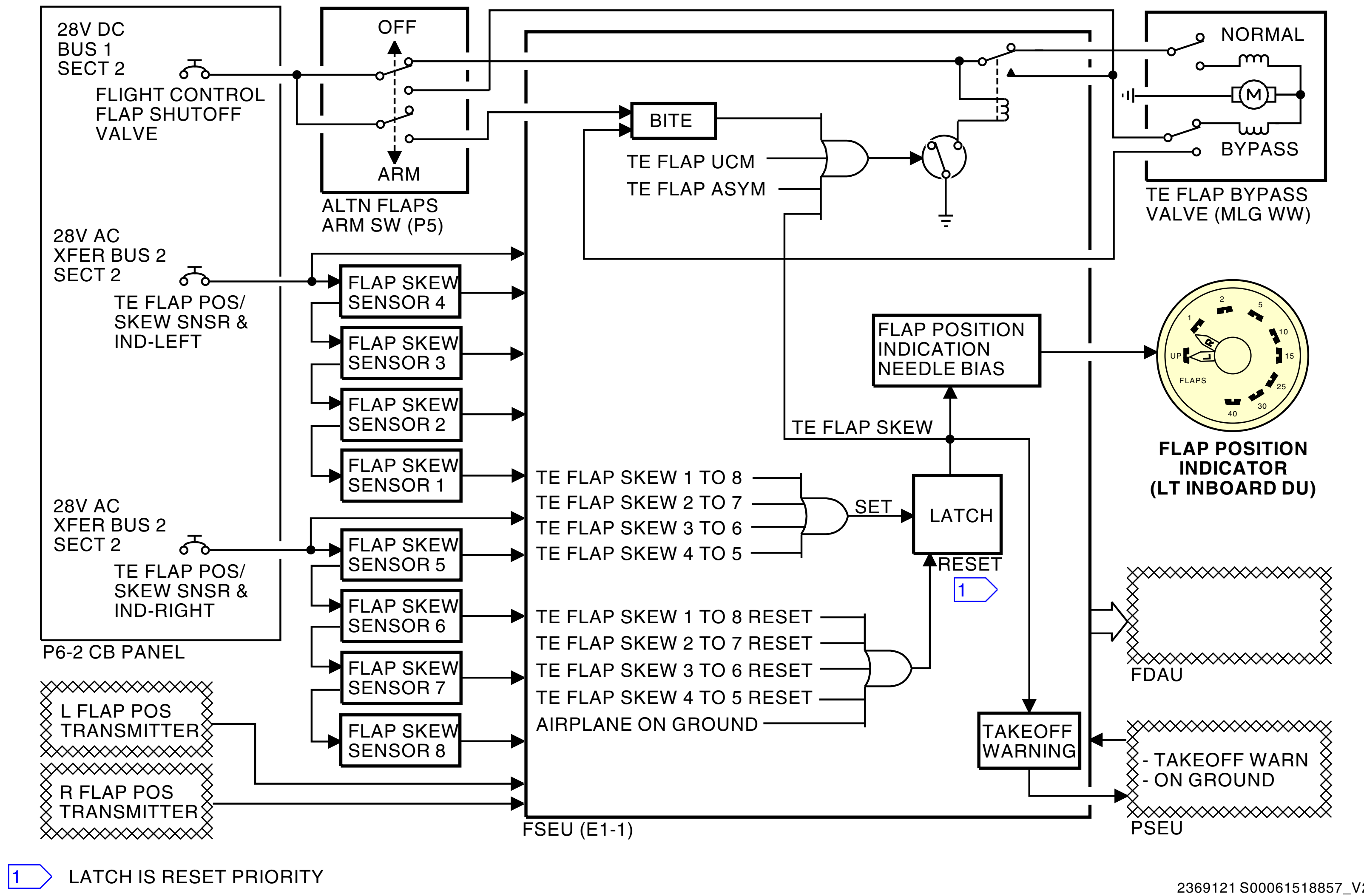
The FSEU compares the left skew sensor to the left flap position transmitter. If they disagree, then the skew is on the left wing, otherwise the skew is on the right wing.

The FSEU then compares the skew sensor on the skewed wing to the flap position transmitter. If the skew sensor position is more than the position transmitter position, the FSEU makes the needle for the skewed flap move 15 degrees in the extend direction. If the skew sensor position is less than the position transmitter position, the FSEU makes the needle for the skewed flap move 15 degrees in the retract direction.

The FSEU also sends disagree warning signals to the Flight Data Acquisition Unit (FDAU).

See the Flight Data Recorder System (FDRS) section for more information about the FDAU (SECTION 31-31).

TE FLAP SKEW DETECTION SYSTEM - FUNCTIONAL DESCRIPTION



TE FLAP SKEW DETECTION SYSTEM - FUNCTIONAL DESCRIPTION

FLIGHT SPOILER CONTROL SYSTEM - INTRODUCTION

General

The spoilers help the ailerons control airplane roll about the longitudinal axis. They also supply speedbrake control to reduce lift and increase drag during landing and refused takeoff.

There are six spoilers on each wing. The spoiler panels are mounted on the upper trailing edge of each wing and are, starting from the outboard left wing and moving right, designated as panels 1 through 12. The spoiler panels consist of both flight and ground spoilers. The ground spoilers are the most inboard and outboard spoiler panels on each wing (panels 1, 6, 7 and 12). The flight spoilers are the middle four panels on each wing (left wing panels 2, 3, 4 and 5; right wing panels 8, 9, 10, and 11).

The spoiler panels are also used as speedbrakes. The eight flight spoiler panels are used as both in-flight and ground speedbrakes while the ground spoilers are only used as ground speedbrakes.

The ground spoilers only deploy after a landing and have two positions, either full up or full down.

The new fly-by-wire lateral system provides control for the eight flight spoilers and the four ground spoilers via a single Spoiler Control Electronics (SCE) unit.

Each flight spoiler is controlled by a single hydraulic PCU, and positioned in response to control wheel and speedbrake lever position and also commanded based on airplane configuration and situational data.

Deployment of the ground spoilers is controlled by the Ground Spoiler Control Module (GSCM) which contains electronically actuated arm and control valves.

Roll Control

During roll control, the flight spoilers on one wing move up and all the other spoilers stay down.

The pilots manually control roll with the control wheels. When the autopilot is in autoland, the autopilot commands the flight spoilers.

Speedbrake Control

During speedbrake control, the spoilers on both wings move symmetrically.

The pilots manually command speedbrake control with a speedbrake lever on the aisle stand. The autopilot does not control the speedbrake function.

See the speedbrake control section for more information on the speedbrake control system. (SECTION 27-62)

Auto Speedbrake Control

The auto speedbrake function supplies automatic extension or retraction of all the spoilers during landing and refused takeoff.

An auto speedbrake function serves to reduce pilot workload by automatically deploying all spoiler panels to full deflection upon landing to help decelerate the airplane.

See the speedbrake control system section for more information on the auto speedbrake function. (SECTION 27-62)

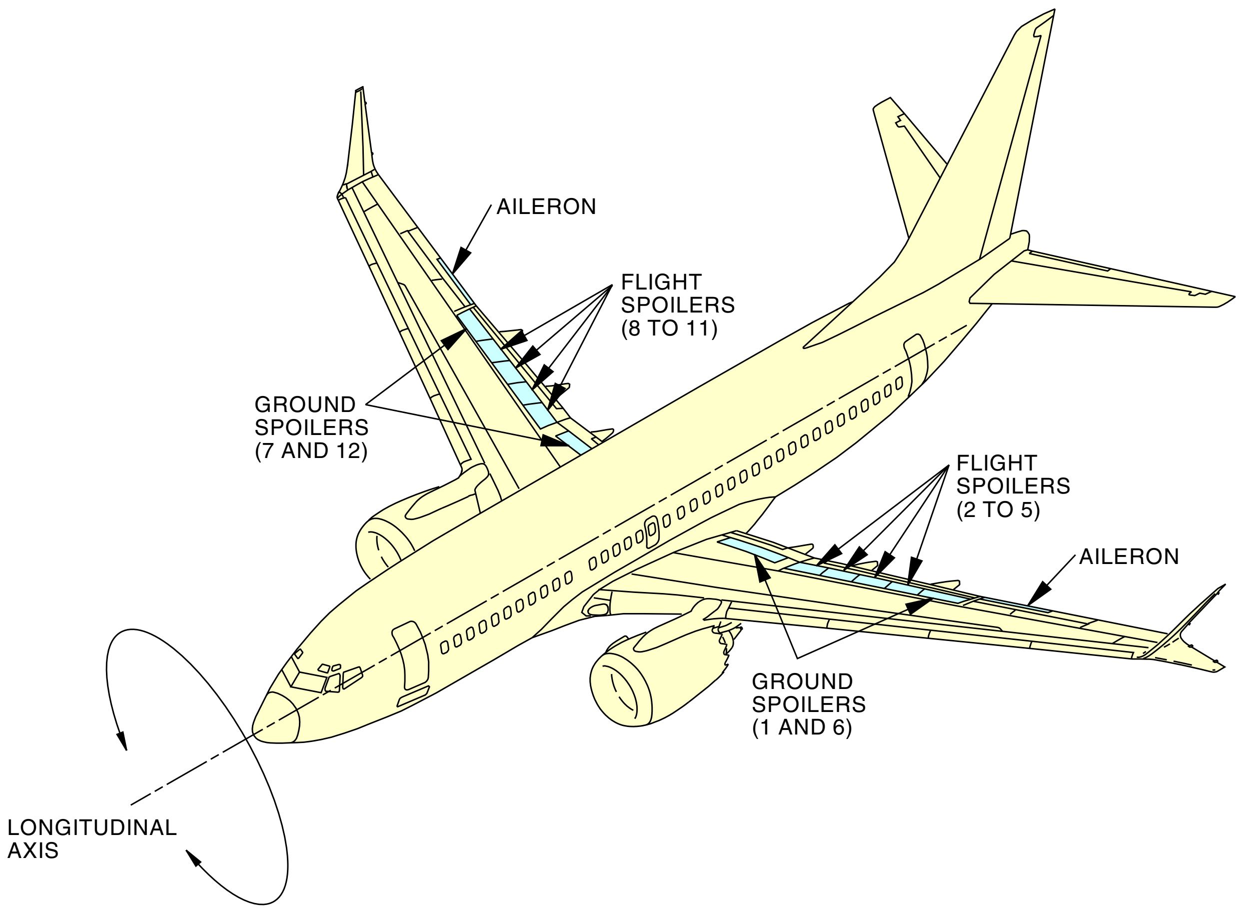
Abbreviations and Acronyms

- alt - altitude
- BITE - built-in test equipment
- deg - degrees
- DFCS - digital flight control system
- DFDAU - digital flight data acquisition unit
- FCC - flight control computer
- ft - feet
- fwd - forward
- gnd - ground
- GSCM - ground spoiler control module
- Hz - hertz
- in - inch
- MLG - main landing gear
- PCU - power control unit

FLIGHT SPOILER CONTROL SYSTEM - INTRODUCTION

- prox - proximity
- PSEU - proximity switch electronics unit
- RTO - refused takeoff
- SCE - spoiler control electronics
- sect - section
- spdbk - speedbrake
- splr - spoiler
- sw - switch
- sys - system
- TD - time delay
- TE - trailing edge

FLIGHT SPOILER CONTROL SYSTEM - INTRODUCTION



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FLIGHT SPOILER CONTROL SYSTEM - INTRODUCTION

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FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION

General

The flight crew uses the control wheels and speedbrake lever to manually move the flight spoilers. The autopilot controls them during autoland.

Manual Operation - Control Wheels

The flight crew uses the control wheels to control the roll. The control wheels drive one single load path cable system providing input to the aileron control quadrant.

The left control wheel is connected directly to the aileron cable system and a bus cable to the right control wheel. The aileron cable system controls the position of the aileron control quadrant.

The right control wheel is connected to the left control wheel to provide synchronous operation of the two control wheels. The connection is accomplished via a bus cable connected to a drum at the base of each control column. The bus cable is dual load path to prevent a single failure from causing a disconnect between the Captain and First Officer Control Wheels.

The ailerons are positioned by two independent PCUs. The PCUs are hydro-mechanical servos, each powered by a separate hydraulic system.

This aileron cable system is installed along the left side of the aircraft. Hydraulic pressure from the spoiler shutoff valves goes to the actuators. After a specified amount of control wheel movement, a control valve in each flight spoiler actuator permits hydraulic power to move the actuators. Each actuator moves a flight spoiler.

Aileron travel is limited by stops within the PCU. Control wheel feel and centering force is provided by the feel and centering mechanism.

The aileron cable system drives the aileron control quadrant which provides input to two parallel moving-body Power Control Units (PCUs). The aileron PCUs drive the aileron surfaces through single load path wing cable runs. The ailerons are mass balanced for flutter suppression. Balance panels are used to reduce aileron hinge moment which reduces control wheel forces in manual reversion. Each aileron also contains a geared tab mechanism to aid in lowering control forces during manual reversion.

The flight crew uses the spoiler shutoff switches on the P5 aft overhead panel to close the spoiler shutoff valves. This stops the hydraulic power to the flight spoiler actuators and the flight spoilers move down.

There is no manual reversion for the flight spoilers.

Manual Operation - Aileron Trim

During aileron trim, the aileron trim switches cause the trim actuator to move the feel and centering unit. This movement goes to the flight spoiler actuators. The actuators move the flight spoilers only if there is a large amount of trim.

See the ailerons section for more information on the aileron and aileron trim control system. (SECTION 27-11)

Autopilot Operation

When engaged, the autopilot system gives mechanical input to the aileron system. The aileron PCUs supply inputs to the flight spoiler actuators. The actuators move the flight spoilers if the flight control computers (FCCs) command is more than a specified amount of control wheel movement.

See the ailerons section for more information on the aileron autopilot operation. (SECTION 27-11)

Speedbrake Operation

The speedbrakes are controlled through a single conventional speedbrake lever located on the center aisle stand just left of the engine throttle levers.

The flight crew uses the speedbrake lever to control the speedbrake operation. The new fly-by-wire lateral system provides control for the eight flight spoilers and open-loop control of the four ground spoilers via a single Spoiler Control Electronics (SCE) unit.

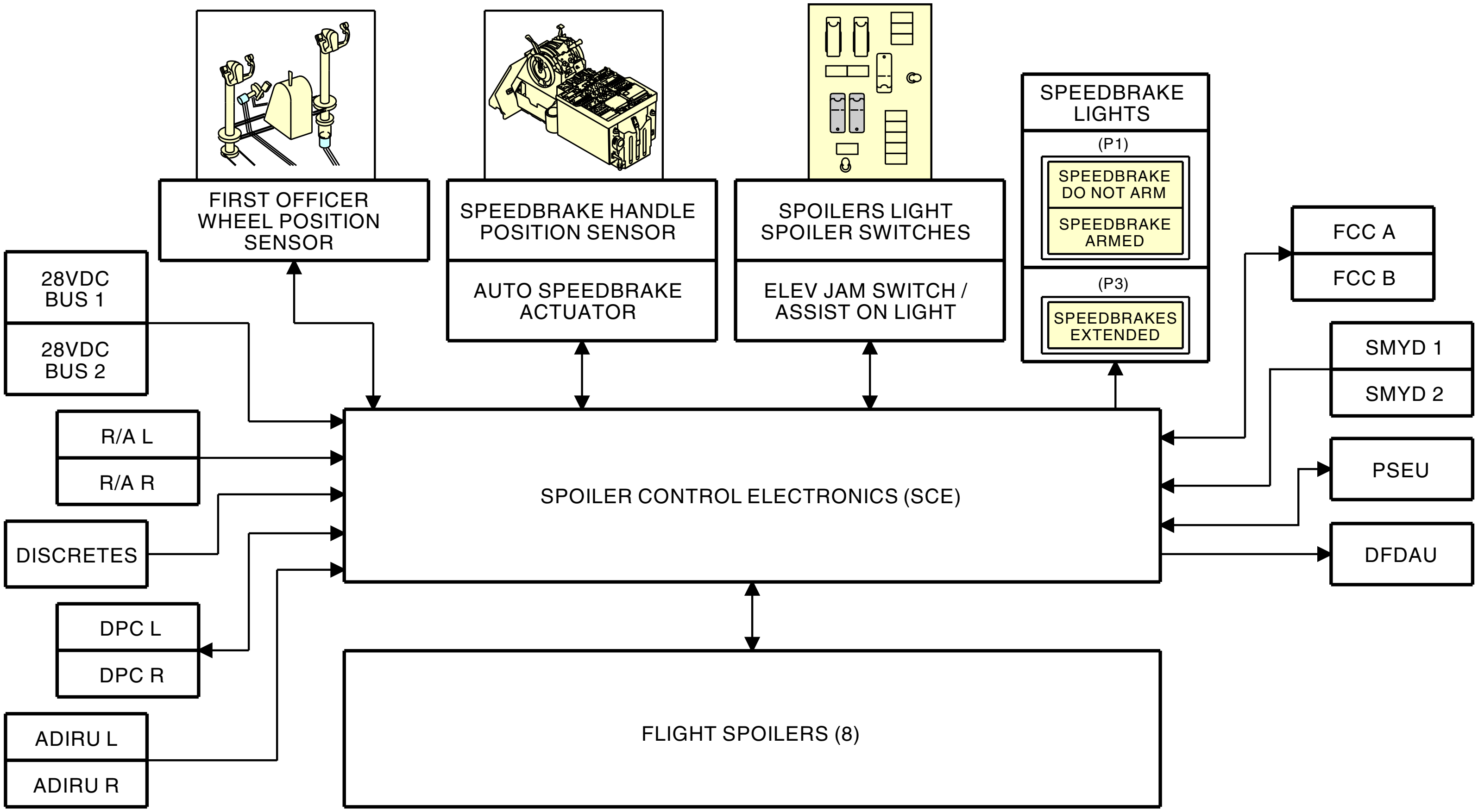
See the speedbrake control system section for more information on the speedbrake control system. (SECTION 27-62)

When the speedbrake handle moves, it gives an input to the speedbrake lever position sensor. The speedbrake lever position sensor provides an input to the DFDAU.

FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION

When the flight spoilers move, they give an input to the spoiler position transmitters and the spoiler position sensors. The spoiler position transmitters provide an input to the DFDAU. The spoiler position sensors provide an input to the FCCs.

FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION



LEGEND:

ADIRU	AIR DATA INERTIAL REFERENCE UNIT	PSEU	PROXIMITY SWITCH ELECTRONICS UNIT
DFDAU	DIGITAL FLIGHT DATA ACQUISITION UNIT	R/A	RADIO ALTIMETER
DPC	DIGITAL PROCESSING CONTROLLER	SMYD	STALL MANAGEMENT YAW DAMPER
FCC	FLIGHT CONTROL COMPUTER		

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FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION

FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION - FLY-BY-WIRE

General

These are the components of the flight spoiler control system:

- Spoiler control electronics (SCE)
- Ground spoiler control module (GSCM)
- Control wheel position transducer
- Speedbrake lever position transducer
- Flight spoiler shutoff valve
- Flight spoilers (8)
- Flight spoiler actuators

The flight spoiler control system receives inputs from the first officer control wheel position transducer and the speedbrake lever position transducer.

Spoiler Control Electronics

The SCE supplies control of the spoilers and speedbrakes.

The SCE supplies control for these functions:

- Roll and speedbrake control for eight flight spoilers (four pairs)
- Control of ground spoiler control module (GSCM)
- Control of the auto speedbrake actuator
- Interfaces with other airplane systems
- Safety and maintenance monitoring.

The SCE receives inputs from the control wheel, the speedbrake lever, and the flight spoiler position sensors.

The SCE uses the GSCM to operate the ground spoilers.

See the speedbrake control system section for more information about the ground spoilers and the ground spoiler control module (SECTION 27-62).

Ground Spoiler Control Module

The GSCM sends input to the ground spoiler actuators to extend or retract.

The ground spoiler actuators use hydraulic power to move the spoilers.

The ground spoilers have two positions, full extend or full retracted.

Control Wheel Position Transducer

The control wheel position transducer sends input to the SCE.

See the speedbrake control system section for more information about the ground spoilers and the ground spoiler control module (SECTION 27-62).

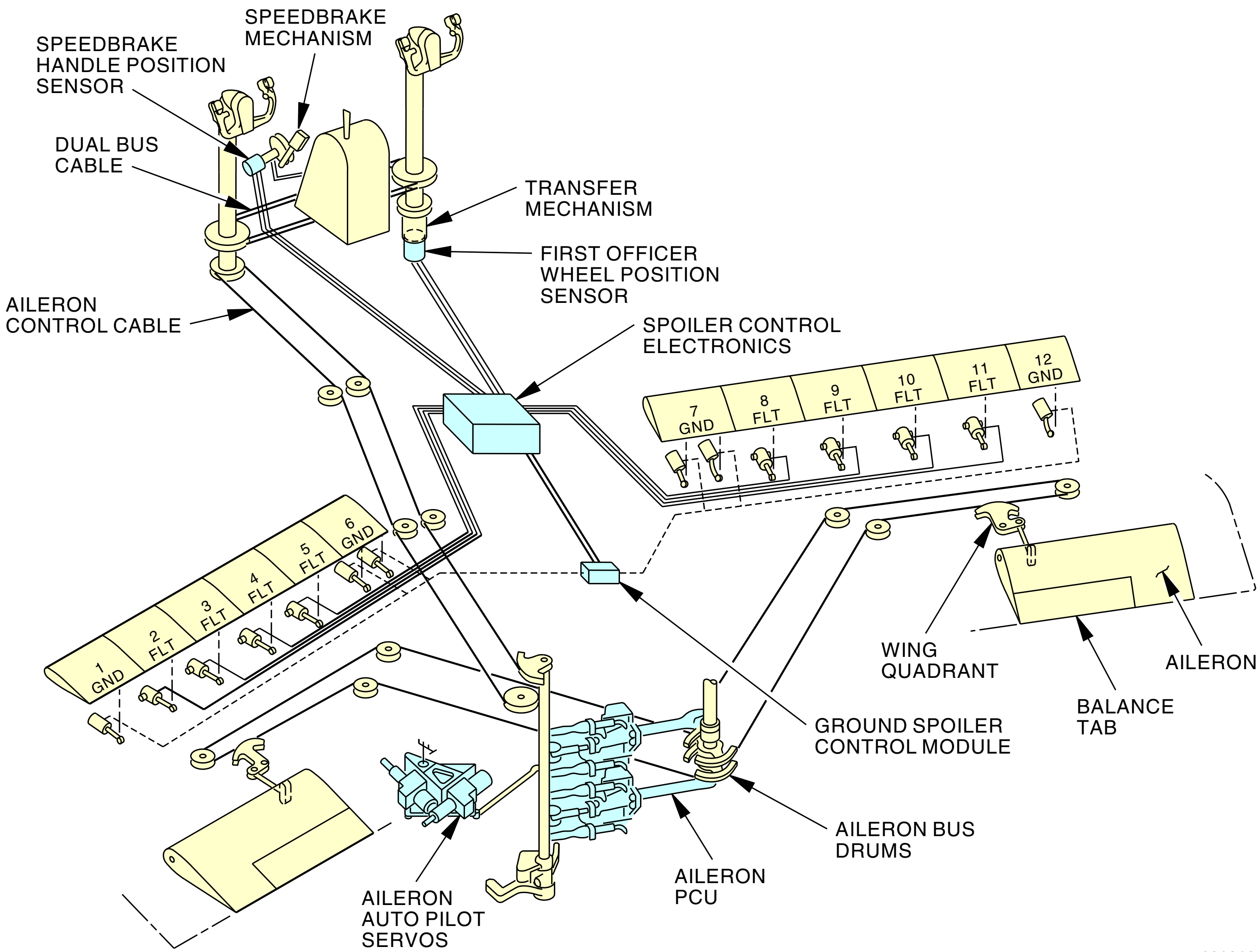
Flight Spoiler Actuator

The SCE sends input to the flight spoiler actuators to extend or retract.

The flight spoiler actuators use hydraulic power to move the flight spoilers.

The flight spoiler actuators use a linear varable differential transducer (LVDT) to send spoiler position to the SCE.

FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION - FLY-BY-WIRE



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FLIGHT SPOILER CONTROL SYSTEM - GENERAL DESCRIPTION - FLY-BY-WIRE

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FLIGHT SPOILER CONTROL SYSTEM - SPOILER CONTROL ELECTRONICS - INTERFACES

General

The spoiler control electronics (SCE) has ARINC 429 interfaces with the following systems:

- FCC
- DPC
- DFDAU
- SMYD
- ADIRU
- Radio altimeter
- Data loader.

The SCE has discrete inputs interfaces with the following systems:

- Cabin altitude switch
- Spoiler shutoff switch
- Main landing gear ground proximity switch
- Reset interlock
- AACU
- PSEU
- Engine/electric pressure switch
- Program pins
- Spares.

The SCE has analog interfaces with the following systems:

- Control wheel position
- Speed brake Lever position.

Lateral and Speedbrake Command Mixing

The lateral and speedbrake input let the two control inputs at the same time. With a speedbrake lever movement, control wheel input will retract flight spoilers on one wing and extend on the other wing. The two inputs to the spoilers will give results that the difference between the spoilers on each wing will cause the necessary lateral movement.

Maneuver Load Alleviation (MLA)

The maneuver load alleviation (MLA) system lowers the wing and aft fuselage loads during some maneuvers and usual load factors. The MLA system retracts extended speedbrakes during maneuvers that cause higher load factors at some gross weights. The speedbrake lever does not move during MLA activation. When the conditions that cause MLA are gone, the speedbrakes will go back to the set position.

Landing Attitude Modifier (LAM)

The landing attitude modifier (LAM) system performs two functions.

The first LAM function applies when the flaps are in the 30 or 40 unit position. The LAM system use the flight spoilers to keep the nose landing gear contact. The LAM system equally deploys flight spoilers on approach. This will decrease lift and make the airplane use a higher angle of attack. The spoiler position depends on the approach speed. Movement starts at approximately 10 knots above VREF.

The second LAM function applies when flaps are positions 15 through 30 units and the throttles are near the idle position. This function also equally deploys flight spoilers, to give more drag to keep glide slope capture capacity.

The LAM function requires valid inputs from these:

- ADR
- RA
- FCC
- EEC (via DPC)
- SMYD.

FLIGHT SPOILER CONTROL SYSTEM - SPOILER CONTROL ELECTRONICS - INTERFACES

Emergency Descent Spoilers (EDS)

To keep risk to a minimum to high altitude conditions, an emergency descent speedbrakes (EDS) function is included. When the airplane is more than 30,000 feet and the cabin altitude warning is on, the EDS function is on.

Move the speedbrake lever to the FLIGHT DETENT position to start the EDS function. The speedbrakes will extend more than usual. EDS stops when the spoilers are stowed, or when the cabin altitude warning is not on.

Direct Lift Control (DLC)

Direct lift control is to help the pilot to land the airplane, with an elevator system jam.

During the approach and landing phase, the elevator jam landing assist function uses the spoilers in the DLC mode. This lets the pilots control the descent rate.

To activate the system these items must be true:

- The elevator jam landing assist switch must be selected ON
- The flap position must be 1 or greater
- The autopilot must be disconnected.

With the function started, the flight spoilers deploy to a neutral position. Force applied to the control wheel is sensed. The SCE uses this input to make a DLC command. A push on the control column causes the spoilers to extend more. This makes the descent go more than usual. A pull on the control column causes the spoilers to retract. This makes the descent go less than usual.

The extension and retraction schedules give the pilots flight path control to land the airplane. The DLC keeps the pitch drift to a minimum when spoiler positions change.

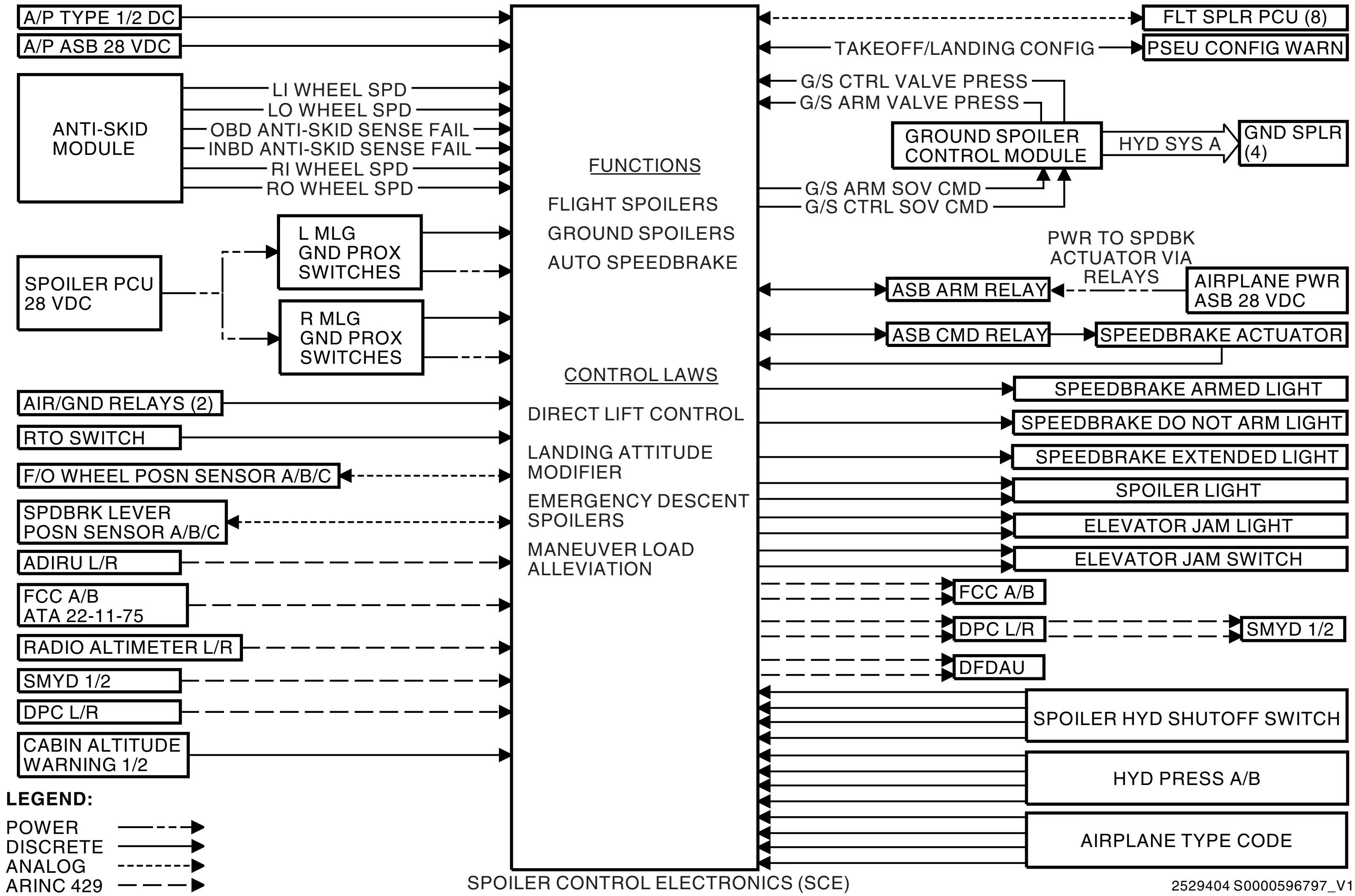
Weight Estimator

The weight estimator provides the SCE with an estimate of the airplanes gross weight based on a combination of these:

- Flight surface positions
- Throttle lever position
- Air data signals
- Inertial data signals

The weight estimate is utilized by LAM for spoiler command calculations and MLA for disablement when gross weight is below 149,500 lb.

FLIGHT SPOILER CONTROL SYSTEM - SPOILER CONTROL ELECTRONICS - INTERFACES



FLIGHT SPOILER CONTROL SYSTEM - SPOILER CONTROL ELECTRONICS - INTERFACES

FLIGHT SPOILER CONTROL SYSTEM - CONTROLS AND INDICATIONS

General

These are the flight spoiler controls and indications in the flight compartment:

- Aileron control wheel (2)
- Aileron trim switch (2)
- Speedbrake lever
- SPOILER shutoff switch (2)
- Elevator Jam Landing Assist switch
- SPOILER amber light
- ASSIST ON amber light.

Controls

The control wheels control the ailerons and flight spoilers.

The flight SPOILER shutoff switches control the flight spoiler shutoff valves. The switches are a two position guarded switch, with the usual position guarded to the ON position. The switches are on the flight control panel P5.

The ELEVATOR JAM LANDING ASSIST switch is a two position switch OFF and ON, with the switch guarded to the OFF position. The elevator jam assist function starts at flap position 1 or more and the switch is in the ON position. The switch is on the P5 aft overhead panel.

The AILERON trim switches are spring-loaded to the neutral position. The switches move the aileron feel and centering unit to a new neutral control point. The switches are on the aileron/rudder trim panel on the aft electronic panel P8.

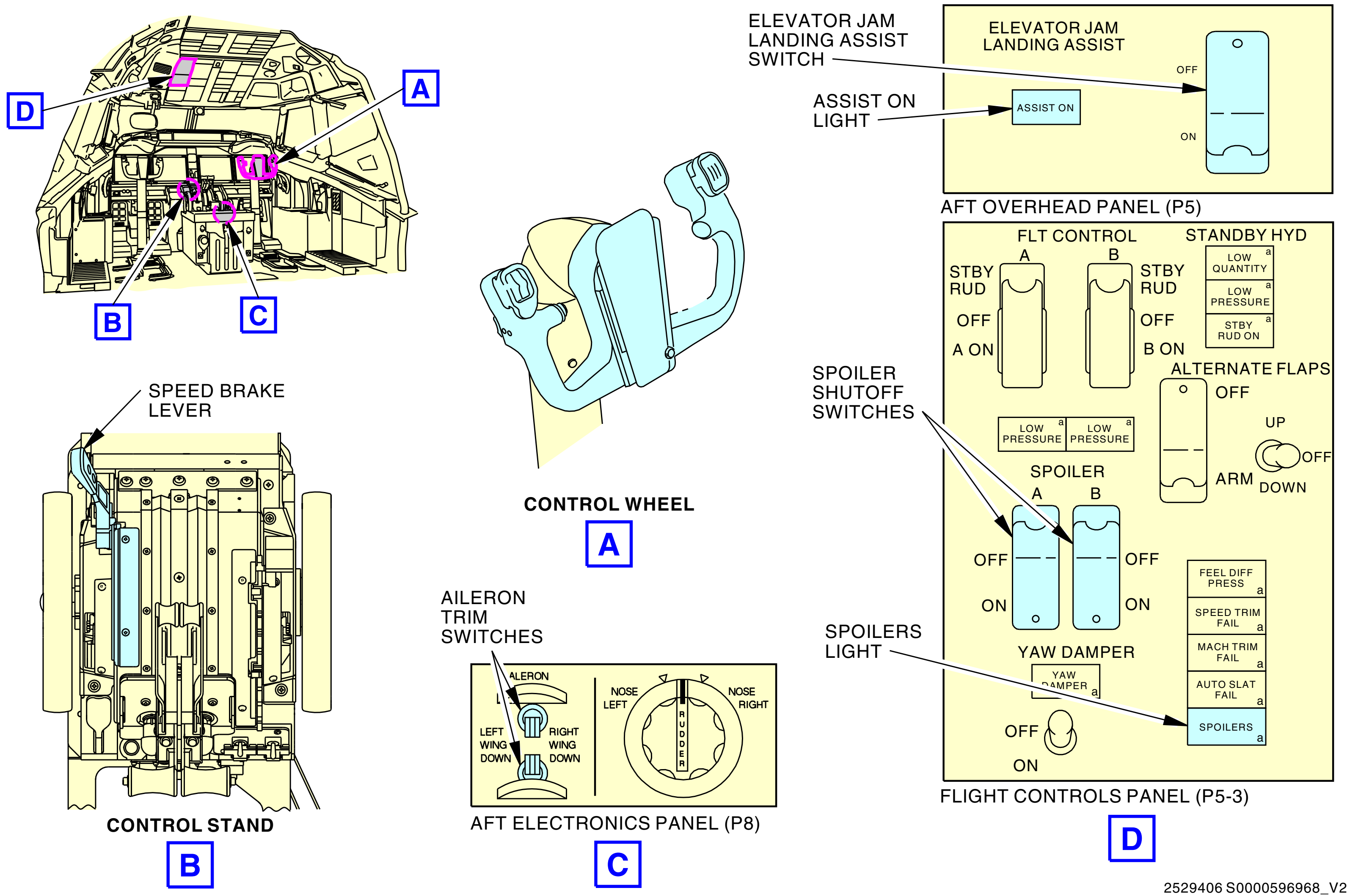
See the aileron system for more information about the aileron trim system (SECTION 27-11).

Indications

The spoiler control electronics (SCE) turns on the amber SPOILERS light to show a spoiler system fault.

The elevator jam landing assist is on when the ASSIST ON amber light is on.

FLIGHT SPOILER CONTROL SYSTEM - CONTROLS AND INDICATIONS



FLIGHT SPOILER CONTROL SYSTEM - CONTROLS AND INDICATIONS

FLIGHT SPOILER CONTROL SYSTEM - COMPONENT LOCATIONS

General

The components of the flight spoiler control system are in the electronic equipment compartment, main landing gear wheel well and the wings.

Electronic Equipment Compartment

The spoiler control electronics is on the E3-3 rack in the electronic equipment compartment.

Main Landing Gear Wheel Well Components

The spoiler shutoff valves (2) are in the MLG wheel well.

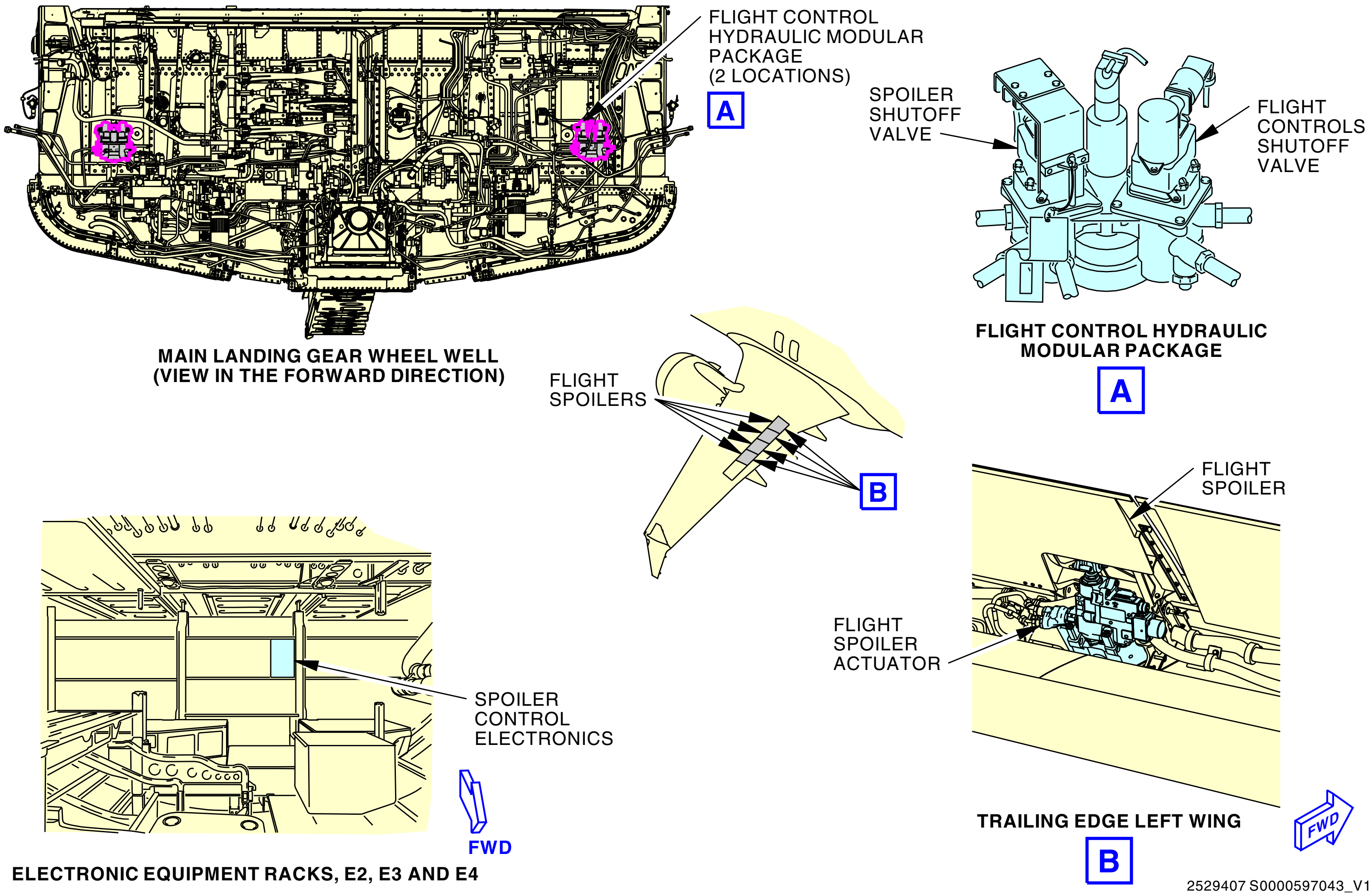
The spoiler shutoff valves are on the flight controls hydraulic modular package. The package is on the forward bulkhead of the MLG wheel well.

Wing Components

The eight flight spoiler actuators are at the fixed trailing edge (TE) of the wings:

To get access to these components, extend the TE flaps.

FLIGHT SPOILER CONTROL SYSTEM - COMPONENT LOCATIONS



FLIGHT SPOILER CONTROL SYSTEM - COMPONENT LOCATIONS

FLIGHT SPOILER CONTROL SYSTEM - CONTROL WHEEL POSITION TRANSDUCER

Purpose

The control wheel position transducer supplies the control wheel position to the spoiler control electronics (SCE).

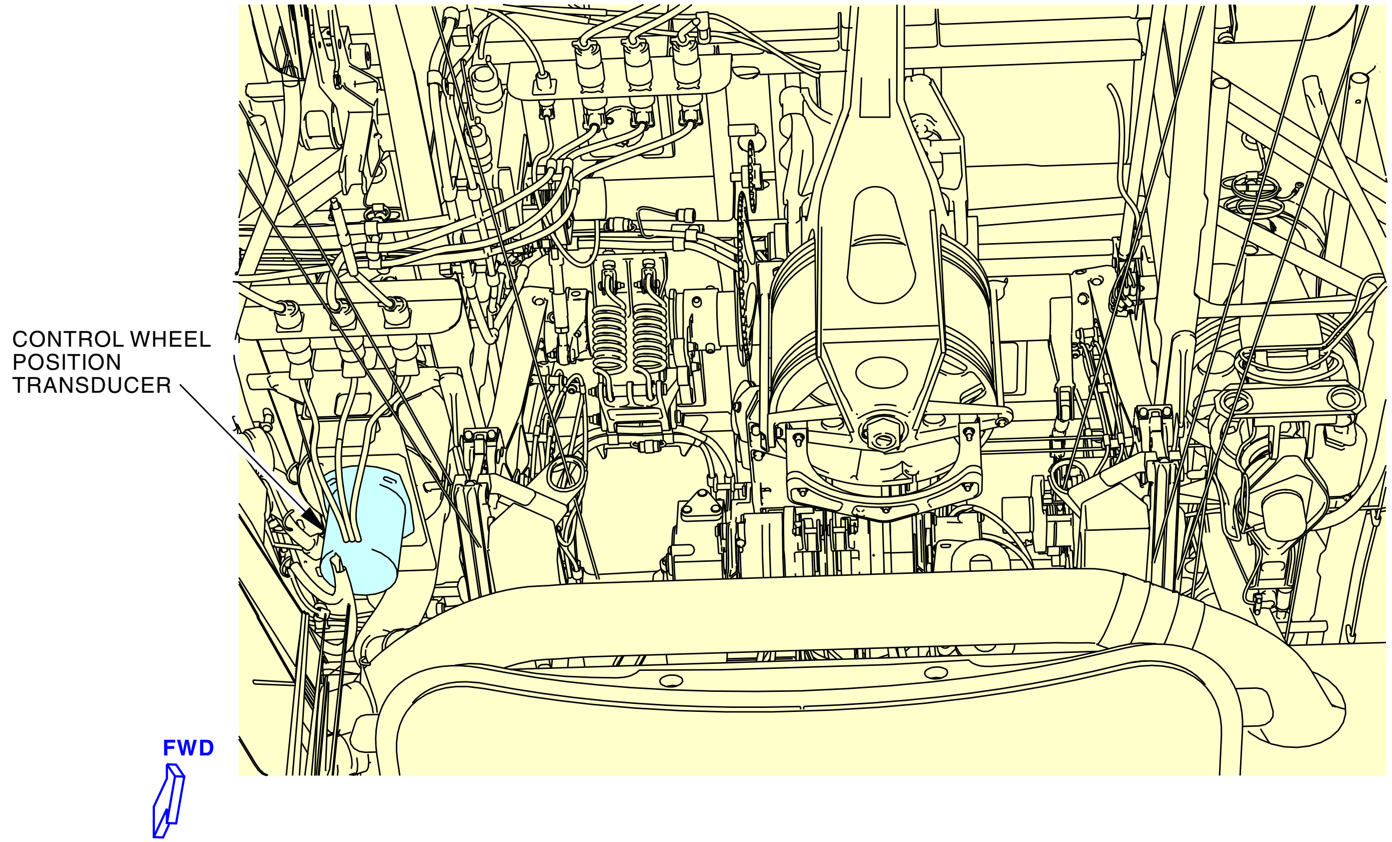
Location

The control wheel position transducer is below the flight compartment floor. Access to the transducer is through the forward equipment door.

Physical Description

The right control wheel output shaft connects to the control wheel position transducer through a spline interface. The control wheel position transducer has three rotational variable differential transducers (RVDTs), connected to the same input shaft. If a RVDT does not operate, its input shaft will break to let the other two RVDT operate. If a control wheel position transducer breaks, its input shaft will break. This lets the other control wheel operate.

FLIGHT SPOILER CONTROL SYSTEM - CONTROL WHEEL POSITION TRANSDUCER



(VIEW THROUGH THE FORWARD
EQUIPMENT DOOR)

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FLIGHT SPOILER CONTROL SYSTEM - CONTROL WHEEL POSITION TRANSDUCER

FLIGHT SPOILER CONTROL SYSTEM - SPOILER SHUTOFF VALVES

Purpose

The spoiler shutoff valves control the system A and B pressure to the flight spoilers.

Location

The spoiler shutoff valves are on the left side of each flight control hydraulic modular package in the main landing gear wheel well forward bulkhead.

Physical Description

Each spoiler shutoff valve has a valve and a 28v dc motor. When the motor operates, it moves the valve.

Each valve has a red manual override/position indicator lever with positions 1 and 2. When the valve opens, the indicator moves to position 1. When the valve closes, the indicator moves to position 2.

Functional Description

The spoiler shutoff valves are normally open to let pressure go to each flight spoiler acuator. When you move the SPOILER A switch to the OFF position, the system A flight spoiler shutoff valve closes. This removes the system A hydraulic power to the flight spoiler actuators for spoilers 2, 4, 9, and 11. When you move the switch to the ON position, the valve opens.

The system B spoiler shutoff valve operates the same as the system A spoiler shutoff valve. It stops the system B hydraulic power to the flight spoiler actuators for spoilers 3, 5, 8, and 10.

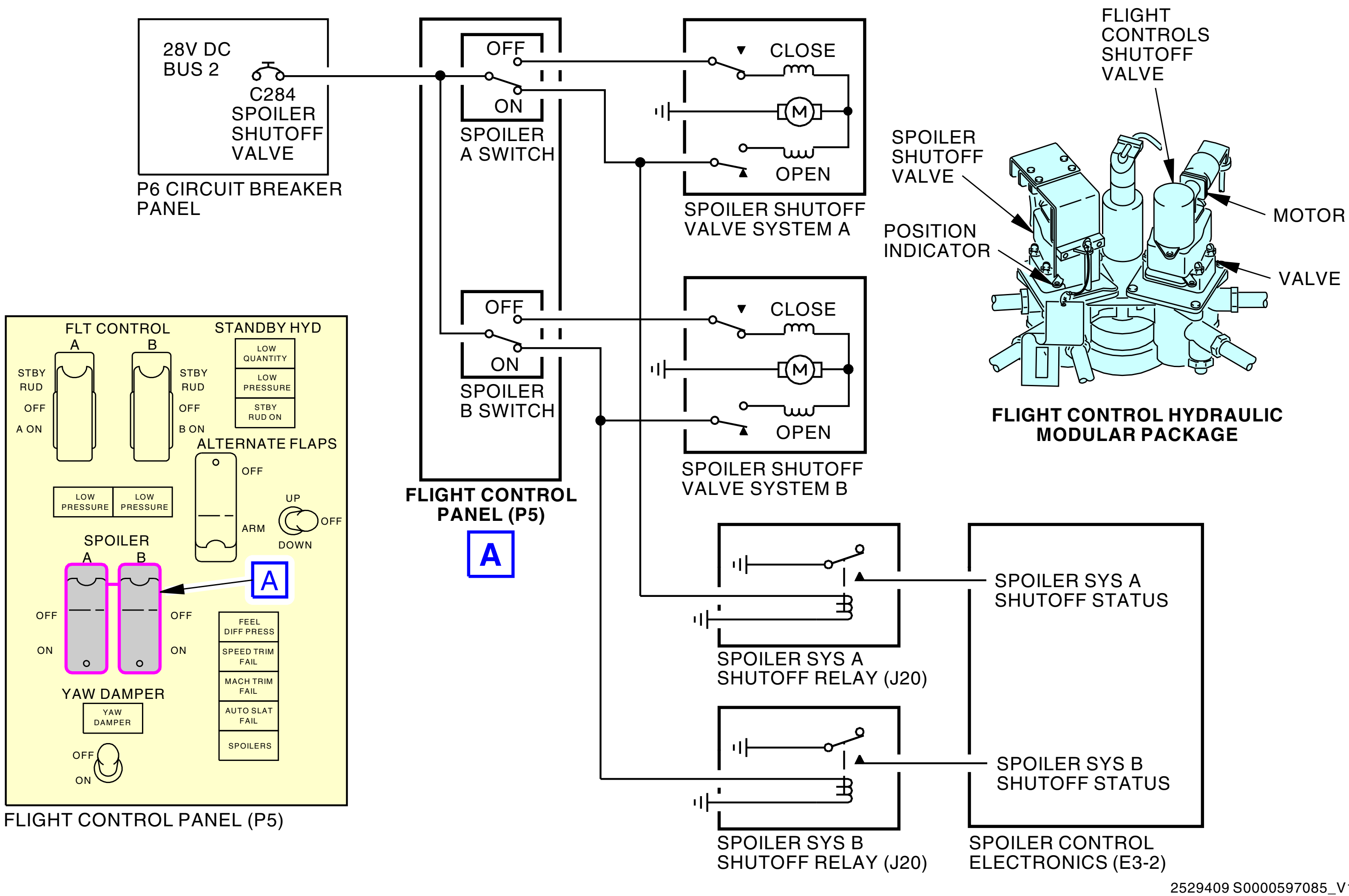
The SPOILER switches give on/off status of the flight spoiler hydraulic systems to the spoiler control electronics (SCE) .

Training Information Point

The flight controls shutoff valves and the spoiler shutoff valves are interchangeable.

You can replace the valve and motor as a unit, or you can replace only the motor or valve.

FLIGHT SPOILER CONTROL SYSTEM - SPOILER SHUTOFF VALVES



FLIGHT SPOILER CONTROL SYSTEM - SPOILER SHUTOFF VALVES

FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILER ACTUATOR

Purpose

The flight spoiler actuators use inputs from the spoiler control electronics to move the flight spoilers.

Location

There are eight spoiler actuators. The flight spoiler actuators attach to the rear spar of the wing below each flight spoiler. You extend the trailing edge flaps to get access to the actuators.

Physical Description

The flight spoiler actuator has these components:

- Linear variable differential transducer (LVDT)
- Electro-hydraulic servo valve (EHSV)
- Extension check and thermal relief valve
- Manual release cam
- Electrical connector.

Functional Description

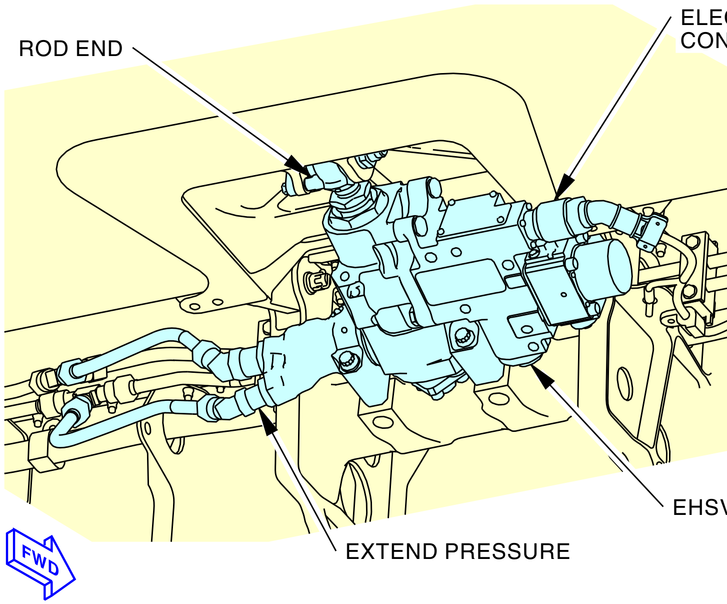
The spoiler actuator contains an electro-hydraulic servo valve (EHSV) controlled by the spoiler control electronics (SCE). The SCE uses the EHSV to control hydraulic pressure to extend or retract the spoiler panel. A linear variable differential transducer (LVDT) gives feedback to the SCE for spoiler position. If the SCE has a failure, the EHSV causes the spoiler actuator to retract. If you disconnect the electrical connector for a spoiler actuator (PCU), then the opposite spoiler in the spoiler pair will retract.

The extension check and thermal relief valve prevents actuator extension when hydraulic pressure is gone. The valve prevents damage to the actuator and manifold because of thermal expansion of entrapped hydraulic fluid. The release cam lets you manually extend the actuator for servicing.

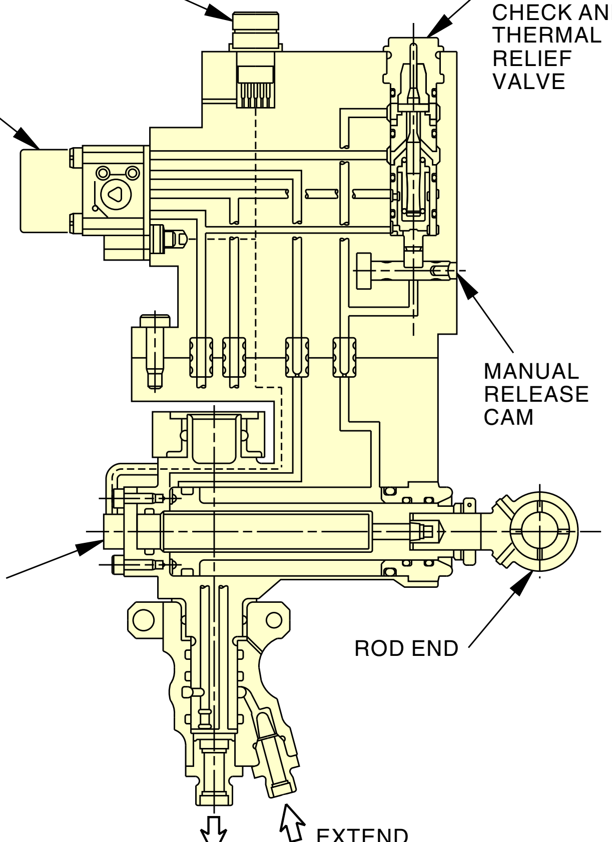
Flight spoiler actuators 2, 4, 9, and 11 receive hydraulic power from system A.

Flight spoiler actuators 3, 5, 8, and 10 receive hydraulic power from system B.

FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILER ACTUATOR



FLIGHT SPOILER ACTUATOR



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FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILER ACTUATOR

FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILERS

Purpose

The flight spoilers help the ailerons with the roll of the airplane while in flight. The flight spoilers extend to supply more roll when more roll is necessary.

The flight spoilers operate as speedbrakes in-flight and on the ground.

Location

The flight spoilers are on the top surface of the wings. They are at the fixed trailing edge of the wings, between the engine struts and the ailerons. There are four panels on each wing, number 2 thru 5 on the left wing and 8 thru 11 on the right wing. They operate together as pairs, panels 2 and 11, 3 and 10, 4 and 9, and 5 and 8.

Physical Description

The flight spoilers are made of composite materials. They are not interchangeable.

Functional Description

They are a fly-by-wire system controlled by the spoiler control electronics (SCE). The SCE uses inputs from the control wheel, the autopilot, and the speedbrake lever to operate the flight spoilers.

The flight spoilers start to move up during these conditions:

- Flight crew turns the control wheel
- Autopilot actuators make an input
- Speedbrake lever is moved more than the ARMED detent.

Turn the control wheel more than 70 degrees tells the SCE to set the flight spoilers to full up. When you put the speedbrake lever to the UP position, the SCE put the flight spoilers to full up.

Flight spoilers 2, 3, 10, and 11 move up a maximum of 33 degrees.

Flight spoilers 4, 5, 8, and 9 move up a maximum of 38 degrees.

Training Information Point

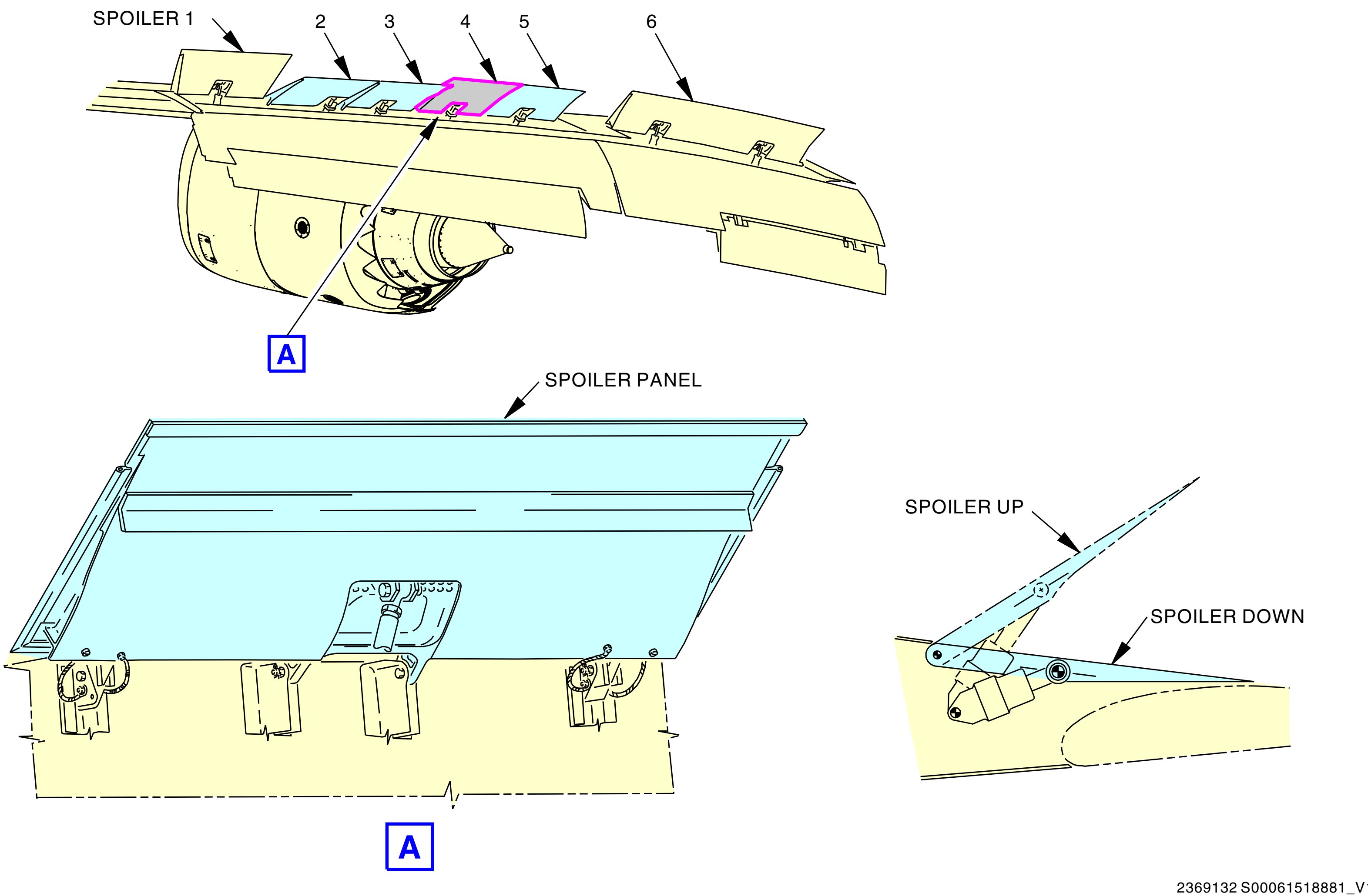
When you rig the spoilers, keep a small gap between the spoiler and the TE flap.

When you do maintenance around the spoilers, obey this warning:

WARNING

KEEP PERSONS AND EQUIPMENT AWAY FROM ALL CONTROL SURFACES AND THE NOSE GEAR WHEN HYDRAULIC POWER IS SUPPLIED. THE AILERONS, ELEVATORS, RUDDER, FLAPS, SLATS, SPOILERS, AND THE NOSE GEAR ARE SUPPLIED WITH POWER BY THE HYDRAULIC SYSTEMS. INJURIES TO PERSONS OR DAMAGE TO EQUIPMENT CAN OCCUR WHEN HYDRAULIC POWER IS SUPPLIED.

FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILERS



FLIGHT SPOILER CONTROL SYSTEM - FLIGHT SPOILERS

FLIGHT SPOILER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

General

The flight spoiler control system hydraulically operates the flight spoilers. One of the two control wheels or the speedbrake lever controls the flight spoilers. The autopilot automatically controls them.

In the air, flight spoilers operate as speedbrakes. On the ground the flight and ground spoilers remove lift and increase brake performance.

Functional Description - Roll Control

The spoiler control electronics (SCE) controls the eight flight spoilers and the four ground spoilers. Roll control is by the position of one aileron and four flight spoilers on each wing. For more roll, the flight spoilers give more roll rate performance.

The flight spoilers operate by the control wheel and speedbrake lever position. They also move because of the airplane configuration and where the airplane operates.

When the pilot turns the control wheel clockwise, the flight spoilers on the right wing start to move up. When the control wheel turns more, the flight spoilers on the right wing move more. The flight spoilers on the right wing move to their maximum positions at 70 degrees clockwise movement.

When the pilot turns the control wheel counter clockwise, the left flight spoilers move the same as described for the right flight spoilers.

There is no manual reversion for the spoilers.

Functional Description - One Control Wheel Cannot Move

If one control wheel can not move, force applied to the control wheels will identify which system, ailerons or spoilers, is serviceable. This will identify which control wheel can give roll control.

If the aileron control system is jammed, the Captain's control wheel can not move. Force applied to the First Officer’s control wheel will give roll control from the flight spoilers.

If the flight spoiler control system is jammed, the First Officer's control wheel cannot move. Force applied to the Captain's control wheel will give roll control from the spoilers.

Functional Description - Speedbrake Control

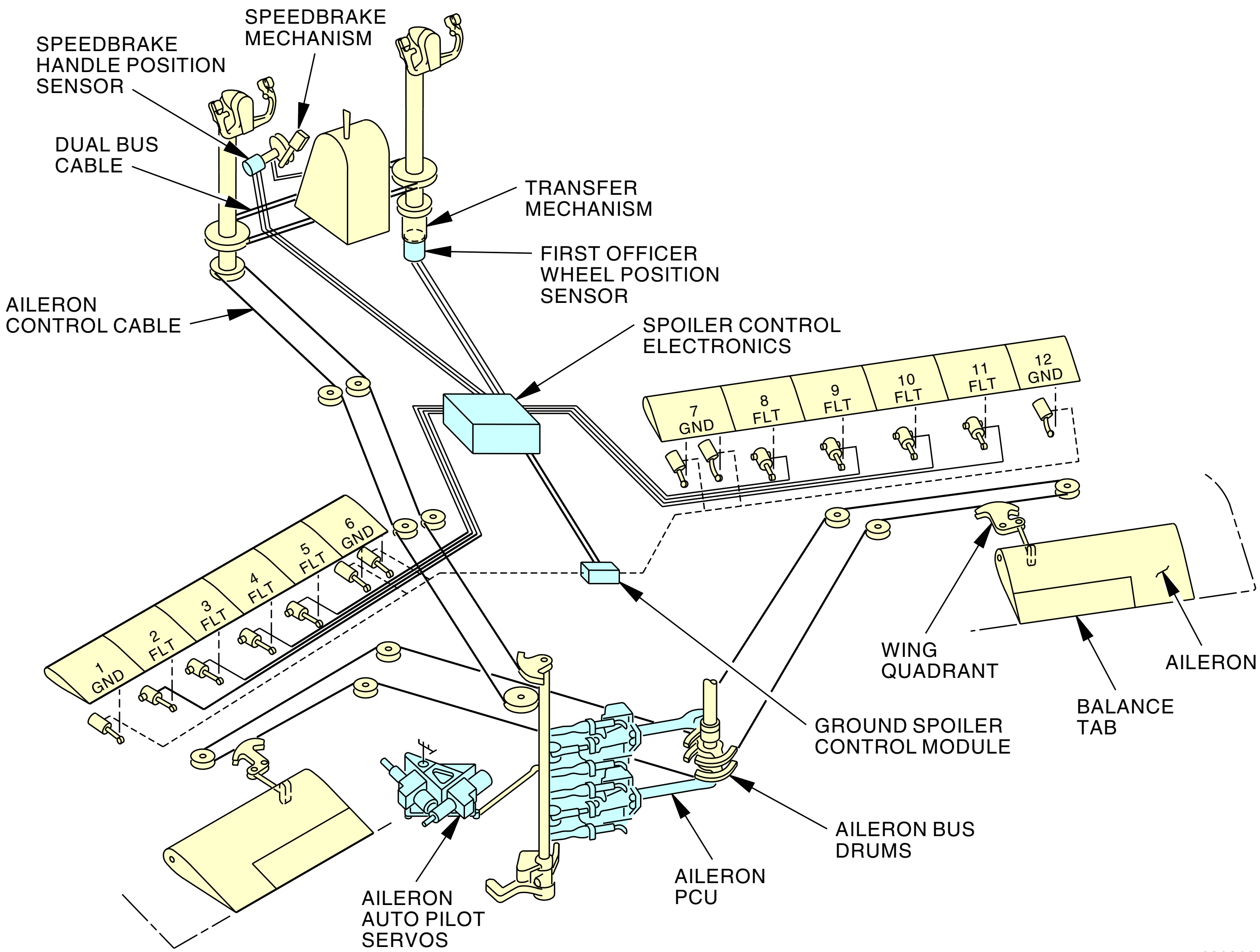
The flight spoilers start to move up after 5 degrees of speedbrake lever movement. The flight spoilers on each wing move symmetrically.

When the speedbrake lever moves more, the flight spoilers on both wings move more. When the speedbrake lever is in the FLIGHT DETENT position, flight spoilers 2, 3, 10 and 11 move to a maximum of 15 degrees. When the speedbrake lever is at the UP position, these spoilers move to a maximum of 56 degrees.

When the speedbrake lever is in the FLIGHT DETENT, flight spoilers 4, 5, 8 and 9 move to a maximum of 21 degrees. When the speedbrake lever is at the UP position, these spoilers move to a maximum of 65 degrees.

See the speedbrake control system section for more information. (SECTION 27-62)

FLIGHT SPOILER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



FLIGHT SPOILER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

FLIGHT SPOILER CONTROL SYSTEM -- SPOILER SYSTEM ANNUNCIATION - FUNCTIONAL DESCRIPTION

Purpose

The amber SPOILERS light shows the crew that the spoiler system has a fault.

The amber ASSIST ON light shows the crew that the elevator jam landing assist function is on.

Functional Description

The SCE has four channels. One of the four channels can find a fault. When a fault is found it removes the ground for the R1164 spoiler fault A1 or R1165 spoiler fault A2 relays. This supplies a ground for the SPOILERS amber light. This makes the SPOILERS light and the MASTER CAUTION lights come on. The relays also supply a spoiler condition signal to the two flight control computers.

The SPOILERS light comes on and the airplane is on the ground. Use the master caution to make the light go off. If the light goes off, you can dispatch the airplane. To dispatch the airplane, do maintenance if the light stays on.

The SPOILERS light comes on when the SCE detects a fault with these components:

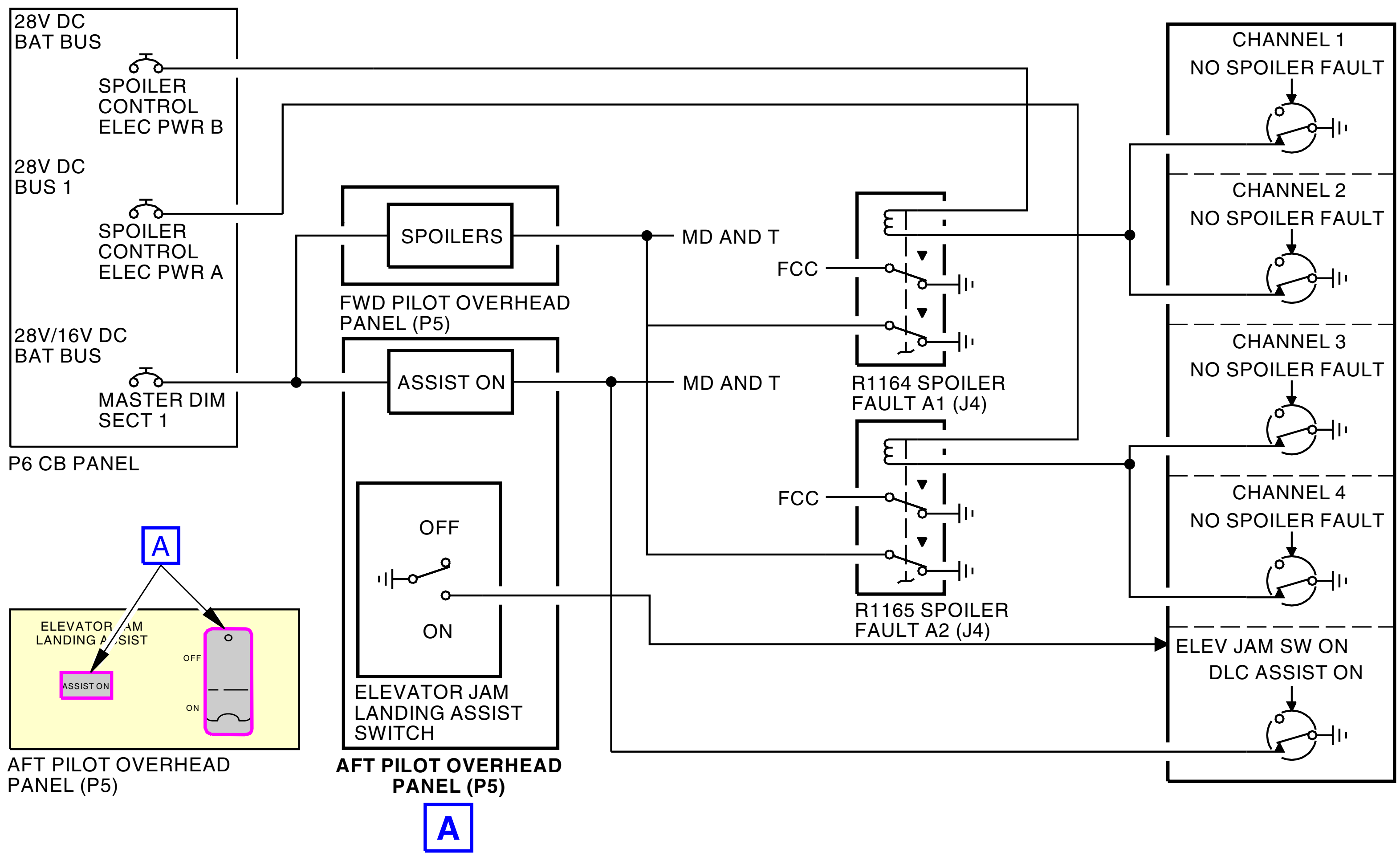
- Control wheel position transducer
- Speedbrake lever position transducer
- Spoiler actuators
- Ground spoiler control module (GSCM)
- Spoiler control electronics (SCE) test is in progress.

The SCE gives a DLC assist on signal when these are true:

- The ELEVATOR JAM LANDING ASSIST switch is in the ON position
- Flaps are at 1 or more.

The ASSIST ON light comes on when the SCE gives the DLC assist on signal.

FLIGHT SPOILER CONTROL SYSTEM -- SPOILER SYSTEM ANNUNCIATION - FUNCTIONAL DESCRIPTION



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FLIGHT SPOILER CONTROL SYSTEM - SPOILER SYSTEM ANNUNCIATION - FUNCTIONAL DESCRIPTION

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SPEEDBRAKE CONTROL SYSTEM -- INTRODUCTION

Purpose

The speedbrake control system decreases lift and increases drag during landing and refused takeoff.

The ground spoilers are the outboard and the inboard spoiler on each wing.

Speedbrake Control

The spoilers on the two wings move symmetrically during speedbrake control.

The pilots manually give inputs for speedbrake control with a speedbrake lever on the control stand. The autopilot does not control the speedbrake function.

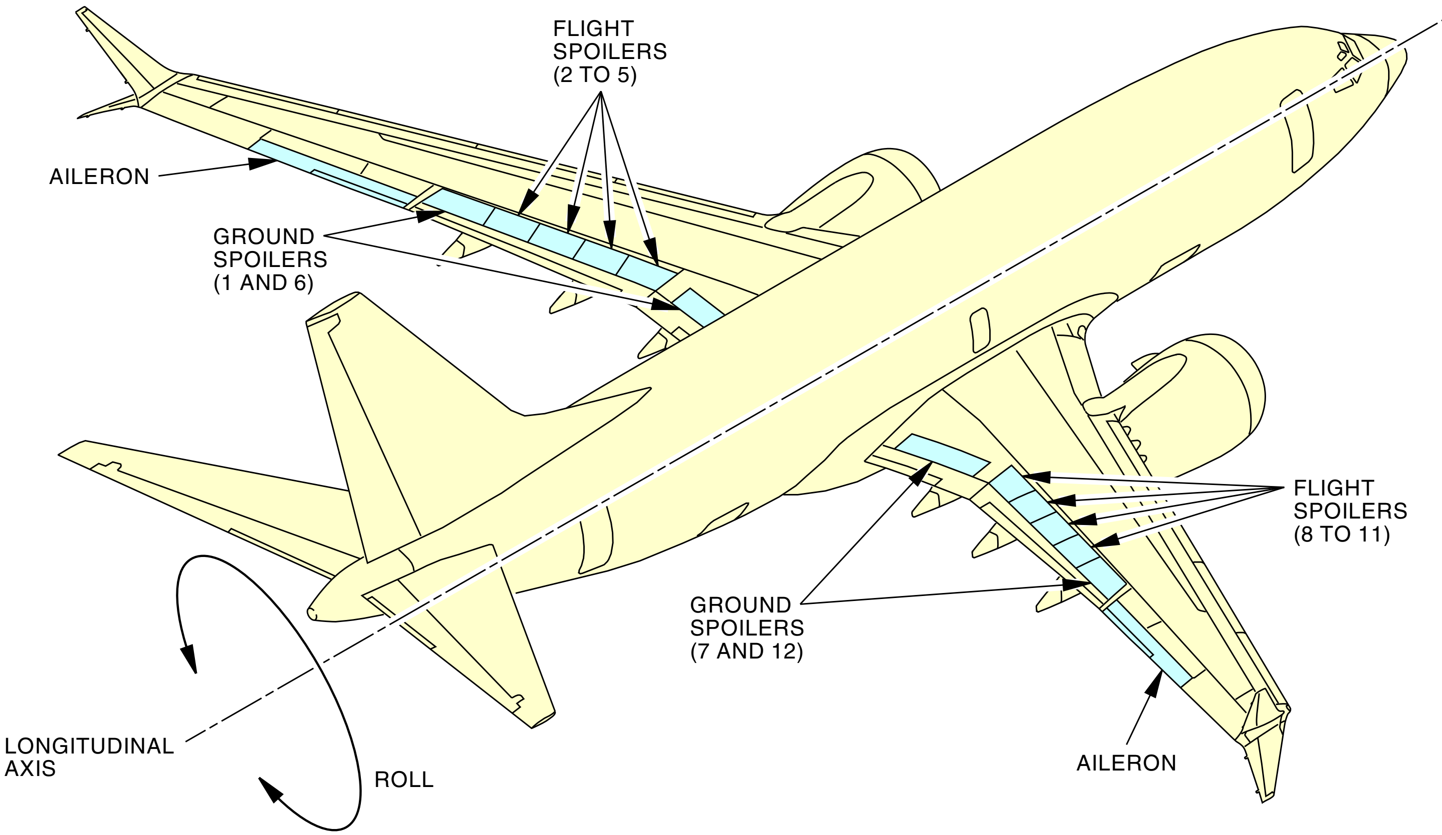
Auto Speedbrake Control

The auto speedbrake function supplies automatic extension or retraction of all the spoilers during landing or refused takeoff.

Abbreviations and Acronyms

- AACU - antiskid/autobrake control unit
- AMM - aircraft maintenance manual
- dc - direct current
- DFCS - digital flight control system
- DFDAU - digital flight data acquisition unit
- FCC - flight control computer
- FDRS - flight data recording system
- ft - feet
- fwd - forward
- gnd - ground
- GSCM - ground spoiler control module
- inbd - inboard
- kts - knots
- LI - left inboard
- MLG - main landing gear
- PCU - power control unit
- prox - proximity
- PSEU - proximity switch electronics unit
- ref - reference
- rev - reverser
- RO - right outboard
- RTO - refused takeoff
- R/A - radio altitude
- SCE - spoiler control electronics
- sect - section
- snsr - sensor
- spdbk - speedbrake
- sw - switch
- sys - system
- TE - trailing edge
- TD - time delay
- TRA - thrust resolver angle
- v - volts
- ww - wheel well

SPEEDBRAKE CONTROL SYSTEM -- INTRODUCTION



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SPEEDBRAKE CONTROL SYSTEM -- INTRODUCTION

SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OPERATION

General

These are the components of the speedbrake control system:

- Speedbrake lever
- Speedbrake lever position transducer
- Spoiler control electronics (SCE)
- Auto speedbrake actuator
- Ground spoiler control module (GSCM)
- Ground spoiler actuators.

Speedbrake Lever

The speedbrake lever sends mechanical inputs to the speedbrake lever position transducer. The speedbrake lever transducer sends the inputs to the SCE. The SCE uses the inputs to move the GSCM.

Auto Speedbrake Actuator

The auto speedbrake actuator moves the speedbrake lever during landings and refused takeoffs (RTO).

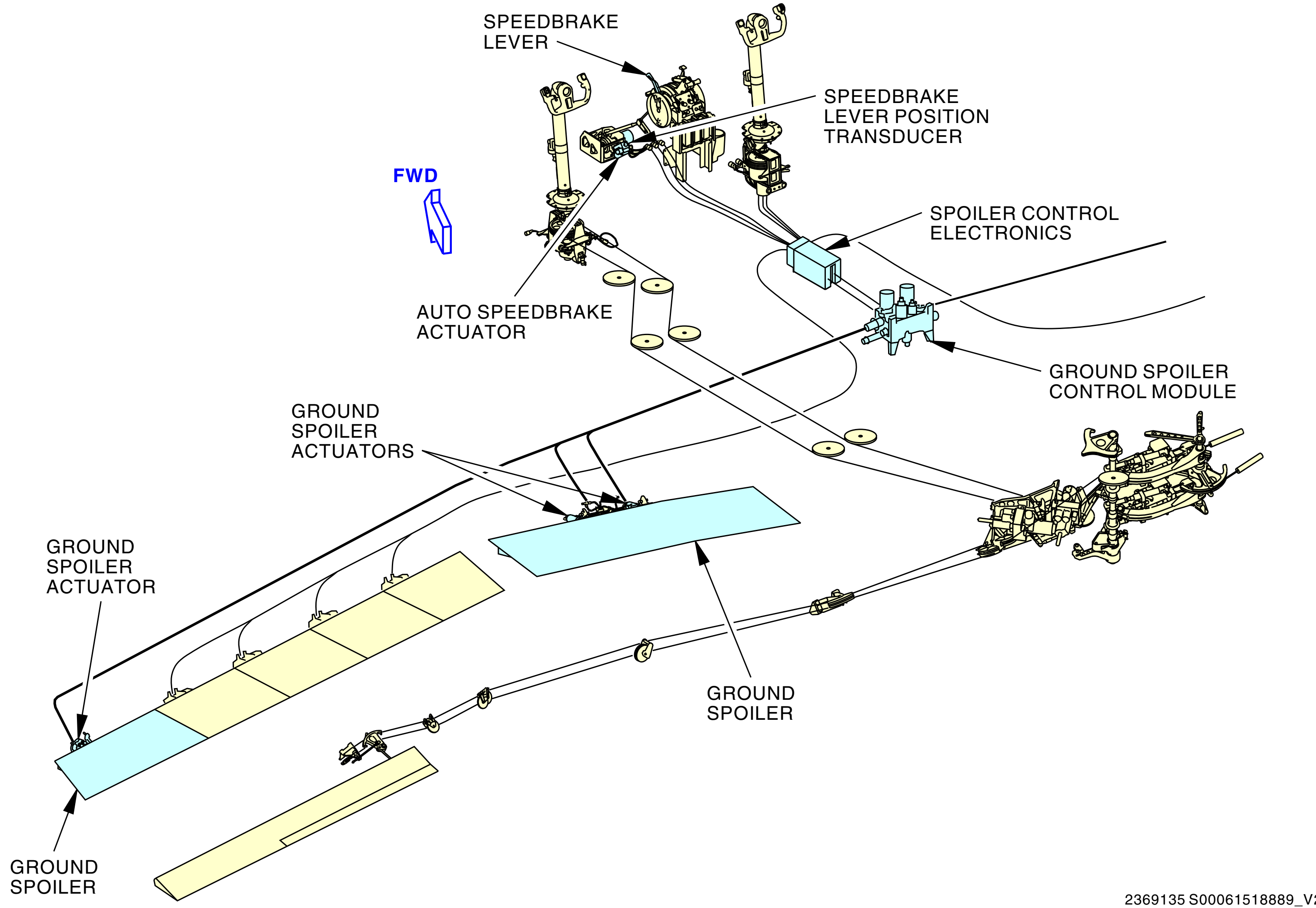
Ground Spoiler Control Module

The SCE tells the ground spoiler control module to send hydraulic power to the ground spoiler actuators.

Ground Spoiler Actuators

The ground spoiler actuators use hydraulic system A pressure to move the ground spoilers.

SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OPERATION



SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OPERATION

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SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OVERVIEW

General

The speedbrakes control system has flight spoilers and ground spoilers. The speedbrake lever controls the spoilers. On the ground when the speedbrake lever moves all the spoilers extend. In the air only the flight spoilers extend.

The spoiler control electronics (SCE) tells the ground spoiler control module (GSCM) to move all four ground spoilers with hydraulic system A.

The SPEEDBRAKES EXTENDED light gives an indication of spoiler operation in-flight and on the ground.

In-flight the light tells that the speedbrakes are extended when:

- The airplane is in the landing configuration or below 800 feet
- Speedbrakes are extended and the thrust levers are more than idle for 15 seconds.

On the ground the light indicates that the speedbrakes are extended when these are true:

- Hydraulic pressure is sensed in the GSCM
- With the speedbrake lever in the DOWN position.

Manual Operation

This is the sequence of manual operation of the speedbrake control system:

- The speedbrake lever gives input through the speedbrake position transducer to the SCE
- The SCE tells the GSCM to extend the ground spoilers when the airplane is on the ground
- The GSCM sends hydraulic system A pressure to the ground spoiler actuators
- This moves all the ground spoilers.

There is one actuator for each outboard ground spoiler and two actuators for each inboard ground spoiler.

The SCE send spoiler configuration data to the proximity switch electronics unit (PSEU). The PSEU uses this data for the aural warning in the takeoff warning function.

The SCE send signals to the DFDAU for flight data recording.

See the digital flight data recording system section for more information about the DFDAU (SECTION 31-31).

Automatic Operation

The SCE controls the automatic operation of the speedbrakes. The SCE uses data from these sources:

- Speedbrake refused takeoff (RTO) switch
- Air/ground from the PSEU
- Wheel speed from the AACU
- TRA from the DPC (2).

The SCE sends signals through relays to the auto speedbrake actuator during landings and refused takeoffs.

The auto speedbrake actuator moves the speedbrake forward drum and lever brake. This causes the speedbrake lever to move and sends an input to the SCE. This causes all the ground spoilers to extend and a signal to go to the DFDAU.

Indications

The SCE controls the amber SPEED BRAKE DO NOT ARM light and the green SPEED BRAKE ARMED light. The SPEED BRAKE ARMED light shows when the automatic operation of the speedbrake system arms correctly. The SPEED BRAKE DO NOT ARM light shows when the automatic operation of the speedbrake system does not arm correctly.

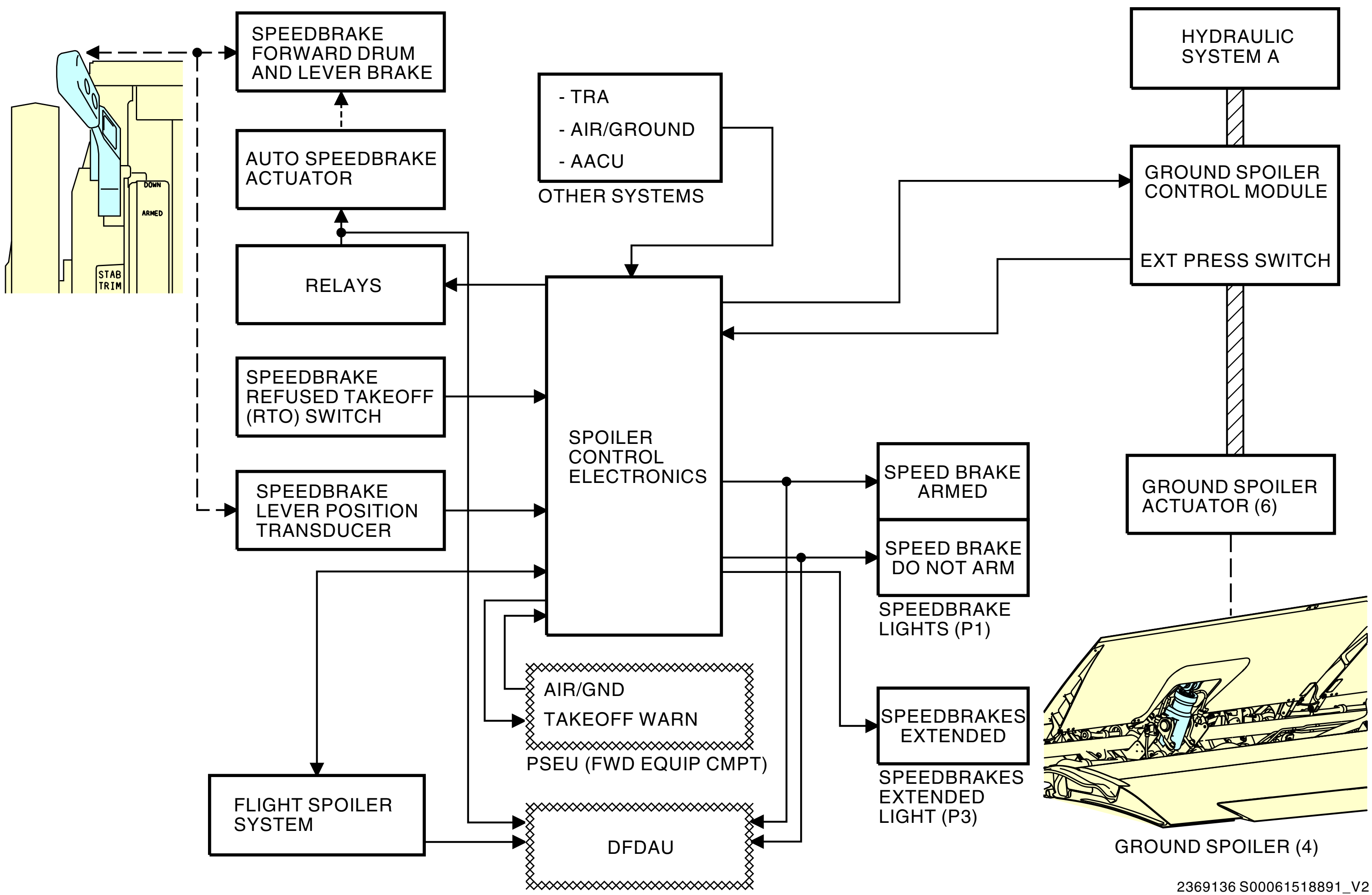
The SCE also sends signals to the DFDAU for flight data recording when the SPEED BRAKE DO NOT ARM or SPEED BRAKE ARMED lights are on.

See the digital flight data recording system (DFDRS) section for more information about the DFDAU (SECTION 31-31).

SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OVERVIEW

The SCE controls the amber SPEEDBRAKES EXTENDED light. In flight the light comes on if the speedbrakes operate during approach. On the ground the light comes on if the SCE senses a problem with the ground spoiler system.

SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OVERVIEW



SPEEDBRAKE CONTROL SYSTEM - GENERAL DESCRIPTION - OVERVIEW

SPEEDBRAKE CONTROL SYSTEM - CONTROLS AND INDICATIONS

Purpose

The pilots use the speedbrake lever to move the spoilers. All the spoilers move up when the airplane is on the ground, and only the flight spoilers move up when the airplane is in the air.

General

These are the speedbrake controls and indications in the flight compartment:

- SPD BRK (speedbrake) lever
- Speedbrake placard
- SPEED BRAKE DO NOT ARM light (P1 panel)
- SPEED BRAKE ARMED light (P1 panel)
- SPEEDBRAKES EXTENDED light (P3 panel).

Controls

The speedbrake lever is on the P10 control stand.

The speedbrake lever has detents at these positions:

- Down
- Armed
- Flight detent.

A placard next to the speedbrake lever shows the position of the lever. The UP position on the placard shows the maximum position of the lever.

Indications

The amber SPEED BRAKE DO NOT ARM light comes on when the spoiler control electronics (SCE) senses a fault in the auto speedbrake system.

The green SPEED BRAKE ARMED light comes on when the auto speedbrake system arms.

The amber SPEEDBRAKES EXTENDED light comes on when:

- The airplane is in the air
- And the speedbrake lever is more than the ARMED position
- And a thrust lever is more than approximately 40 degrees for 3 seconds.

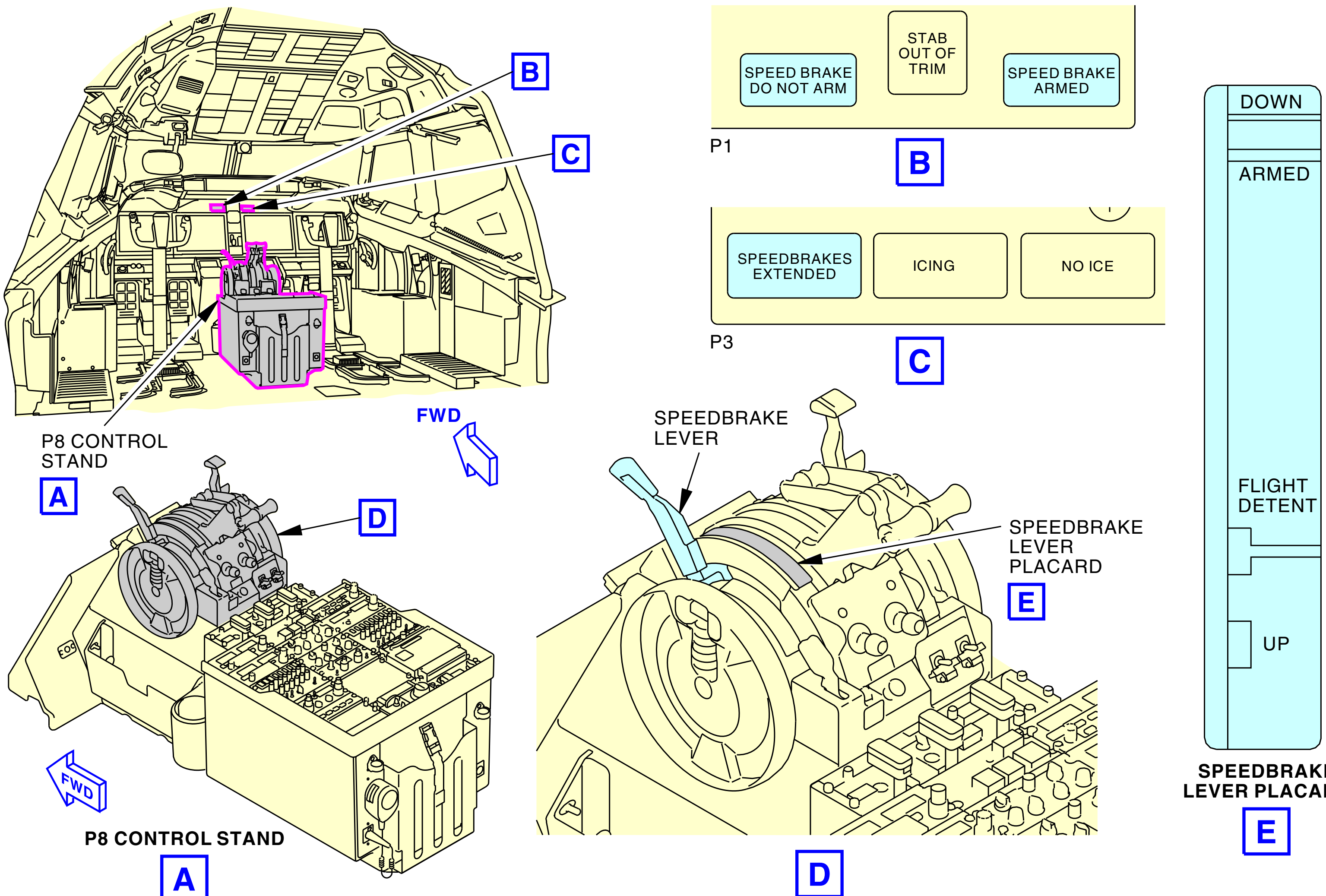
Plus one of these conditions also must be true:

- TE flaps extended more than flaps 10 units
- Radio altitude is less than 800 feet
- A thrust lever is more than idle for 15 seconds, or its position is greater than 44 degrees.

On the ground the amber SPEED BRAKES EXTENDED light comes on when the SCE senses that all of these conditions are true:

- Airplane is on the ground
- Speedbrake lever is in the DOWN position
- Ground spoilers are not stowed.

SPEEDBRAKE CONTROL SYSTEM - CONTROLS AND INDICATIONS



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SPEEDBRAKE CONTROL SYSTEM - CONTROLS AND INDICATIONS

SPEEDBRAKE CONTROL SYSTEM - COMPONENT LOCATION

General

The components of the speedbrake control system are in these areas:

- Flight compartment
- Forward equipment compartment
- Electronic equipment compartment
- Main wheel well.

Flight Compartment

The speedbrake lever is on the captains side of the control stand. The speedbrake refused takeoff (RTO) switch is in the control stand.

Forward Equipment Compartment

These components are in the forward equipment compartment:

- Auto speedbrake actuator
- Speedbrake lever position transducer.

Electronic Equipment Compartment

The spoiler control electronics (SCE) is on the E3-2 rack.

Main Wheel Well

The ground spoiler control module (GSCM) is on the forward right bulkhead.

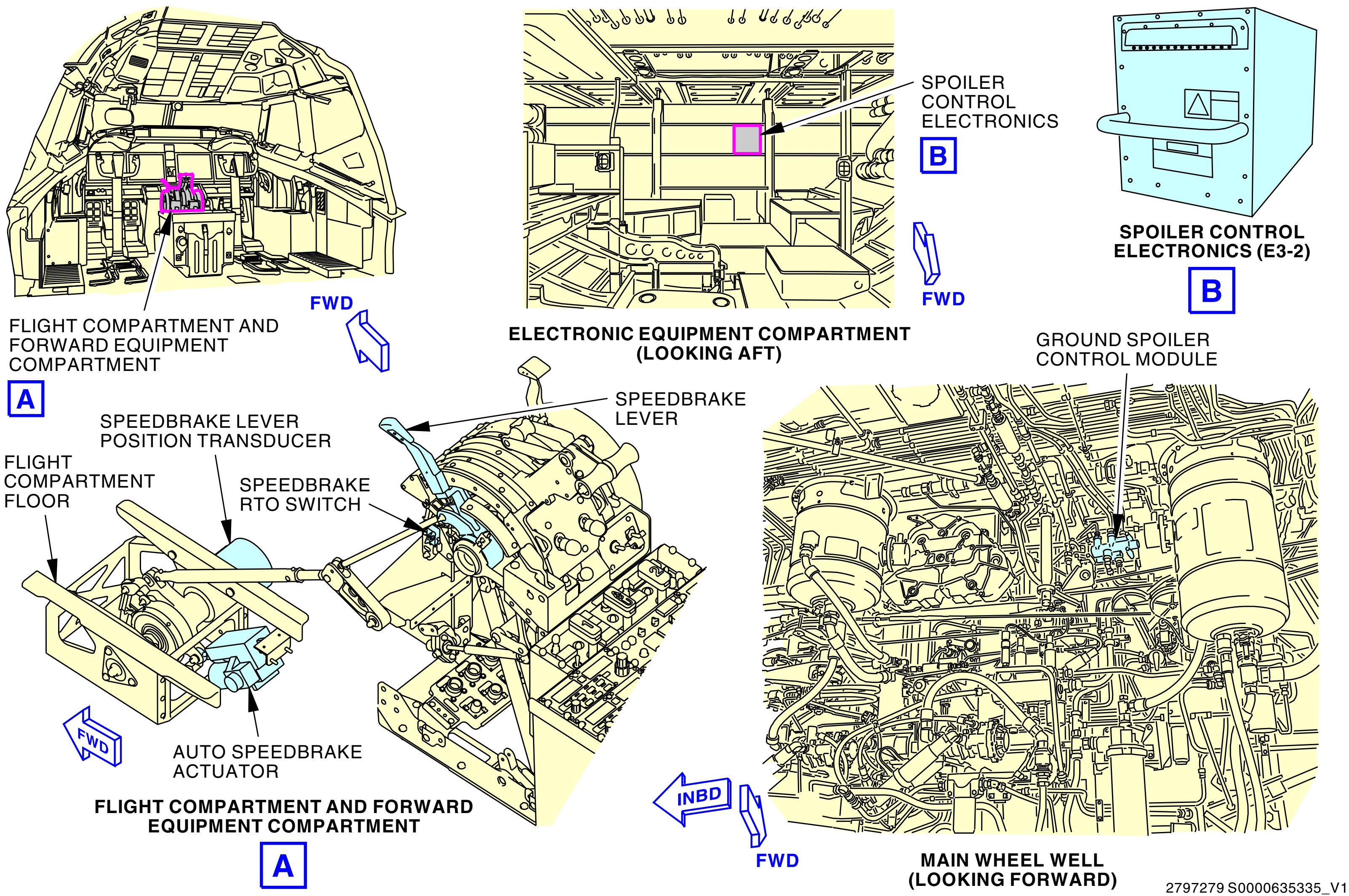
Wing Components (not shown)

These components are at the fixed trailing edge (TE) of the wings:

- Inboard ground spoiler actuator (4)
- Outboard ground spoiler actuator (2)
- Inboard ground spoiler (2)
- Outboard ground spoiler (2).

To get access to these components, extend the TE flaps.

SPEEDBRAKE CONTROL SYSTEM - COMPONENT LOCATION



SPEEDBRAKE CONTROL SYSTEM - COMPONENT LOCATION

SPEEDBRAKE CONTROL SYSTEM - FORWARD COMPONENTS

Purpose

The speedbrake lever brake transmits speedbrake lever movement to the forward drum. It also supplies a friction force to the speedbrake lever. This is to prevent accidental movement of the speedbrake lever.

The speedbrake forward drum connects the speedbrake lever to the speedbrake lever position transducer.

The speedbrake lever position transducer sends data to the spoiler control electronics (SCE).

The auto speedbrake actuator moves the speedbrake lever to operate the ground spoilers during landings and refused takeoffs.

The speedbrake refused takeoff (RTO) switch is on the left forward part of the control stand. The switch operates by the movement of the reverse thrust levers in a reverse thrust direction.

Location

These components are below the flight compartment floor

- Speedbrake lever brake
- Speedbrake forward drum
- Speedbrake lever position transducer
- Auto speedbrake actuator.

To get access, go through the forward equipment compartment access door.

Speedbrake Lever Brake

The lever brake receives inputs from the speedbrake lever and the auto speedbrake actuator. The lever brake uses these inputs to move the forward drum.

The lever brake has a no-back brake assembly. This permits movement of the auto speedbrake actuator to back-drive the speedbrake lever, but prevents the speedbrake lever from moving the auto speedbrake actuator. It also lets the pilot do an override of the position of the auto speedbrake actuator.

Speedbrake Forward Drum

The speedbrake forward drum receives inputs from the lever brake and operates the speedbrake lever position transducer.

The speedbrake forward drum also has a detent cam. The detent cam has the arm detent and the flight detent for the speedbrake lever.

Speedbrake Lever Position Transducer

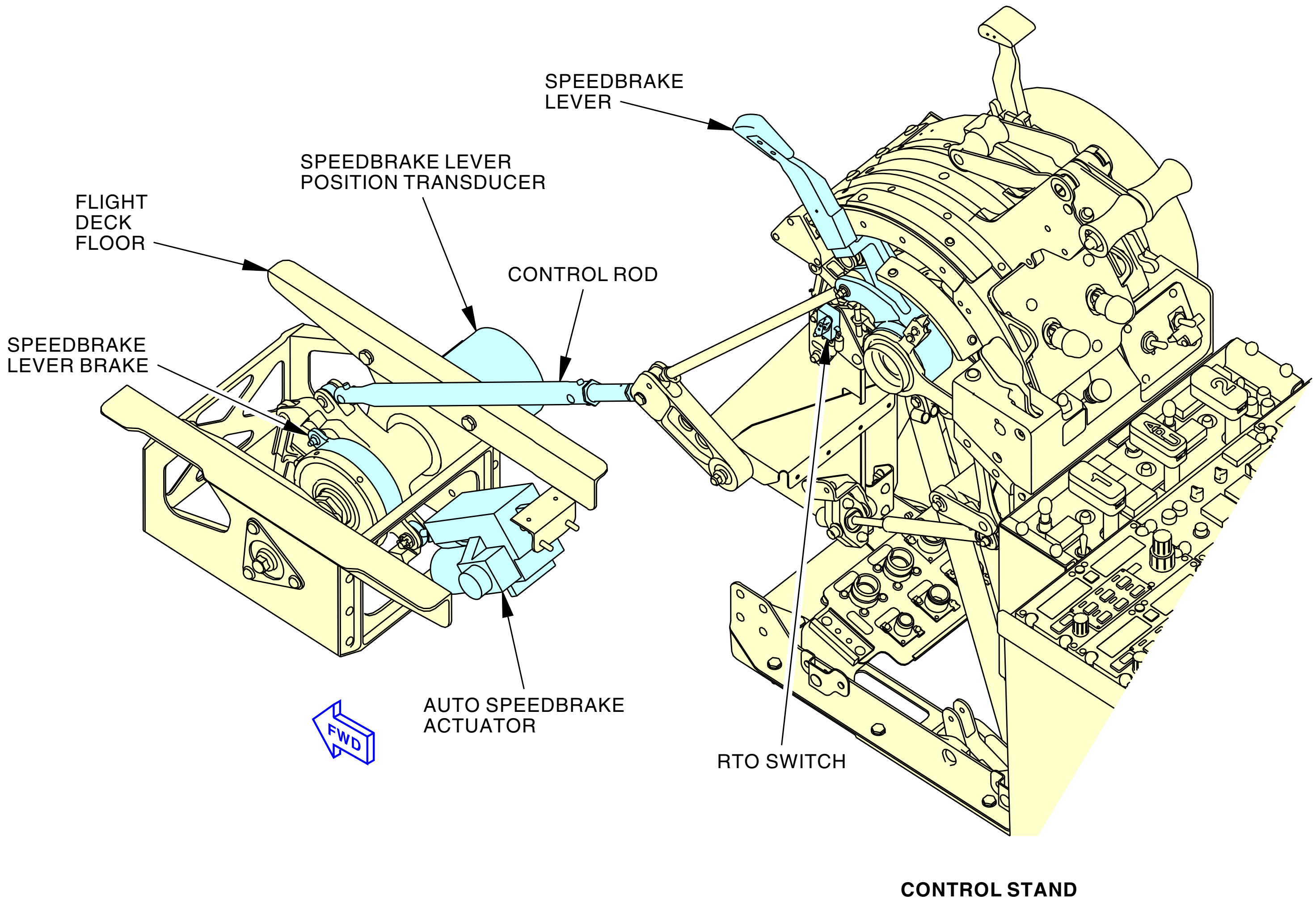
The speedbrake lever position transducer has three independent rotational variable differential transducers (RVDTs) that give data to the SCE.

Auto Speedbrake Actuator

The auto speedbrake actuator connects to the speedbrake lever brake. The actuator uses 28v DC power and has internal limit switches. When the actuator extends, the lever brake moves the speedbrake lever and the forward drum.

The auto speedbrake actuator does not move when the pilot moves the speedbrake lever manually.

SPEEDBRAKE CONTROL SYSTEM - FORWARD COMPONENTS



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SPEEDBRAKE CONTROL SYSTEM - FORWARD COMPONENTS

SPEEDBRAKE CONTROL SYSTEM - SPEEDBRAKE REFUSED TAKEOFF (RTO) SWITCH

Purpose

When the thrust levers engage the RTO switch, the automatic speedbrake function starts. The RTO switch sends a signal to the spoiler control electronics (SCE). This tells the SCE to start the auto speedbrake function during refused takeoffs.

Location

The speedbrake RTO switch is in the left forward part of the control stand. To get access, remove the manual stabilizer trim wheel and the panel on the left side of the control stand.

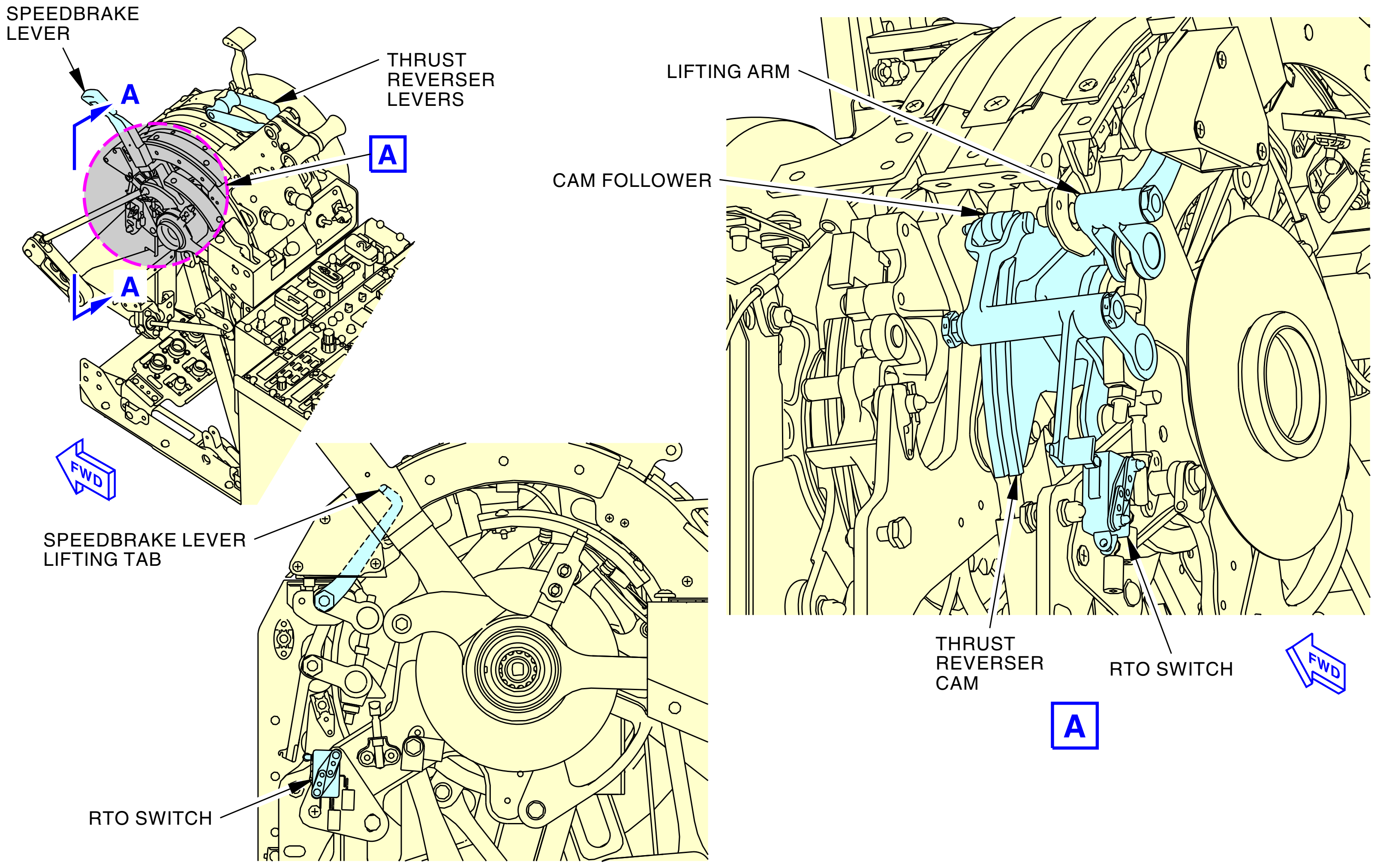
Physical Description

The speedbrake RTO switch is on a vertical bracket attached to the control stand. It is a cam operated microswitch. The thrust reverser cam follower operates the RTO switch.

Functional Description

The speedbrake RTO switch operates when the thrust reverser levers move to the reverse thrust position. The thrust reverser levers move the thrust reverser cam. The cam turns the cam follower. The cam follower operates the speedbrake RTO switch. The cam follower also turns the lifting arm. While the lifting arm turns it hits the lifting tab, this lifts the speedbrake lever.

SPEEDBRAKE CONTROL SYSTEM - SPEEDBRAKE REFUSED TAKEOFF (RTO) SWITCH



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SPEEDBRAKE CONTROL SYSTEM - SPEEDBRAKE REFUSED TAKEOFF (RTO) SWITCH

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER CONTROL MODULE

Purpose

The ground spoiler control module (GSCM) receives inputs from the spoiler control electronics (SCE) to deploy or stow the ground spoilers.

Location

The GSCM is on the forward right bulkhead of the main landing gear wheel well.

General

The module consists of the following components:

- Arm valve (not shown)
- Control valve (not shown)
- ARM solenoid
- Control solenoid
- Extend pressure switch
- Arm solenoid pressure switch

Physical Description

The module has two shuttle valves specified as the arm valve and the control valve. A solenoid valve operates each shuttle valve. The module has two pressure switches to monitor the extend supply pressure after the arm solenoid valve and after the arm valve.

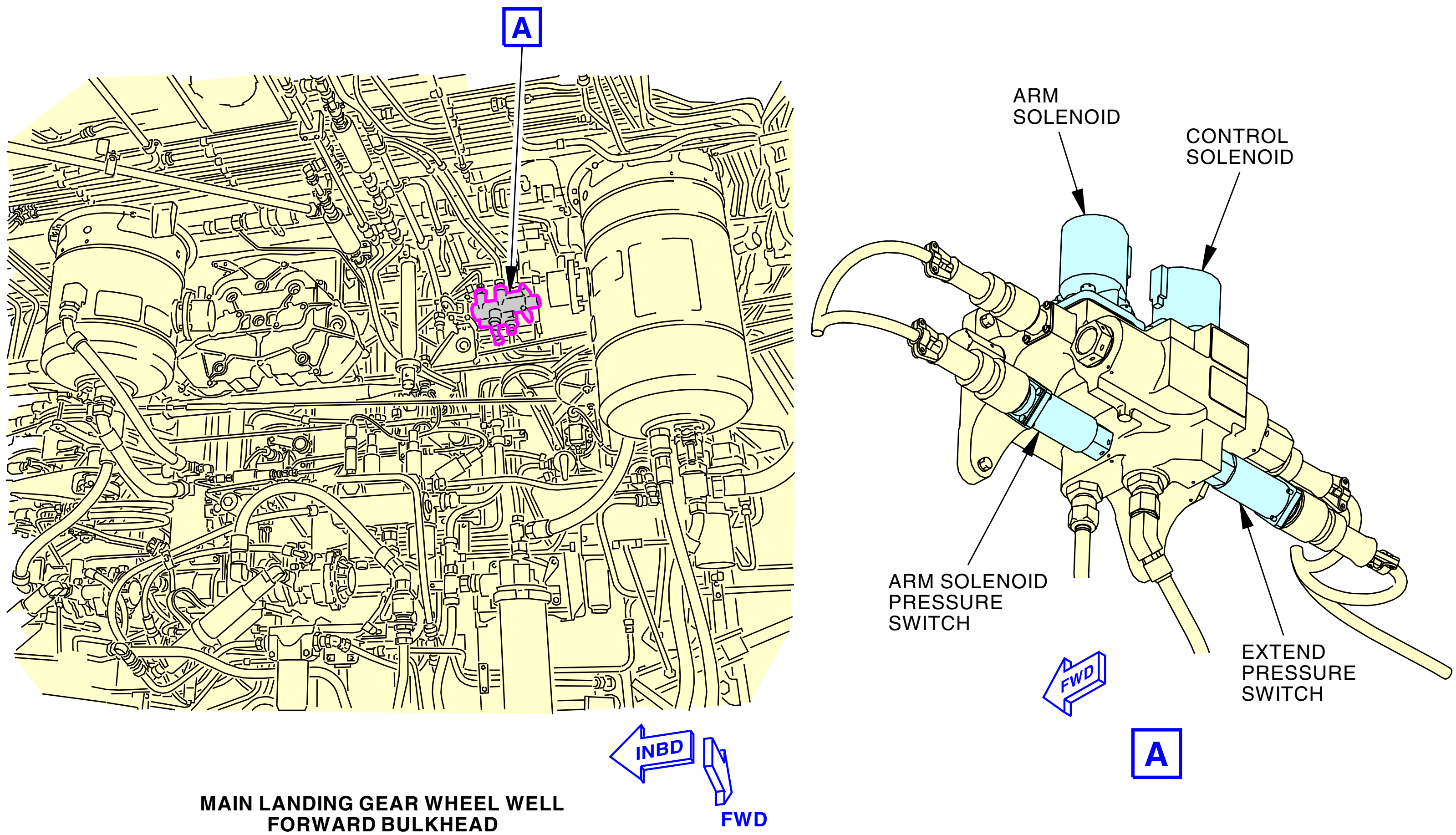
Functional Description

The module hydraulically operates the ground spoiler panels by the use of ground spoiler actuators.

During ground speedbrake operation, the module receives inputs from the SCE. The SCE will use the arm solenoid and the control solenoid to send hydraulic fluid to extend and retract the ground spoilers.

The GSCM has two pressure switches to monitor the extend supply pressure after the ARM solenoid valve and after the ARM valve. The SCE receives pressure input to monitor for system faults.

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER CONTROL MODULE



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SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER CONTROL MODULE

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FLIGHT SPOILER CONTROL SYSTEM - GROUND SPOILER CONTROL - FUNCTIONAL DESCRIPTION

General

The ground spoiler control module (GSCM) receives inputs from the spoiler control electronics (SCE). The SCE uses the GSCM to extend or retract the ground spoilers.

The SCE has four command functions to control the GSCM:

- Arm
- Control
- Deploy
- Retract.

Each function has two command signals.

Operation - Arm Function

When the SCE finds that the airplane is on the ground, it supplies two signals, identified as the arm solenoid command. This gives a ground to the arm solenoid.

Operation - Control Function

When the SCE senses that the speedbrake lever is more than 29 degrees, it supplies two signals, identified as the control solenoid command. This gives a ground to the control solenoid.

Operation - Deploy Function

When the SCE senses that these three conditions are correct, it supplies two signals, identified as the relay command:

- Airplane is on ground
- Speedbrake lever is > 29 degrees
- Both thrust levers are < 50 degrees.

This gives a ground to the R1169 ground spoiler control relay. When the R1169 relay energizes, it supplies power to the arm and ground solenoids.

When the arm and ground solenoids are energized, they open the arm and control valves (not shown). This moves the ground spoiler panels to the extend position.

Operation - Retract Function

When the speedbrake lever position goes less than 29 degrees, the control function is removed. This removes the ground for the control solenoid. This gives hydraulic pressure to retract the ground spoilers.

The deploy function keeps the ground spoiler control relay energized for five seconds because of the time delay in the retract function. After five seconds the SCE removes the ground for R1169. This removes power to the arm solenoid.

This sequence lets the SCE monitor the GSCM. The SCE makes sure that the extend pressure switch goes less than 750 psi. This tells the SCE that the control valve moved to the retract position. The SCE then makes sure that the arm solenoid pressure switch has no pressure. This tells the SCE that the arm solenoid is not energized.

Monitor

The spoiler control electronics monitors the operation of the ground spoiler control for correct operation.

The SCE receives the following inputs:

- R1169
- Arm solenoid pressure
- Extend pressure.

If the SCE finds a fault, it will set a fault and give applicable warnings.

Take-off Warning

The SCE sends to the PSEU two inputs for use in the take-off aural warning function.

FLIGHT SPOILER CONTROL SYSTEM - GROUND SPOILER CONTROL - FUNCTIONAL DESCRIPTION

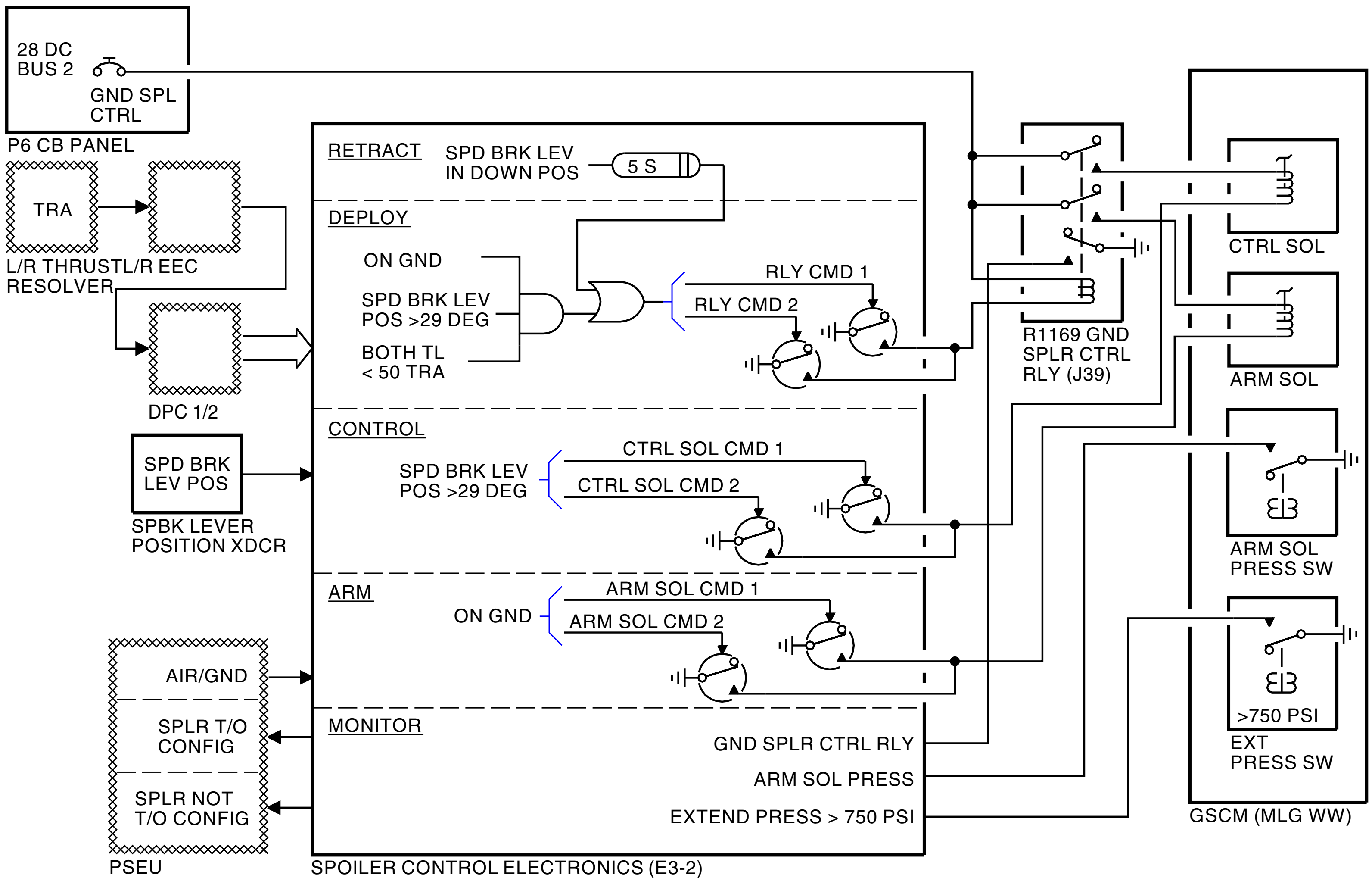
The SCE sends a signal to the PSEU that the spoilers are in the take-off configuration when these occur:

- Speedbrake lever is in the DOWN position
- The pressure at the extend pressure switch is less than 750 psi.

The SCE tells the PSEU that the spoilers are not in the take-off configuration when one of these are true:

- Speedbrake lever is not in the DOWN position
- The pressure at the extend pressure switch is more than 750 psi.

FLIGHT SPOILER CONTROL SYSTEM - GROUND SPOILER CONTROL - FUNCTIONAL DESCRIPTION



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FLIGHT SPOILER CONTROL SYSTEM - GROUND SPOILER CONTROL - FUNCTIONAL DESCRIPTION

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC

General

The pilots use the speedbrake lever to operate the ground spoilers. The spoiler control electronics operates the spoilers on the ground with hydraulic system A.

Manual Speedbrake Control

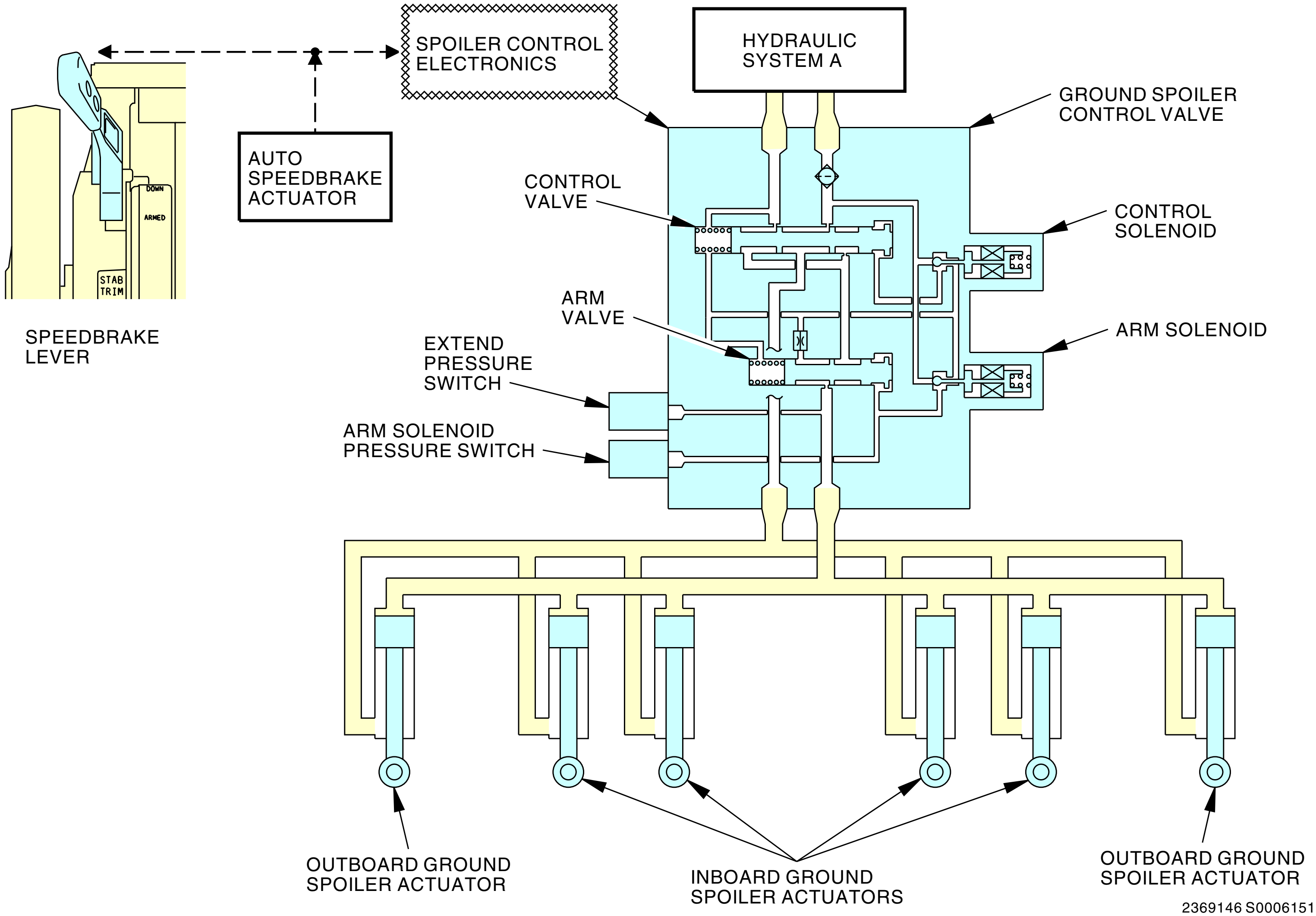
When the speedbrake lever moves, the speedbrake lever position transducer gives an input to the SCE. The SCE tells the ground spoiler control valve to send hydraulic power to the ground spoiler actuators.

When the airplane is on the ground, this permits hydraulic pressure to go to the ground spoiler actuators. This causes the ground spoilers to move up.

Auto Speedbrake Control

During landing and refused takeoffs, the SCE operates the auto speedbrake actuator. This actuator moves the speedbrake lever. The SCE tells the arm and control solenoids to energize. This causes the arm and control valve to send extend pressure to the actuators. This causes the actuators to extend and the ground spoilers to move up.

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC



SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - HYDRAULIC

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER ACTUATORS

Purpose

The ground spoiler actuators use hydraulic power to move the ground spoilers.

Location

There are two ground spoiler actuators for each inboard ground spoiler and one ground spoiler actuator for each outboard ground spoiler.

The ground spoiler actuators attach to the rear spar of the wing below each ground spoiler. To get access, raise the spoiler panels and extend the TE flaps.

Functional Description

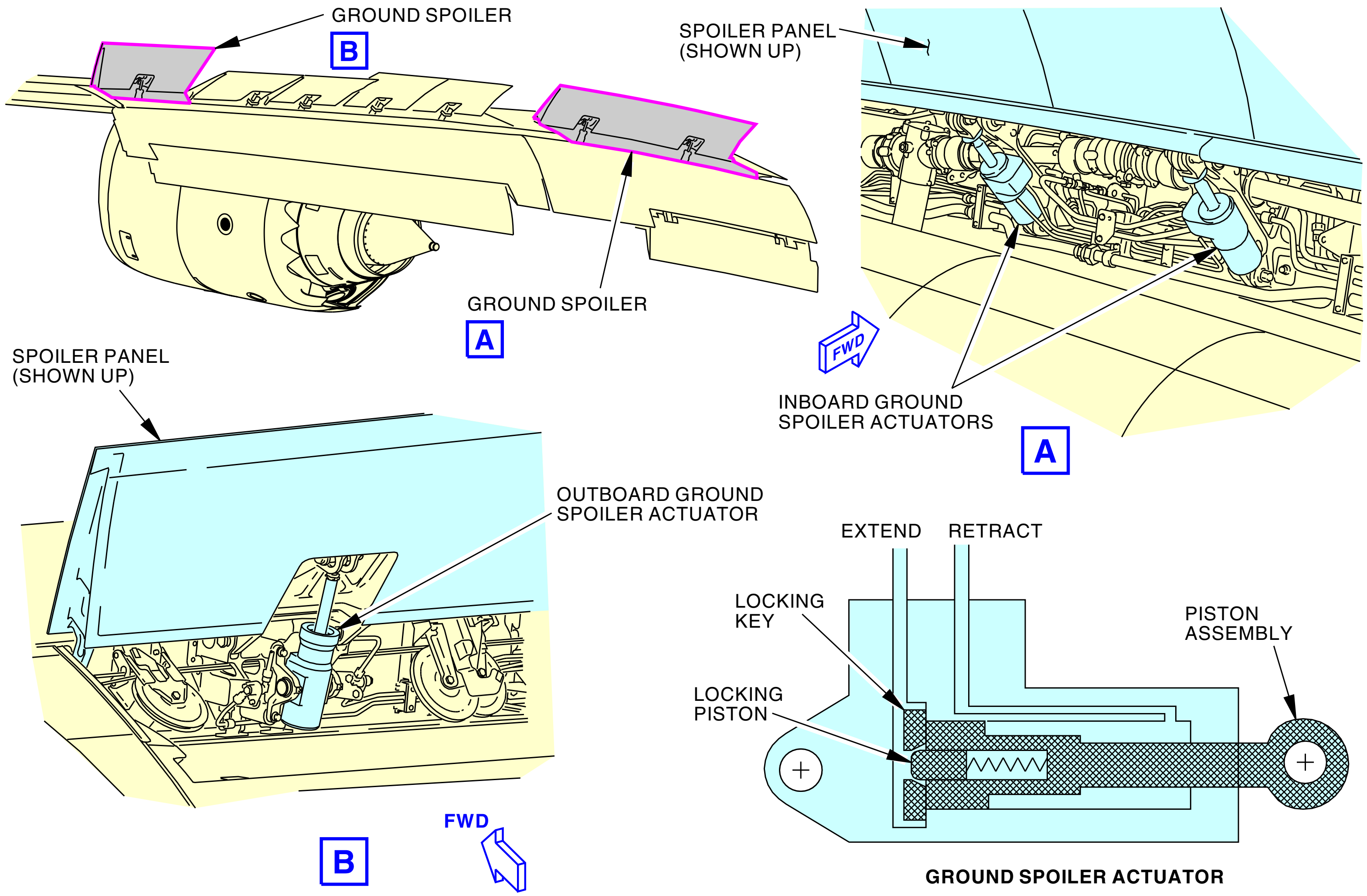
Each ground spoiler actuator has these components:

- Piston assembly
- Locking piston
- Locking keys
- Spring.

Each ground spoiler actuator has an internal mechanical lock which locks the actuator in the retract position. With no extend pressure, the spring moves the locking piston in the direction of the locking keys. This causes the locking keys to move away from the locking piston. This keeps the piston assembly in the retract position.

When the actuator receives extend pressure, the pressure causes the locking piston to compress the spring. This permits the locking keys to move in. This unlocks the piston assembly and permits it to extend.

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER ACTUATORS



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SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILER ACTUATORS

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILERS

Purpose

The ground spoilers help reduce lift and increase drag of the airplane during landing and refused takeoffs.

Location

There are two ground spoilers on each wing. The ground spoilers are at the fixed trailing edge of the wings. On each wing, there is one ground spoiler inboard of the engine strut and one ground spoiler just inboard of the aileron.

Physical Description

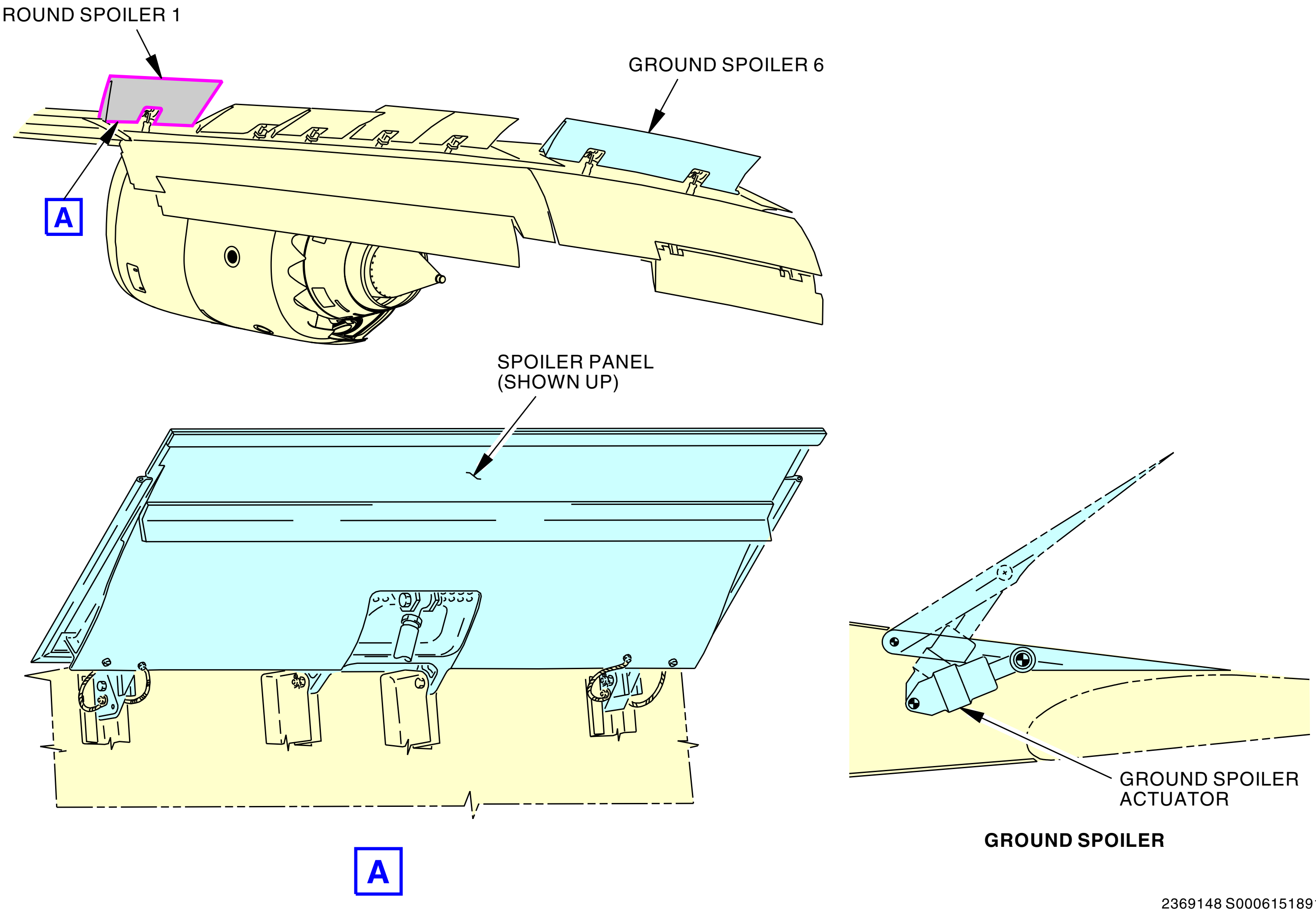
The ground spoilers are made of composite materials. The ground spoilers are not interchangeable.

Functional Description

The ground spoilers operate on the ground only. They use inputs from the speedbrake lever.

The ground spoilers move up when the speedbrake lever moves more than 31 degrees. Ground spoilers 1, 6, 7, and 12 move up 60 degrees. Stops in the ground spoiler actuators limit the movement of the ground spoilers.

SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILERS



SPEEDBRAKE CONTROL SYSTEM - GROUND SPOILERS

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE

General

The Spoiler Control Electronics (SCE) controls the automatic operation of the speedbrakes. The SCE uses data from these sources:

- Speedbrake lever position transducer
- Speedbrake Refused Take Off (RTO) switch
- Thrust position angle resolvers through the Electronic Engine Control (EEC) and the Display Processing Computer (DPC)
- Antiskid/Autobrake Control Unit (AACU)
- Proximity Sensing Electronics Unit (PSEU)
- Antiskid sense relay (2)
- Radio Altimeter (RA).

Landing

During a landing or an RTO, the SCE will generate a raise command to the autospeedbrake actuator if the following criterias are met:

- Speedbrake lever is in the armed position (greater than 3.5°) or RTO switch is engaged
- Radio altitude height is less than 6'
- Both throttle positions are less than 50° Throttle RVDT Angle (TRA), and
- Wheel speed is greater than 60 knots or PSEU air/ground inputs indicate on ground.

NOTE: The autospeedbrake command logic causes the on-ground input to the autospeedbrake logic to "expire" 4 seconds after the air-to ground transition.

Refused Takeoffs (RTO)

During a RTO, when the pilot moves at least one of the thrust reverser levers, the speedbrake refused takeoff switch closes. This permits the auto speedbrake actuator to extend fully. This commands all spoilers to move up.

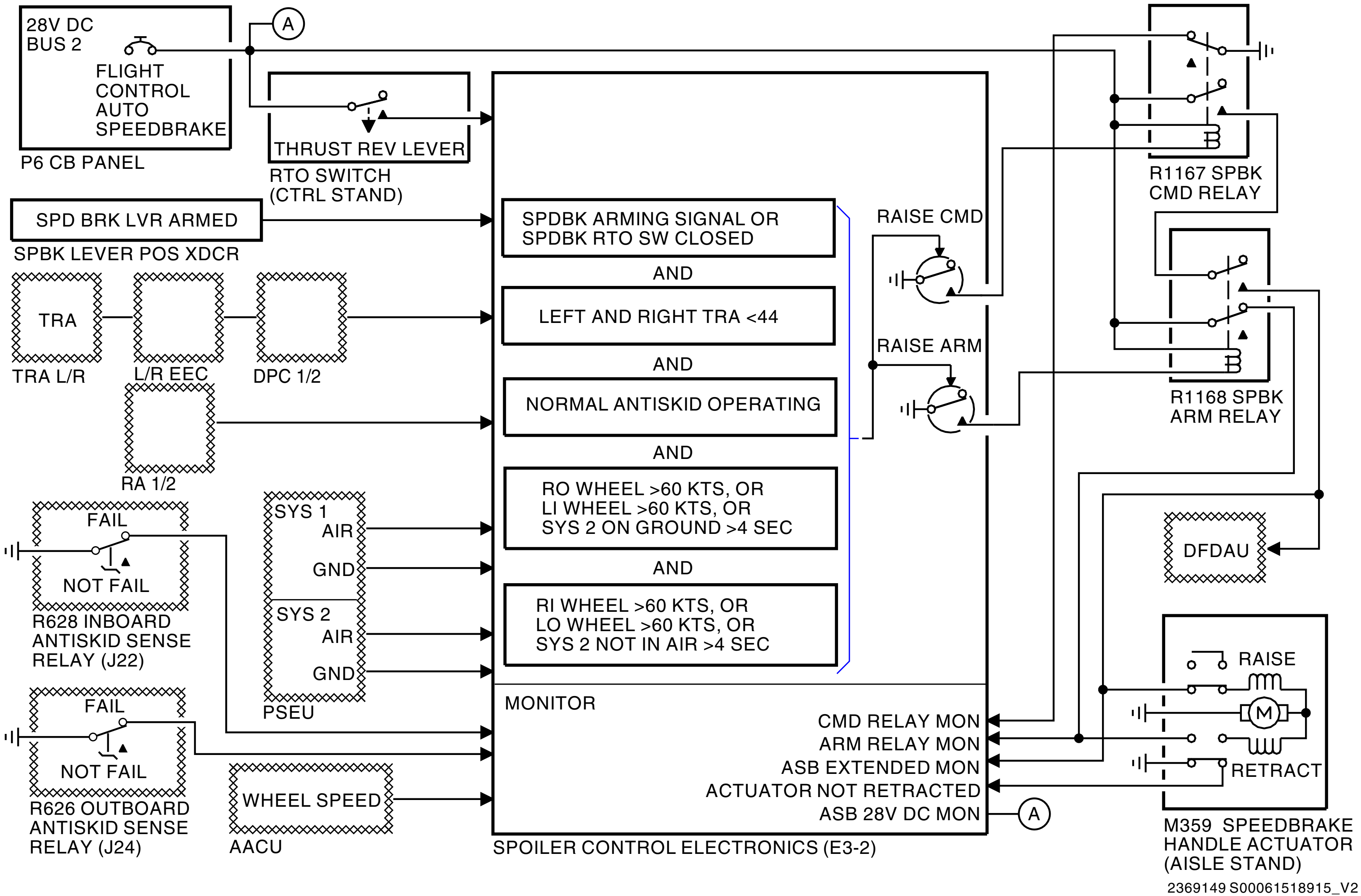
The auto speedbrake actuator retracts if either thrust lever is more than the IDLE position.

Monitor

The SCE controls the amber SPEED BRAKE DO NOT ARM light and the green SPEED BRAKE ARMED light. The SCE also sends signals to the flight data acquisition unit for flight data recording.

See the Digital Flight Data Recording System (DFDRS) section for more information about the Digital Flight Data Acquisition Unit (DFDAU) (SECTION 31-31).

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE



SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE INDICATIONS

Indications

The SCE controls the amber SPEED BRAKE DO NOT ARM light and the green SPEED BRAKE ARMED light. The SCE also sends signals to the flight data acquisition unit for flight data recording.

See the Digital Flight Data Recording System (DFDRS) for more information about the Digital Flight Data Acquisition Unit (DFDAU). (SECTION 31-31)

The SPEED BRAKE DO NOT ARM light comes on when the automatic operation of the speedbrake system does not arm correctly. This occurs when the speedbrake lever is in the ARMED detent, or a thrust lever is in reverse, and one of these occurs:

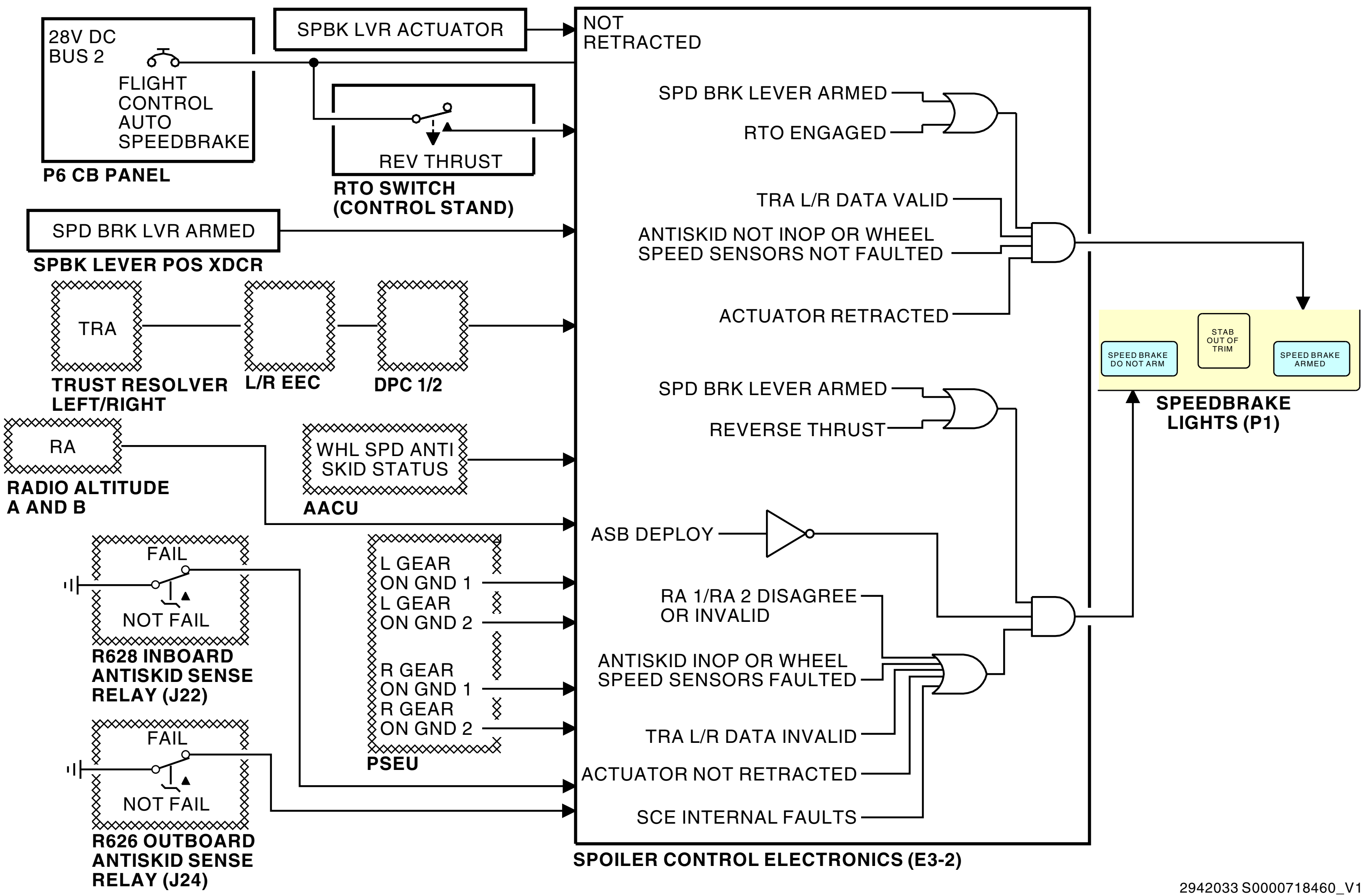
- Antiskid system unserviceable/inoperative
- Wheel speed sensors unserviceable
- Radio altitude data fault
- Thrust resolver angle data fault
- Auto speedbrake lever actuator not retracted
- Internal faults in the spoiler control electronics unit.

NOTE: On landing, if the wheel speed is <60kts, and the speedbrake handle is in the UP position, the SPEEDBRAKE DO NOT ARM light will NOT illuminate. This is the normal operation of the SPEEDBRAKE DO NOT ARM light, and is not a system fault.

The SPEED BRAKE ARMED light comes on when the automatic operation of the speedbrake system arms correctly. This occurs when the speedbrake lever is in the ARMED detent, or the Refused Take Off (RTO)switch is engaged, and all of these occur:

- Normal inboard or outboard antiskid channel operates
- Auto speedbrake actuator is retracted
- There is no disagree in the wheel spin speeds and air/ground signals.

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE INDICATIONS



SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - AUTO SPEEDBRAKE INDICATION

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - SPEEDBRAKES EXTENDED LIGHT

General

The spoiler control electronics (SCE) controls the operation of the SPEEDBRAKES EXTENDED light. The SCE uses data from these sources:

- Speedbrake lever position transducer
- Trailing edge flaps landing warning switch
- Ground spoiler control module (GSCM) extend pressure switch
- Two radio altimeters (RA).

In-flight

The SPEEDBRAKES EXTENDED light comes on when in-flight with the speedbrake lever more than the ARM position for more than 5 seconds and one of these conditions occur:

- Thrust lever is above idle for more than 15 seconds
- Thrust lever is above 40 degrees for more than 3 seconds.
- TE flaps are greater than 10 units
- Radio altitude is less than 800 feet.

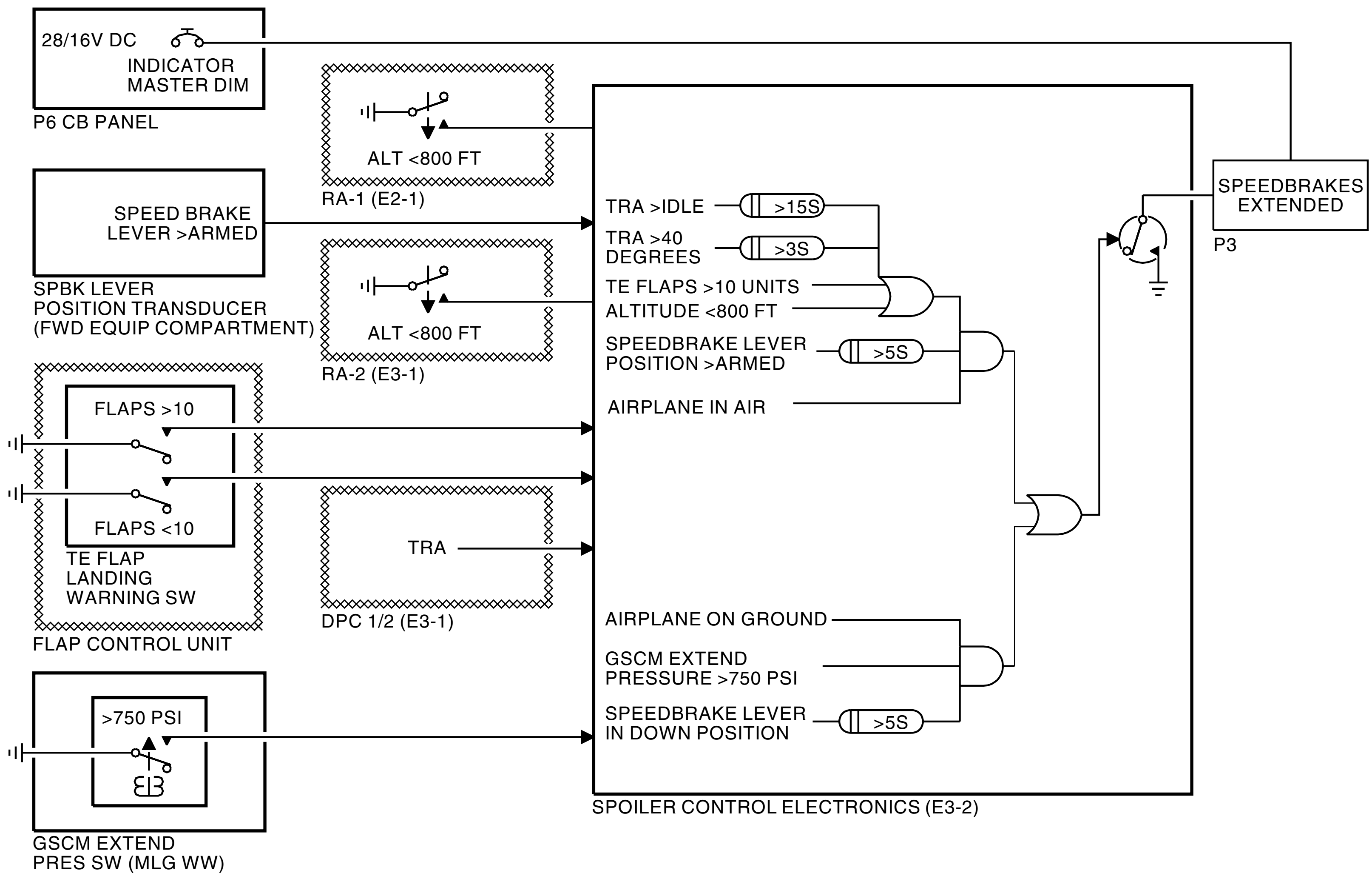
On ground

The SPEEDBRAKES EXTENDED light comes on when all these conditions occur:

- Airplane on the ground
- GSCM extend pressure switch measures more than 750 psi
- Speedbrake lever is in the DOWN position for more than 5 seconds.

NOTE: If the SPEEDBRAKES EXTENDED light comes on the when the airplane is on the ground, the onboard maintenance system records a fault message.

SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - SPEEDBRAKES EXTENDED LIGHT



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SPEEDBRAKE CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - SPEEDBRAKES EXTENDED LIGHT

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LE FLAP AND SLAT CONTROL SYSTEM - INTRODUCTION

Purpose

The leading edge (LE) flaps and slats increase the wing area and the wing camber. This increases lift to help improve the takeoff and landing performance of the airplane.

General

The LE devices include two Krueger flaps and four slats on the leading edge of each wing. During cruise, these surfaces fully retract. These surfaces extend during takeoff to increase lift, which permits slower speeds for airplane rotation. During landing, the LE slats fully extend to increase lift and help prevent a stall.

During normal operation, the LE flaps and slats are mechanically controlled. During alternate operation, the LE flaps and slats are electrically controlled.

The LE cruise depressurization function depressurizes the LE flap and slat actuators. This occurs when all the LE devices and the flap lever are at the up position and the airplane is in the air.

The LE uncommanded motion (UCM) detection function stops the LE normal operation if two or more LE flaps or slats move away from their commanded position.

There is position indication in the flight deck for all the LE devices during normal operation and alternate operation.

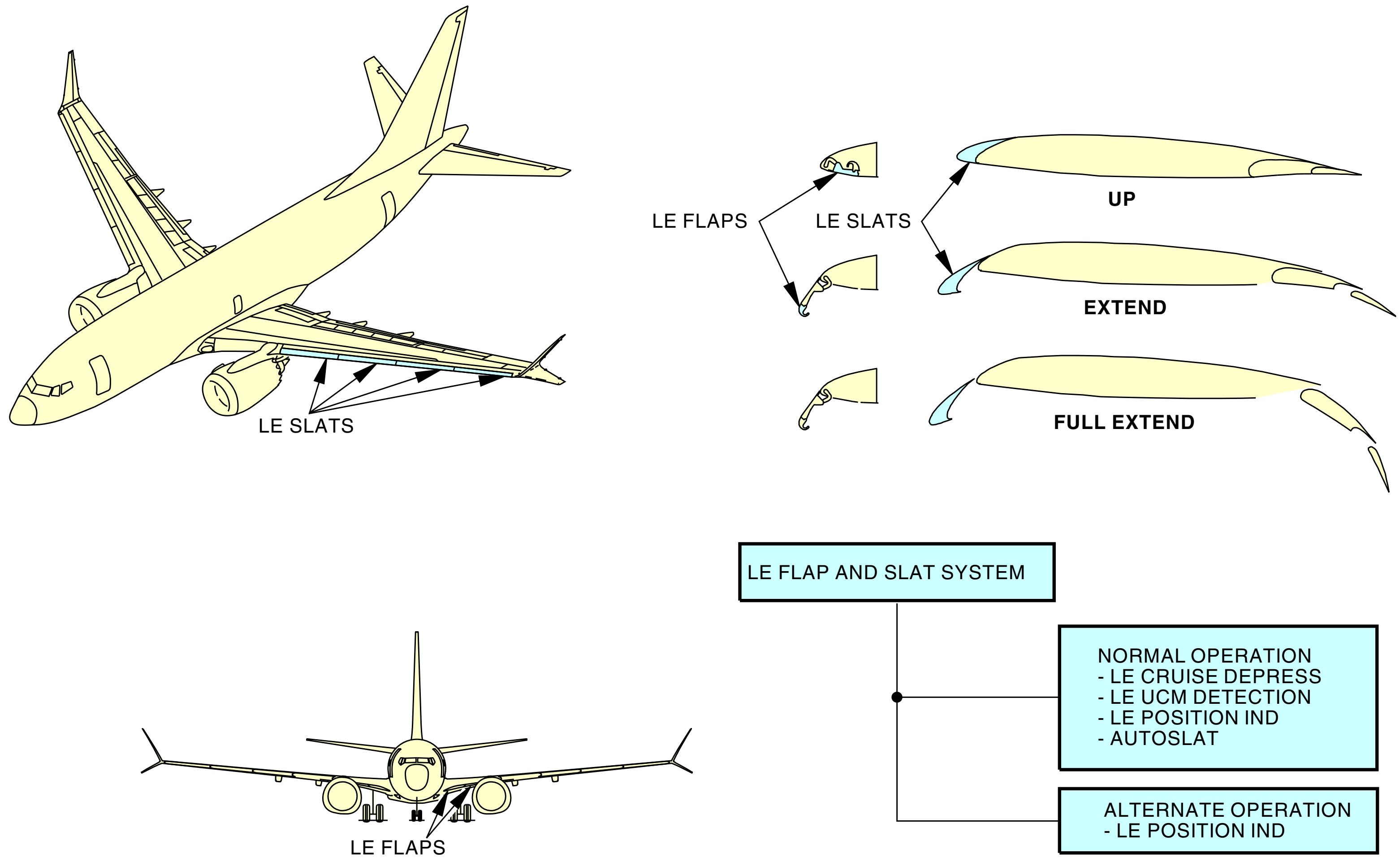
During the normal operation, if the airplane comes near a stall condition, the autoslat function fully extends the LE slats. This helps prevent a stall.

You can do tests of the LE flaps and slats with built in test equipment (BITE) in the flap/slat electronic unit (FSEU). The FSEU BITE also permits you to see other maintenance data.

Abbreviations and Acronyms

- ADIRU - air data inertial reference unit
- alt - alternate
- BITE - built-in test equipment
- cntl - control
- depress - depressurization
- DFDAU - digital flight data acquisition unit
- EMDP - electric motor-driven pump
- ext - extend
- FCC - flight control computer
- FSEU - flap/slat electronic unit
- gnd - ground
- GPM - gallons per minute
- inbd - inboard
- ind - indication
- LE - leading edge
- MLG - main landing gear
- PDU - power drive unit
- prox - proximity
- PSEU - proximity switch electronics unit
- PTU - power transfer unit
- sec - second(s)
- sect - section
- SMYD - stall management yaw damper
- SOV - shutoff valve
- stdby - standby
- TE - trailing edge
- T/R - thrust reverser
- UCM - uncommanded motion
- vlv - valve
- WW - wheel well.

LE FLAP AND SLAT CONTROL SYSTEM - INTRODUCTION



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LE FLAP AND SLAT CONTROL SYSTEM - INTRODUCTION

LE FLAP AND SLAT CONTROL SYSTEM - GENERAL DESCRIPTION

General

The LE flaps and slats use hydraulic power to move. For the normal operation, hydraulic system B supplies hydraulic power. The commands for the LE flaps and slats come from the TE flap system. During the alternate operation, the standby hydraulic system supplies hydraulic power. The commands come from the alternate flaps switches.

Normal Operation

The TE flap system sends inputs to the LE flap and slat control valve during normal operation. The flap lever moves a cable system that supplies a mechanical input to the TE flap system. As the TE flaps move, feedback from the TE flap system moves the LE flap and slat control valve. The LE flap and slat control valve is in the TE flap control unit.

The LE flap and slat control valve receives hydraulic system B pressure from the LE cruise depressurization valve. The LE flap and slat control valve sends hydraulic power through the autoslat control valve to the LE flap and slat actuators. These actuators move the LE flaps and slats.

The LE flap and slat proximity sensors send signals to the flap/slat electronics unit (FSEU). The FSEU sends this data to the LE devices annunciator panel and the LE flaps lights in the flight deck.

The FSEU closes the LE cruise depressurization valve when the airplane is in a cruise condition. This valve stops the hydraulic power to the LE flap and slat actuators to prevent extension.

The FSEU closes the LE uncommanded motion (UCM) shutoff valve if there is an uncommanded motion of the LE devices. This occurs when two or more LE devices move away from their commanded position. The LE uncommanded motion (UCM) shutoff valve removes the retract pressure from the LE flap and slat actuators. This prevents more movement of the LE flaps and slats.

If the LE slats are at the extend position and the airplane gets near a stall condition, the stall management yaw dampers (SMYDs) send signals to the autoslat control valve. The autoslat control valve sends hydraulic power to the LE slat actuators to fully extend the LE slats.

See the leading edge autoslat system section for more information on the autoslat valve. (SECTION 27-83)

See the stall warning system section for more information on the SMYDs. (SECTION 27-32)

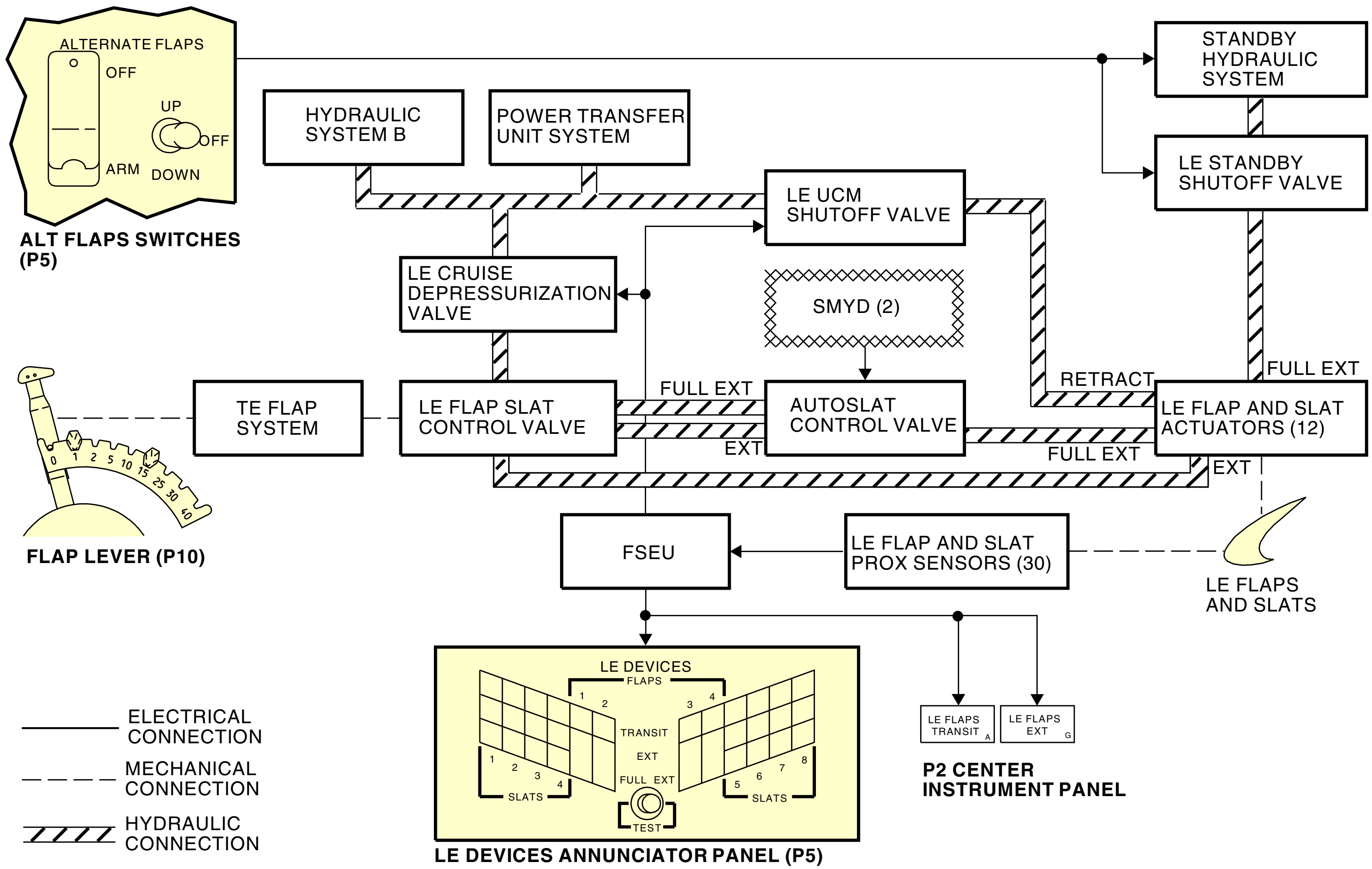
See the trailing edge flap system section for more information on the TE flap system. (SECTION 27-51)

Alternate Operation

During the alternate operation, the alternate flaps switches send a signal to the LE standby shutoff valve and to the standby hydraulic system. The LE standby shutoff valve sends hydraulic power to the LE flap and slat actuators to extend the LE flaps and slats. Hydraulic power from the LE standby shutoff valve has priority over the hydraulic power from the LE flap and slat control valve.

During the alternate operation, the LE flaps and slats can not retract.

LE FLAP AND SLAT CONTROL SYSTEM - GENERAL DESCRIPTION



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LE FLAP AND SLAT CONTROL SYSTEM - GENERAL DESCRIPTION

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 1

General

The LE flap and slat system components are in these areas:

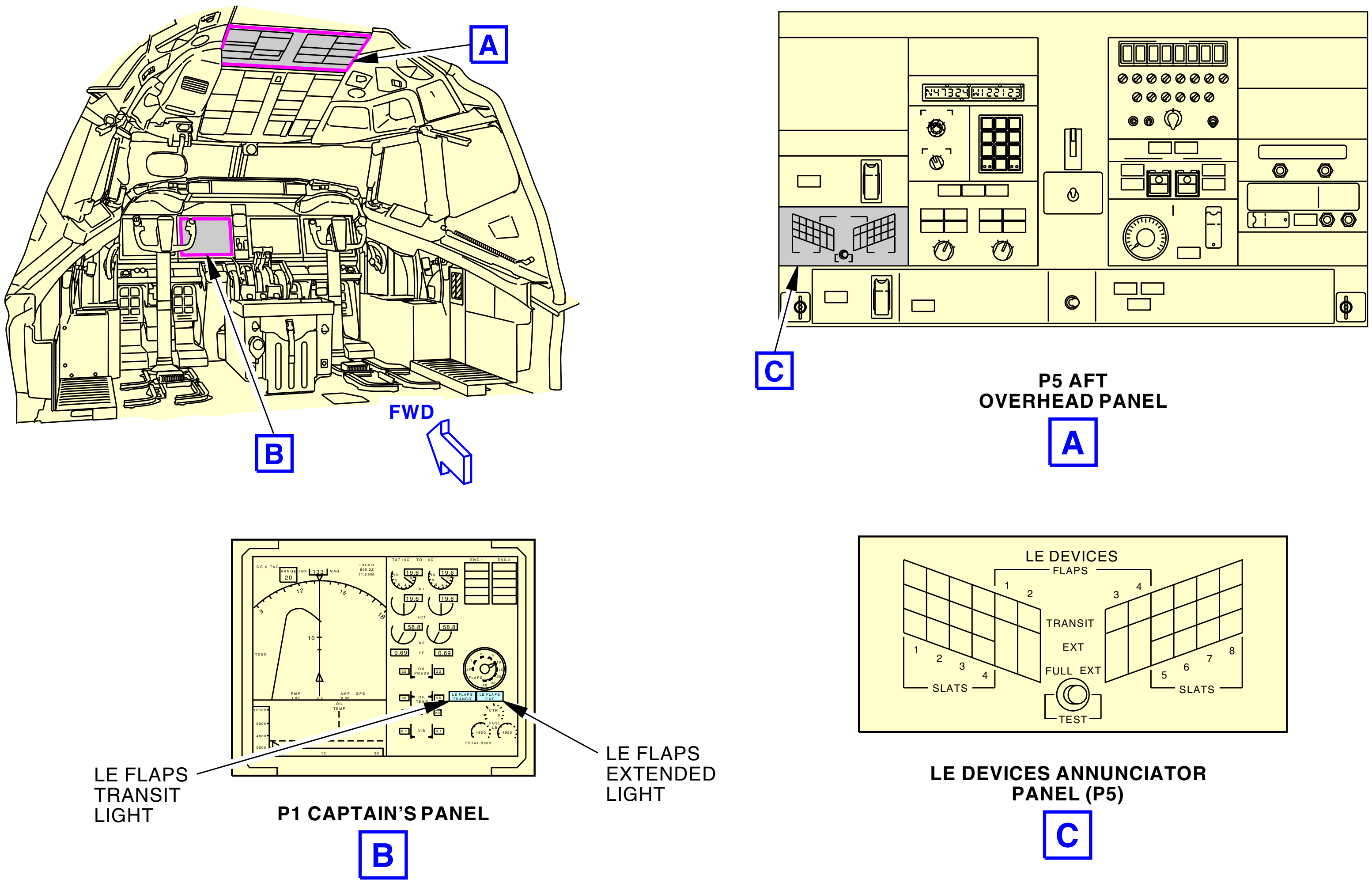
- Flight deck
- Main landing gear (MLG) wheel well
- Right wing-to-body fairing
- Wing.

The components outside of the flight deck are shown later.

Flight Deck Components

The LE devices annunciator panel is on the P5 aft overhead panel. The LE FLAPS TRANSIT light and the LE FLAPS EXT light are on the P1 captain's panel.

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 1



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LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 1

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 2

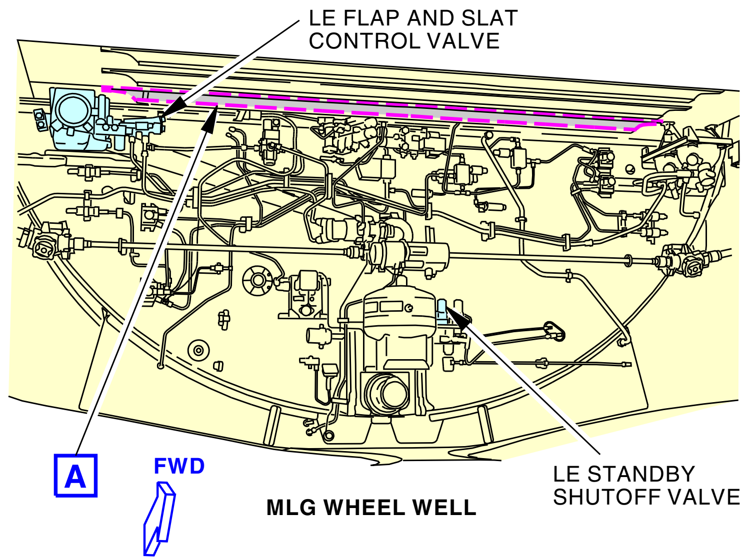
MLG Wheel Well Components

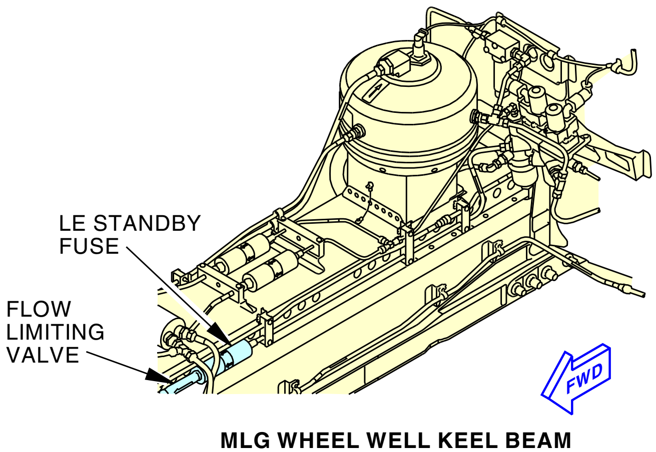
These are the components in the MLG wheel well:

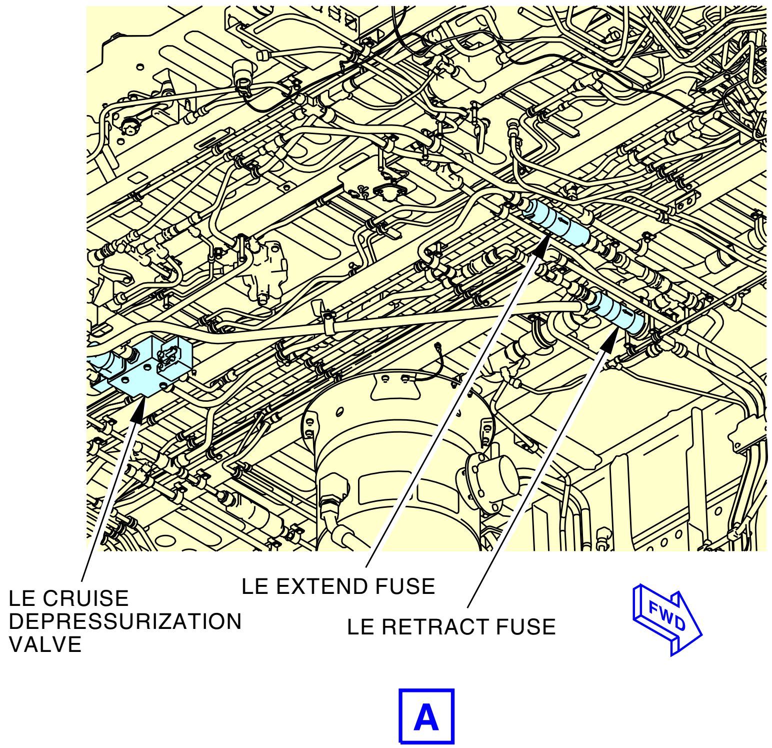
- LE flap and slat control valve
- LE cruise depressurization valve
- LE standby shutoff valve
- LE flap and slat flow limiting valve
- LE flap and slat hydraulic fuses.

The LE flap and slat control valve is on the flap control unit on the aft bulkhead. The LE standby shutoff valve is on the flight controls module on the aft bulkhead. The flow limiting valve and the LE standby hydraulic fuse are on the keel beam. The LE cruise depressurization valve, and the extend and retract fuses are on the ceiling.

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 2







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LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 2

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 3

Right Wing-to-Body Fairing Components

The LE UCM shutoff valve is in the right wing-to-body fairing, forward of the main gear wheel well. To get access, open the ram air inlet duct access panel.

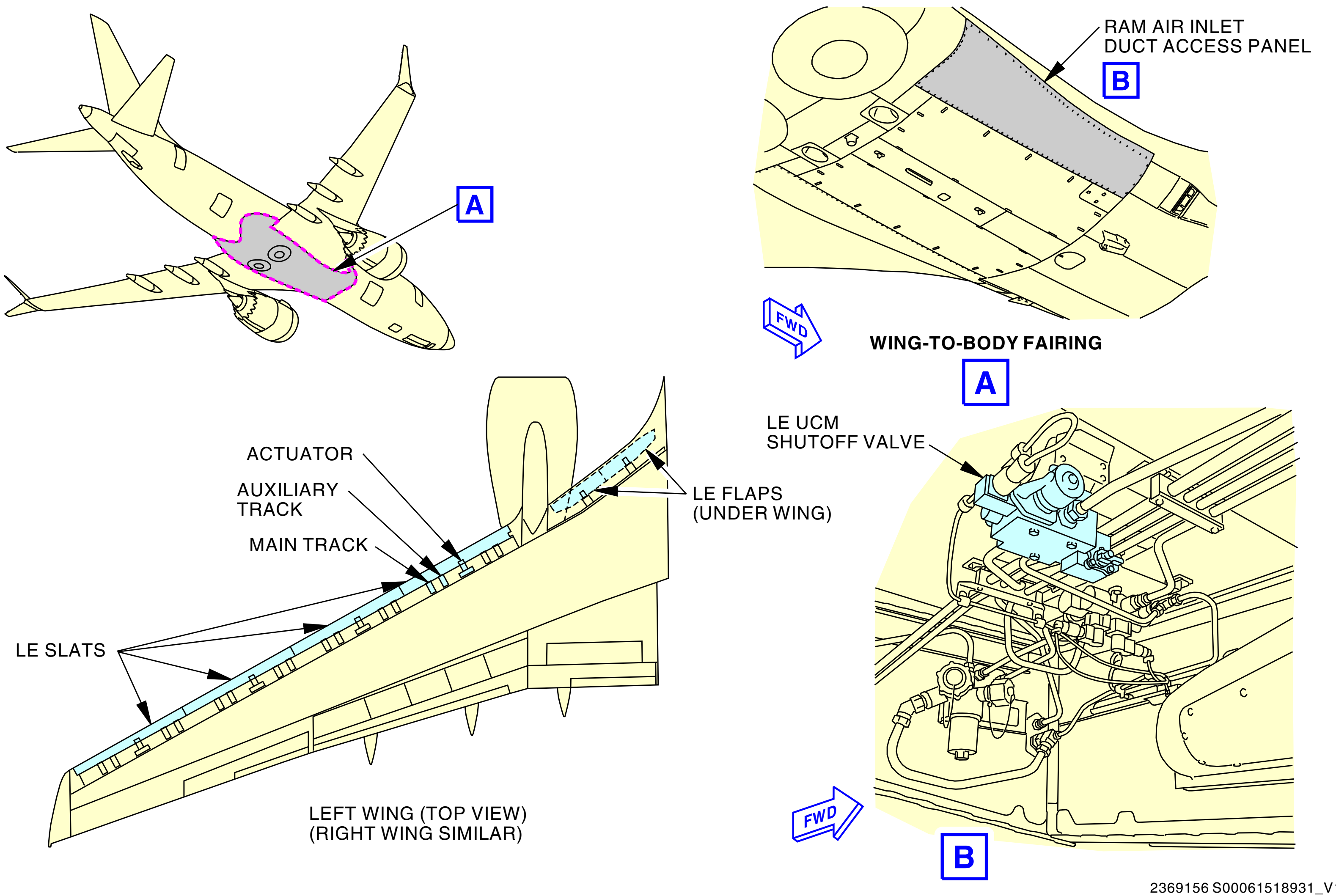
Wing Components

These are the components on the wings:

- LE flaps and slats
- LE flap actuators
- LE slat actuators
- Slat main and auxiliary tracks.

To get access to the LE flap actuators, extend the LE flaps. To get access to the LE slat actuators and tracks, go through access panels under the wing.

LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 3



LE FLAP AND SLAT CONTROL SYSTEM - COMPONENT LOCATIONS 3

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP AND SLAT CONTROL VALVE

Purpose

The TE flap PDU gives mechanical inputs to the LE flap and slat control valve. The LE flap and slat control valve sends hydraulic power to the LE flap and slat actuators.

Location

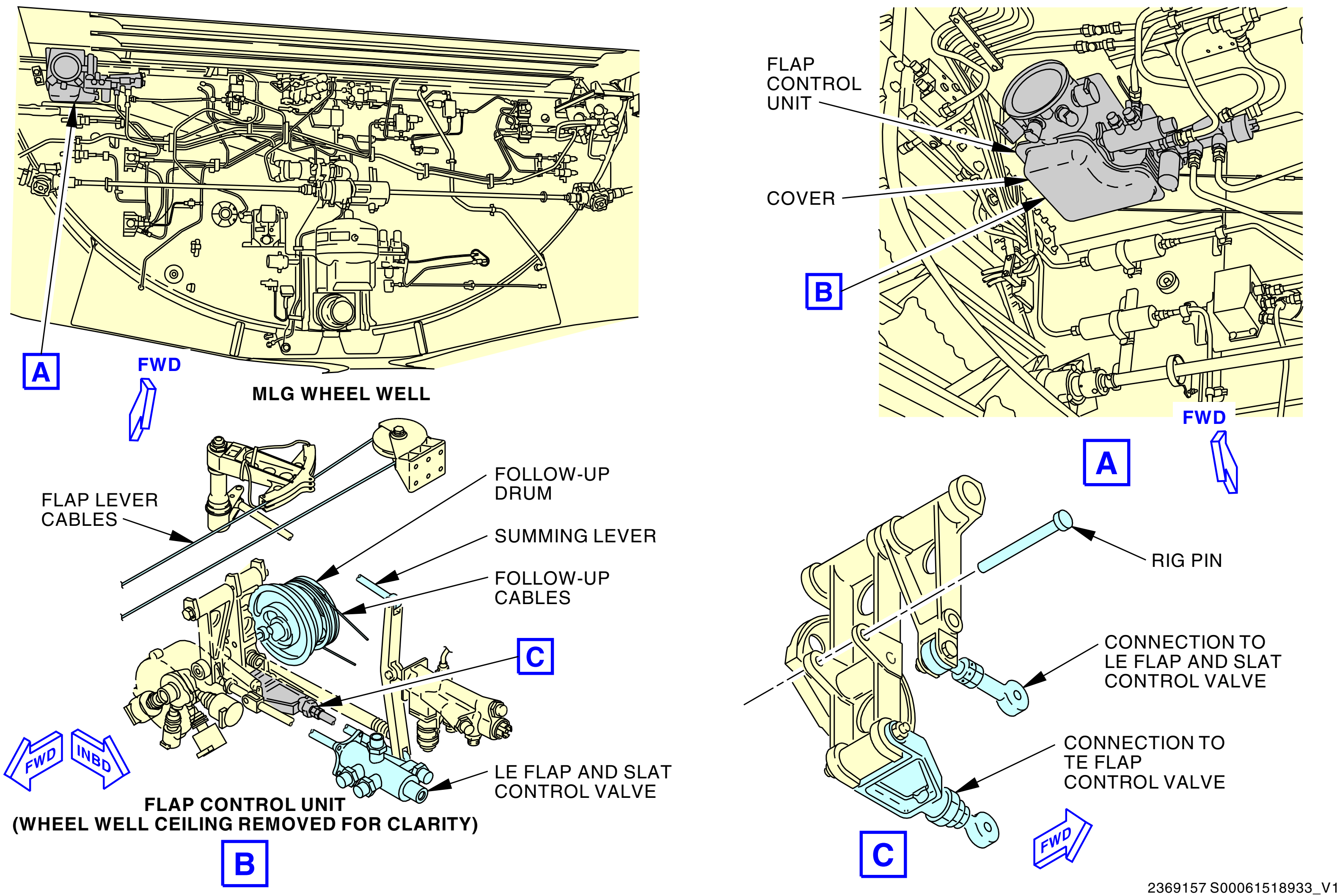
The LE flap and slat control valve is on the TE flap control unit in the MLG wheel well. The TE flap control unit is on the right side of the aft bulkhead, near the ceiling.

Physical Description

Through the follow-up cables, the TE flap PDU gives mechanical inputs to the LE flap and slat control valve. As the TE flaps move, the follow-up cables move the follow-up drum on the TE flap control unit. The follow-up drum moves a cam roller, which moves the LE flap control valve link. This link moves the LE flap and slat control valve. The LE flap and slat control valve sends hydraulic power to the LE flap and slat actuators and to the autoslat control valve.

See the trailing edge flap system section for more information on the TE flap PDU and TE flap control unit. (SECTION 27-51)

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP AND SLAT CONTROL VALVE



LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP AND SLAT CONTROL VALVE

LE FLAP AND SLAT CONTROL SYSTEM - LE CRUISE DEPRESSURIZATION VALVE

Purpose

The LE cruise depressurization valve prevents LE flap and slat extension during cruise.

Location

The LE cruise depressurization valve is on the ceiling in the main landing gear wheel well.

Physical Description

The LE cruise depressurization valve has a 28v dc solenoid-operated valve and a pressure-operated valve.

The LE cruise depressurization valve is identical and interchangeable with the LE UCM shutoff valve.

Functional Description

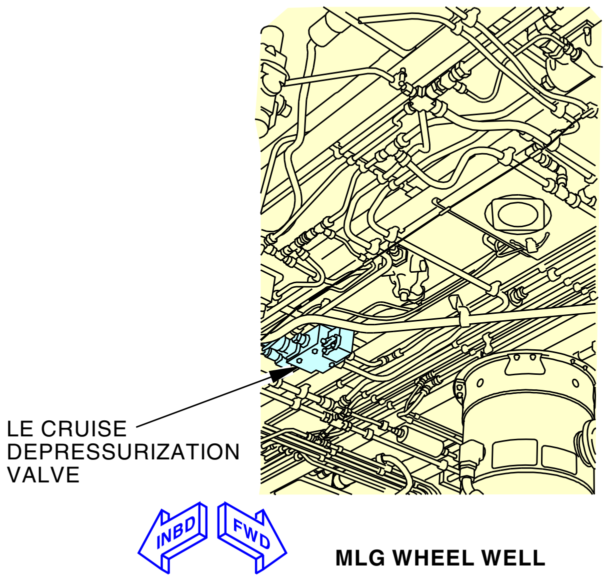
The LE cruise depressurization valve is normally open. This permits hydraulic system B pressure to the LE flap and slat control valve. The LE flap and slat control valve sends this pressure to the extend lines of the LE flap and slat actuators.

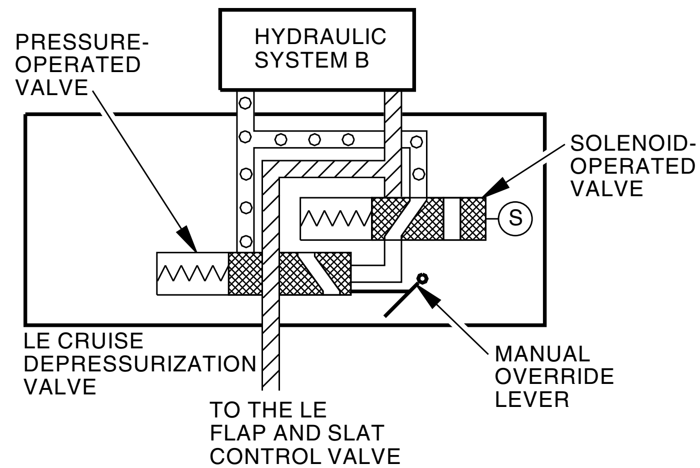
The FSEU controls the solenoid operated valve in the LE cruise depressurization valve.

When the FSEU sends a signal to energize the solenoid valve operated valve, it moves and sends pressure to move the pressure-operated valve.

This stops the hydraulic system B pressure to the LE flap and slat control valve. This prevents extend pressure to the LE flap and slat actuators.

LE FLAP AND SLAT CONTROL SYSTEM - LE CRUISE DEPRESSURIZATION VALVE





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LE FLAP AND SLAT CONTROL SYSTEM - LE CRUISE DEPRESSURIZATION VALVE

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE CRUISE DEPRESSURIZATION

Purpose

The LE cruise depressurization valve prevents LE flap and slat extension during cruise.

Functional Description

The flap lever position switch that operates when the flap lever is up provides power for the LE cruise depressurization valve solenoid. The FSEU provides a ground for the solenoid.

The FSEU gets the inputs from these components for operation of the LE cruise depressurization valve:

- LE flap and slat proximity sensors
- Flap lever position sensor
- Alternate flaps ARM switch
- PSEU for air/ground information.

The FSEU sends a signal to close the LE cruise depressurization valve closes when all of these conditions occur for five seconds:

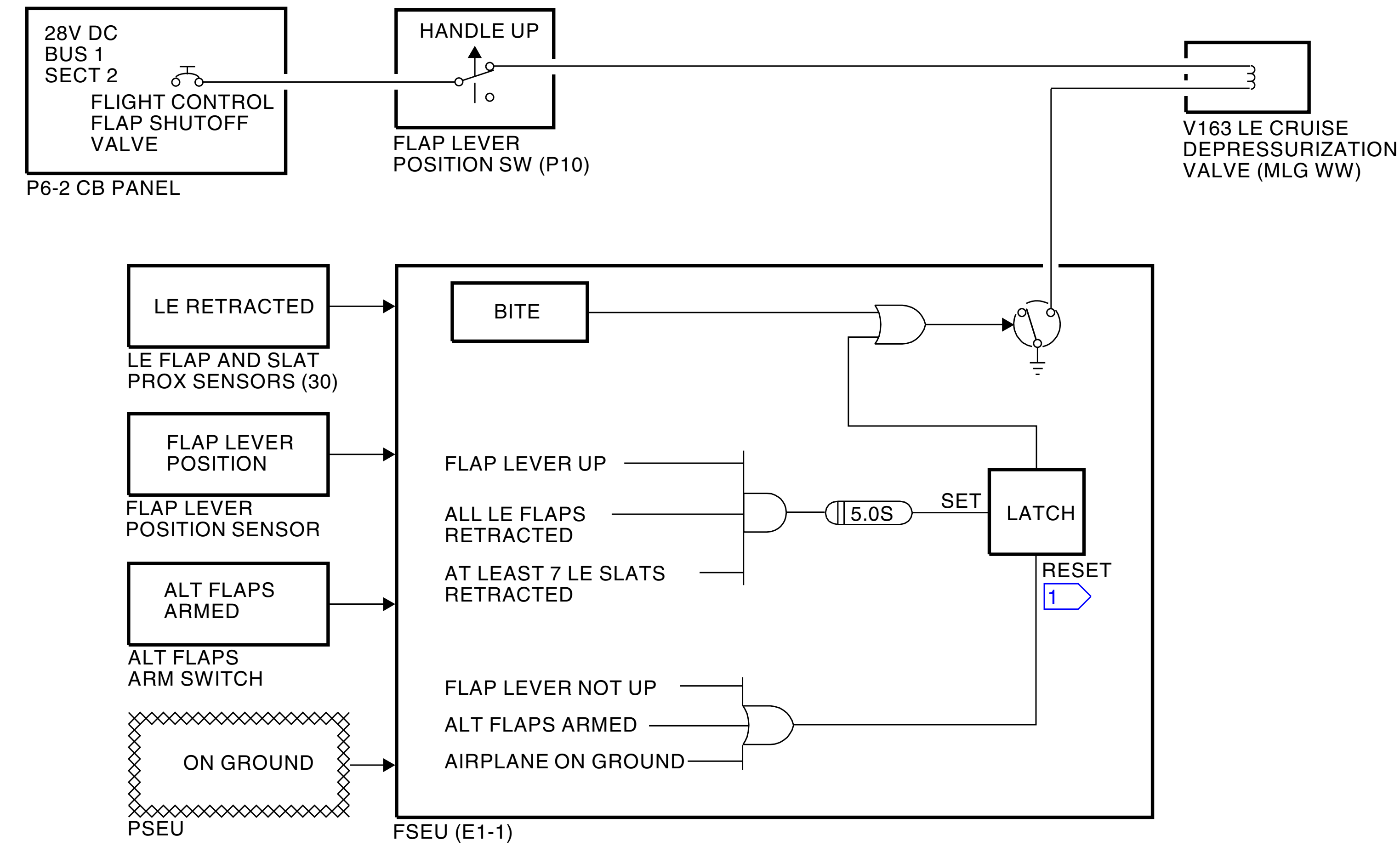
- Flap lever at up
- All LE flaps retracted
- At least 7 LE slats retracted.

The LE cruise depressurization valve does not operate if any of these conditions occur:

- Flap lever not up
- Alternate flaps arm switch is in the ARM position
- Airplane is on the ground.

You can use the FSEU BITE to send a command to operate the LE cruise depressurization valve.

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE CRUISE DEPRESSURIZATION



1 LATCH IS RESET PRIORITY

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LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE CRUISE DEPRESSURIZATION

LE FLAP AND SLAT CONTROL SYSTEM - LE UCM SHUTOFF VALVE

Purpose

The LE UCM shutoff valve prevents LE flap and slat movement if two or more LE flaps or three or more LE slats move away from their commanded position.

Location

The LE UCM shutoff valve is in the right wing-to-body fairing, forward of the main landing gear wheel well. To get access, open the ram air inlet duct access panel.

Physical Description

The LE UCM shutoff valve has a 28v dc solenoid-operated valve and a pressure-operated valve.

The LE UCM shutoff valve is identical and interchangeable with the LE cruise depressurization valve.

Functional Description

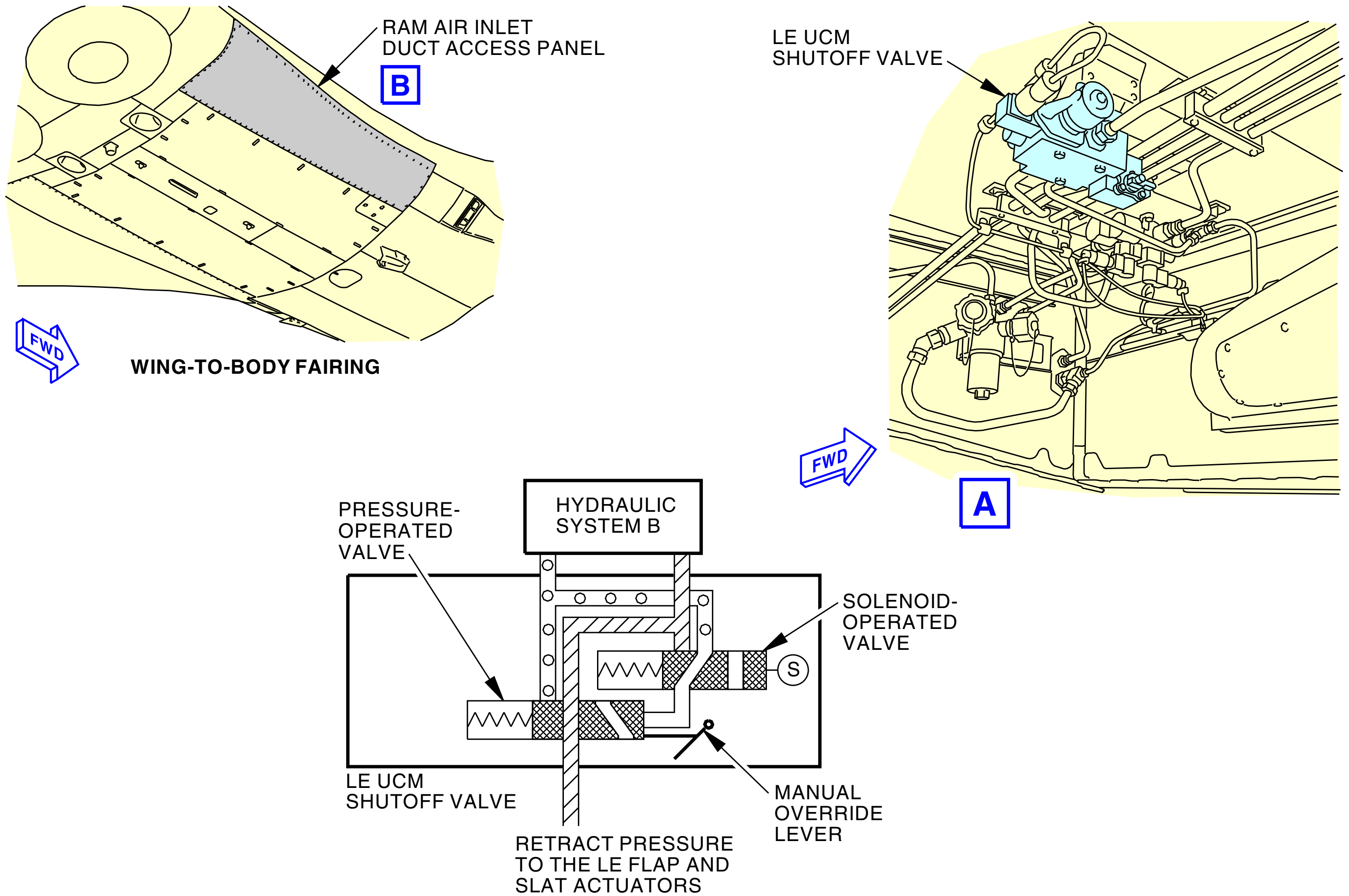
The LE UCM shutoff valve is normally open. This permits hydraulic system B pressure to the retract lines of the LE flap and slat actuators.

The LE uncommanded motion (UCM) detection function in the FSEU controls the solenoid operated valve in the LE UCM shutoff valve.

When the FSEU sends a signal to energize the solenoid operated valve, it moves and sends pressure to move the pressure operated valve.

This stops the hydraulic system B pressure to the retract lines of the LE flap and slat actuators. When retract pressure is removed, a system blocking valve in the LE flap and slat actuators moves to the closed position. This prevents movement of the LE flaps and slats by creating a hydraulic lock on the actuator.

LE FLAP AND SLAT CONTROL SYSTEM - LE UCM SHUTOFF VALVE



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LE FLAP AND SLAT CONTROL SYSTEM - LE UCM SHUTOFF VALVE

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE UCM DETECTION

Purpose

The LE UCM shutoff valve prevents LE flap and slat movement if two or more LE flaps or three or more LE slats move away from their commanded position.

Functional Description

The FSEU gets inputs from these components for operation of the LE UCM shutoff valve:

- LE flap and slats proximity sensors
- Flap lever position sensor
- Alternate flaps arm switch
- ADIRU for airspeed data
- SMYDs for autoslat command data
- TE flap skew sensors 1 and 8.

The LE UCM shutoff valve is normally open. This lets hydraulic system B pressure go to the retract lines of the LE flap and slat actuators.

The LE uncommanded motion (UCM) detection function in the FSEU controls the LE UCM shutoff valve. This valve closes when all the LE flaps and slats move to their commanded position and then these conditions occur:

- Two or more LE flaps or three or more LE slats move away from the flap lever position
- Flap lever is in a detent.

This stops the hydraulic system B pressure to the retract lines of the LE flap and slat actuators. This prevents movement of the LE flaps and slats.

The SMYDs send a signal to the FSEU when an autoslat function is commanded. The FSEU uses this information to change the LE slat commanded position from extend to full extend.

The FSEU sends a signal to the SMYD 1 and SMYD 2 when an LE uncommanded motion is detected. The SMYDs use this information to apply a bias to the trip point for the stall warning system.

The FSEU also sends a takeoff warning signal to the PSEU when an LE uncommanded motion is detected.

The LE UCM detection function is not available when these conditions occur:

- Airplane speed is less than 60 knots
- Alternate flaps arm switch is at ARM

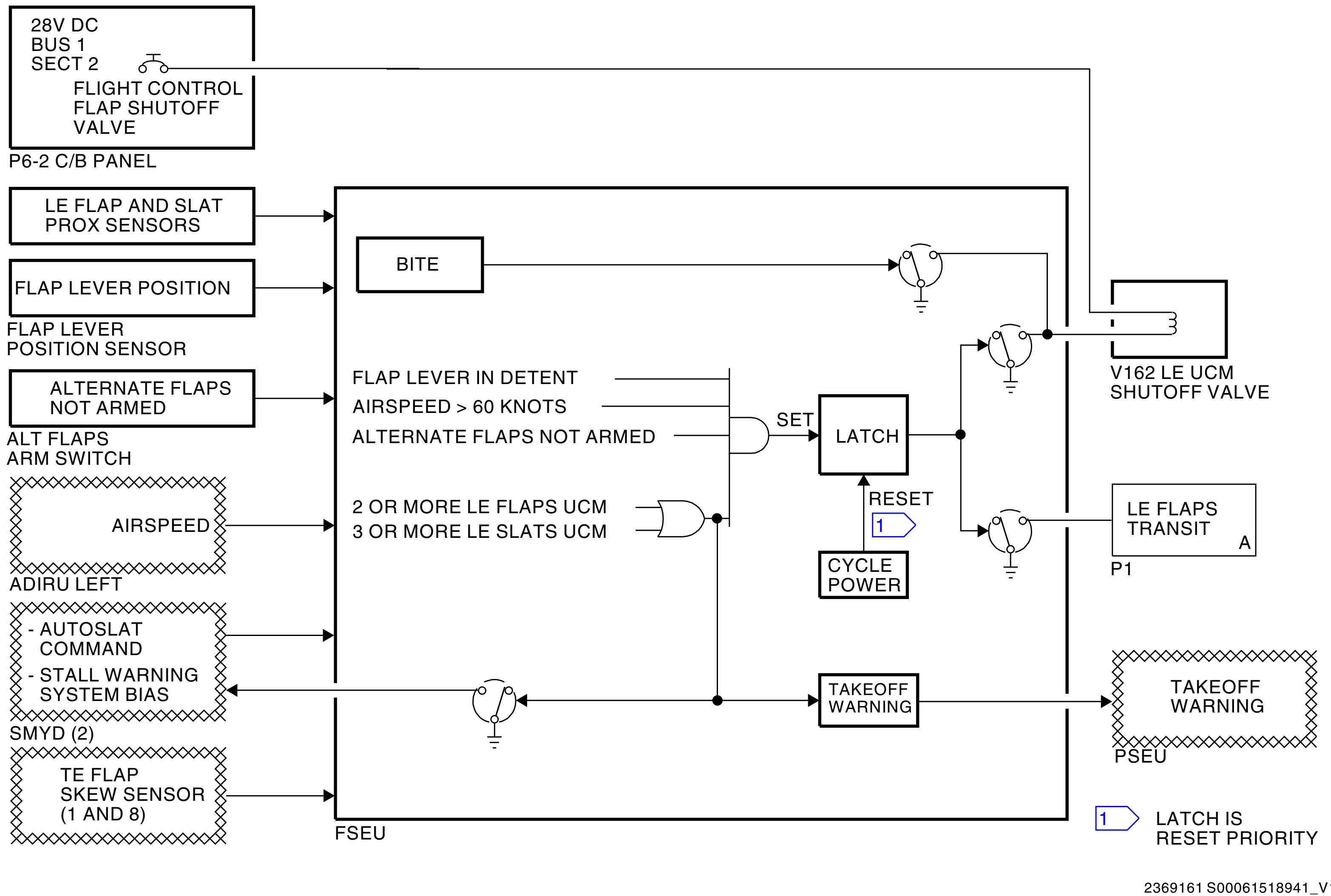
If an uncommanded motion (UCM) occurs, you must cycle the power to the FSEU on the ground to permit normal operation again.

The SET OUTPUTS? function of the FSEU BITE lets you send a signal to operate the LE UCM shutoff valve.

Indication

If a LE UCM occurs, the LE FLAPS TRANSIT light on the P1 captain's panel comes on.

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE UCM DETECTION



LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - LE UCM DETECTION

LE FLAP AND SLAT CONTROL SYSTEM - FLOW LIMITING VALVE AND HYDRAULIC FUSES

Purpose

The LE flow limiting valve and the hydraulic fuses control the flow of hydraulic fluid to the LE flap and slat hydraulic components. The LE flow limiting valve limits the speed of movement of the LE flaps and slats. Three hydraulic fuses stop the flow of hydraulic fluid if there is a leak. These are the three hydraulic fuses:

- LE extend hydraulic fuse
- LE retract hydraulic fuse
- LE standby hydraulic fuse.

Location

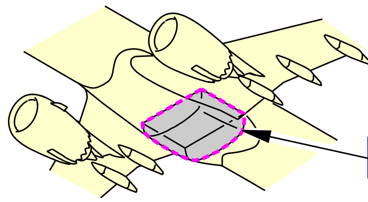
The flow limiting valve and the LE standby hydraulic fuse are on the keel beam in the MLG wheel well. The LE extend and retract hydraulic fuses are on the ceiling in the MLG wheel well, near the flap control unit.

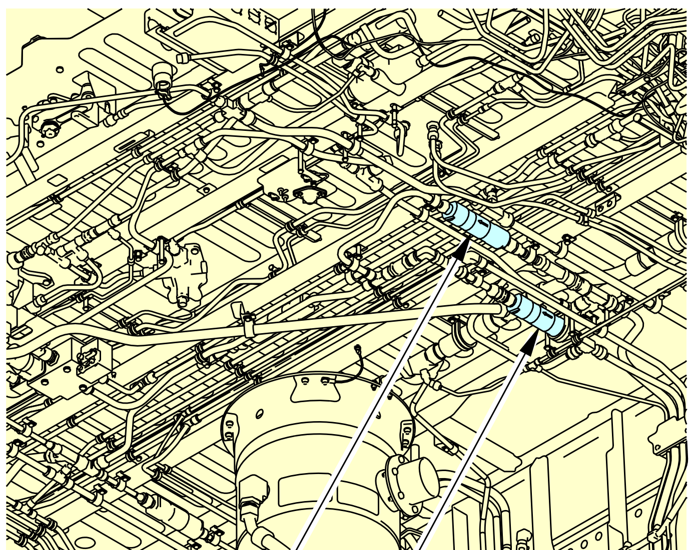
Physical Description

The LE flow limiting valve limits the standby hydraulic fluid flow to 2.1 gpm (7.9 l/min).

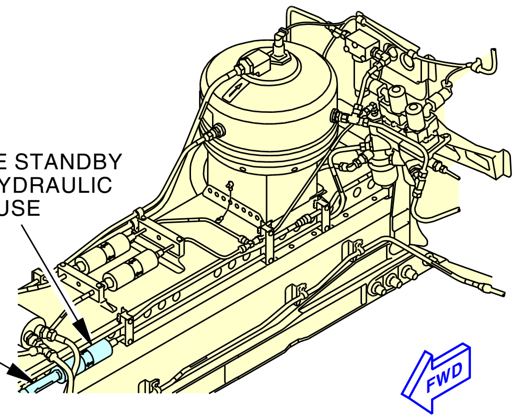
The LE extend and retract hydraulic fuses stop the hydraulic flow when the volume of fluid through it is more than 180 in^3 (2.9 l) - 250 in^3 (4.1 l). The LE standby hydraulic fuse stops the hydraulic flow when the volume of fluid through it is more than 270 in^3 (4.4 l) - 350 in^3 (5.7 l).

LE FLAP AND SLAT CONTROL SYSTEM - FLOW LIMITING VALVE AND HYDRAULIC FUSES





MLG WHEEL WELL CEILING
(LOOKING UP AND FORWARD)
A



MLG WHEEL WELL KEEL BEAM
A

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LE FLAP AND SLAT CONTROL SYSTEM - FLOW LIMITING VALVE AND HYDRAULIC FUSES

LE FLAP AND SLAT CONTROL SYSTEM - LE STANDBY SHUTOFF VALVE

Purpose

The LE standby shutoff valve supplies hydraulic power to the LE flap and slat actuators during alternate operation.

Location

The LE standby shutoff valve is on the standby system module in the MLG wheel well.

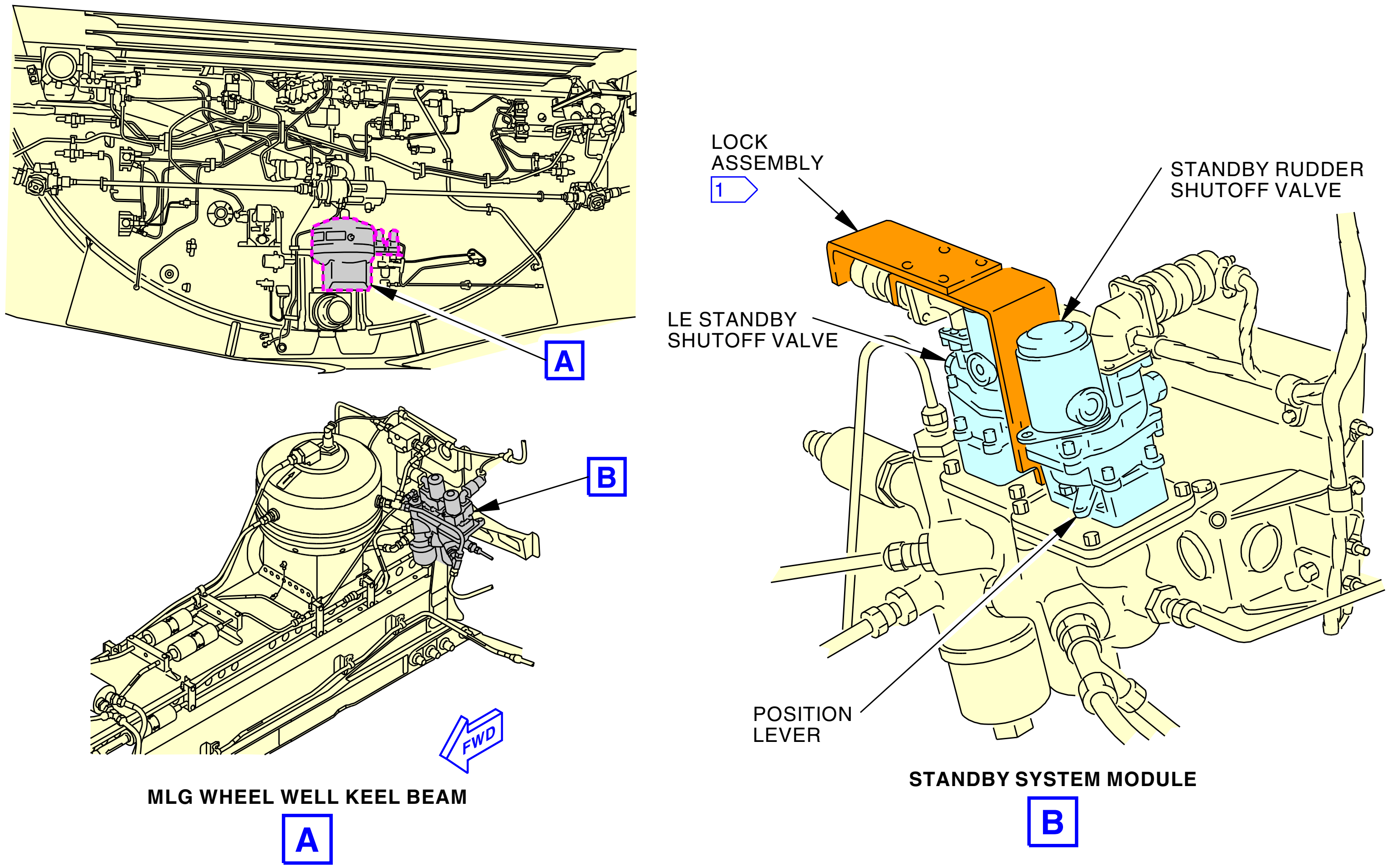
Physical Description

The LE standby shutoff valve is a 28v dc motor with a two-position valve. The valve is usually in the closed position. During the alternate operation of the LE flaps and slats, the LE standby shutoff valve receives electrical power from the alternate flaps switches. There is more information on the alternate operation later in this section.

The LE standby shutoff valve has a red lever that shows the position of the valve. You can move this lever to move the valve manually. When you move the lever manually, install a lock to prevent movement of the valve.

The LE standby shutoff valve is interchangeable with the standby rudder shutoff valve.

LE FLAP AND SLAT CONTROL SYSTEM - LE STANDBY SHUTOFF VALVE



1 LOCK ASSEMBLY IS USUALLY NOT INSTALLED

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LE FLAP AND SLAT CONTROL SYSTEM - LE STANDBY SHUTOFF VALVE

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP ACTUATORS

Purpose

The LE flap actuators use hydraulic power to move the LE flaps.

Location

The LE flap actuators are on the leading edge of the wings. To get access to the actuators, extend the LE flaps.

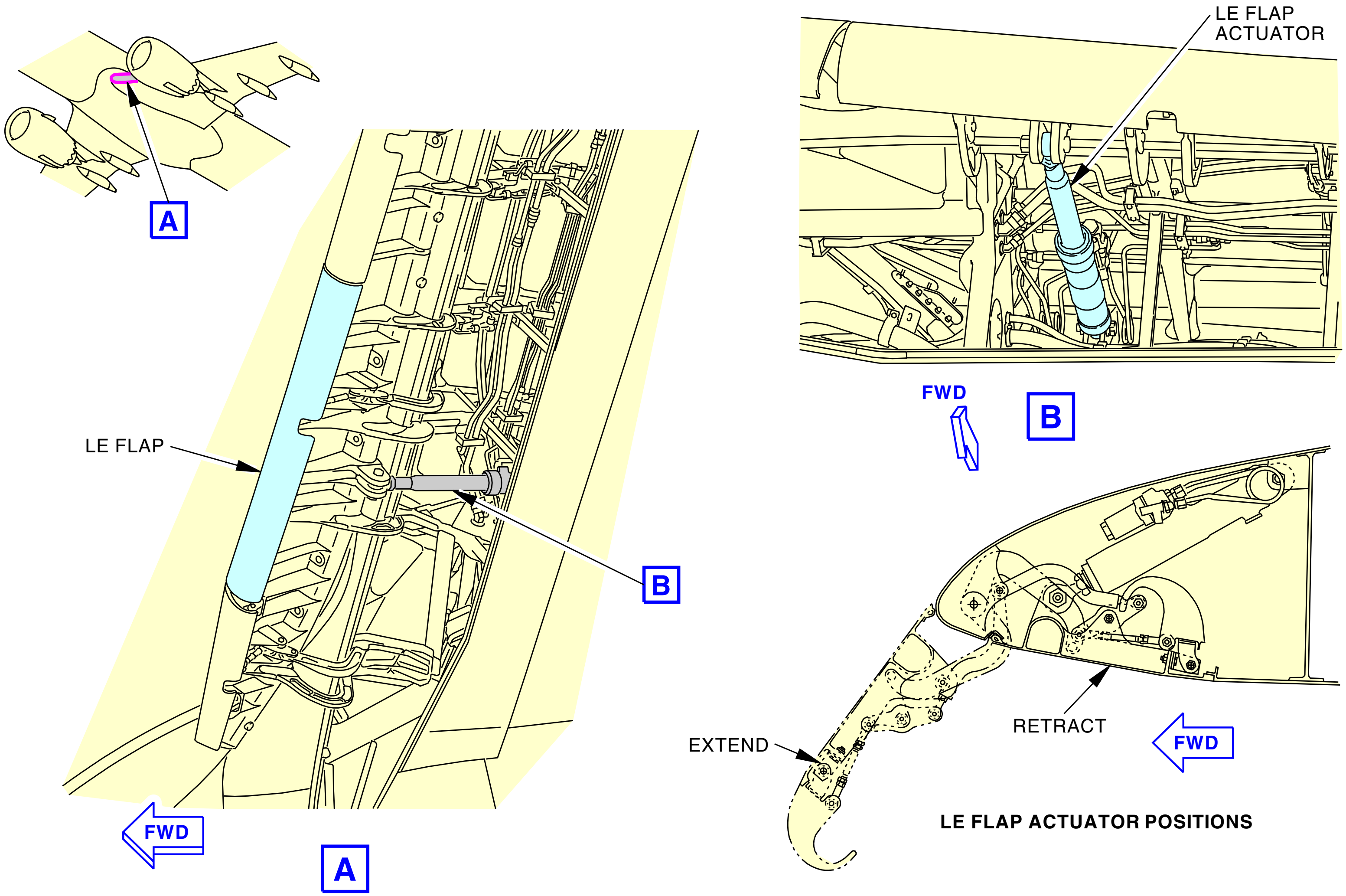
Physical Description

Each LE flap actuator weighs approximately 14 lb (6.4 kg).

The LE flap actuators have two positions: retract and extend.

All the LE flap actuators are interchangeable.

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP ACTUATORS



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LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP ACTUATORS

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP ACTUATORS - FUNCTIONAL DESCRIPTION

General

The LE flap actuators use hydraulic power. Hydraulic system B or the standby hydraulic system move the LE flaps.

During the normal operation, the LE flap actuators use hydraulic power from system B. The LE flap actuators receive extend pressure from the LE flap and slat control valve. The LE flap actuators receive retract pressure from the LE UCM shutoff valve.

During the alternate operation, the LE flap actuators use hydraulic power from the standby system to extend the LE flaps. The LE flaps do not retract during the alternate operation.

The LE flap actuators have two positions: retract and extend.

Functional Description

Each LE flap actuator has these components:

- Piston
- Two blocking valves
- Two restrictors.

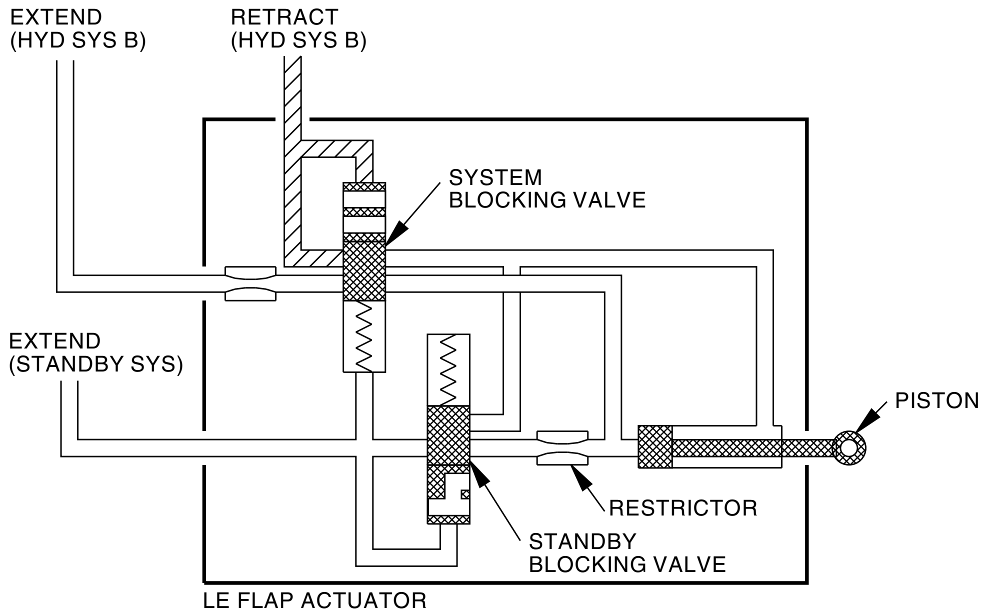
During extension in the normal operation, the actuator receives retract pressure from hydraulic system B and extend pressure from the LE flap and slat control valve. This causes the system blocking valve to open, which permits pressure to both sides of the piston.

The actuator is a differential area piston. When the pressure is the same on both sides of the piston, the piston extends. The restrictors help the piston move smoothly.

During retraction in the normal operation, the actuator receives retract pressure only. This opens the system blocking valve, which sends pressure to the retract side of the piston. This causes the piston to retract.

If the hydraulic system B pressure is less than 2000 psi (13,790 kPa), the blocking valves hydraulically lock the piston. This prevents piston movement during hydraulic system failures.

During the alternate operation, the standby hydraulic system supplies extend pressure to the LE flap actuators. This causes both blocking valves to move. This stops the hydraulic power from the system B to the piston. Instead, both sides of the piston receives hydraulic power from the standby system. This causes the piston to extend.



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LE FLAP AND SLAT CONTROL SYSTEM - LE FLAP ACTUATORS - FUNCTIONAL DESCRIPTION

LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATORS

Purpose

The LE slat actuators use hydraulic power to move the LE slats.

Location

The LE slat actuators are on the leading edge of the wings. To get access to the actuators, extend the LE slats and remove the access panels under the wing.

Physical Description

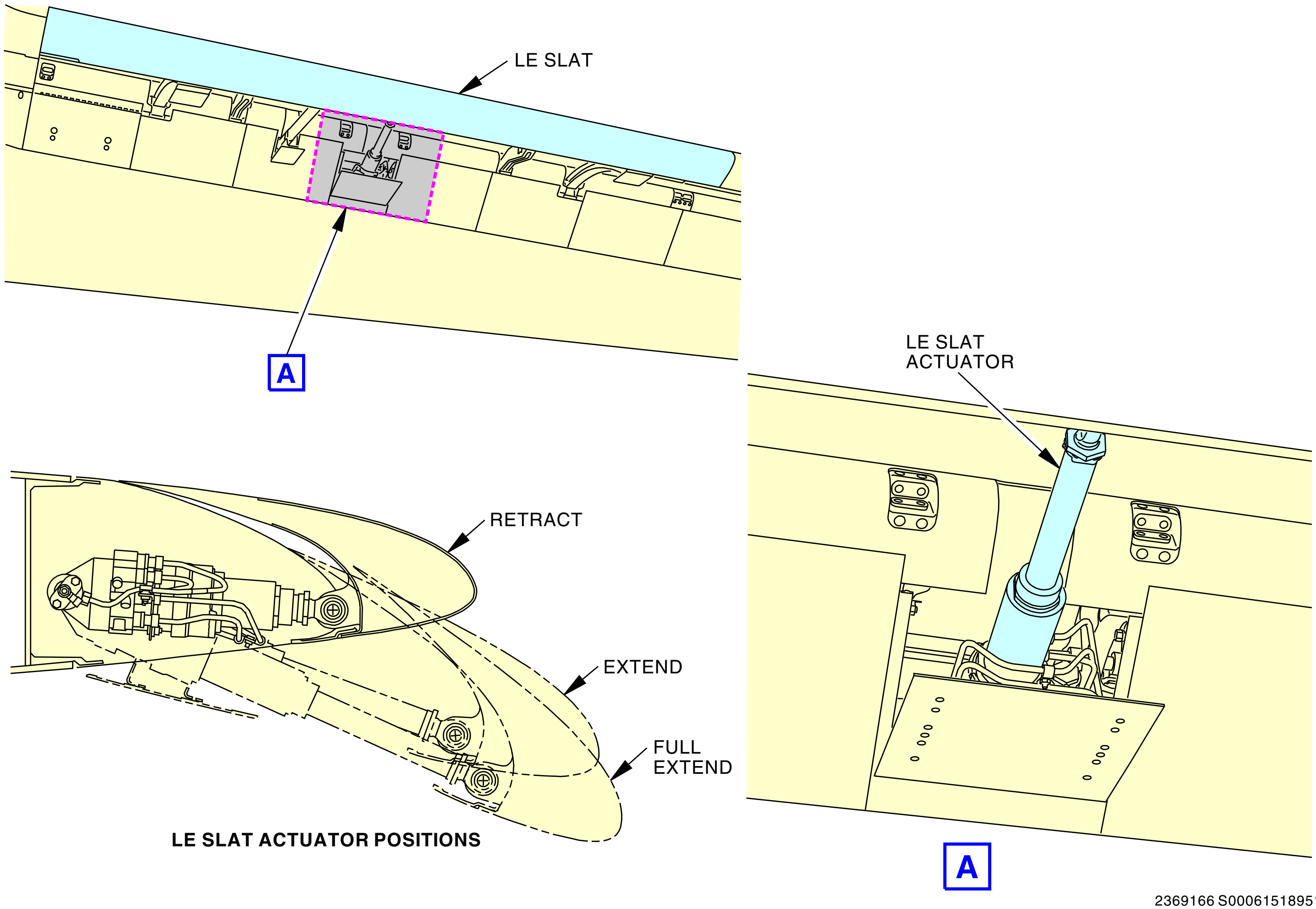
Each LE slat actuator weighs approximately 20 lb (9.1 kg).

The LE slat actuators have three positions:

- Retract
- Extend
- Full extend.

All the LE slat actuators are interchangeable.

LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATORS



LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATORS

LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATORS - FUNCTIONAL DESCRIPTION

General

The LE slat actuators use hydraulic power from either the hydraulic system B or the standby hydraulic system to move the LE slats.

During the normal operation, hydraulic system B supplies hydraulic power to the LE slat actuators. The LE flap and slat control valve supplies extend pressure to the LE slat actuators. Hydraulic system B supplies retract pressure to the LE slat actuators.

During the alternate operation, the standby system supplies hydraulic power to the LE slat actuators to fully extend the LE slats. The LE slats do not retract during the alternate operation.

The LE slat actuators have three positions:

- Retract
- Extend
- Full extend.

Functional Description

Each LE slat actuator has these components:

- Inner piston
- Outer piston
- Blocking valves
- Restrictors
- Relief valve
- Lock piston
- Lock stud
- Lock segment.

During the normal operation, hydraulic system B supplies hydraulic pressure to the actuator. This causes the system blocking valve to open, which permits pressure to go to the retract side of the inner and outer pistons. This causes the actuator to retract. When the actuator fully retracts, the lock segments rotate to the position shown in the graphic. Because the lock stud does not move, the lock segments prevent extension of the inner piston.

The LE flap and slat control valve supplies extend pressure to the actuator to move the actuator to the extend position. This causes pressure to go through the lock stud to the lock piston. The lock piston extends and releases the lock segments. This permits the inner piston to move.

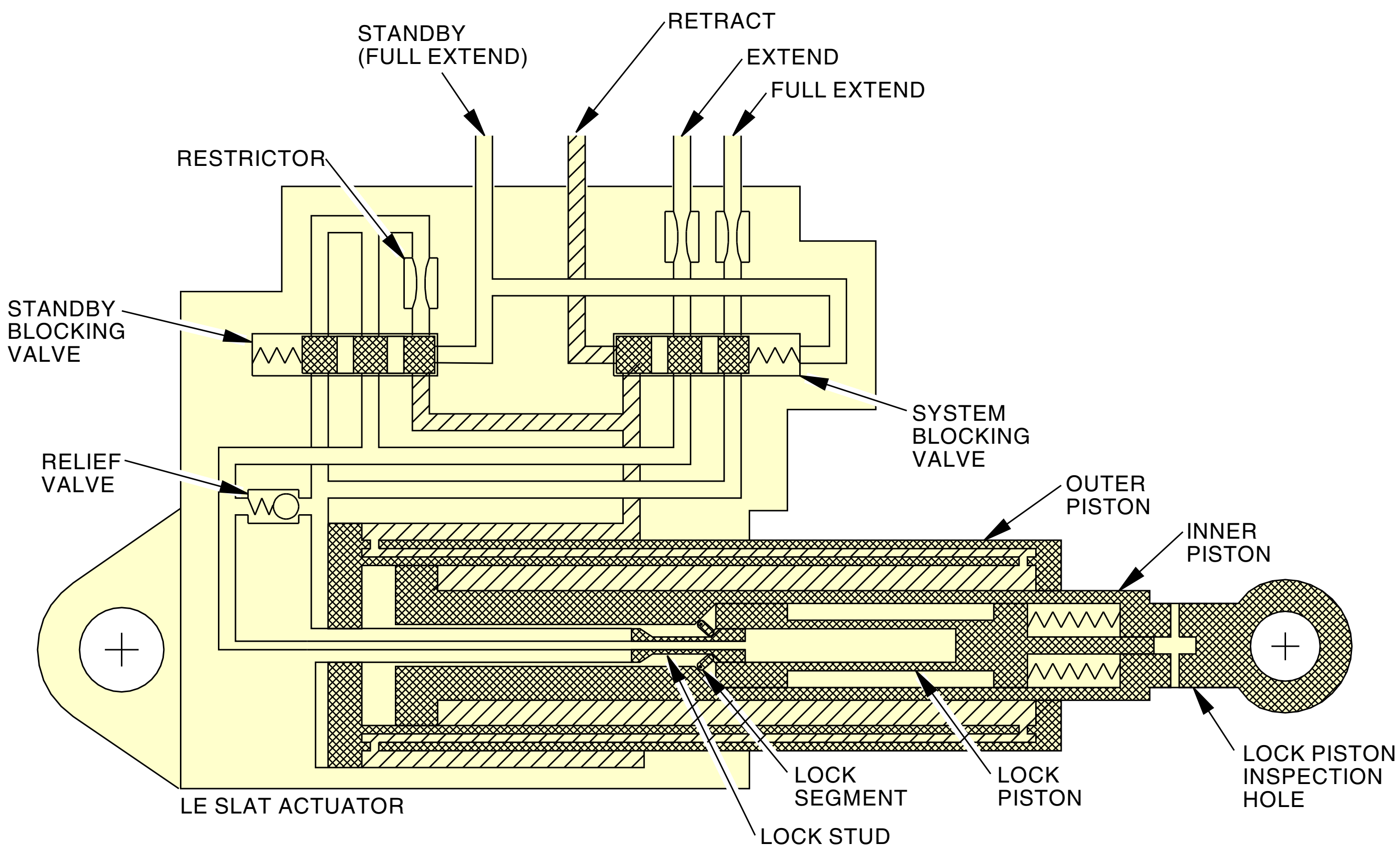
Pressure also goes around the lock stud to the extend side of the inner piston. Because the inner piston is a differential area piston, the piston extends. The restrictors help the piston move smoothly.

The LE flap and slat control valve supplies full extend pressure to the actuator to move the actuator to the full extend position. This pressure goes through the system blocking valve to the extend side of the outer piston. Because the outer piston is also a differential area piston, the piston extends. As this occurs, the inner piston stays in the extend position. This causes the actuator to move to its full extend position.

During retraction in the normal operation, the LE flap and slat control valve stops the full extend pressure first. This causes the outer piston to retract first. Then, the LE flap and slat control valve stops the extend pressure. This causes the inner piston to retract. Springs cause the lock piston to retract, and this engages the lock segments.

If the hydraulic system B pressure is less than 2000 psi, the blocking valves close and hydraulically lock the pistons. This prevents the piston movement during hydraulic system failures.

During the alternate operation, the standby hydraulic system supplies full extend pressure to the LE slat actuators. This causes the standby blocking valve to open and the system blocking valve to close. This stops the hydraulic power from the system B to the pistons. Instead, standby hydraulic pressure goes to the extend side of all the pistons. This causes the pistons to extend and the actuator moves to the full extend position.



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LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATORS - FUNCTIONAL DESCRIPTION

LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATOR POSITIONS

General

The LE slat actuators have three positions:

- Retract
- Extend
- Full extend.

Retract

When the hydraulic system B pressurizes, both the inner and outer pistons retract.

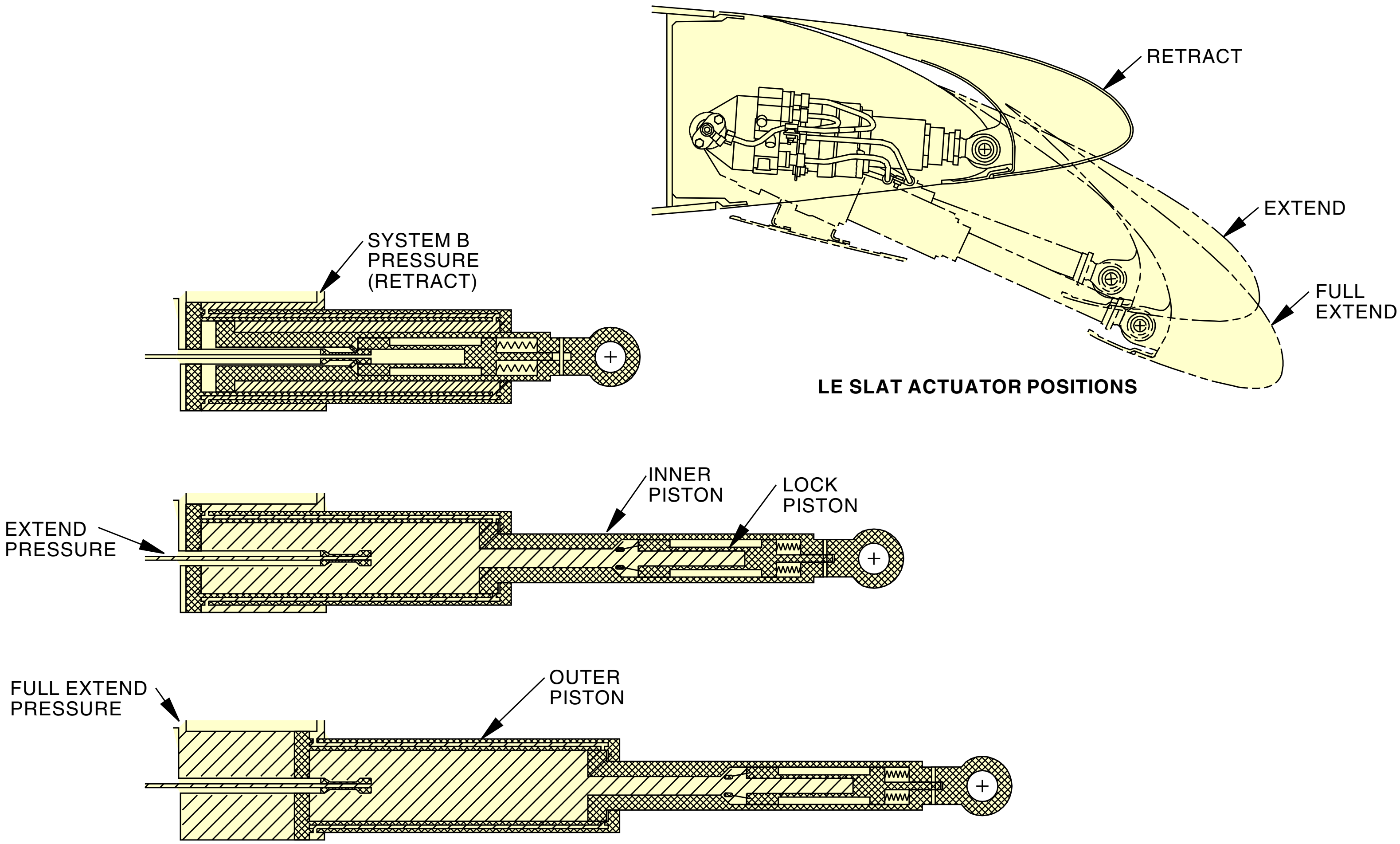
Extend

When the LE slat actuator receives extend pressure, the lock piston extends and the inner piston extends.

Full Extend

When the LE slat actuator receives full extend pressure, the outer piston extends.

LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATOR POSITIONS



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LE FLAP AND SLAT CONTROL SYSTEM - LE SLAT ACTUATOR POSITIONS

LE FLAP AND SLAT CONTROL SYSTEM - MAIN AND AUXILIARY TRACKS

Purpose

The main and auxiliary tracks help hold the LE slats in three positions. These tracks cause the LE slats to move to the correct positions when the LE slat actuators move.

Location

The tracks attach to the LE slats. To get access to the tracks, extend the LE slats and remove the access panels under the wing.

Main Track

There are two main tracks for each LE slat.

The main track moves between two pairs of rollers. The main track has a non-adjustable downstop (stop fittings) that limits the full extend position of the LE slat.

WARNING

DO NOT LET OBJECTS GET IN THE HOUSING ASSEMBLY OF THE SLAT TRACK. THIS WILL HELP PREVENT A PUNCTURE OF THE HOUSING ASSEMBLY THAT COULD CAUSE A FUEL LEAK. THE FUEL LEAK COULD CAUSE A FIRE AND POSSIBLE DEATH OR INJURY TO PERSONNEL.

Auxiliary Track

There are two auxiliary tracks for each LE slat.

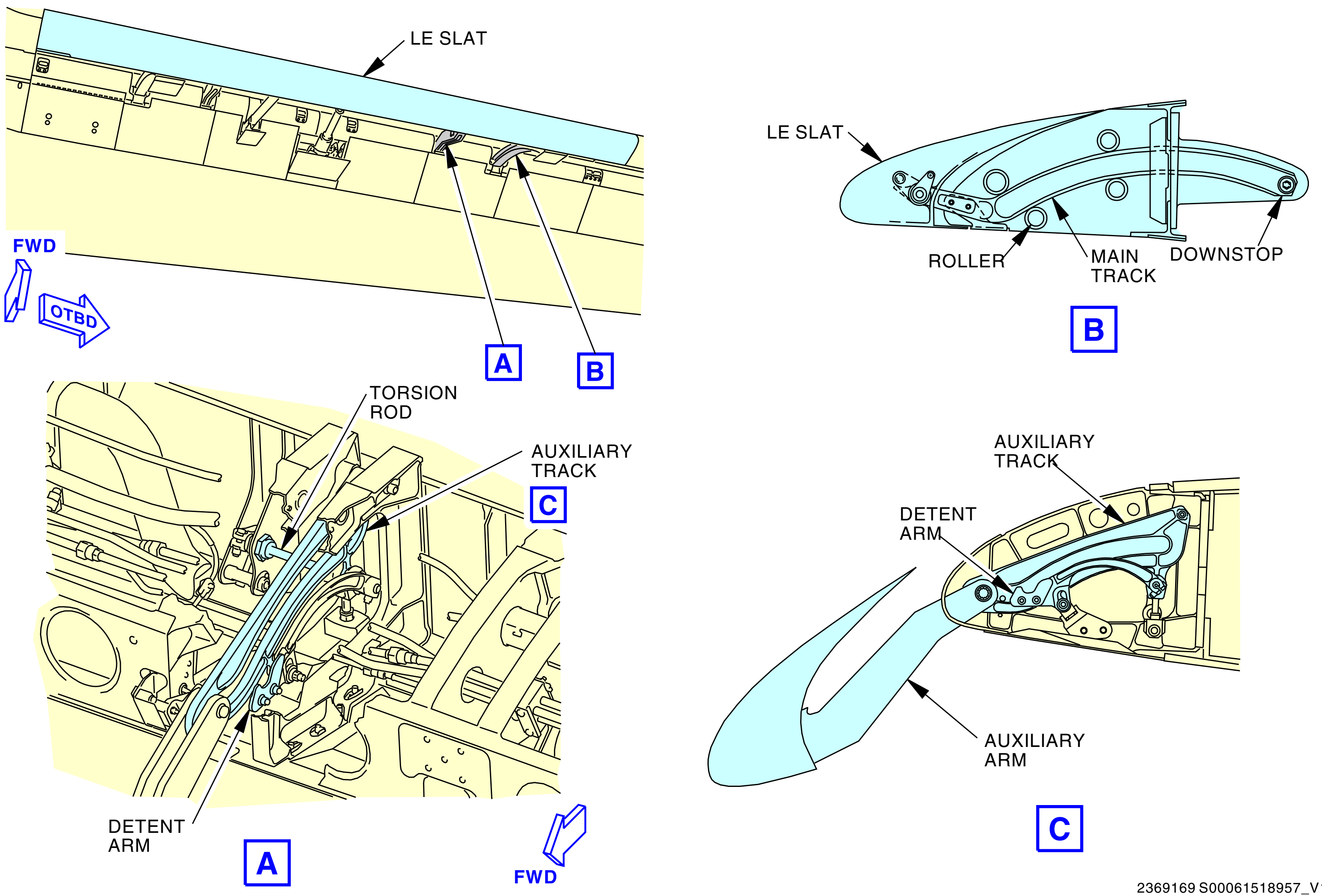
The auxiliary track interfaces with the following parts:

- Auxiliary arm
- Detent arm
- Torsion rod.

When the LE slat moves, a roller in the auxiliary arm moves in the auxiliary track. When the LE slat moves to the extend position, the roller moves the detent arm down, then stops in the cam of the detent arm. The torsion rod keeps the roller in the cam. This keeps the LE slat in the extend position.

When the LE slat moves from the extend position to the full extend or retract positions, the force from the slat actuator causes the slat to move. This causes the roller in the auxiliary arm to move the detent arm down, and the LE slat continues to move.

LE FLAP AND SLAT CONTROL SYSTEM - MAIN AND AUXILIARY TRACKS



LE FLAP AND SLAT CONTROL SYSTEM - MAIN AND AUXILIARY TRACKS

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAPS AND LE SLATS

Purpose

The LE flaps and slats increase the lift of the wing during takeoff and landing. They retract during cruise.

Location

The LE flaps are below the leading edge of the wings, between the fuselage and the engines. The LE slats are on the leading edge of the wings, outboard of the engines.

Physical Description

The LE flaps and slats are made of aluminum skins and ribs.

The dimensions of each LE flap are approximately 65 in. (1.7 m) by 12 in. (0.3 m). The LE flaps are not interchangeable.

The dimensions of each LE slat are approximately 117 in. (3.0 m) by 18 in. (0.5 m). The LE slats are not interchangeable.

Functional Description

The LE flaps have two positions: retract and extend. The LE flaps are at the retract position when the flap lever is in the 0 detent. The LE flaps are at the extend position when the flap lever is at any other detent.

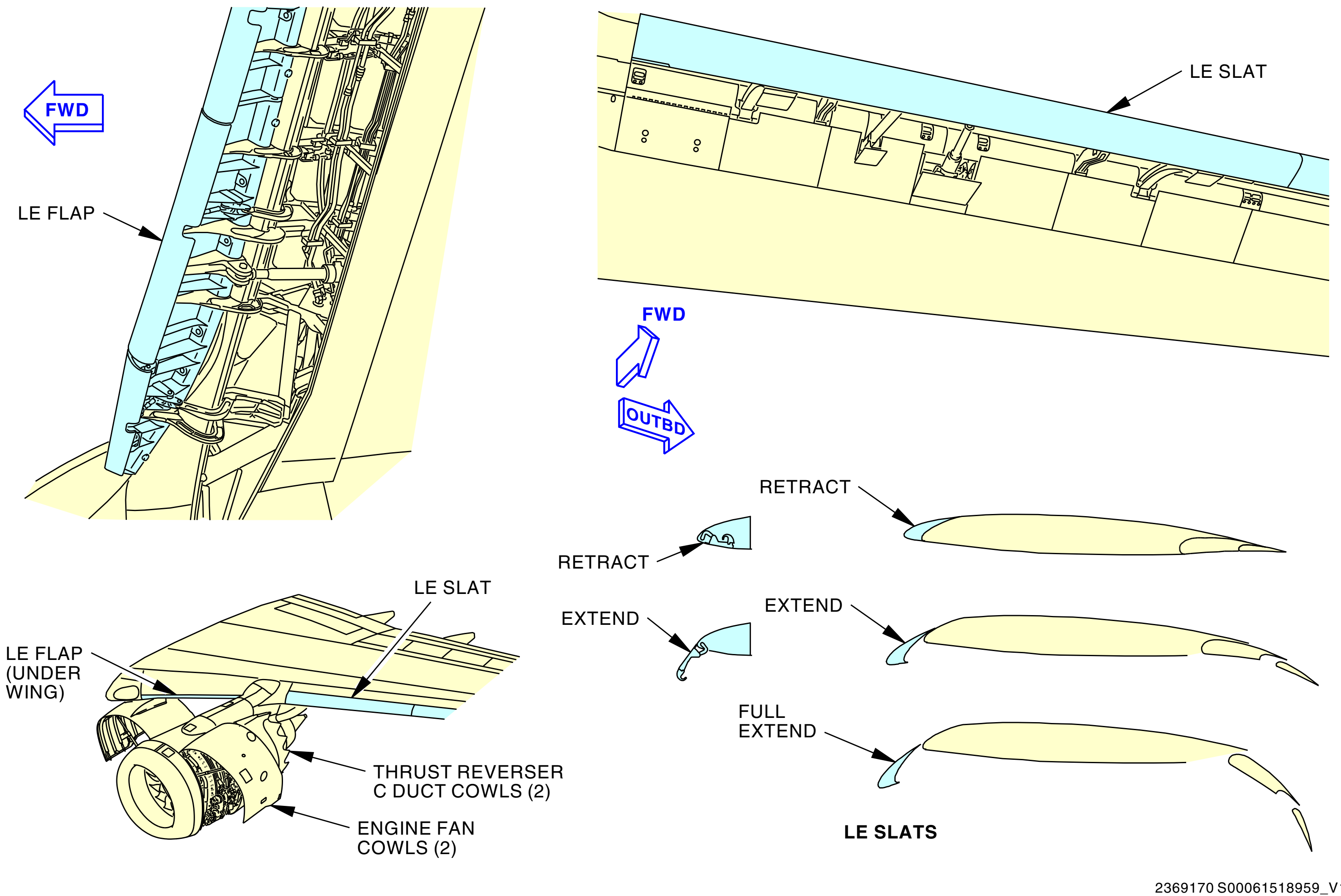
The LE slats have these three positions:

- Retract
- Extend
- Full extend.

The LE slats are at the retract position when the flap lever is in the 0 detent.

- The LE slats are at the extend position when the flap lever is in the 1, 2, 5, 10, 15, and 25 detent.
- The LE slats are at the full extend position when the flap lever is in the 30 and 40 detent.

LE FLAP AND SLAT CONTROL SYSTEM - LE FLAPS AND LE SLATS



LE FLAP AND SLAT CONTROL SYSTEM - LE FLAPS AND LE SLATS

LE FLAP AND SLAT CONTROL SYSTEM - OPERATION

Normal Operation

During the normal operation, use the flap lever to operate the Leading Edge (LE) flaps and slats. The normal operation requires system B hydraulic power.

The LE flaps move to two positions and the LE slats move to three positions. The LE devices annunciator panel in the flight compartment shows the position of the LE flaps and slats. The LE FLAPS TRANSIT light and the LE FLAPS EXT light show the condition of the LE flaps and slats.

During the normal operation of the flaps and slats, the Trailing Edge (TE) flaps move.

During cruise, the LE cruise depressurization function prevents extension of the LE flaps and slats. This function operates when all the LE devices and the flap lever are at the up position and the airplane is in the air.

If two or more LE devices move away from their commanded position, the LE Uncommanded Motion (UCM) detection function stops the LE normal operation.

If the airplane comes near a stall condition, the autoslat function causes the LE slats to move from the extend position to the full extend position. If this function is not available, the AUTOSLAT FAIL light shows on the flight controls panel.

See the leading edge autoslat system section for more information on the autoslat function. (SECTION 27-83)

See the trailing edge flap system section for more information on the TE flap system. (SECTION 27-51)

Alternate Operation

During the alternate operation, use the alternate flaps switches to extend the LE flaps and slats. The alternate operation uses standby hydraulic power instead of system B hydraulic power.

First, move the alternate flaps arm switch to the arm position. This starts the standby hydraulic pump. Then move the alternate flaps control switch to the down position. This opens the LE flap standby shutoff valve and permits the LE flaps to move to the extend position and the LE slats to move to the full extend position.

During the alternate operation, the LE flaps and slats cannot retract. To retract the LE flaps and slat, you must use the normal operation.

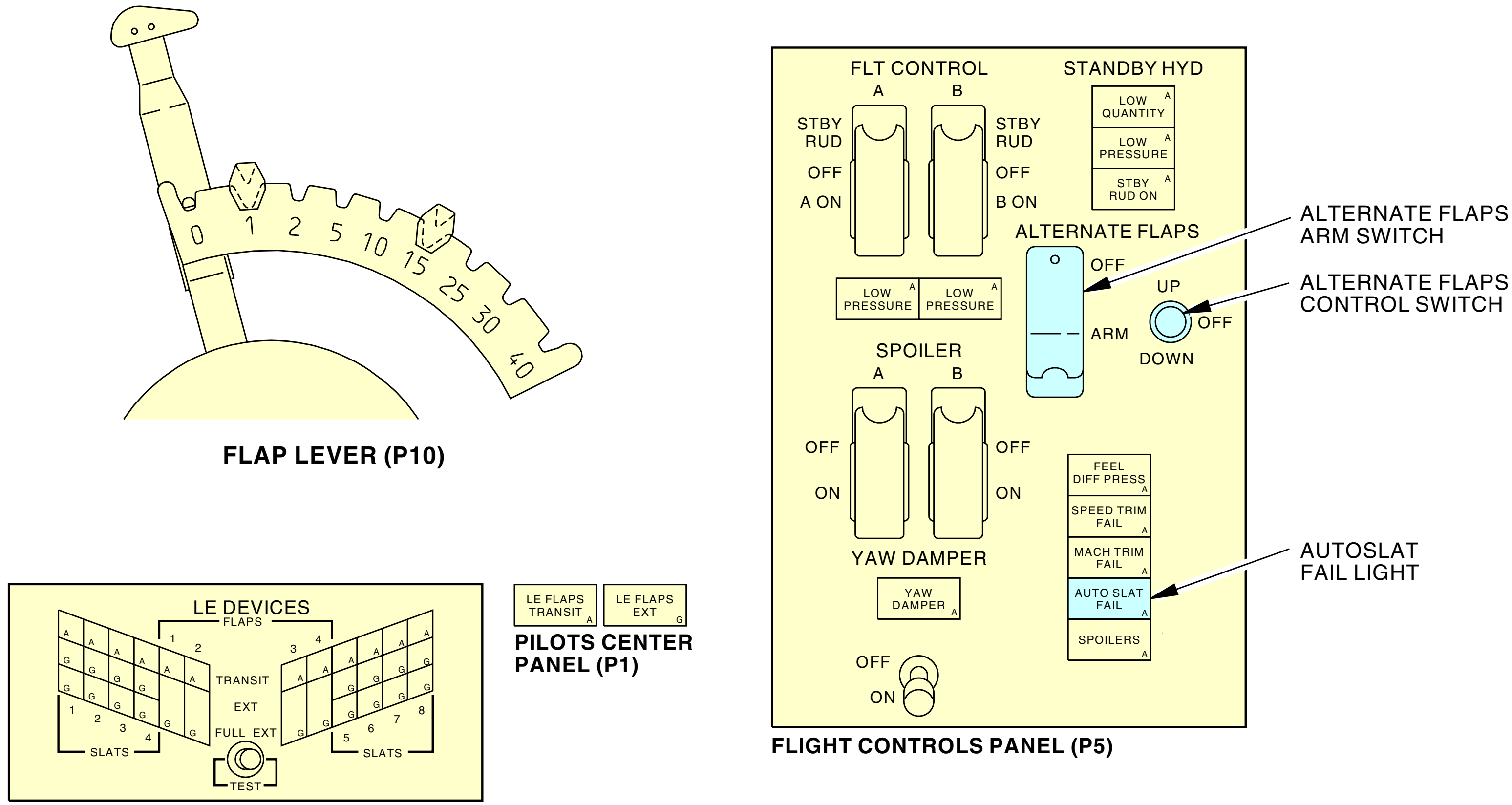
During the alternate operation, the LE cruise depressurization function, LE UCM detection function, and autoslat function are not available.

Operating Times

The table below describes the time it takes (in seconds) for the LE flaps and slats to move in the normal and alternate operation. The times are for normal operating loads. There are small differences in the times for no operating loads.

Operating condition	LE flaps	LE slats
Normal - up to extend	7 sec	8 sec
Normal - extend to full extend	N/A	3.0 sec
Normal - full extend to extend	N/A	4.8 sec
Normal - extend to up	7.5 sec	7.8 sec
Alternate - up to full extend	32 sec	58 sec

LE FLAP AND SLAT CONTROL SYSTEM - OPERATION



FLAP LEVER (P10)

PILOTS CENTER PANEL (P1)

FLIGHT CONTROLS PANEL (P5)

LE DEVICES ANNUNCIATOR PANEL (P5)

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LE FLAP AND SLAT CONTROL SYSTEM - OPERATION

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

General

These are the LE flap and slat hydraulic components that are LRUs:

- Flow limiting valve
- Hydraulic fuses
- LE cruise depressurization valve
- LE UCM shutoff valve
- LE flap and slat control valve
- LE flap actuators
- LE slat actuators.

Normal Operation

During the normal operation, the LE flap and slat actuators use power from hydraulic system B. The flap priority valve reduces the flow of hydraulic fluid to the TE flap components if the system B pressure is low. This gives priority of system B hydraulic power to the LE flaps and slats over the TE flaps.

Hydraulic system B power goes through the LE UCM shutoff valve to the retract port of all the LE flap and slat actuators. If the LE flap and slat control valve is in the retract position, the LE flap and slat actuators retract.

The LE flap and slat control valve uses mechanical inputs from the TE flap PDU follow-up cables. These cables move when the TE flaps move. When you move the flap lever to the 1, 2, 5, 10, 15 or 25 positions, movement of the TE flaps causes the cables to move. This causes the cables to move the LE flap and slat control valve to the extend position.

Hydraulic pressure goes through the LE cruise depressurization valve to the LE flap and slat control valve. The LE flap and slat control valve sends extend pressure to the LE flap and slat actuators. This causes the LE flaps and slats to move to the extend position.

When you move the flap lever to the 30 and 40 positions, the TE flap PDU follow-up cables move the LE flap and slat control valve to the full extend position. The LE flap and slat control valve sends full extend pressure through the autoslat valve to the LE slat actuators only. This causes the LE slats to move to the full extend position.

When the airplane is in a cruise condition, the LE cruise depressurization valve stops the hydraulic power to the LE flap and slat control valve. This makes sure that the LE flaps and slats stay retracted.

If the airplane gets near a stall condition, the autoslat valve sends full extend pressure to the LE slat actuators. This causes the LE slats to move from the extend position to the full extend position.

See the leading edge autoslat system section for more information on the autoslat operation. (SECTION 27-83)

If two or more LE flaps or slats move away from the flap lever position, then the LE UCM shutoff valve closes. This removes the retract pressure from the LE flap and slat actuators and the LE flaps and slats cannot move.

PTU Operation

If there is low pressure from the system B EDP, the power transfer unit (PTU) can supply hydraulic power for the autoslat operation. The PTU operates when all of these conditions occur:

- Airplane is in the air
- TE flaps are between 0 and 15
- System B EDP hydraulic pressure is low.

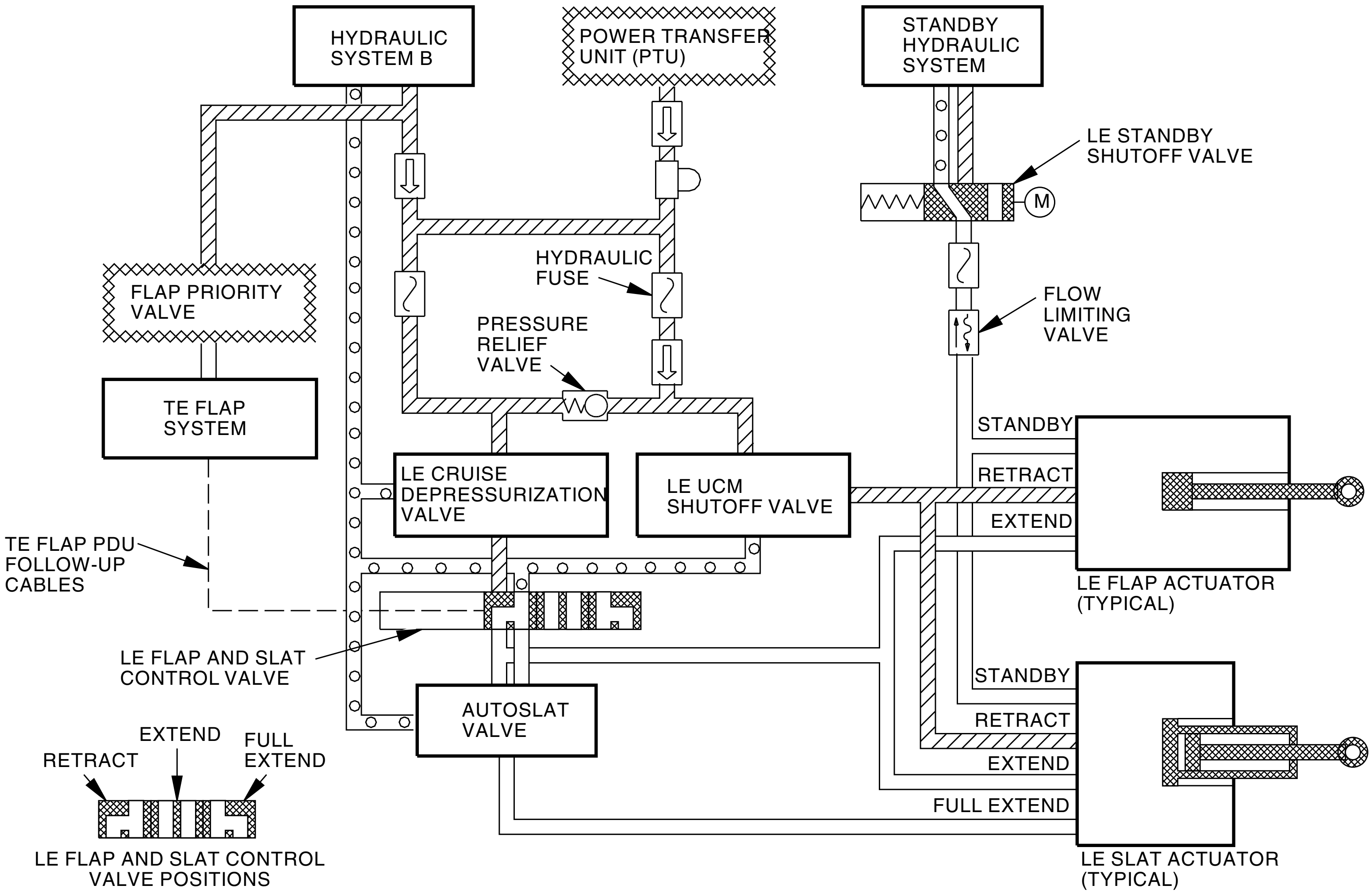
See the power transfer unit system section for more information on the PTU. (SECTION 29-25)

Alternate Operation

During the alternate operation, the LE standby shutoff valve supplies standby hydraulic system power. The flow limiting valve limits the flow of hydraulic fluid to 2.1 gpm (8 l/min). In the alternate operation, the LE flaps and slats extend only. The LE flaps and slats can not retract in the alternate operation.

See the standby hydraulic system section for more information on the standby hydraulic system. (SECTION 29-22)

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION



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LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - ALTERNATE OPERATION

General

During alternate operation, the alternate flaps switches control the operation of the LE flap and slat actuators.

Arm

When you move the alternate flaps arm switch to the arm position, electrical power becomes available to the alternate flaps control switch. The arm switch supplies signals to the standby hydraulic system to operate the standby hydraulic electric motor driven pump (EMDP).

Extend

When you move the alternate flaps control switch to the down position, the LE standby shutoff valve relay energizes. This sends a signal to the LE standby shutoff valve and to the power transfer unit (PTU). The LE standby shutoff valve opens. If the PTU was operating, it stops.

The standby EMDP supplies hydraulic pressure to the LE standby shutoff valve. The standby shutoff valve supplies pressure to the LE flap and slat actuators, and these actuators extend. The LE flaps move to the extend position and the LE slats move to the full extend position.

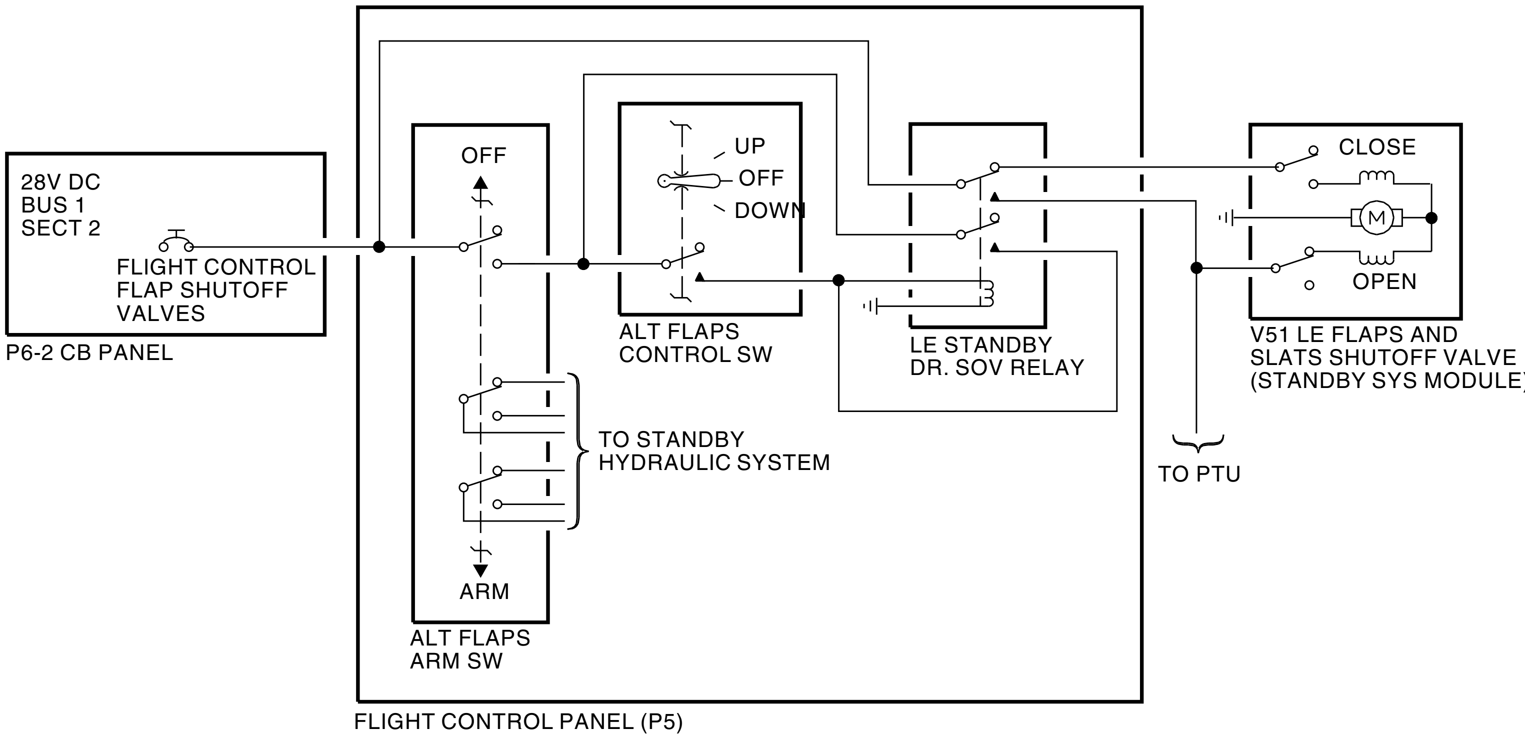
It takes approximately 32 seconds for the LE flaps and 58 seconds for the LE slats to fully extend in the alternate operation.

The LE standby shutoff valve relay latches. When the alternate flaps control switch moves to the off position, the relay stays energized. This relay de-energizes when the alternate flaps arm switch moves to the off position. When you move the alternate flaps arm switch to the off position, the standby EMDP stops and the LE standby shutoff valve closes.

When you move the alternate flaps arm switch to the off position, the alternate operation stops. This permits the normal operation. If hydraulic system B has pressure, then the LE flaps and slats retract.

Retract

During the alternate operation, the LE flaps and slats can not retract. You must use the normal operation to retract the surfaces.



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LE FLAP AND SLAT CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - ALTERNATE OPERATION

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LE AUTOSLAT SYSTEM - GENERAL DESCRIPTION

General

The LE autoslat system moves the LE slats from the extend position to the full extend position when the airplane gets near a stall condition. This helps improve the airplane performance.

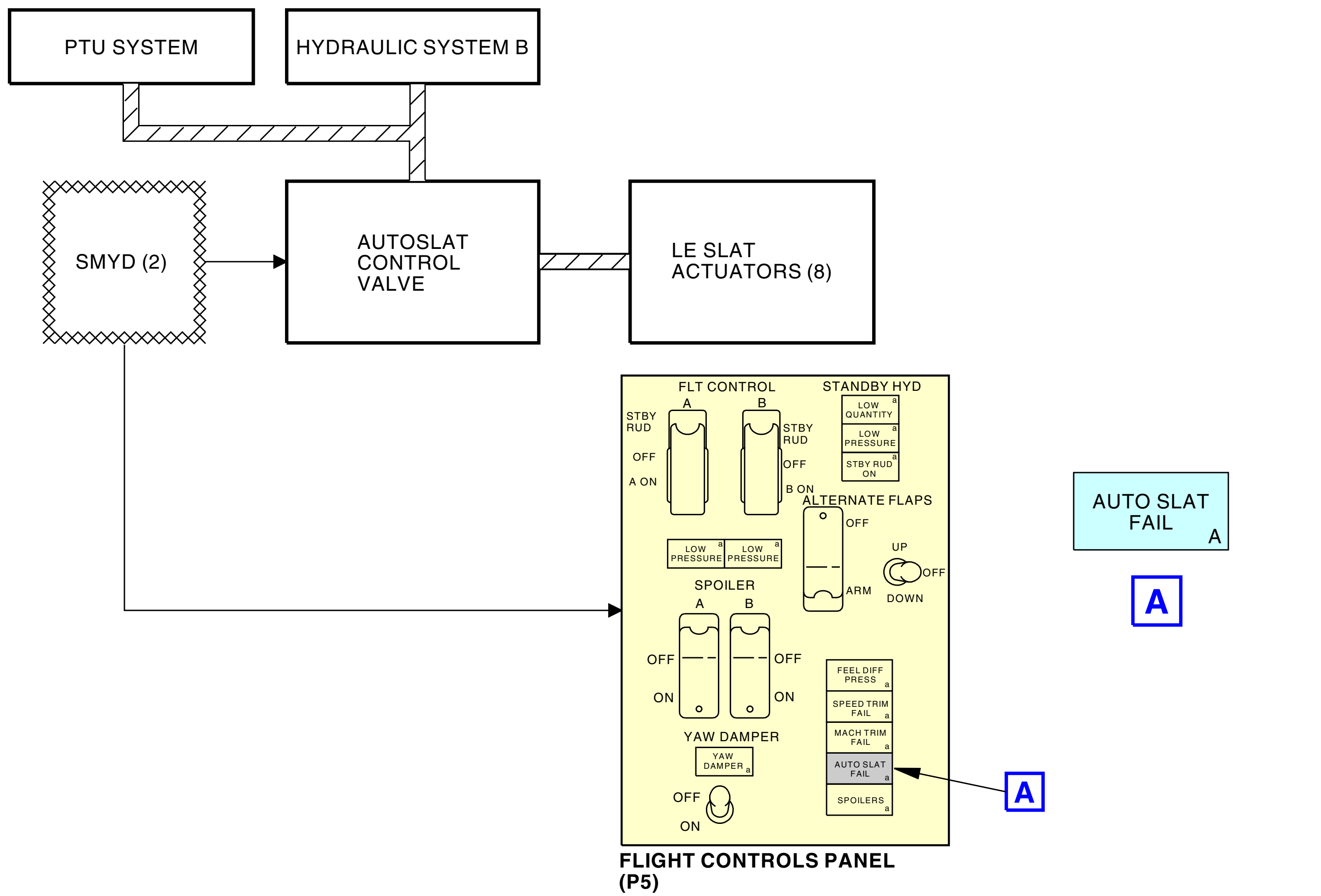
Interfaces

Two stall management yaw damper (SMYD) computers calculate the autoslat commands. Each SMYD sends an autoslat signal to the autoslat control valve. The autoslat control valve sends hydraulic power from hydraulic system B or the PTU system to the LE slat actuators. This causes the LE slats to fully extend.

If the autoslat function is not available, the autoslat fail light shows on the flight controls panel on the P5 overhead panel.

See SMYD SECTION 27-32 for more information.

LE AUTOSLAT SYSTEM - GENERAL DESCRIPTION



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LE AUTOSLAT SYSTEM - GENERAL DESCRIPTION

LE AUTOSLAT SYSTEM - AUTOSLAT CONTROL VALVE

Purpose

The autoslat control valve causes the LE slats to move from extend to full extend if the airplane gets near a stall condition. This valve supplies pressure to the full extend port on the LE slat actuators.

Location

The autoslat control valve is on the right side of the fuselage, just forward of the MLG wheel well. Remove the access panel to get access.

Physical Description

The autoslat control valve has two solenoid valves and two valves that operate by pressure. The solenoids are line replaceable units (LRUs).

Functional Description

The autoslat control valve sends full extend pressure to the LE slat actuators during the usual operation or during the autoslat operation.

Normal Operation

During the usual operation, when the flap lever is at 25 or more, the LE flap/slat control valve sends full extend pressure to the autoslat control valve. This pressure goes through the two valves that operate by pressure. Then the pressure goes to the full extend port on the LE slat actuators.

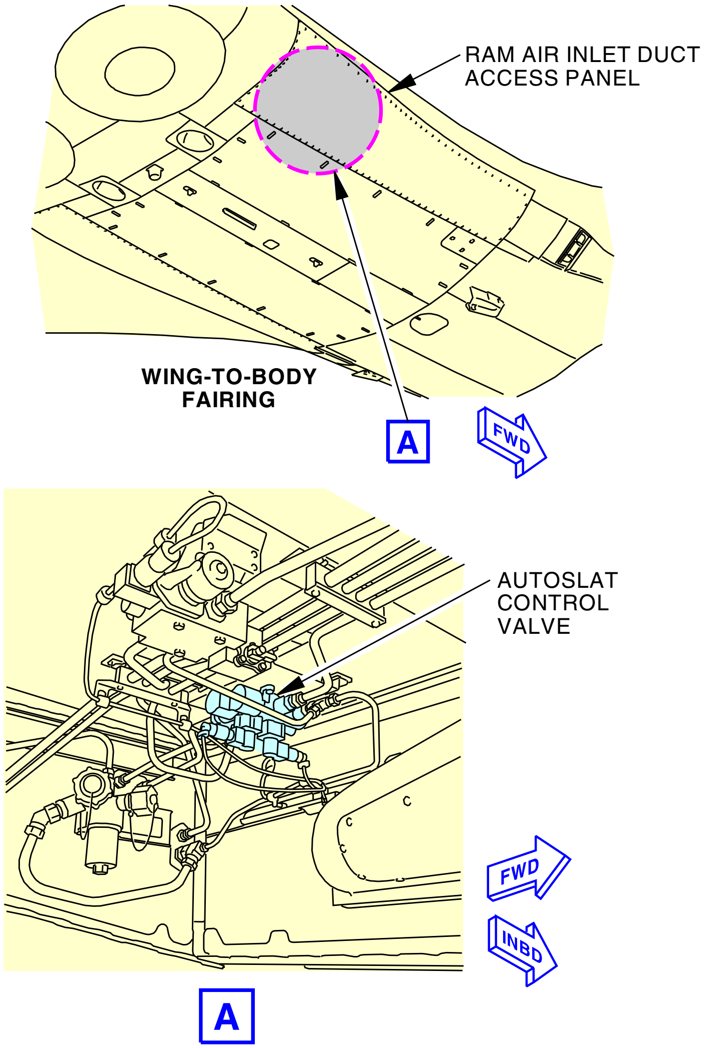
Autoslat Operation

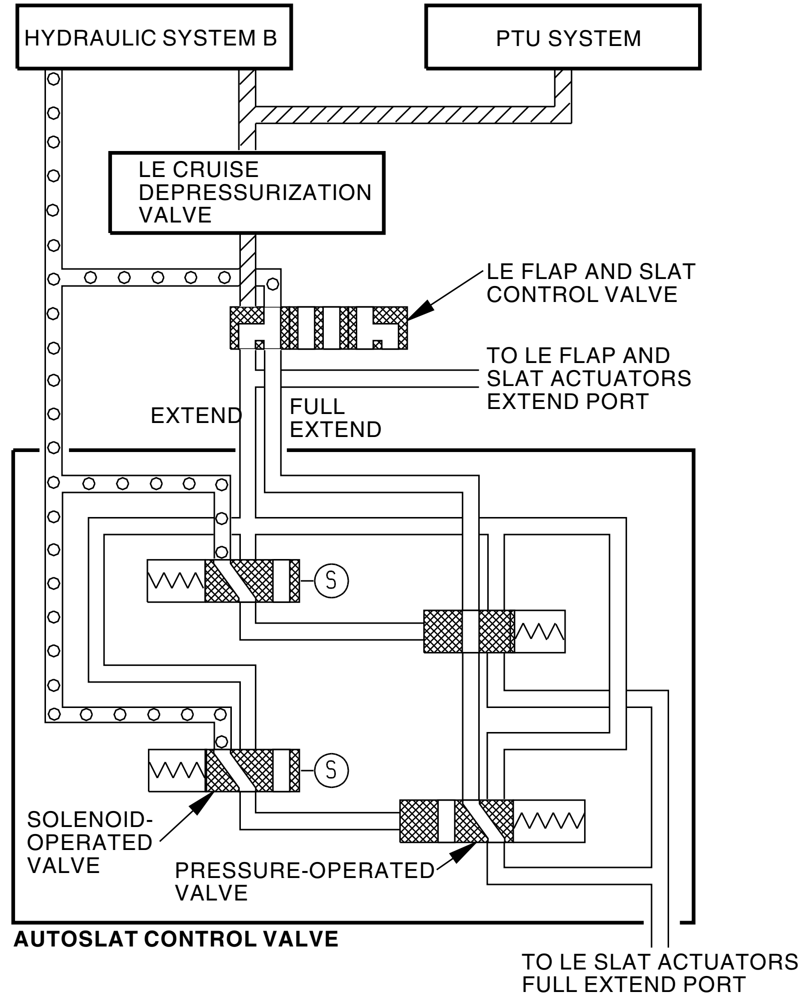
The autoslat operation occurs when all of these conditions occur:

- The flap lever at 1, 2, 5, 10, 15 or 25
- The airplane gets near a stall condition
- Alternative operation is not active.

When all of these conditions occur, the SMYDs energize the two solenoids. The solenoid valves send extend pressure to the pressure-operated valves. This permits either pressure-operated valve to send extend pressure to the full extend port on the LE slat actuators. If one valve, solenoid, or SMYD has a failure, the pressure still goes to the actuators.

LE AUTOSLAT SYSTEM - AUTOSLAT CONTROL VALVE





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LE AUTOSLAT SYSTEM - AUTOSLAT CONTROL VALVE

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LE AUTOSLAT SYSTEM - FUNCTIONAL DESCRIPTION

Functional Description

The SMYDs energize the solenoids in the autoslat control valve if all these conditions are true:

- Angle-of-attack more than a limit.
- Airplane in the air
- Computed airspeed less than 230 knots
- TE flaps not up
- Autoslat function valid

The autoslat function is available if the angle-of-attack data is valid and there are no failures to a SMYD or the autoslat valve. The angle-of-attack data comes from the angle of airflow sensor.

The airplane in air data comes from the PSEU.

The airspeed data comes from the air data inertial reference units (ADIRUs).

The TE flaps not up data comes from the TE flap position sensors. When the TE flaps are not up, the LE slats are not up. The autoslat function can only extend the LE slats from extend to full extend. This function can not extend the LE slats when the LE slats are in the up position.

The angle-of-attack limit is a function of these:

- TE flap position
- Thermal anti-ice (TAI) system condition.

The SMYDs send an autoslat command at a lower angle-of-attack if the TE flaps are at 5 than if the TE flaps are at 1.

During an autoslat command, the SMYDs also send a signal to the FSEU for LE flaps and slats UCM logic.

The SMYDs receive thermal anti-ice system data from the display processing computers (DPCs). The SMYDs send an autoslat command at a lower angle-of-attack if the thermal anti-ice system is on. This occurs when the wing anti-ice switch is on or when one of the engine anti-ice switches are on.

See the navigation chapter for more information on the angle of airflow sensor and the ADIRU (CHAPTER 34).

See the landing gear chapter for more information on the PSEU (CHAPTER 32).

See the trailing edge flap section for more information on the flap position sensors (SECTION 27-51).

See the ice and rain protection chapter for more information on the thermal anti-ice system (CHAPTER 30).

Indications

When the autoslat function becomes active, the SMYDs send a signal to the FSEU. The FSEU uses this data to prevent the LE FLAPS TRANSIT display during the autoslat extension of the LE slats in the air. During ground tests of the autoslat system, the LE FLAPS TRANSIT and the LE FLAPS EXT show on the Engine Display on the main instrument panel.

If the autoslat function is not available in one SMYD, then the other SMYD can continue operate the autoslat function. To see the indication of this condition, push the master caution recall switch. This causes the autoslat fail light to show. If you push the master caution reset switch, the autoslat fail light goes off the view.

Examine the autoslat signal during each flight. Each time that the TE flaps move from 25 to 30, the SMYDs energize the solenoids in the autoslat control valve. If the autoslat function is not available in two SMYDs, then the autoslat fail light comes on.

Training Information Point

During a manual test of the autoslat system, these are some of the steps you must do:

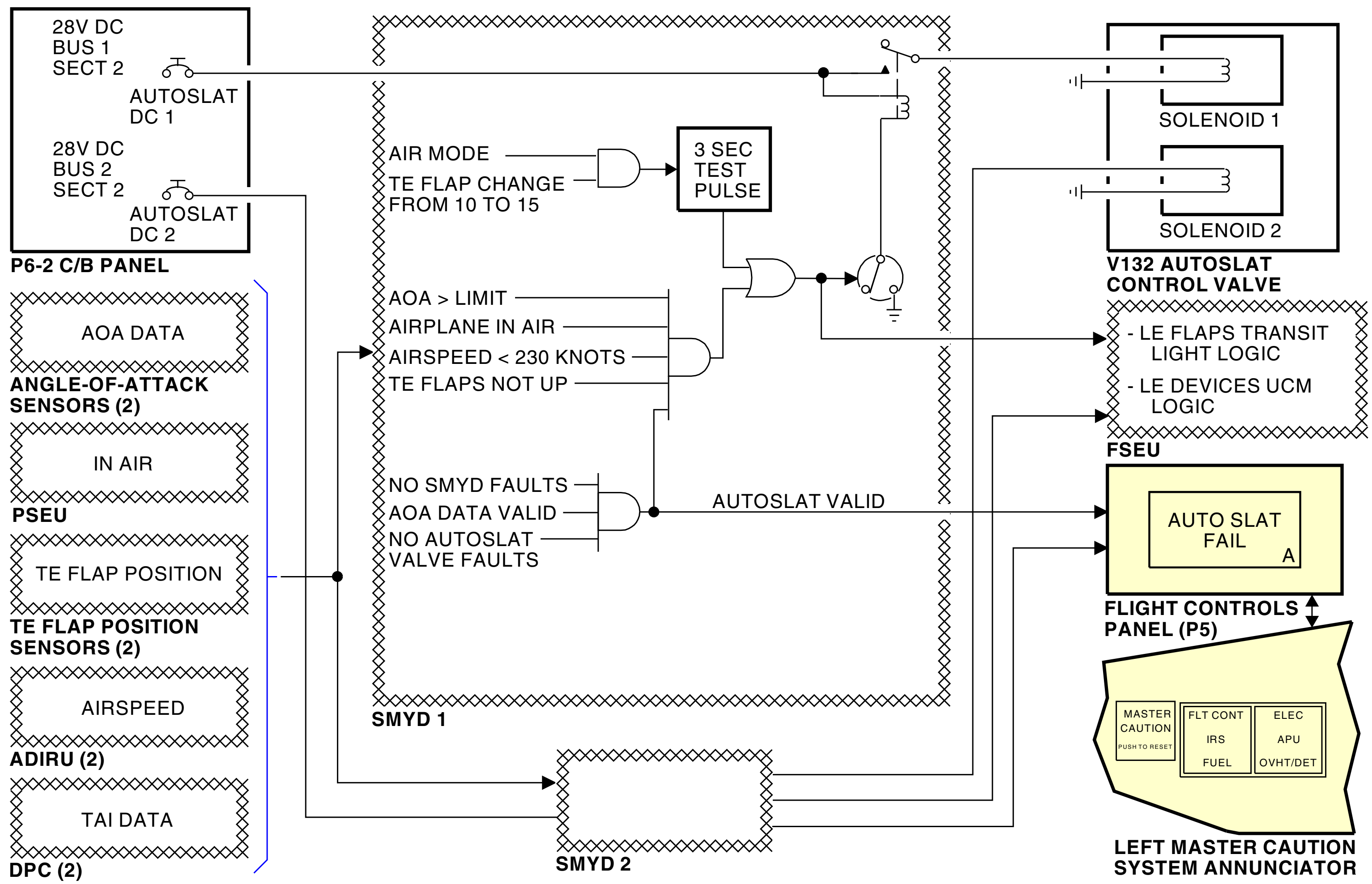
- Simulate the air mode
- Extend the LE slats using hydraulic system B power
- Manually move the AOA vanes.

When you move the AOA vanes, obey this warning:

LE AUTOSLAT SYSTEM - FUNCTIONAL DESCRIPTION

WARNING MAKE SURE THAT THE AOA SENSORS ARE COOL BEFORE YOU TOUCH THEM. THE AOA SENSORS CAN BE SUFFICIENTLY HOT TO BURN YOU.

LE AUTOSLAT SYSTEM - FUNCTIONAL DESCRIPTION



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LE AUTOSLAT SYSTEM - FUNCTIONAL DESCRIPTION

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LE FLAP AND SLAT POSITION INDICATING SYSTEM - GENERAL DESCRIPTION

General

The LE flap and slat position indicating system measures the position of the LE flaps and slats. The FSEU uses this data to show the lights on the LE devices annunciator panel in the flight deck. The FSEU also uses this data to show the LE FLAPS TRANSIT light and the LE FLAPS EXT light.

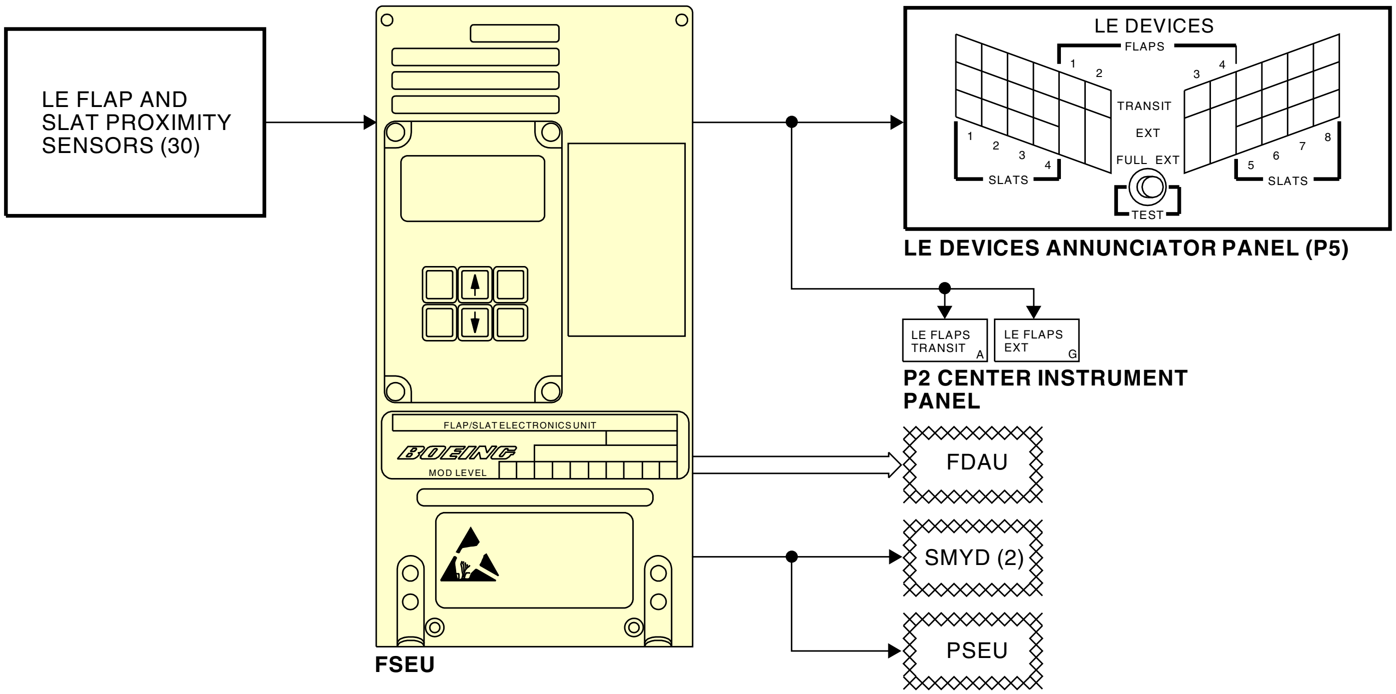
Interfaces

There are 30 proximity sensors, two for each LE flap and slats 1 and 8, and three for slats 2 thru 7. These proximity sensors measure the position of targets that move with the surfaces. The proximity sensors send this data to the FSEU. The FSEU uses this data to control the LE devices annunciator panel and lights in the flight deck.

The FSEU also sends this data to these components:

- Flight data acquisition unit (FDAU)
- Stall management yaw damper (SMYD) computers
- Proximity switch electronic unit (PSEU).

LE FLAP AND SLAT POSITION INDICATING SYSTEM - GENERAL DESCRIPTION



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LE FLAP AND SLAT POSITION INDICATING SYSTEM - GENERAL DESCRIPTION

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE FLAP PROXIMITY SENSORS

Purpose

The LE flap proximity sensors send LE flap position data to the FSEU. The FSEU uses this data for position indication and sends this data to other user systems.

Location

There are eight LE flap proximity sensors, two for each LE flap. To get access to the LE flap proximity sensors, extend the LE flaps.

The LE flap proximity sensors that have a target near at the retract position are identified as the retract sensors. The LE flap proximity sensors that have a target near at the extend position are identified as the extend sensors.

Functional Description

The LE flaps proximity sensors use ferrous metal targets that are not magnets.

The FSEU monitors the impedance of the proximity sensors. The impedance has a relation to the position of the targets to the sensors. As the LE flaps move, the targets move with them and the impedance of the proximity sensors change.

The FSEU detects a target-near condition when a target is directly in front of the sensor. When no part of a target is in front of the sensor, the FSEU detects a target-far condition.

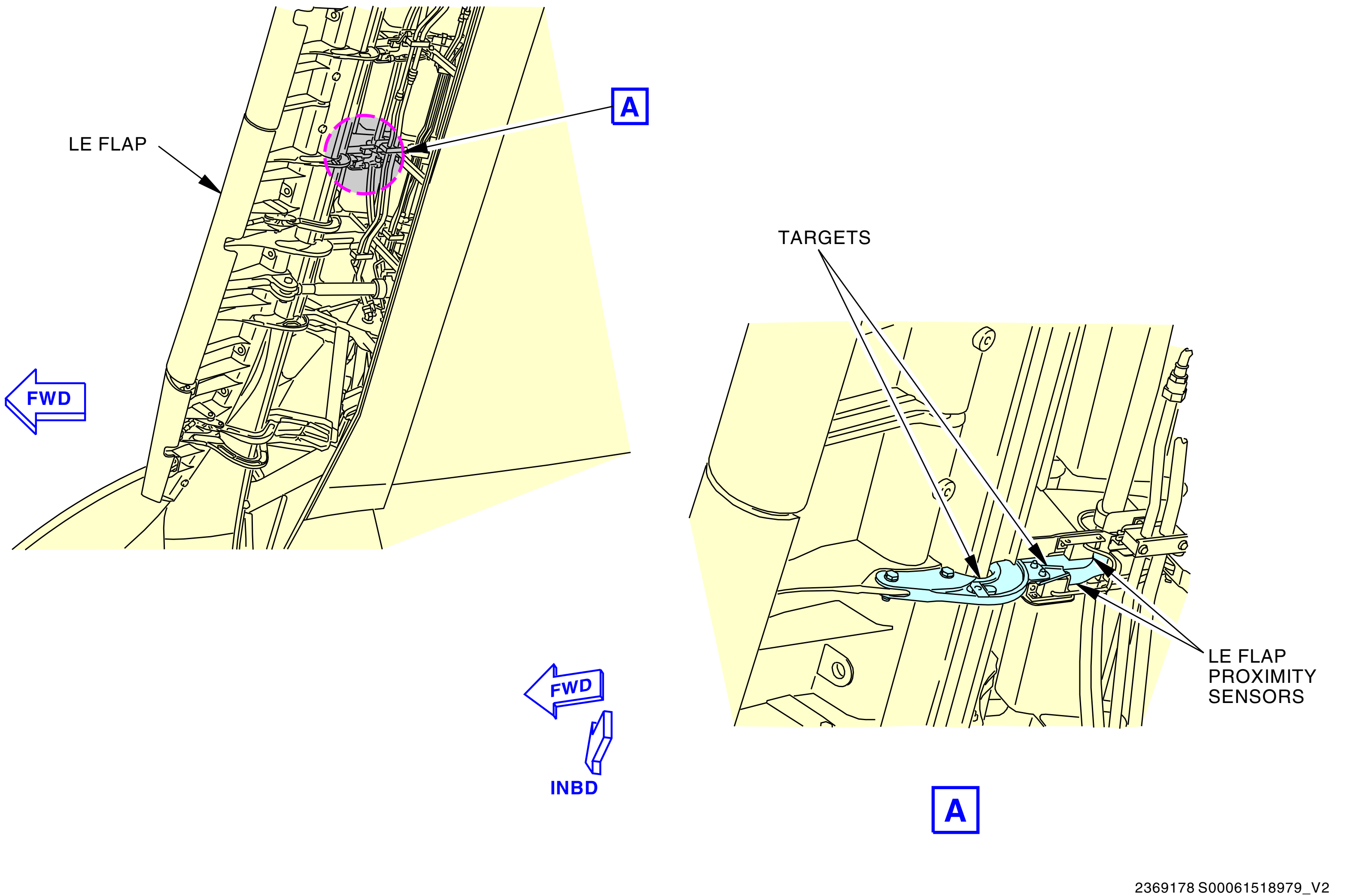
Training Information Point

The LE flap proximity sensors are interchangeable with each other and with the LE slat inboard and outboard sensors.

Remove or install shims to adjust the sensors.

You can use the FSEU BITE to see the target gap information for each sensor.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE FLAP PROXIMITY SENSORS



LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE FLAP PROXIMITY SENSORS

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE SLAT PROXIMITY SENSORS

Purpose

The LE slat proximity sensors send LE slat position data to the FSEU. The FSEU uses this data for position indication and sends this data to other user systems.

Location

There are 22 proximity sensors for the LE slats. There are two proximity sensors for LE slats 1 and 8 and three for slats 2 thru 7. LE slats 1 and 8 each have an inboard and an outboard sensor. LE slats 1 and 8 have two targets for each sensor. LE slats 2 thru 7 each have an inboard sensor, retract sensor, and an outboard sensor. To get access to the LE slat proximity sensors, remove the access panel under the wing.

The targets for the outboard sensors are on the outboard auxiliary arms. The targets for the inboard sensors are on the inboard auxiliary arms. The LE slat retract sensors are near the slat actuators and have targets that are on the inside cove of the LE slats.

Functional Description

The LE flap and slat position indication system uses two different types of proximity sensors. The LE slat retract sensors are score type of proximity sensors and use magnets for their targets. All the other proximity sensors are the usual type and use ferrous metal targets that are not magnets.

The FSEU monitors the impedance of the proximity sensors. The impedance has a relation to the position of the targets to the sensors. As the LE slats move, the targets move with them and the impedance of the proximity sensors change.

The FSEU detects a target-near condition when a target is directly in front of the sensor. When no part of a target is in front of the sensor, the FSEU detects a target-far condition.

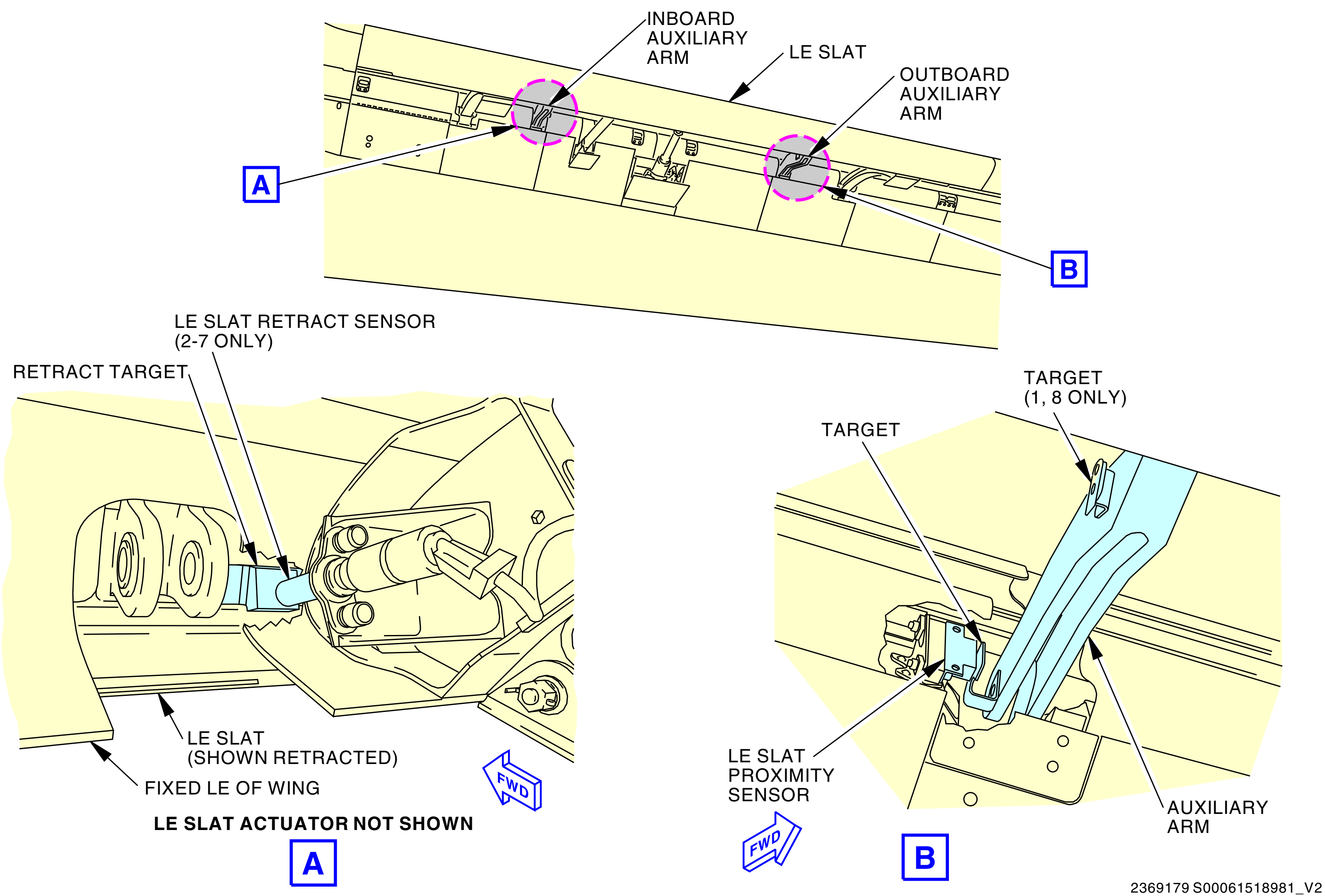
Training Information Point

The LE slat retract sensors are interchangeable with each other. The LE slat inboard and outboard sensors are interchangeable with each other and with the LE flap proximity sensors.

Remove or install shims to adjust the sensors.

You can use the FSEU BITE to see the target gap information for each sensor.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE SLAT PROXIMITY SENSORS



LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE SLAT PROXIMITY SENSORS

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE DEVICES ANNUNCIATOR PANEL

Purpose

The LE devices annunciator panel shows the position of all the LE flaps and slats independently.

Location

The LE devices annunciator panel is on the P5 aft overhead panel.

Physical Description

The LE devices annunciator panel has green and amber lights to show the position of each LE flap and slat. These are the lights on the LE devices annunciator panel:

- Transit (amber)
- Extend (green)
- Full extend (green).

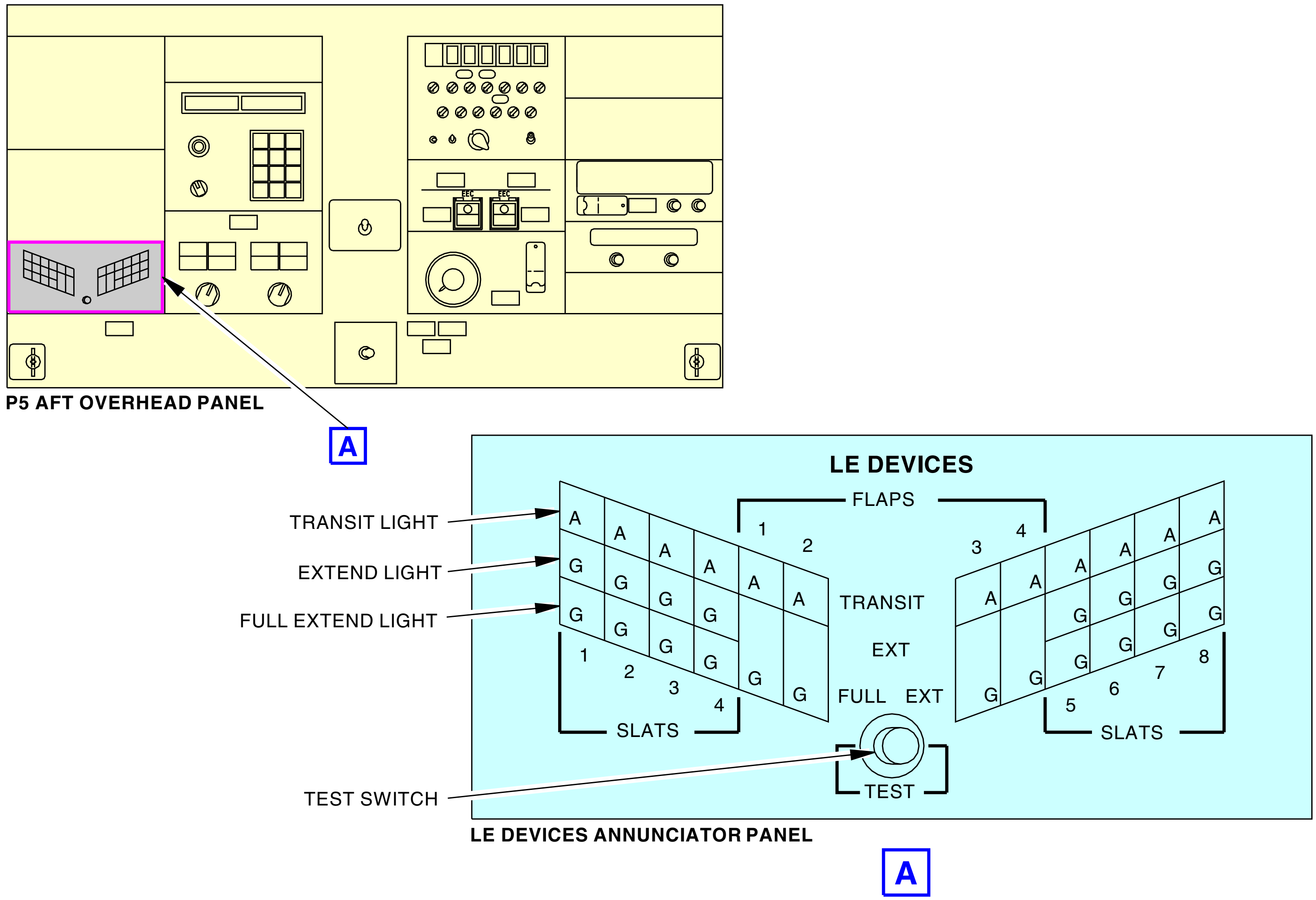
The LE devices annunciator panel has all three types of lights for the LE slats, but only the transit and extend lights for the LE flaps. This is because the LE flaps have only two positions.

Functional Description

When the LE flaps and slats are in the retract position, all the lights go out of view. When the surfaces move, the transit lights show. When the surfaces are in the extend position, the extend lights show. When the LE slats are in the full extend position, the full extend lights show.

There is a test switch on the LE devices annunciator panel. When you push this switch, all the lights show.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE DEVICES ANNUNCIATOR PANEL



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LE FLAP AND SLAT POSITION INDICATING SYSTEM - LE DEVICES ANNUNCIATOR PANEL

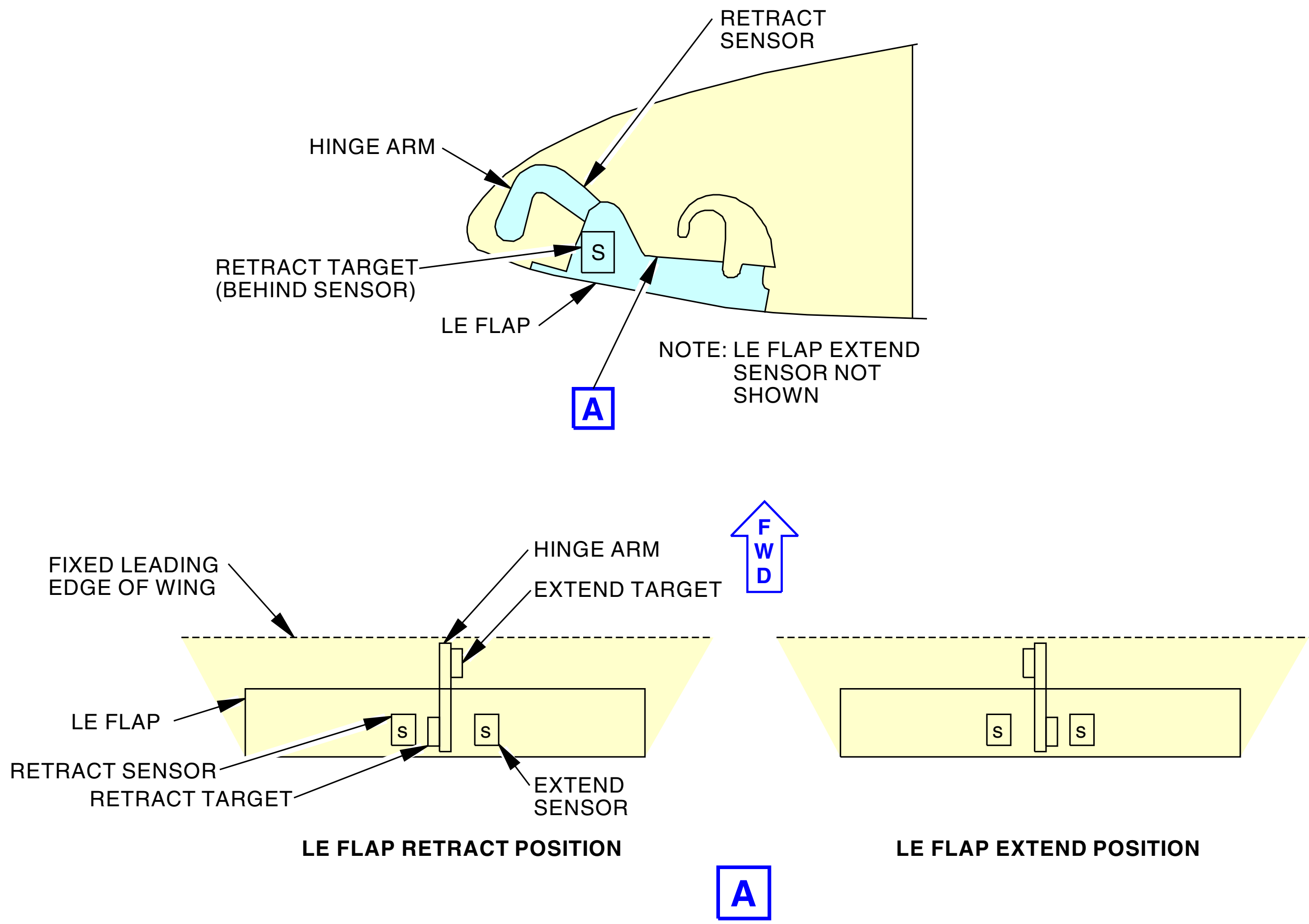
LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 1

LE Flap Position Indication

There are eight LE flap proximity sensors. For each LE flap, there is one sensor and one target on each side of the hinge arm. The sensors are at the same location on the fixed leading edge, but on opposite sides of the hinge arm. The targets are on opposite sides of the hinge arm and at different locations on the hinge arm.

Each LE flap proximity sensor monitors the position of only one target. When the LE flaps are in the retract position, the retract sensor for each LE flap is in a target-near condition and the extend sensor is in a target-far condition. When the LE flap is in the extend position, the retract sensor changes to a target-far condition and the extend sensor changes to a target-near condition.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 1



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LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 1

LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 2

LE Slat Position Indication

There are 22 LE slat proximity sensors.

For LE slats 1 and 8, there are two proximity sensors for each slat. These sensors are the inboard sensor and the outboard sensor. Each of these sensors have two targets.

For LE slats 2 thru 7, there are three proximity sensors for each slat instead of two. This provides a more accurate monitor of the surface position.

For LE slats 2 thru 7, the sensors are identified as the retract sensor, the inboard sensor, and the outboard sensor. Each of these sensors have one target.

Retract

When the LE slats are retracted, the inboard sensors and the outboard sensors for LE slats 1 and 8 have a target near. For LE slats 2 thru 7, only the retract sensors have a target near.

Extend and Full Extend

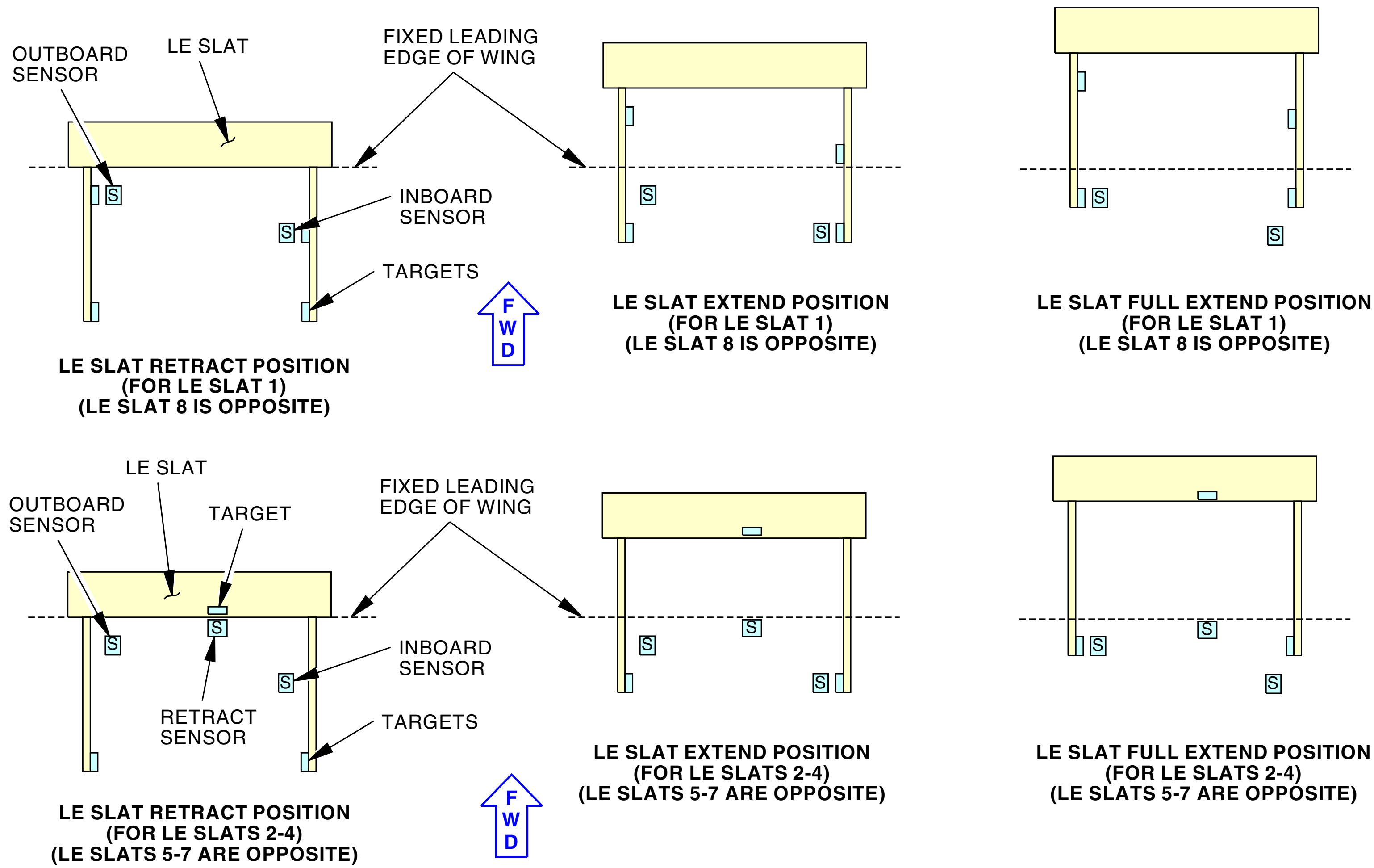
When the LE slats are in the extend position, the inboard sensors for all the LE slats have a target near and the outboard sensors are in a target-far condition. When the LE slats are in the full extend position, the inboard sensors change to a target-far condition and the outboard sensors change to a target-near condition.

Slat Failures

The FSEU uses the proximity sensor data to find if a slat did not move to the correct position. If the position of one LE flap or slat is not in the same position as the other surfaces, the FSEU commands the LE FLAPS TRANSIT light to show.

For LE slats 2 thru 7, only one sensor has a target near at the retract, extend, or full extend positions. If two sensors have a target near, the slat has a failure and the FSEU commands the LE FLAPS TRANSIT light to show.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 2



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LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 2

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LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 3

Functional Description

There are 30 LE flap and slat proximity sensors that send data to the FSEU. The FSEU uses this data for position indication on the LE devices annunciator panel. The FSEU also sends this data to these components:

- SMYDs for stall warning
- FDAU for the flight data recorder
- PSEU for takeoff warning.

LE FLAPS EXT Light

The LE FLAPS EXT light shows when all of the LE flaps and slats are in an extend or full extend position.

LE FLAPS TRANSIT Light

The LE FLAPS TRANSIT light shows when a LE flap or slat is not in the correct position or when a LE uncommanded motion (UCM) occurs.

LE Flap or Slat Not in Correct Position

The FSEU compares the LE flap and slat positions with the flap lever position and the TE flap position to make sure the LE flaps and slats move to the correct position.

When the TE flaps are at up, the LE flaps and slats should be at the retract position. When the TE flaps are at 1 through 25 positions the LE flaps are extended, and slats should be at the extend position. When the TE flaps are at 30 or more, the LE flaps should be at the extend position and the LE slats should be at the full extend position. If any LE flap or slat is not in the correct position, the LE FLAPS TRANSIT light shows.

LE Uncommanded Motion (UCM)

A LE uncommanded motion (UCM) occurs when two or more LE flaps or slats move away from their commanded position. If this occurs, the FSEU turns on the LE FLAPS TRANSIT light and sends a command to the LE UCM shutoff valve to stop the movement of the LE flaps and slats.

LE Devices Annunciator Panel

These are the lights on the LE devices annunciator panel:

- Transit (amber)
- Extend (green)
- Full extend (green).

If a LE flap or slat is not in the correct position, one of these indications will show on the LE devices annunciator panel:

- TRANSIT amber light comes on
- Incorrect EXT or FULL EXT green light comes on
- No lights come on.

Operation

When the LE flaps and slats are retracted, all the lights go out of view.

When the TE flaps move from 0 to 1, the LE FLAPS TRANSIT light shows. When each LE flap and slat moves, the transit light for each surface shows on the LE devices annunciator panel. When each LE flap and slat are in the extend position, the extend light shows and the transit light goes out of view. When all the LE flaps and slats are in the extend position, the LE FLAPS TRANSIT light goes out of view and the LE FLAPS EXT light shows.

When the TE flaps move from 25 to 30, the LE FLAPS EXT light goes out of view and the LE FLAPS TRANSIT light shows. When each LE slat moves, the transit light for each surface shows and the extend light goes out of view. When each LE slat is in the full extend position, the full extend light shows and the transit light goes out of view. When all the LE slats are in the full extend position, the LE FLAPS TRANSIT light goes out of view and the LE FLAPS EXT light shows.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 3

Autoslat Operation

During an autoslat extension, the FSEU inhibits the LE FLAPS TRANSIT light. The SMYDs send an autoslat signal to the FSEU when the airplane gets near a stall condition. When this occurs, the FSEU gives a 12-second time delay to the LE FLAPS TRANSIT light. This causes the LE FLAPS TRANSIT light to not show during autoslat extension of the LE slats.

When the SMYDs remove the autoslat command, the 12-second time delays becomes active again. This causes the LE FLAPS TRANSIT light to not show during retraction of the LE slats after an autoslat extension.

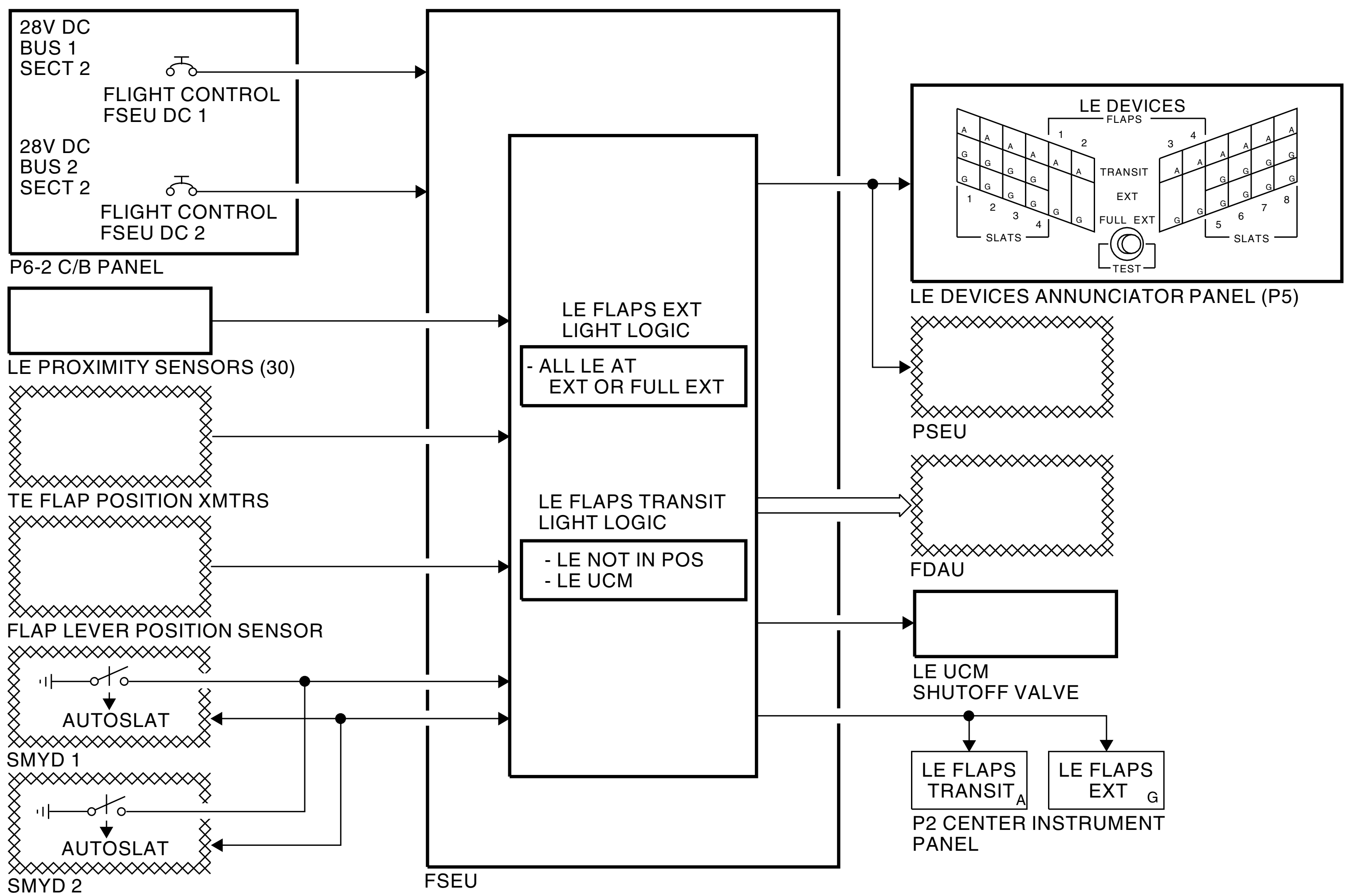
Other Interfaces

The FSEU sends LE flap and slat position data to the PSEU for the takeoff warning logic. The takeoff warning horn sounds during a takeoff roll if one of these conditions occurs:

- A LE UCM condition
- A LE flap is not in the extend position
- A LE slat is not in the extend or full extend position.

The FSEU also sends LE flap and slat position data to the flight data acquisition unit for the flight data recorder.

LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 3



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LE FLAP AND SLAT POSITION INDICATING SYSTEM - FUNCTIONAL DESCRIPTION 3