

12.8 (ATA 27) FLIGHT CONTROLS

12.8.1 Introduction

The Dash 8-Q400 primary flight controls consist of rudder, elevators and ailerons to provide yaw, pitch and roll respectively. Spoilers assist the ailerons for roll control. Secondary flight controls consist of flaps.

12.8.2 General

All flight controls may be operated from either the pilot's or copilot's seat. The ailerons and spoilers provide roll control, elevators pitch control, and rudder yaw control (Figure 12.8-1). Elevators, spoilers and rudder are hydraulically powered and designated the Powered Flight Control Surfaces (PFCS). A gust lock system is provided for the aileron controls to protect the aileron surfaces from damage due to strong wind gusts.

Spoilers have two functions:

- To assist the ailerons in providing roll control.
- To provide lift dump after the aeroplane touches down.

PFCS positions are shown on the pilot's Multi-Function Display (MFD) in the Permanent Systems Data Area (PSDA) of the display. This PFCS positions are transmitted to the MFD from the control surfaces through the Integrated Flight Cabinet (IFC). Trim indicators show trim position of the flight controls. Caution lights, provide indications of flight control malfunctions while advisory lights indicate system operation.

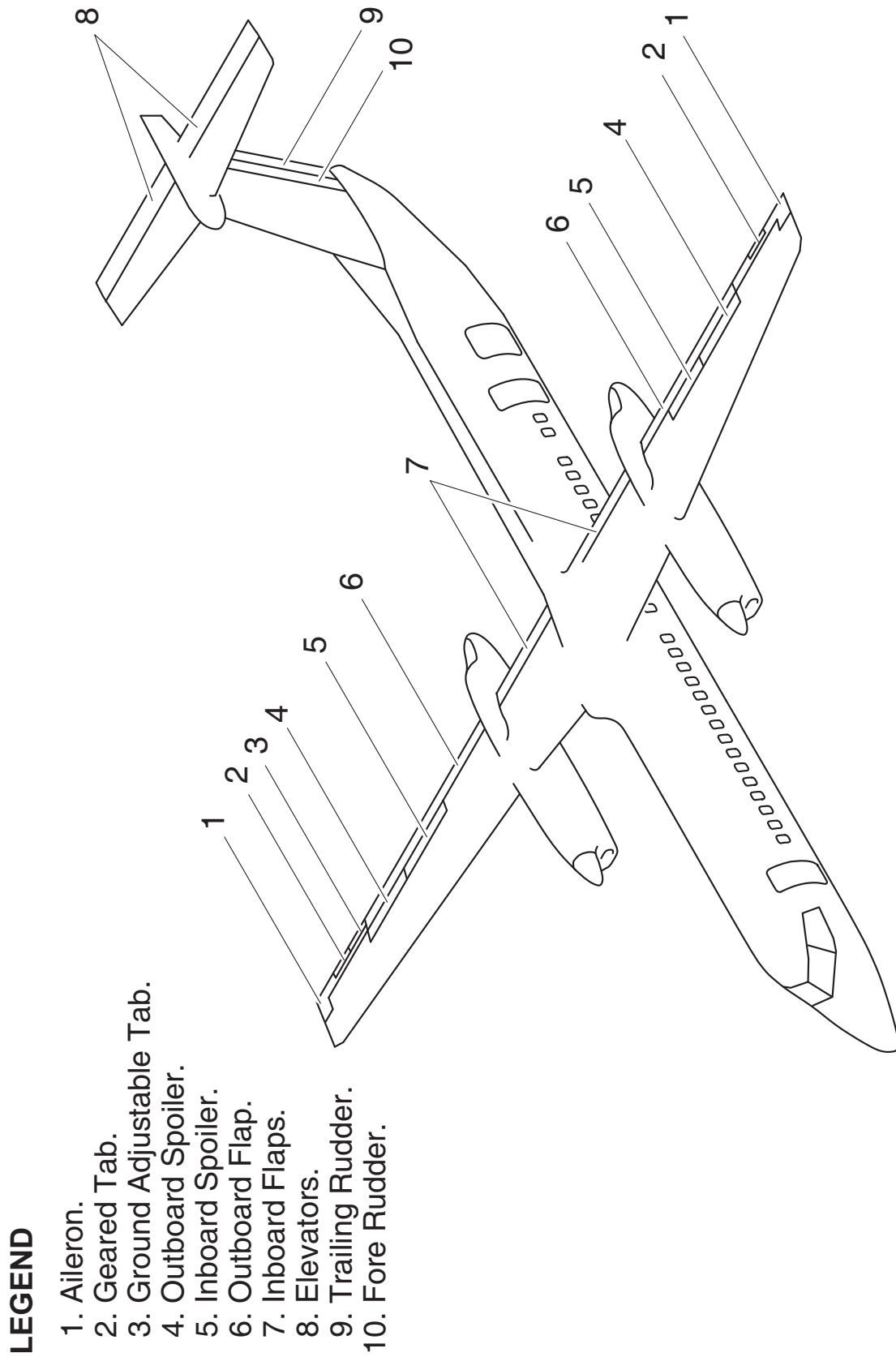
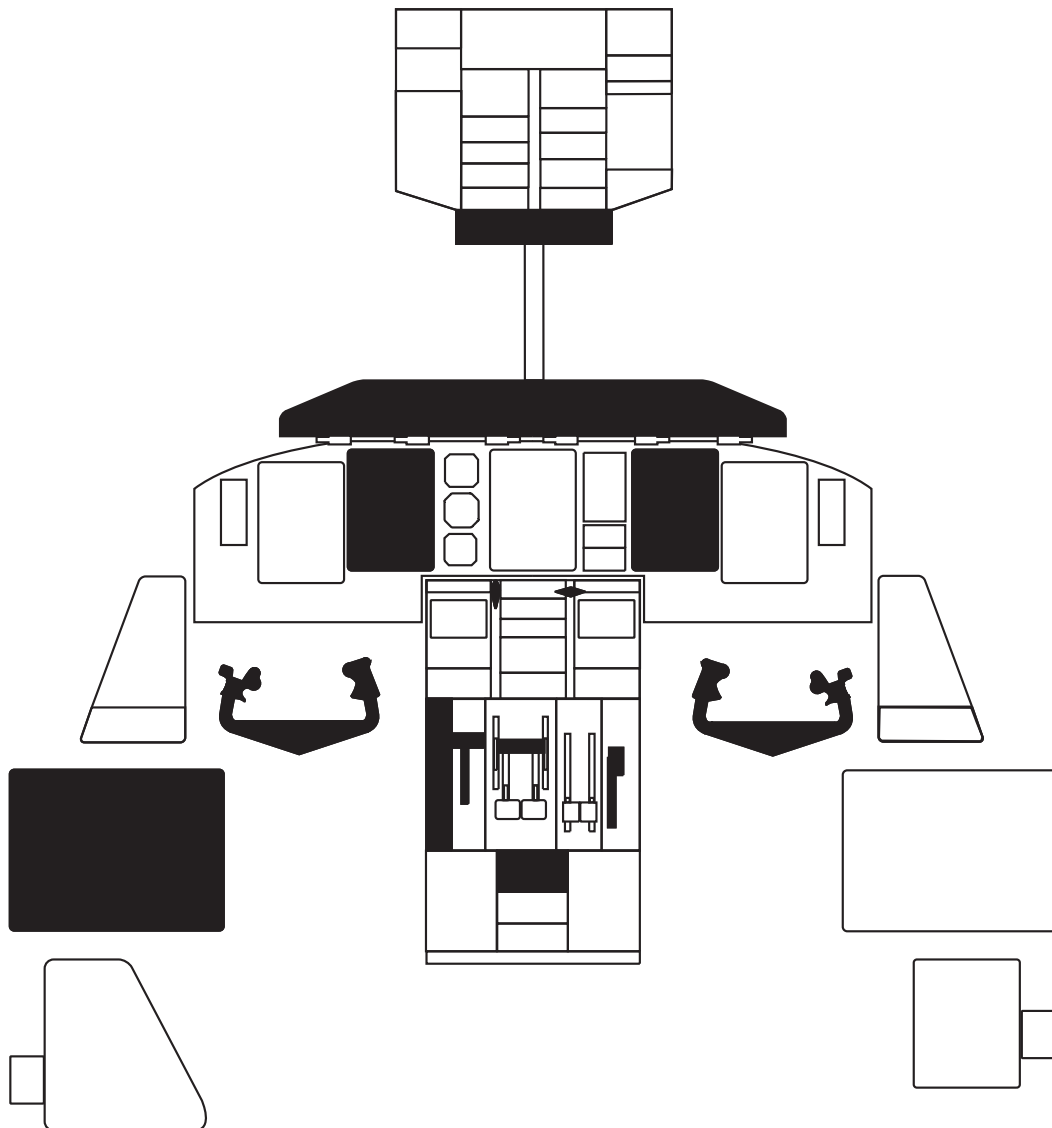


Figure 12.8-1 Flight Control Surface Locations

12.8.3 Controls and Indications - Flight Controls



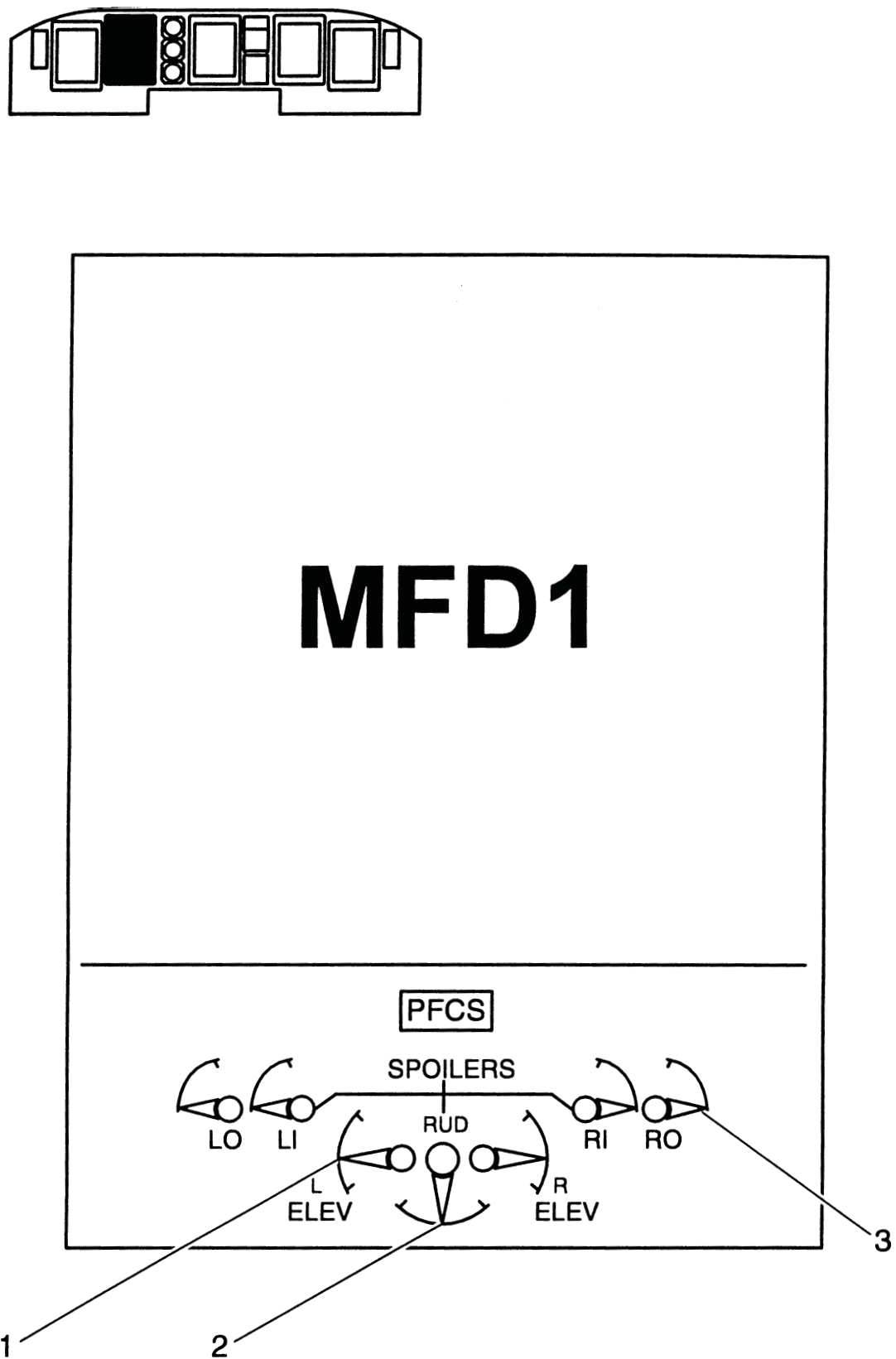
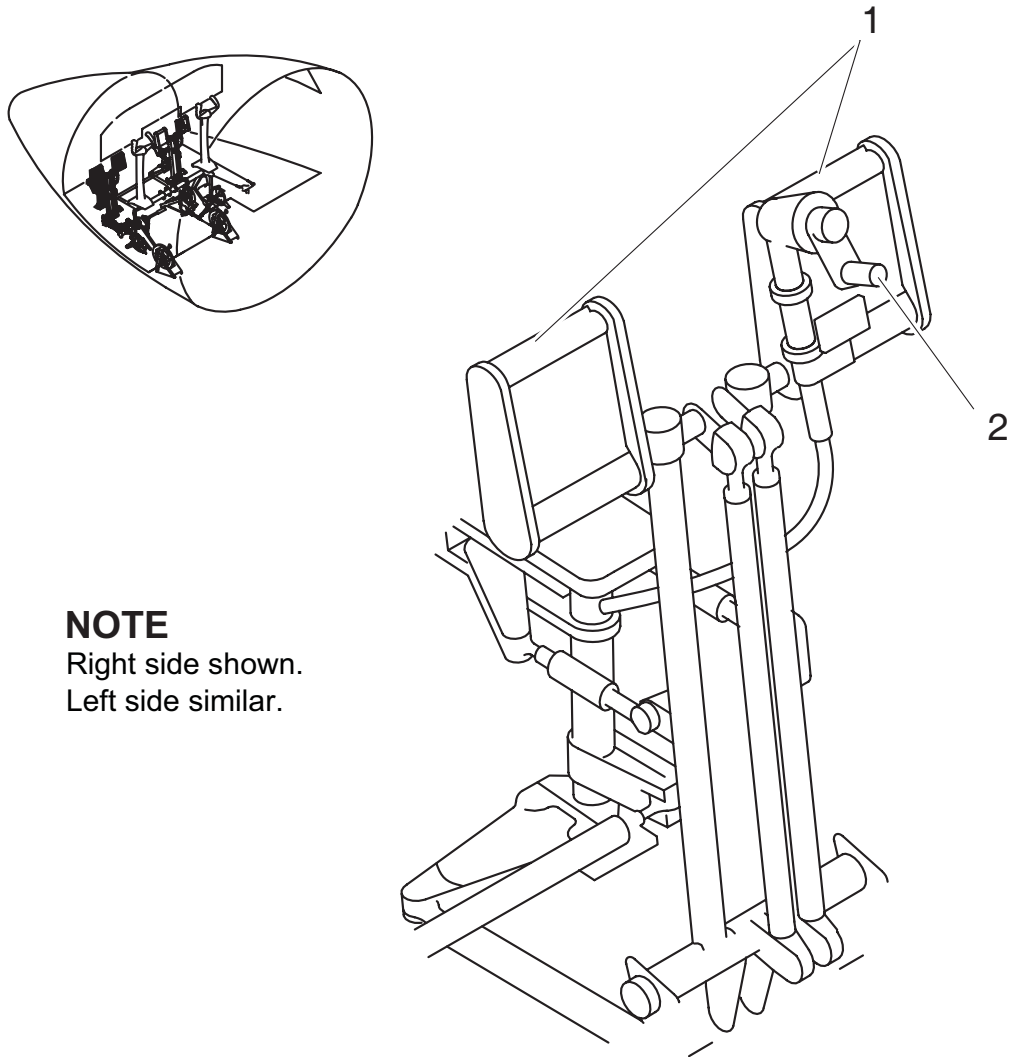


Figure 12.8-2 Powered Flight Control Surface Indications

MFD CALLOUTS RELATED TO FLIGHT CONTROLS

- 1. ELEVATOR POSITION INDICATOR (white)**
 - indicates deflection of left and right elevator
- 2. RUDDER POSITION INDICATOR (white)**
 - indicates rudder deflection
- 3. SPOILER POSITION INDICATOR (white)**
 - indicates inboard and outboard spoiler deflection



NOTE

Right side shown.
Left side similar.

Figure 12.8-3 Rudder Pedals

RUDDER PEDAL CALLOUTS

- 1 RUDDER PEDALS (differential action)**
PUSH - deflects rudder in desired direction
PUSH - top of pedals for brakes
- 2. RUDDER PEDALS ADJUSTMENT HANDLE (rotary action)**
ROTATE - extends or reduces distance of both pedals from the pilot's feet

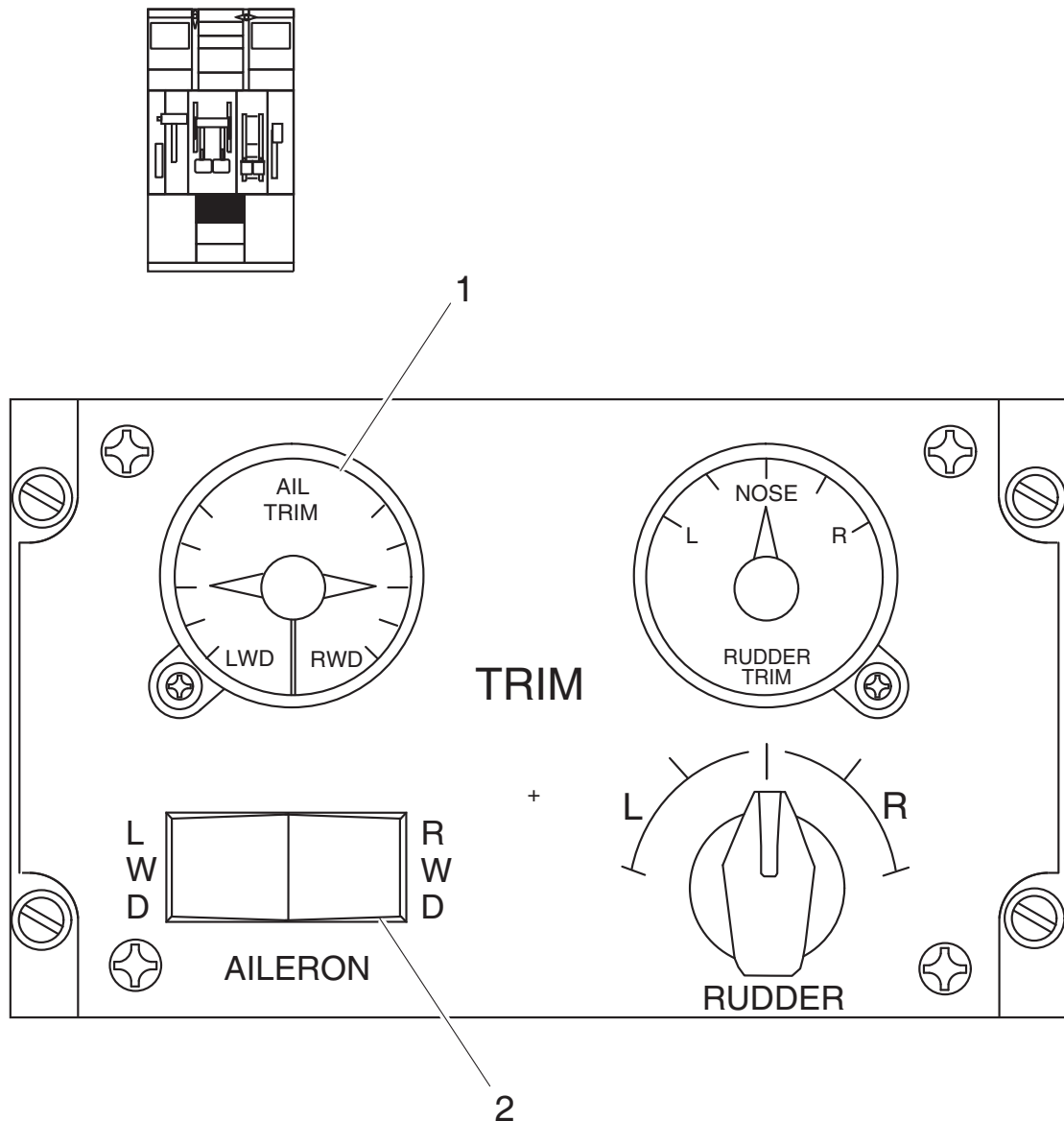


Figure 12.8-4 Aileron Trim and Indication

AILERON TRIM CALLOUTS

1. AILERON TRIM POSITION INDICATOR

- shows aileron trim position indication, left wing down or right wing down

2. AILERON TRIM SWITCH

(rocker switch - momentary action, spring loaded to neutral)

- controls aileron trim actuator which trims the ailerons

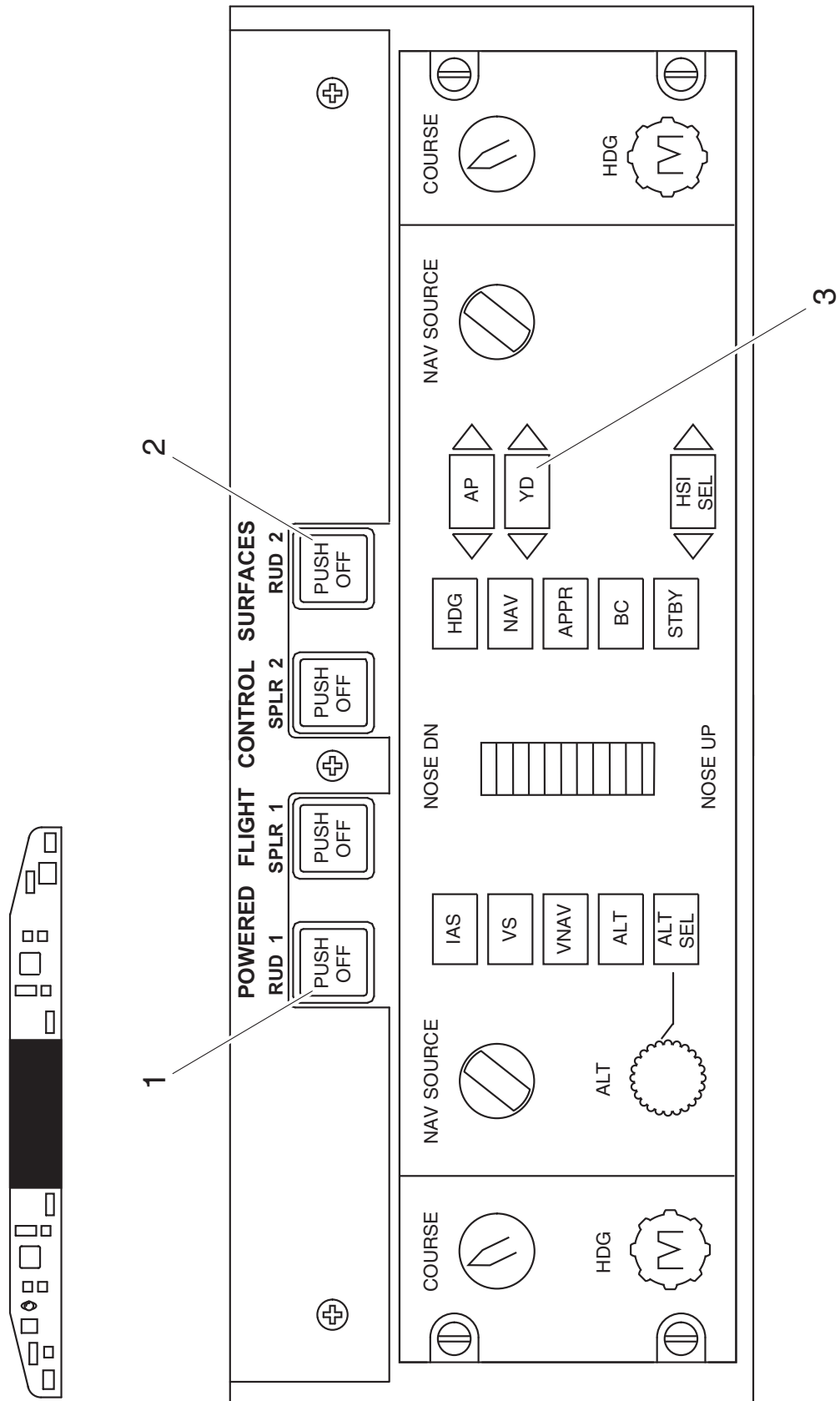


Figure 12.8-5 Rudder Push-of Switchlights and Yaw Damper

PFCS PANEL CALLOUTS PERTAINING TO FLIGHT CONTROL

1. RUD 1 PUSH OFF SWITCHLIGHT (amber) (alternate action)

- turns on to indicate a jam in lower rudder PCU

PUSH - PUSH segment (blank)

- OFF segment remains (amber)
- RUD 1 PUSH OFF switchlight depressurizes the lower rudder PCU

2. RUD 2 PUSH OFF SWITCHLIGHT (amber) (alternate action)

- turns on to indicate a jam in upper rudder PCU

PUSH - PUSH segment (blank)

- OFF segment remains (amber)
- RUD 2 PUSH OFF switchlight depressurizes the upper rudder PCU

3. YD PUSHBUTTON (amber) (momentary action)

PUSH - engages/disengages yaw damper

- pointer on left and right side of YD switchlight, turns on when yaw damper is engaged

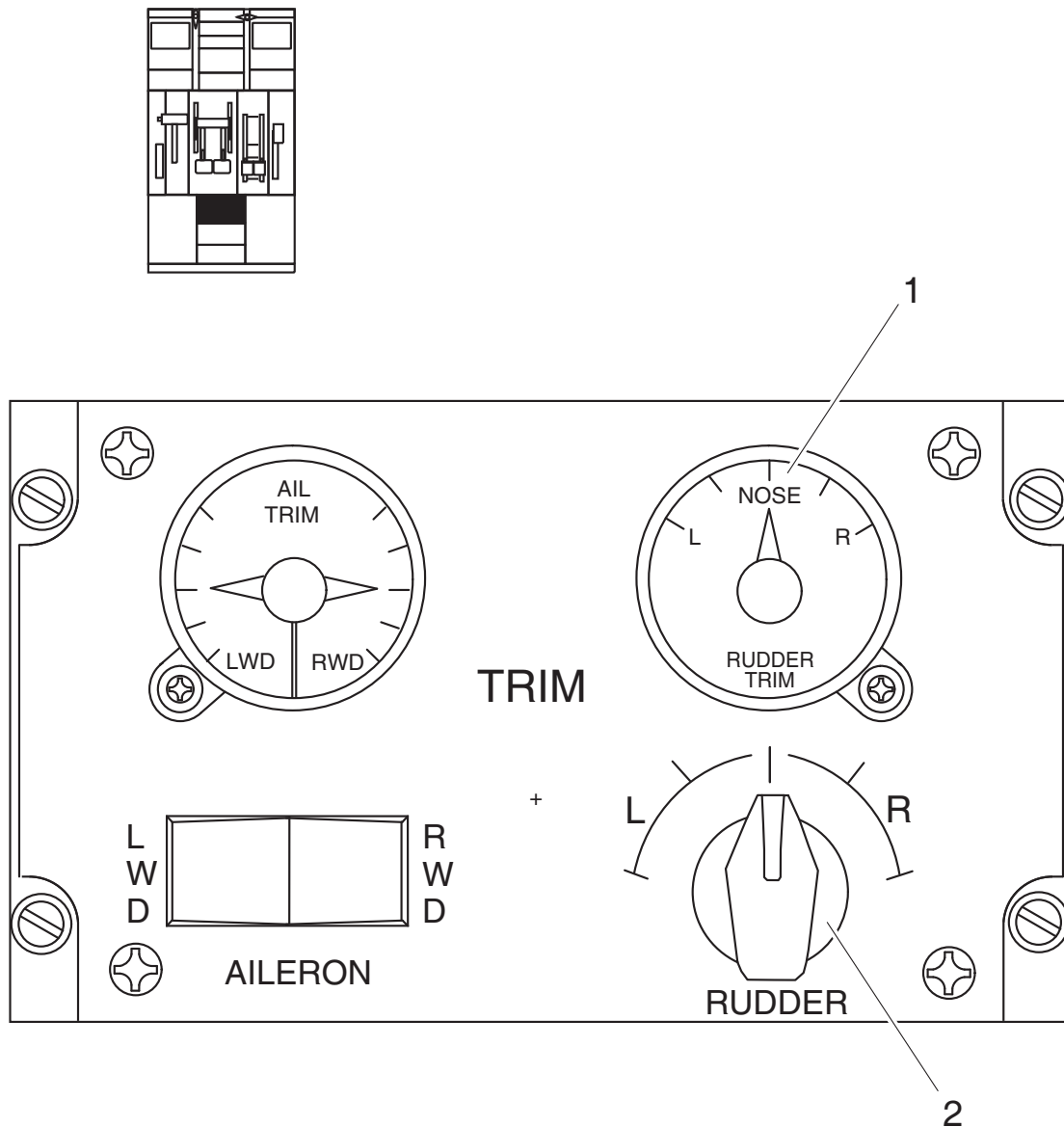


Figure 12.8-6 Rudder Trim and Indication

RUDDER TRIM CALLOUTS

1. **RUDDER TRIM INDICATOR**
 - indicates trimmed rudder position
2. **RUDDER TRIM KNOB (rotary action spring loaded to neutral)**
 - ROTATE** - trims rudder in desired direction
 - first graduation trims slow, second graduation trims fast

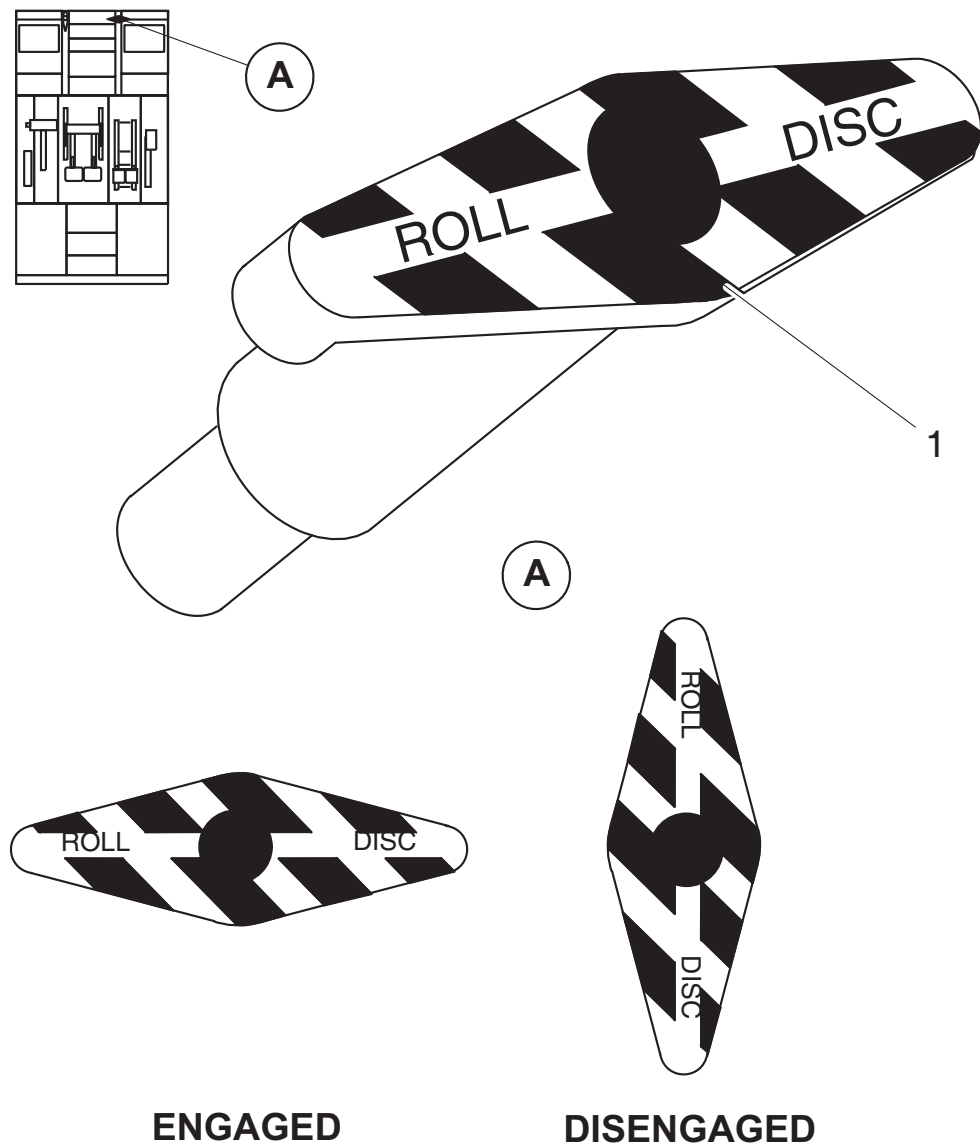


Figure 12.8-7 Roll Disconnect Handle

ROLL DISCONNECT HANDLE CALLOUT

1. ROLL DISC HANDLE (two position, spring loaded in, rotary action out)

ENGAGED - spring loaded in, both pilots have roll control

DISENGAGED - pulled out and turned 90° clockwise or counterclockwise, the pilot with the unjammed wheel will have roll control

- pilot's control wheel operates the spoilers only
- copilot's control wheel operates the ailerons only

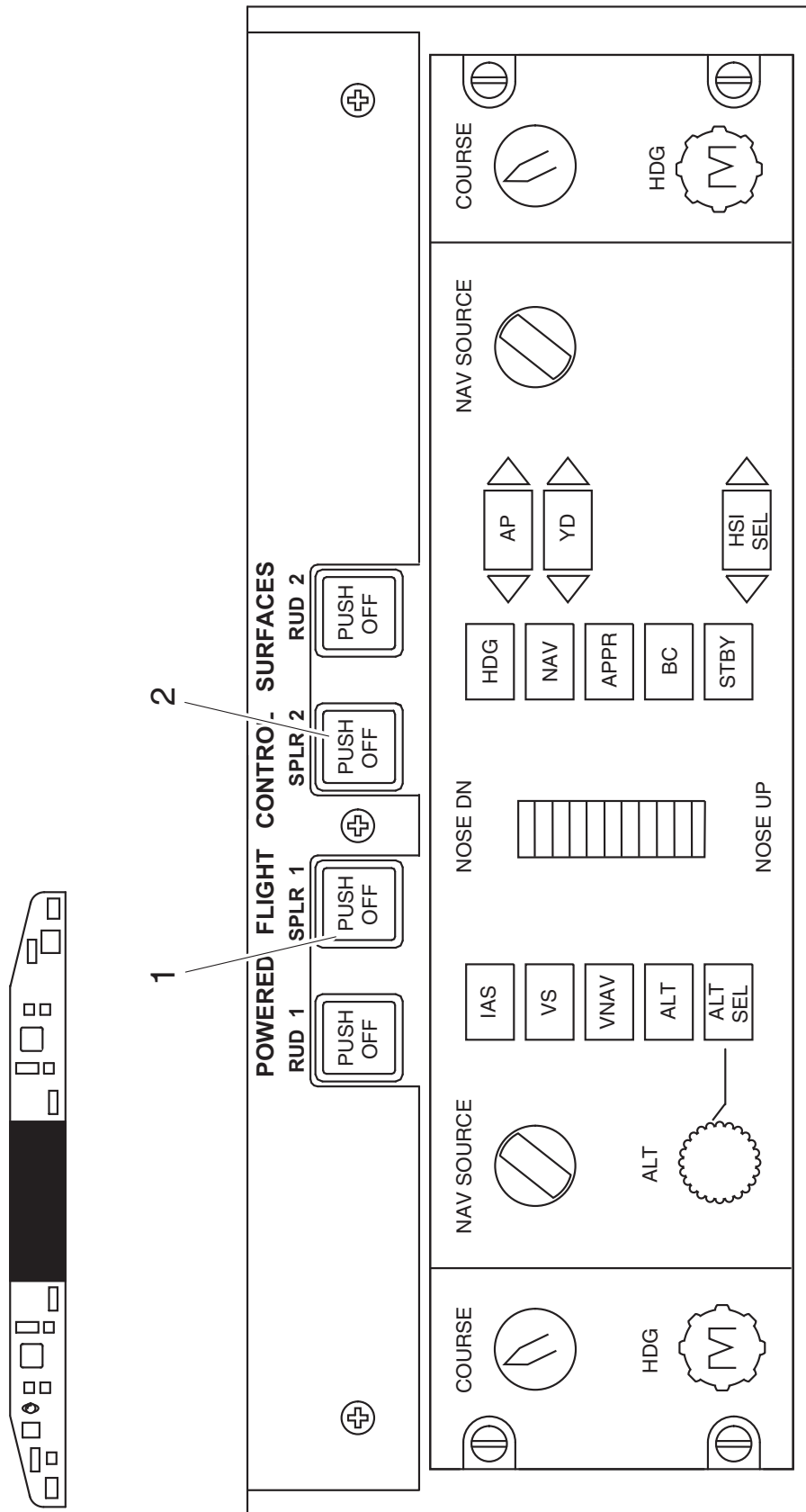


Figure 12.8-8 Spoiler Pushbutton Switchlights

PFCS CALLOUTS PERTAINING TO FLIGHT CONTROL

1. SPLR 1 PUSH OFF SWITCHLIGHT (amber) (alternate action)

- turns on to indicate a jam in an inboard spoiler PCU or linkage

PUSH - PUSH segment (blank)

- **OFF** segment (amber)
- SPLR 1 PUSH OFF switchlight depressurizes both inboard spoiler PCUs (ROLL SPLR INBD HYD caution light will illuminate)

2. SPLR 2 PUSH OFF SWITCHLIGHT (amber) (alternate action)

- turns on to indicate a jam in an outboard spoiler PCU or linkage

PUSH - PUSH segment (blank)

- **OFF** segment (amber)
- SPLR 2 PUSH OFF switchlight depressurizes both outboard spoiler PCUs (ROLL SPLR OUTBD HYD caution light will illuminate)

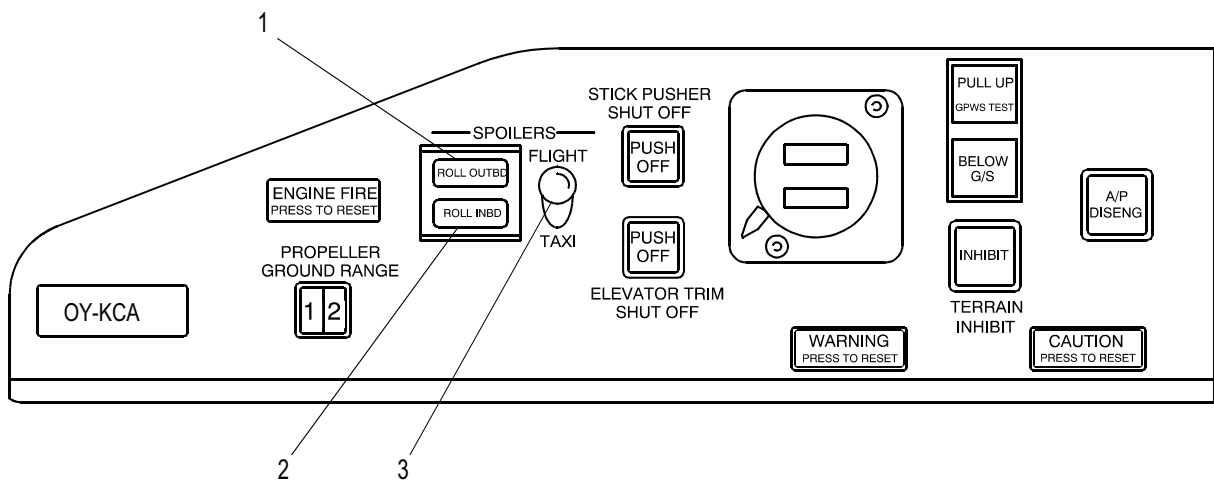
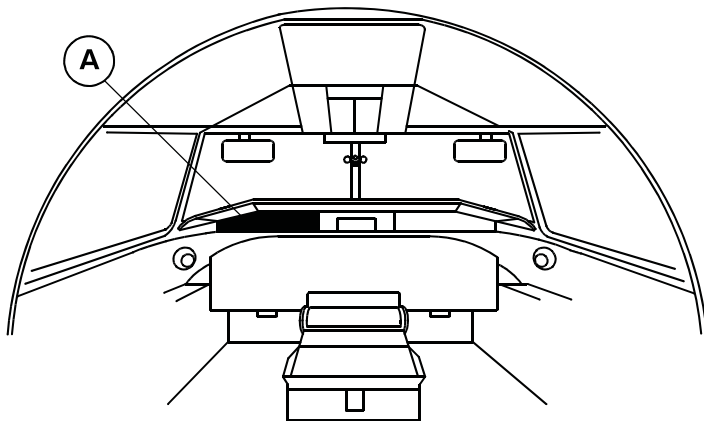


Figure 12.8-9 Spoiler Advisory Lights

GLARESHIELD CALLOUTS PERTAINING TO FLIGHT CONTROL

1. OUTBOARD SPOILER ADVISORY LIGHT (GROUND)

ROLL OUTBD segment (amber) - outboard spoilers have extended on touchdown

- aeroplane on the ground with FLIGHT/TAXI switch selected to FLIGHT

2. INBOARD SPOILER ADVISORY LIGHT (GROUND)

ROLL INBD segment (amber) - inboard spoilers have extended on touchdown

- aeroplane on the ground with FLIGHT/TAXI switch selected to FLIGHT

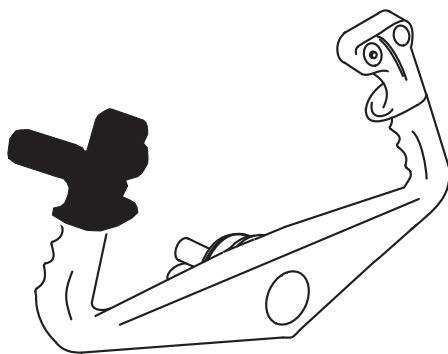
3. FLIGHT/TAXI SWITCH (two position, lever locked switch)

FLIGHT - must be selected for take-off

- lever locked in **FLIGHT** position
- allows inboard and outboard spoilers to extend on touchdown

TAXI - switch automatically moves to FLIGHT position when power levers are advanced to FLIGHT IDLE +12°

- retracts inboard and outboard spoilers for taxi after touchdown



NOTE

Pilot Handwheel shown.
Copilot opposite.

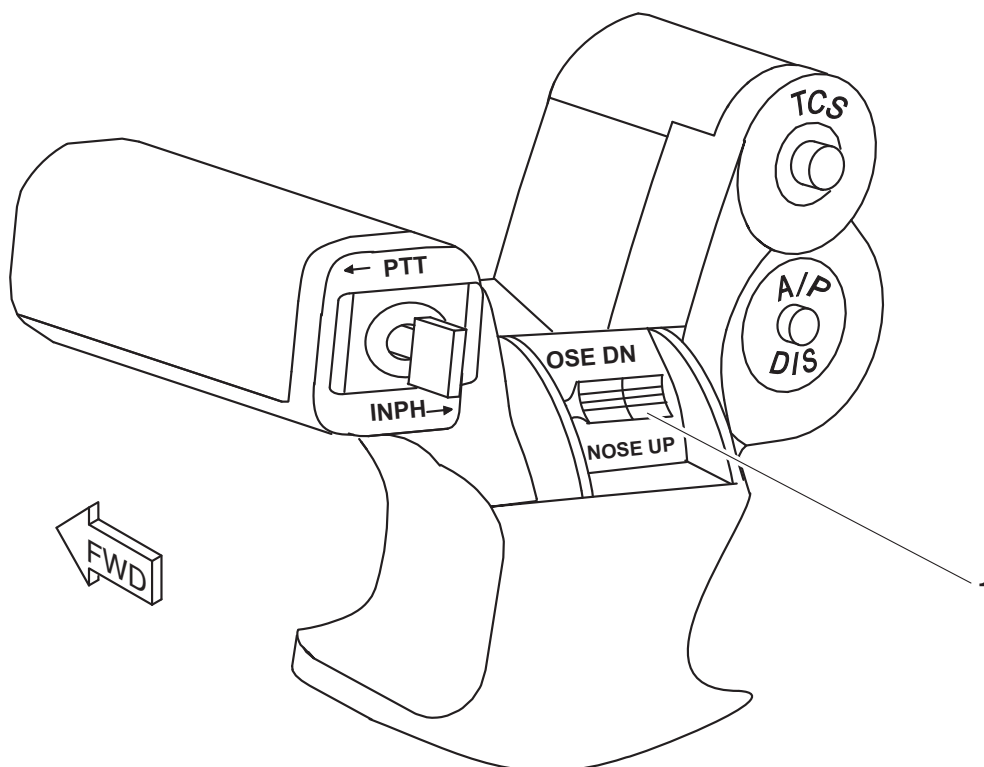


Figure 12.8-10 Pitch Trim Switches

CONTROL WHEEL CALLOUTS PERTAINING TO FLT CONTROLS

1. PITCH TRIM SWITCHES (fore and aft action, spring-loaded to neutral)

PUSH (both halves) - electrically trims elevators in desired direction

NOSE DN - trims elevators down for nose down direction

NOSE UP - trims elevators up for nose up direction

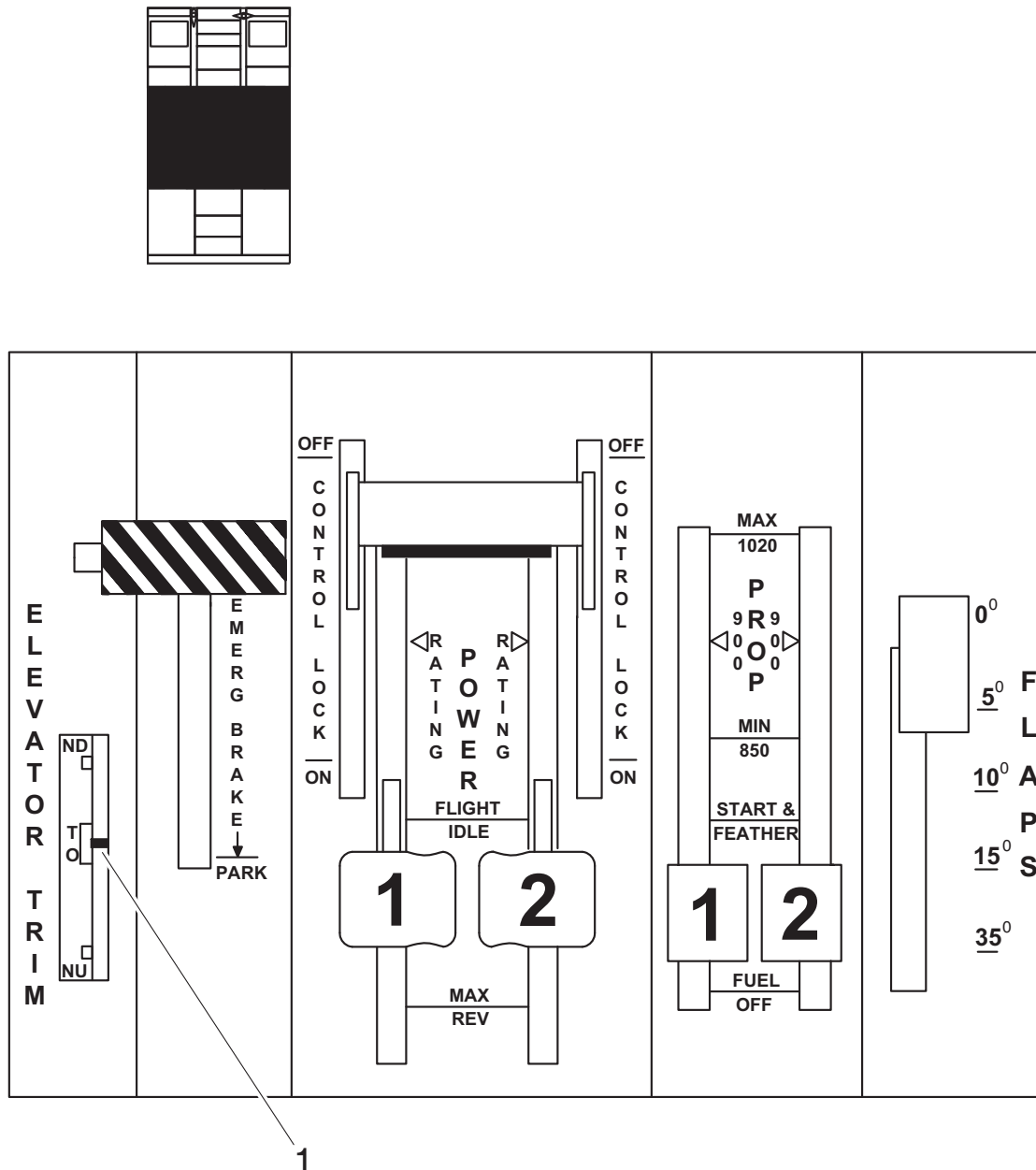


Figure 12.8-11 Pitch Trim Indicator

POWER QUADRANT CALLOUTS PERTAINING TO FLIGHT CONTROLS

1. ELEVATOR TRIM INDICATOR

- pointer indicates elevator trim position relative to:
ND - nose down
TO - take-off range
NU - nose up

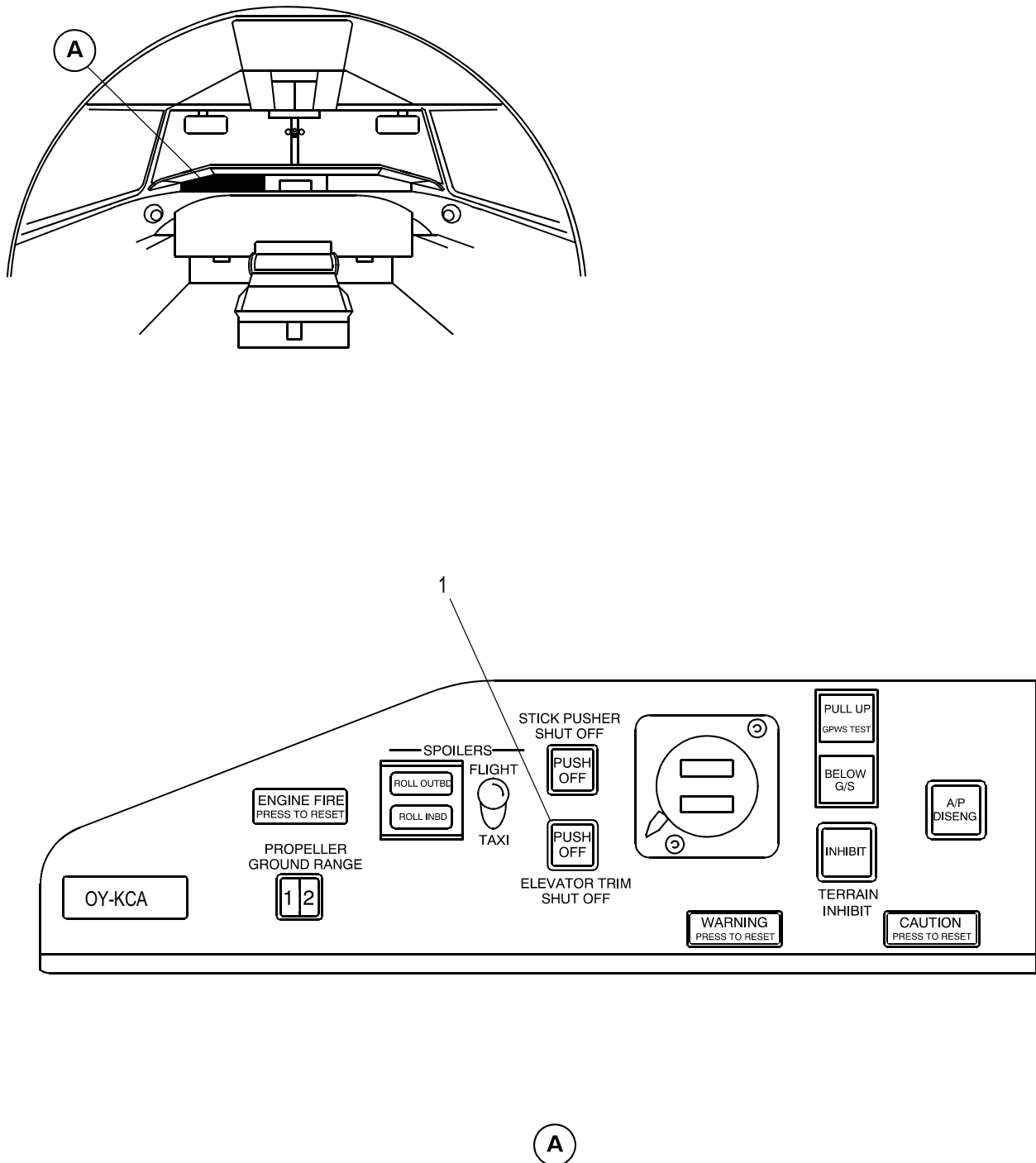


Figure 12.8-12 Elevator Trim Shut-off

GLARESHIELD PANEL CALLOUT

1. ELEVATOR TRIM SHUTOFF (alternate action)

PUSH - located on pilots and copilots glareshield

- if either ELEVATOR TRIM PUSH OFF switchlight is pushed, elevator trim is disabled (OFF selection remains illuminated)

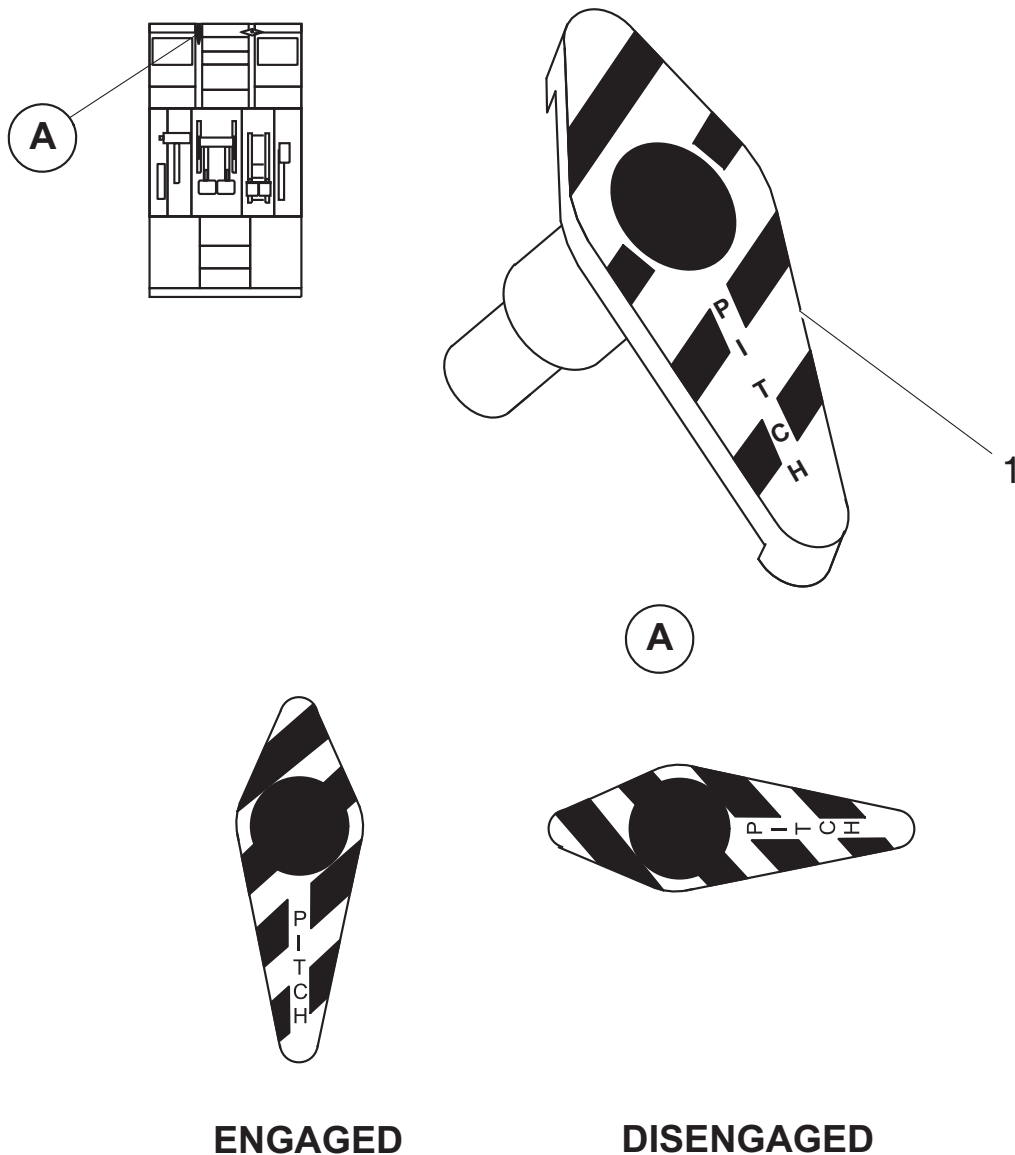


Figure 12.8-13 Pitch Disconnect Handle

PITCH DISCONNECT HANDLE CALLOUT

1. PITCH DISCONNECT HANDLE (two position, spring loaded in, rotary action out)

ENGAGED - spring loaded in, both pilots have pitch control

DISENGAGED - pulled out and turned 90° clockwise or counterclockwise, the pilot with the free control column will have pitch control

- pilot's control column operates the left elevator only
- copilot's control column operates the right elevator only

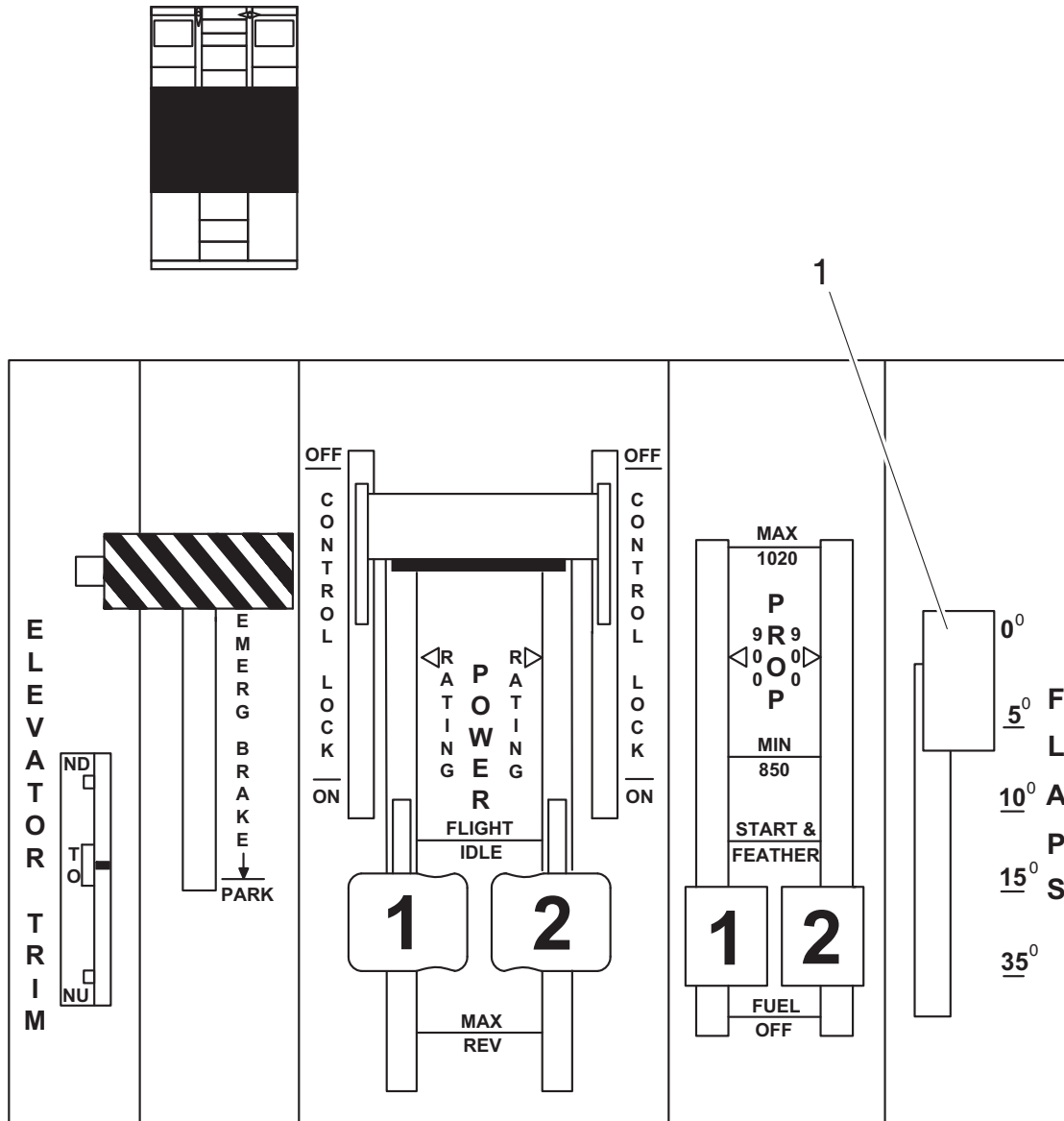


Figure 12.8-14 Flap Selector

PWR QUADRANT CALLOUTS PERTAINING TO FLT CONTROLS

1. FLAP SELECTOR LEVER (5 position)

- signals the Flap Control Unit (FCU) to move the flaps to a selected gate between 0° and 35°
- trigger under the lever must be pulled up before the FLAPS SELECTOR lever can be moved from one gate to the next
- trigger must be released and enter a new gate within 10 seconds before flap starts to move

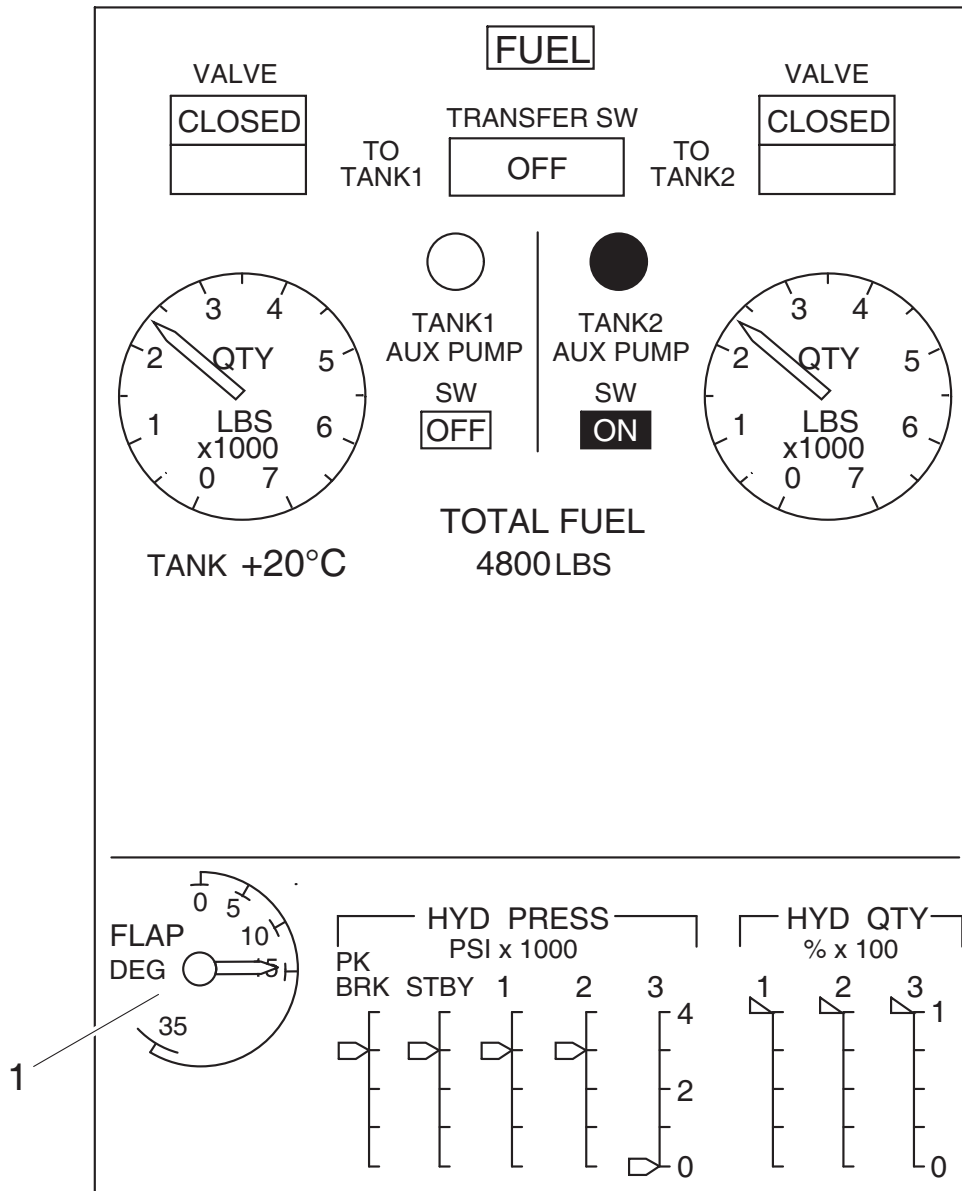
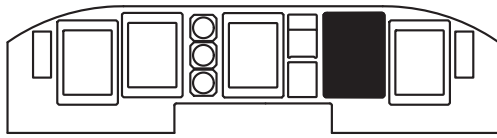


Figure 12.8-15 Flap Position Indicator

MFD CALLOUTS PERTAINING TO FLIGHT CONTROLS

1. FLAP POSITION INDICATOR

- displays current flap position

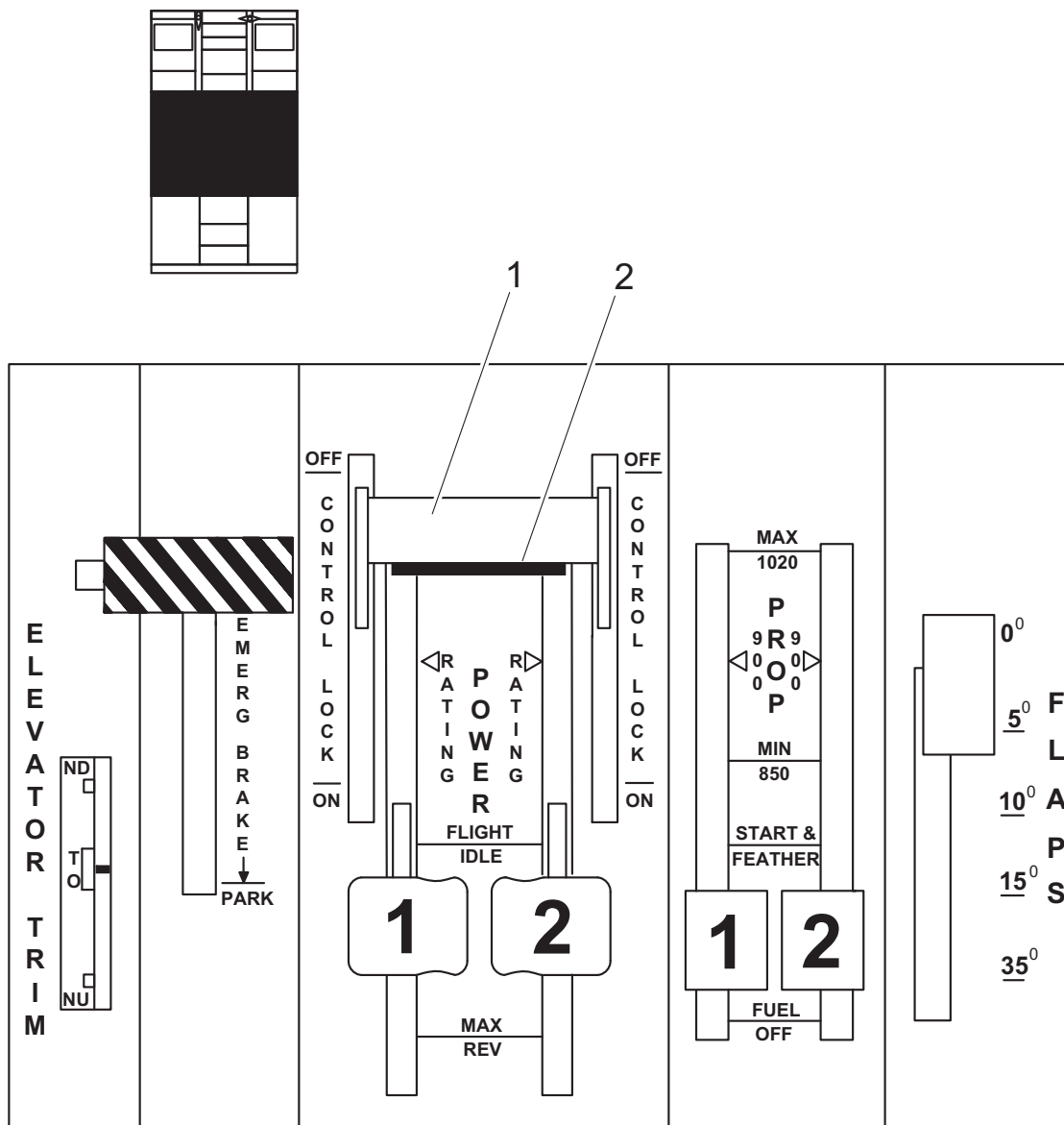


Figure 12.8-16 Aileron Gust Lock

AILERON GUST LOCK CALLOUT

- 1. AILERON CONTROL LOCK LEVER (two position, spring loaded to forward position)**
 - fore and aft movement
- 2. AILERON CONTROL LOCK LEVER TRIGGER**
 - OFF** - pull lever aft, then squeeze trigger to release. Move lever forward to OFF position
 - ON** - pull lever aft until trigger locks into place. Locks only the ailerons

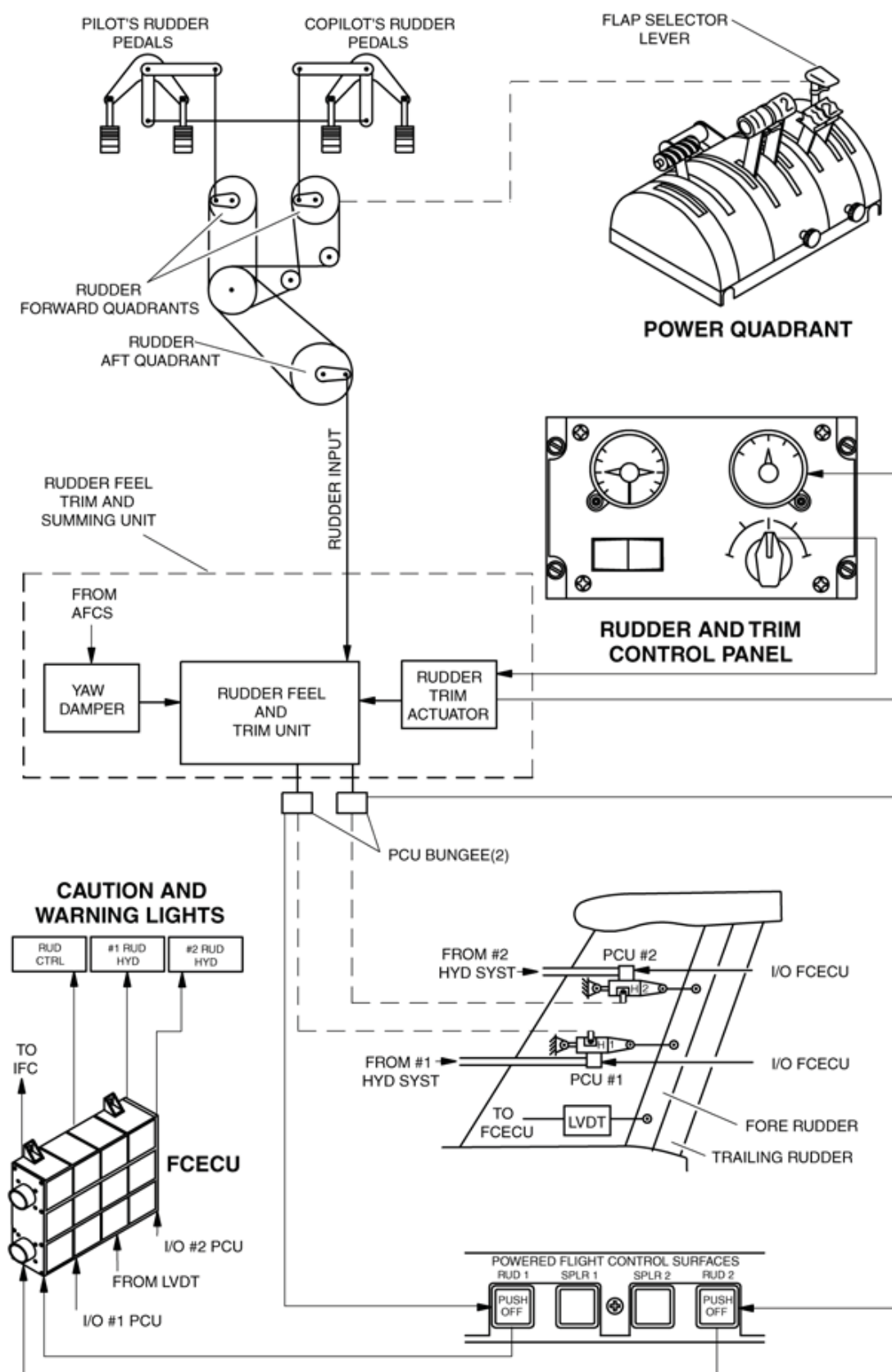


Figure 12.8-17 Rudder Schematic

12.8.4 Primary Flight Controls

12.8.4.1 Yaw Control

Yaw control is provided by a hydraulically powered rudder surface (Figure 12.8-1). The rudder is controlled through displacement of either pilot's rudder pedals. The pilot's and copilot's rudder pedals are connected to each other through an interconnect rod. A mechanical feel and trim unit, provides simulated aerodynamic forces at the rudder pedals during flight. A yaw damper operates through the feel and trim system to improve directional control. Yaw damper is always engaged when autopilot is engaged.

Rudder Control System

The rudder control system (Figure 12.8-17) provides directional control of the aeroplane. The rudder consists of two sections, the fore rudder and trailing rudder.

The fore rudder is attached to the vertical stabilizer and operated by two Power Control Units (PCUs). The PCUs are installed one above the other in the vertical stabilizer. No. 1 hydraulic system powers the lower PCU and No. 2 hydraulic system powers the upper PCU. Moving the rudder pedals operates both PCUs. If either hydraulic system fails, the remaining PCU provides rudder control.

The trailing rudder is attached to the fore rudder by push rods and deflects mechanically with movement of the fore rudder. The trailing rudder deflects twice as far as the fore rudder.

A rudder input restrictor mechanism, limits rudder pedal travel with flap selector lever operation. The flap selector lever is mechanically linked to the copilot's rudder forward quadrant. With 0° flap selected, pushing either rudder pedal to the stops, deflects the fore rudder surface 12° left or right of centre. With flaps selected to 5° or greater, pushing either rudder pedal to the stops, deflects the fore rudder 18° left or right of centre.

Hydraulic pressure supplied to both PCUs is regulated by the Flight Control Electronic Control Unit (FCECU) as airspeeds vary. Rudder authority is limited as a function of airspeed to reduce excessive yaw rate. As airspeed increases, FCECU reduces the hydraulic pressure available to the PCUs. Inputs from either pilot's rudder pedals causes less rudder deflection. The FCECU gets airspeed information from the Air Data Units (ADUs).

Rudder pedal adjustments (Figure 12.8-3) are provided for both sets of rudder pedals. A cable connecting the pilot's and copilot's brake pedals, allows for operation of the brake system from either pilot's position.

Rudder Jam

If a jam occurs in a rudder PCU, the corresponding RUD 1 or RUD 2 PUSH OFF switchlight turns on. The illuminated RUD 1 or RUD 2 switchlight must then be pushed to depressurize the affected PCU. The PUSH legend will go out and the OFF legend will remain on as a reminder that the switchlight has been pushed OFF. The #1 RUD HYD or #2 RUD HYD caution light will turn on as the PCU is de-pressurized. The FCECU will then re-schedule the regulated hydraulic pressure to the operative PCU to maintain the required rudder authority.

As directed by paragraph 4.18.12 of the AFM, only one RUD PUSH OFF switchlight shall be pushed at a time. If both RUD 1 and RUD 2 PUSH OFF switches are pressed inadvertently, the OFF legend will go out, both RUD 1 and RUD 2 PUSH legends will turn on and the previously de-pressurized PCU will be re-pressurized. This ensures the rudder control system remains powered.

Pushing the non-jammed switchlight again turns out both PUSH legends, de-pressurizes the jammed PCU and turns on the appropriate OFF legend on the jammed side. If instead the jammed side switch is pushed, the jammed side RUD PUSH OFF light will turn on while the non-jammed side will be de-pressurized and its corresponding OFF legend will turn on.

When the aircraft is parked on the ground with engines not running, one or both RUD 1 and RUD 2 PUSH OFF switches may be illuminated under conditions of strong tailwinds. This is a result of the rudder PCU bungees being compressed when the rudder is moved to one side under the influence of the wind. As soon as hydraulic pressure is available to the PCU following engine start, the rudder will center and the RUD PUSH OFF switchlights will go out.

Rudder Feel Trim And Summing Unit

The rudder feel trim and summing unit, provides artificial feed-back forces on the rudder pedals. This simulates aerodynamic forces from the rudder control surfaces during flight.

Inputs from the rudder pedals and yaw damper are applied to the summing unit. The unit sums the inputs and then transmits the resultant command as a single input to the rudder PCUs.

Rudder Trim

Rudder trim is accomplished by a RUDDER trim control knob located on the centre console. Turning the knob, operates an electrical trim (Figure 12.8-17) actuator which supplies trim signals to reposition the rudder neutral point of feel unit, and hence, Rudder System neutral. The amount of rudder trim is shown on the RUDDER trim indicator.

Turning the RUDDER trim control knob fully to the second graduation, produces a fast trim rate. When the control knob is turned left or right to the first graduation line, this produces a slower trim rate. The trimming system is electrically powered from the Left Essential bus through two circuit breakers:

- RUD TRIM ACT – F7 for the trim actuator
- RUD TRIM IND – G7 for the RUDDER trim indicator.

Rudder Trim Indication

An integral Linear Variable Differential Transformer (LVDT) monitors the trim actuator position and shows it on the RUDDER trim indicator. If the trim signal fails, the trim actuator remains functional but an off-scale deflection is shown on the RUDDER trim indicator. Rudder position can be monitored on the pilot's MFD. When the yaw damper is engaged, rudder damping is accomplished by the yaw damper, which receives input signals from the Auto Flight Control System (AFCS).

Yaw Damper

The yaw damper is an actuator that supplies automatic compensation for minor yaw acceleration during flight. It also improves directional stability and turn coordination. Yaw damper authority is 4.5° maximum of rudder deflection either side of centre. The yaw damper gets its inputs from Flight Guidance Modules No.1 and No.2 and needs both inputs for operation.

Caution Lights

#1 or #2 RUD HYD

- #1 or #2 hydraulic system - hydraulic pressure is not available, or
- The FCECU has shut down a PCU because of a malfunction, or
- The RUD 1 or RUD 2 PUSH OFF switch has been pushed.

RUD CTRL

- The FCECU unable to control rudder pressure, or
- #1 and #2 hydraulic systems have failed, or
- Airspeed #1 is not equal to Airspeed #2 $\pm$ 17 kts (IAS MISMATCH message on PFD and ELEVATOR FEEL, SPLR OUTBD, and PITCH TRIM caution lights will also turn on),
- Airspeed must be reduced to below 200 kts.

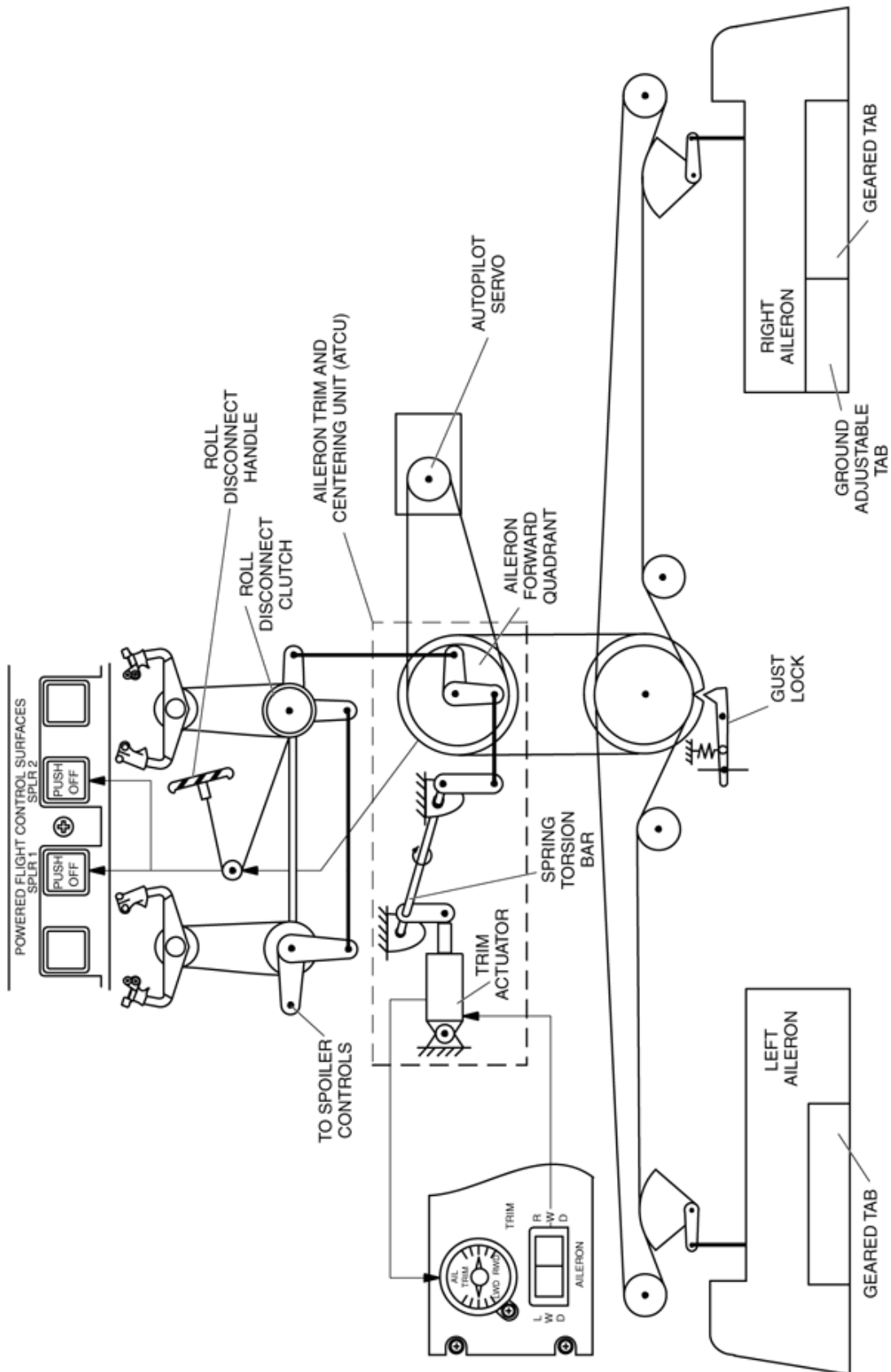


Figure 12.8-18 Aileron System Schematic

12.8.4.2 Roll Control

Roll control is provided by ailerons assisted by flight spoilers. The aileron control system (Figure 12.8-18) and flight spoiler control system are two independent systems. Both systems are mechanically interconnected to allow simultaneous operation for normal roll control. The Automatic Flight Control System (AFCS) provides input commands to the roll control system.

- Each wing has one aileron and two flight spoilers
- The pilot's wheel controls the flight spoilers
- The copilot's wheel controls the ailerons
- Ailerons are mechanically controlled and cable operated
- Flight spoilers are mechanically controlled and hydraulically powered

If a roll control jam occurs, the spoiler control system can be separated from the aileron control system. The pilot with the unjammed control hand wheel will have roll control.

Ailerons

An aileron is located on the outboard trailing edge of each wing (Figure 12.8-1). Rotating the control handwheels 70° left or right of centre, deflects the ailerons $\pm 17^\circ$ from the neutral position.

Each aileron has a geared tab. When the aileron control surfaces are deflected up or down, its geared tab moves in the opposite direction. This provides aerodynamic assistance to the pilot flying by reducing the force required to turn the control hand wheel.

A ground adjustable trim tab is installed on the right hand aileron. This tab is adjusted by maintenance personnel when required.

Aileron Trim And Centering Unit (ATCU)

The ATCU (Figure 12.8-18), provides aileron trim and automatic centering of the aileron control surfaces. The ATCU is connected to the aileron trim actuator and the aileron forward quadrant. Rotating the control hand wheel, turns the forward quadrant. When the input to the hand wheel is released, the handwheels return to the neutral position in zero trim condition.

Aileron Trim

The Aileron Trim switch controls the trim actuator and has three positions. The switch is spring-loaded and returns to the centre-off position. The ATCU transfers input commands from the aileron trim actuator to the aileron forward quadrant. The forward quadrant rotates and transfers the trim commands to both aileron control surfaces. Therefore aileron trim is accomplished by deflecting both aileron control surfaces. The neutral position of the control wheel is also repositioned. The amount is shown on the aileron trim indicator of the centre console.

The aileron trim system is electrically powered from the Left Essential bus. through circuit breakers:

- G8–AIL TRIM ACT for the aileron trim actuator
- H8–AIL TRIM IND for the aileron trim indicator.

When the autopilot is engaged and aileron trim is required, MISTRIM [TRIM L WING DN] or MISTRIM [TRIM R WING DN] is shown on the Primary Flight Display (PFD), Flight Module Annunciator (FMA) area. The autopilot must be disengaged and the control wheel turned until the trim message goes out. The pilot then sets the required aileron trim with the AILERON trim switch until the control forces are removed from the hand wheel.

Aileron Trim Runaway

If the aileron trim switch fails closed, causing the ailerons to trim uncontrolled, a limit switch shuts off the electrical power to the trim actuator causing it to stop at the maximum trim input. If the limit switch fails to stop the trim actuator, a mechanical stop on the trim actuator stops it at the maximum trim setting.

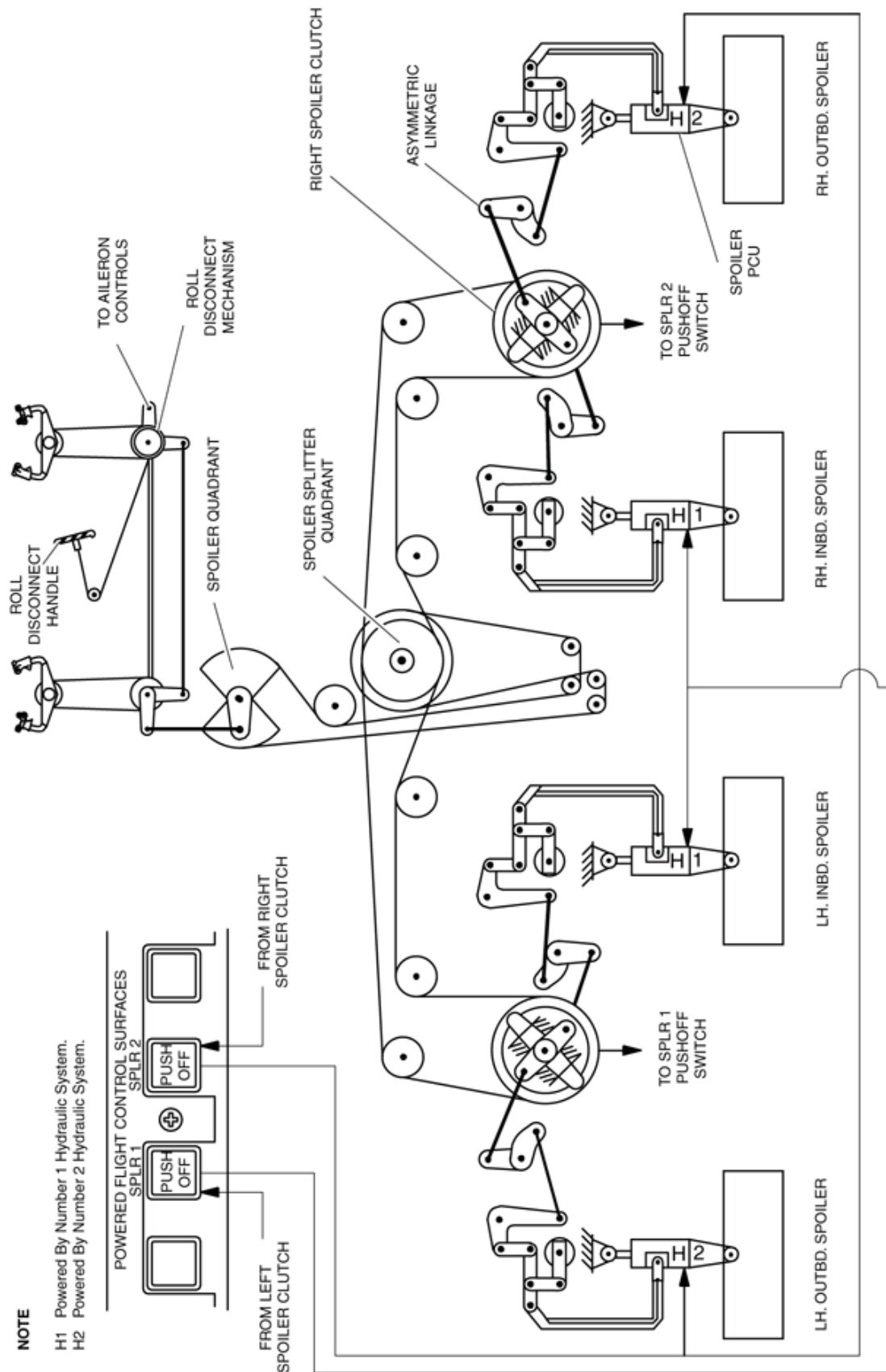


Figure 12.8-19 Roll Spoiler System Schematic

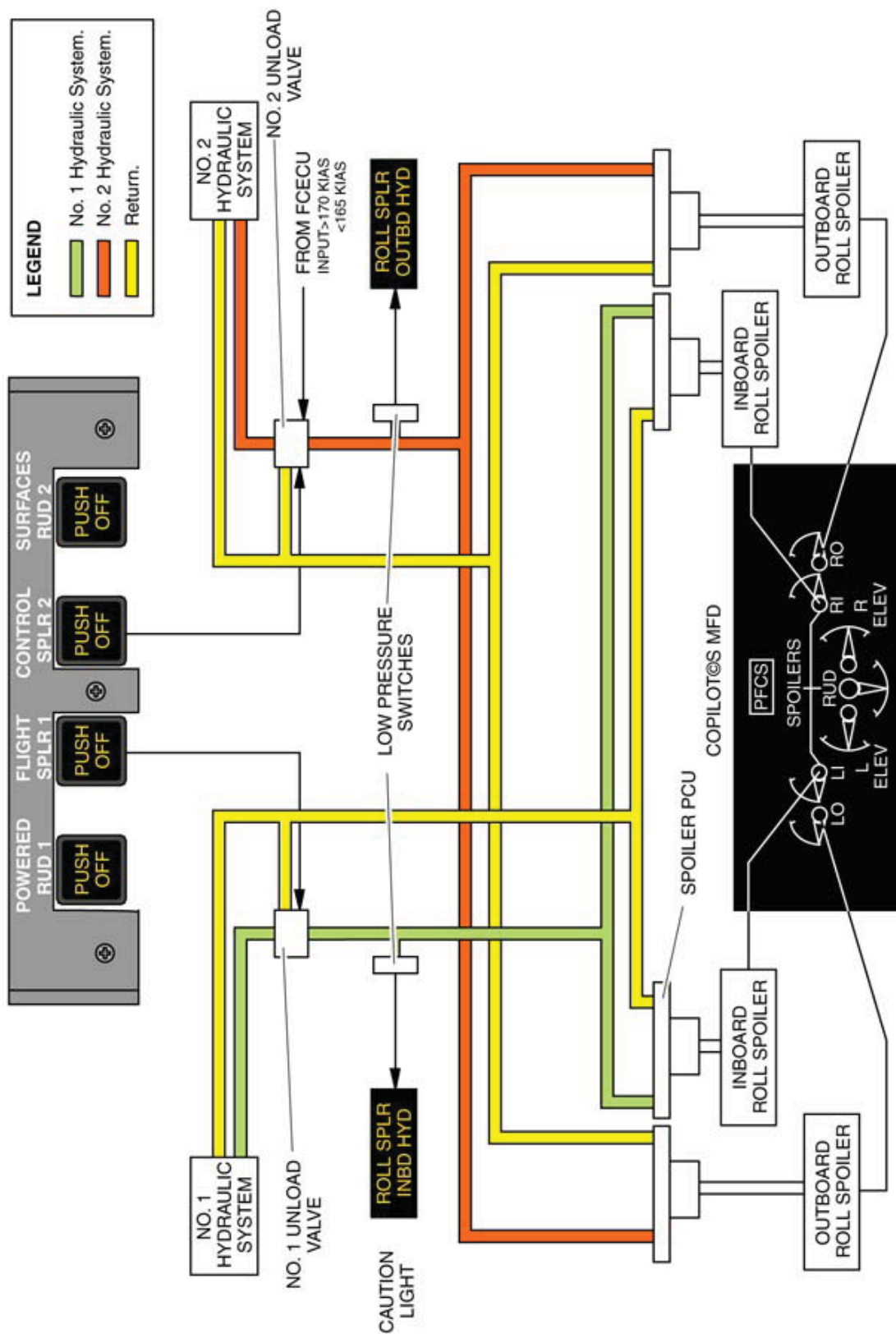
Spoiler Control

There is an inboard and outboard roll spoiler panel on each wing (Figure 12.8-19). The roll spoilers operate with the ailerons to assist roll control of the aeroplane in flight. The roll spoilers extend and retract by hydraulically powered Power Control Units (PCUs).

Pushing either SPLR1 or SPLR2 switchlight, inhibits hydraulic pressure to its related spoiler PCU extend ports and turns on the ROLL SPLR INBD HYD or ROLL SPLR OUTBD HYD caution light.

There are three modes of spoiler operation:

- Flight
- Ground
- Taxi



NOTE: Spoiler hold down pressure lines are not shown.

Figure 12.8-20 Spoiler System Schematic

Flight Mode

The spoilers operate in proportion to, the up going aileron to provide roll control. Turning either the pilot's or copilot's control wheel, operates the spoilers and ailerons at the same time. No.1 hydraulic system powers the inboard spoilers and No. 2 hydraulic system powers the outboard spoilers (Figure 12.8-20). At airspeeds greater than 170 KIAS, only the inboard spoilers operate, the Flight Control Electronic Control Unit (FCECU) disables the outboard spoilers. At decreasing airspeeds less than 165 KIAS, inboard and outboard spoilers operate.

If the outboard spoilers are not disabled above 185 KIAS or activated below 150 KIAS, the SPLR OUTBD caution light turns on.

Pushing either SPLR1 or SPLR2 switchlight, inhibits hydraulic pressure to its related spoiler PCU extend ports. This turns on the ROLL SPLR INBD HYD or ROLL SPLR OUTBD HYD caution light. The continuous hold down pressure returns the related spoilers to the down position.

Ground Mode

There are two lift-dump valves in the inboard spoiler system and two in the outboard spoiler system for ground spoiler operations. The lift-dump valves in each spoiler system, are hydraulically in series; both valves must open together before the spoilers can extend on the ground. When the lift-dump valves are energized open, hydraulic input commands are sent to the PCUs which fully extend both inboard and outboard spoilers.

The lift-dump valves are energized by signals from the FCECU and the Proximity Sensor Electronic Unit (PSEU). For the spoilers to extend on landing, the FCECU and PSEU must receive valid input signals before energizing the lift-dump valves (Figure 12.8-21).

Inboard and outboard roll spoilers extend on touchdown when:

- The FLIGHT/TAXI switch, is in the FLIGHT position.
- Power Levers No. 1 and No. 2, are positioned to less than FLIGHT IDLE +12°.
- Weight-On-Wheels (WOW) proximity on both landing gear detect the aeroplane has landed.

After the aeroplane touches down on landing, and inputs are valid, roll input commands are cancelled and the roll spoilers automatically extend. This eliminates the lift on the wings to assist in maximum braking efficiency. When inboard and outboard spoiler panels extend on touch down, the ROLL INBD and ROLL OUTBD advisory lights turn on.

If a lift-dump valve fails to energize, its inboard or outboard spoilers will not extend in ground mode. The applicable ROLL SPLR INBD GND or ROLL SPLR OUTBD GND caution light will come on after a time delay of 5 seconds.

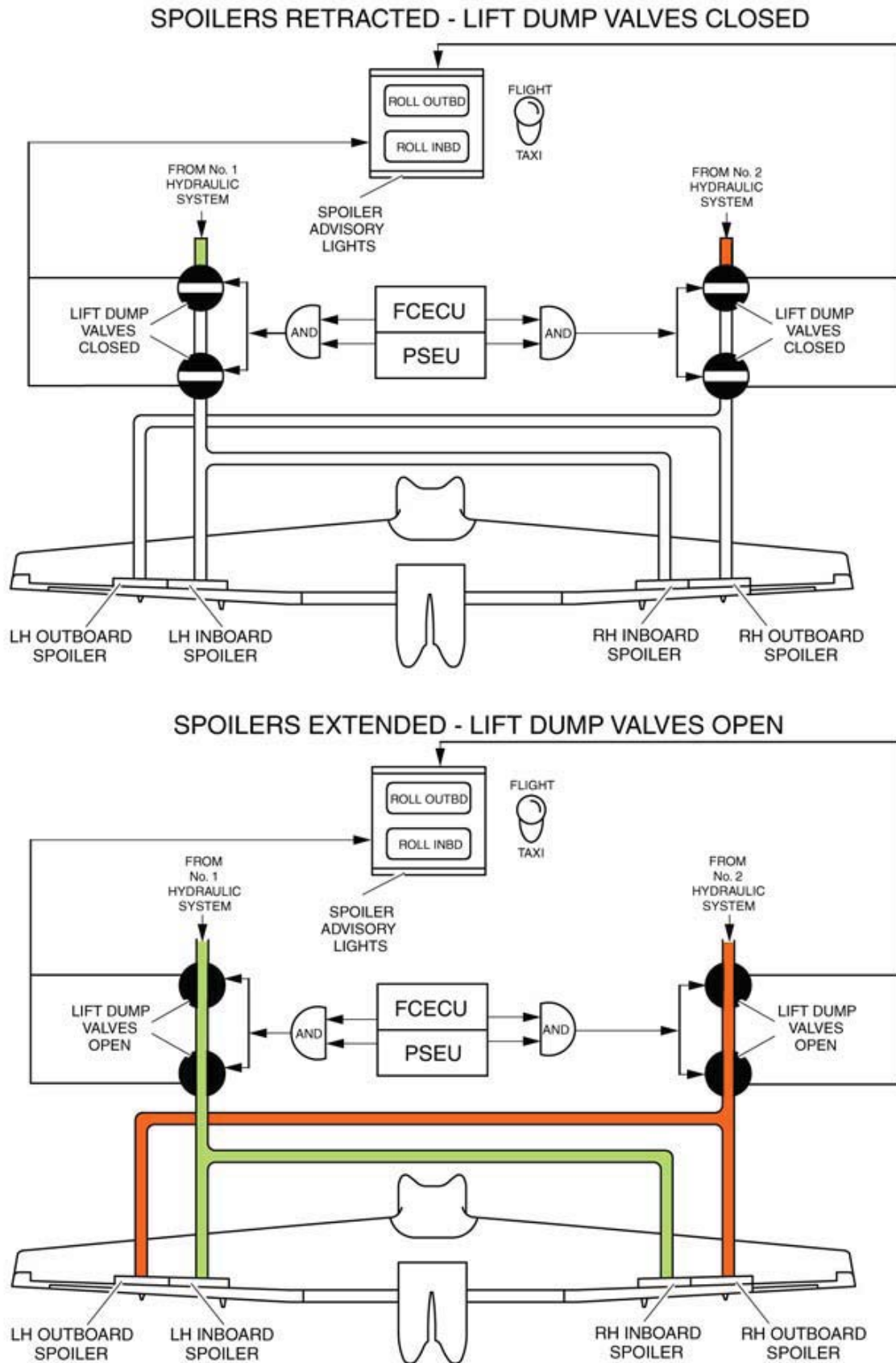


Figure 12.8-21 Roll Spoilers Ground Mode

Taxi Mode

Flight/Taxi Switch

The FLIGHT/TAXI switch (Figure 12.8-9) has two positions FLIGHT and TAXI. The switch is spring-loaded to FLIGHT position but must be manually selected to the TAXI position. It is maintained in the TAXI position by a hold-in solenoid. When Power Levers No.1 and No.2 are moved to a position greater than FLIGHT IDLE +12°, the solenoid is de-energized, and the switch moves automatically to the FLIGHT position. The FLIGHT/TAXI switch must be selected to FLIGHT position for take-off.

After the aeroplane touches down, all spoilers panels can be retracted for taxiing by selecting the FLIGHT/TAXI switch to TAXI position. However, if both power levers are advanced above Flight Idle +12°, for take-off again, the FLIGHT/TAXI switch automatically moves to FLIGHT position and all spoiler panels retract. The ROLL INBD and ROLL OUTBD advisory lights will go off. The spoiler system is also monitored by ROLL SPLR INBD GND or ROLL SPLR OUTBD GND caution lights.

ROLL SPLR INBD GND or ROLL SPLR OUTBD GND caution light will come on:

- If FCECU detects a loss of lift-dump valve function.
- If a spoiler panel fails to extend after landing.
- If a spoiler panel remains extended after the FLIGHT/TAXI switch is selected to TAXI position after touchdown.

Roll Control Jam

A roll control jam can result if a malfunction occurs in the spoilers or aileron control system. During normal operation, the ailerons and spoilers operate at the same time. The roll disconnect system is a clutch mechanism attached to the base of the copilot's control column and controlled by the ROLL DISC handle.

During flight, if a roll control jam occurs in the spoiler or aileron system, the ROLL DISC handle is pulled out to the limit and turned through 90° clockwise or counterclockwise. This disengages the clutch and isolates the jammed system from the operating system. The pilot with the unjammed wheel will have roll control and should take the appropriate action.

Left Control Wheel Free

If the left control hand wheel is free, (Figure 12.8-19) only roll spoilers will operate. Roll control forces will be low and the tendency to overcontrol should be avoided.

Right Control Wheel Free

If the right control wheel is free, only ailerons will be operational. If the control wheel is rotated more than 50° from neutral to maintain wings level, SPLR 1 and SPLR 2 switchlights (Figure 12.8-18) will come on. This may be due to one or both roll spoilers on the same side being stuck extended.

If the SPLR 1 and/or SPLR 2 switchlights remain on continuously, they must be pushed off to depressurize the PCU(s) and retract the affected spoiler(s). This will turn on the ROLL SPLR INBD HYD and/or ROLL SPLR OUTBD HYD caution lights. ROLL SPLR OUTBD HYD caution light will not turn on until speed is less than 165 kts. The OFF legend remains displayed on both switchlights to indicate they have been pushed off. Roll spoiler positions may be monitored on the pilot's Multi Function Display (MFD).

Four Linear Variable Differential Transformers (LVDT) located in the wing, feedback spoiler positions to the FCECU and to the Integrated Flight Cabinet (IFC). The IFC then displays the spoiler panel positions on the pilot's MFD.

Caution Lights

ROLL SPLR INBD GND

- FCECU detects loss of inboard spoiler lift dump functionality, or
- Inboard spoilers do not extend on touchdown, or
- Inboard spoilers extend after FLIGHT/TAXI switch has been selected to TAXI.

ROLL SPLR OUTBD GND

- FCECU detects loss of outboard spoiler lift dump functionality, or
- Outboard spoilers do not extend on touchdown, or
- Outboard spoilers extend after FLIGHT/TAXI switch has been selected to TAXI.

SPLR OUTBD

- The FCECU fails to lockout outboard spoilers when airspeed is greater than 185 KIAS, or fails to enable below 150 KIAS,
- Airspeed #1 is not equal to Airspeed #2 ± 17 kts (IAS MISMATCH message on PFD, RUD CTRL, ELEV FEEL and PITCH TRIM caution lights also turn on),
- Pressure of hydraulic system 2 is lost.

ROLL SPLR INBD HYD

- #1 hydraulic system pressure is less than 900 psi (or SPLR1 PUSH OFF switch may have been pushed).

ROLL SPLR OUTBD HYD

- #2 hydraulic system pressure is less than 900 psi, and the FCECU detects that the airspeed is less than 165 KIAS, or
- SPLR 2 PUSH OFF switch is pushed, or
- No annunciation if airspeed >170 kts.

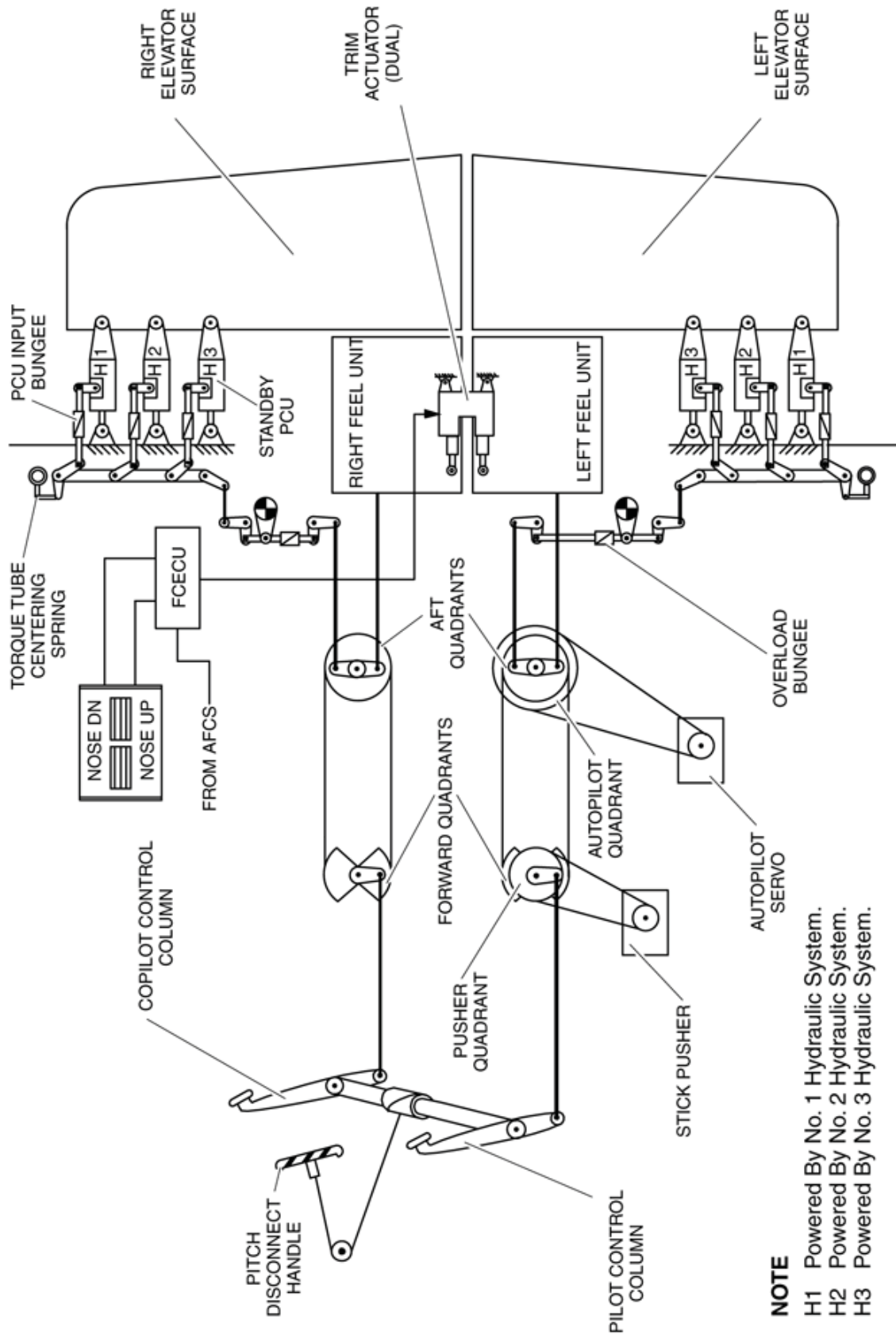


Figure 12.8-22 Elevator System Schematic

12.8.4.3 Pitch Control

Pitch Control System

Pitch control of the aeroplane is maintained by two mechanically controlled, and hydraulically powered elevators (Figure 12.8-22). The elevators are attached to the trailing edge of the left and right horizontal stabilizers. The left control column operates the left elevator and the right control column operates the right elevator. However both control columns are connected to each other by the pitch disconnect system so that they both operate together.

Fore and aft movement of the pilot's and copilot's control columns is transferred through two fully independent cable and pulley control circuits to the elevator Power Control Units (PCU).

There are three identical hydraulic PCUs (outboard, centre and inboard) on each elevator. The outboard and centre PCUs on each elevator are active at all times while the inboard PCU is a standby. The No. 1 hydraulic system supplies power to the left and right outboard PCUs. The No. 2 hydraulic system supplies power to the left and right centre PCUs. The standby No. 3 hydraulic system supplies power to the left and right inboard standby PCUs when required.

The HYD #3 ISOL VLV pushbutton on the HYDRAULIC CONTROL panel when pushed, manually activates the inboard PCUs. This will cause the ELEVATOR PRESS caution light to turn on if the No. 1 and No. 2 hydraulic systems are functioning. The #3 isolation valve will also activate automatically when No. 1 and/or No. 2 hydraulic system fails.

Pitch trim is accomplished by two pitch trim actuators. The actuators are controlled automatically by the autopilot or manually by the trim switches on the pilot's and copilot's control wheels. Elevator trim position is shown on the elevator trim indicator located on the left side of the centre console. If a mismatch occurs between the left and right elevator an ELEVATOR ASYMMETRY caution light comes on. Elevator position indication is displayed on pilot's Multi-Function Display (MFD). Gust protection for the elevators is supplied by trapped hydraulic fluid within the actuators when the system is depressurized.

Elevator Control Jam

The pilot's and copilot's control columns are mechanically connected to each other through the pitch disconnect mechanism (Figure 12.8-22). If an elevator jam occurs in either control circuit, the two control columns can be disconnected from each other by using the pitch disconnect handle located on the left side of the centre console. When the handle is in the engaged position, the pilot's and copilot's control columns are connected to each other by a clutch.

When the handle is pulled out and rotated 90° the clutch disengages and disconnects the two control columns. The pilot with the free control column will have pitch control.

Pitch Feel and Trim Unit

Artificial pitch feel is provided by two Pitch Feel and Trim Units (PFTUs), right and left (Figure 12.8-22). Pitch feel is provided by a right and left pitch feel actuator. The PFTUs are installed in the vertical stabilizer. The right PFTU controls the right elevator and the left PFTU controls the left elevator. Pitch commands from the control columns are transferred to the elevator PCUs which, move the elevator surfaces.

Centering springs in the PFTU systems, help to return the elevator control surfaces to the neutral position. Two pitch trim actuators installed on top of the PFTUs supply elevator trim.

Both pitch feel actuators operate at the same time and supply artificial forces to the control columns. As airspeed varies, the FCECU commands the pitch feel actuators to supply the correct

artificial forces to the control columns. The elevator column force increases with column displacement as a function of airspeed and normal acceleration of the aeroplane. Air Data Units (ADUs) supply airspeed information to the FCECU. Normal acceleration is supplied through ARINC 429 IFC BUS.

If one pitch feel actuator fails, the other actuator will operate normally. The FCECU detects the failed actuator and holds it at its last valid position. The FCECU will continue to provide pitch commands to the operating actuator. The ELEVATOR FEEL caution light will turn on and airspeed should be reduced to 200 KIAS.

Pitch Trim

Pitch trim is accomplished by two pitch trim actuators which extend or retract to trim the elevators. The elevator trim actuator is controlled automatically by the autopilot or manually by the trim switches on the pilot's and copilot's control handwheels.

Pitch trim signals from the trim switches or from the autopilot, are prioritized by the FCECU in the order: pilot, copilot and autopilot. The trim signal with the highest priority controls the pitch trim actuator.

The FCECU controls the elevator pitch trim rate according to the airspeed of the aeroplane. At airspeeds below 150 KIAS, the trim actuators operate in high speed mode. At airspeeds greater than 250 KIAS, the trim actuators operate in low speed mode. The FCECU adjusts the trim rate between 150 KIAS and 250 KIAS. The FCECU receives airspeed inputs from the Air Data Units (ADU).

Pitch Trim Switches

Operation

Elevator trim control is provided through the actuation of trim switches located on the outboard hand grip of each control hand wheel (Figure 12.8-10). The pitch trim switches are divided into two halves. Both halves must be operated for pitch trim commands. They are thumb-operated switches, which are spring-loaded to the centre-off from NOSE DN and NOSE UP positions.

When the switches are pushed forward to NOSE DN position, a nose-down trim is commanded and when the switches are pulled aft to NOSE UP position, a nose-up trim is commanded. If FCECU detects that manual pitch trim command persists for longer than 3 seconds, an aural warning will sound and the ELEVATOR TRIM PUSH OFF switchlight on the glareshield panel will turn on.

The aural warning will stop and the ELEVATOR TRIM PUSH OFF switchlight will cancel when the pitch trim command is removed or the switchlight is pushed. If the left or right ELEVATOR TRIM SHUTOFF switchlight is pushed, the elevator trim is deactivated.

Flap Auto Pitch Trim

During flap extension or retraction (15° to 35° only), automatic pitch trim is provided to reduce the pitch forces originating felt on the control columns. Therefore the elevators are automatically trimmed whenever the flaps are moving between 15° and 35°.

The Flap Auto Trim activates and deactivates automatically without any annunciations. Nose down pitch trim is commanded when flaps are extended, and nose up pitch trim is commanded when flaps are retracted.

Flap Auto Pitch Trim is active when:

- Flaps selected from 15° to 35°, and
- the autopilot is not engaged. and

- the airspeed is less than 180 KIAS, and
- manual pitch trim is not commanded.
- Flap Auto Trim will temporary disengage if manual pitch trim is applied.

Flap Auto Pitch Trim will automatically disengage, when:

- The aeroplane is on the ground (WOW), or
- airspeed is greater than 180 KIAS, or
- the autopilot is engaged, or
- flaps are not in transition, or
- commands are in excess of the pitch limits, or
- unspecified failures within the AFCS occur, or
- flight control system failures occur.

Elevator Trim Indicator

The elevator trim indicator (Figure 12.8-11) is located in the flight deck on left side of the centre console. The LVDTs located in the pitch trim actuators, signal the FCECU which then supplies a signal to the elevator trim indicator. The indicator displays elevator trim position as commanded by the pitch trim switches on the pilot's and copilot's handwheels or the AFCS.

The indicator is labeled NU for nose up, ND for nose down and TO for take-off. A white band next to each the TO label, shows the take-off trim range. An aural warning sounds if both power levers are advanced above FLIGHT IDLE +12°, for take-off, with the elevator trim outside the take-off range.

12.8.5 Caution Lights

Pitch Trim

- Either FCECU channel detects a loss of ability to command or control its associated Pitch Trim Actuator or
- Airspeed #1 is not equal to Airspeed #2 ± 17 kts (IAS MISMATCH message on PFD, RUD CNTRL, SPLR OUTBD and ELEV FEEL caution lights also illuminate) or
- Trim input commands disagree.

Elevator Feel

- If either FCECU channel detects loss of ability to command or control its pitch feel actuator, or
- If airspeed #1 not equal to Airspeed #2 ± 17 kts (IAS MISMATCH message on PFD RUD CNTRL, SPLR OUTBD, PITCH TRIM caution lights also illuminate), or
- Normal acceleration is invalid.

Elevator Asymmetry

- FCECU detects that the left and right elevators mismatch
- Decrease airspeed below 200 kts.

Elevator Press

- No. 1, No. 2, and No. 3 hydraulic systems are supplying pressure to the elevator PCUs.
- Decrease airspeed below 200 kts.

Elevator Trim Switch Failure

- If the ELEVATOR TRIM switch fails closed, after 3 seconds ELEVATOR TRIM SHUTOFF switchlight turns on and aural clicking is heard.
- If PITCH TRIM is held for more than 3 seconds, ELEVATOR TRIM SHUTOFF illuminates and PITCH TRIM audible sounds.
- Either ELEVATOR TRIM SHUTOFF switchlight must be pushed.

12.8.6 Secondary Flight Controls

12.8.6.1 Flaps

Two single-slotted inboard and outboard fowler flaps are attached to the trailing edge of each wing (Figure 12.8-1). The flaps are connected to screw jacks which are operated by a primary drive shaft. A Flap Power Unit (FPU) actuated by the flap selector, operates the flap drive system (Figure 12.8-23) and moves the flaps to their selected positions. The flap surfaces are electronically controlled by the FCU and operated by No.1 hydraulic operated system.

The flap quadrant provides gates at five positions corresponding to the five possible flap positions 0°, 5°, 10°, 15°; and 35°. These Flap positions are shown on the copilot's MFD FLAP indicator.

Flap Control Unit (FCU)

Flap Control Unit (FCU) monitors and controls flap movement. The FCU is responsible for turning on the FLAP POWER and FLAP DRIVE caution lights. It also turns on the Standby Hydraulic Pump and the PTU when flaps are moved out of 0° position.

Flap Selector Lever

The flap selector lever (Figure 12.8-14) moves in a quadrant with five gates at 0°, 5°, 10° 15° and 35°. A trigger located below the flap selector lever knob must be pulled up before the lever can be moved from one gate to the next, the trigger must be released in the next gate before the flaps start moving. The flap selector lever is mechanically connected to the rudder restrictor on the right rudder fore quadrant.

Flap Power Unit (FPU)

The FPU converts hydraulic power to rotary mechanical power to operate the flap actuators, raising or lowering the flaps, when selected. The No.1 hydraulic system supplies pressure to the FPU. The FPU receives flap actuation signals from the Flap Control Unit (FCU). It also sends feedback signals to let the FCU monitor flap movement.

Operation

When the flap selector lever is in the 0° position, all flaps are retracted, and the flap position indicator points to 0°. Moving the flap selector lever signals the FCU that the flap lever is in a new position. The Flap Control Unit (FCU) (Figure 12.8-23) starts the actuation when the flap lever reaches the first gate and an arming switch, located on the flap selector lever, is activated.

Movement of the flap selector lever causes the arming switch to send an enabling signal to the FCU. When the FCU receives the enabling signal, it commands the FPU to start moving the flaps to the newly selected position. When the selected flap position has been reached, the FCU stops any further flap movement. No-backs in each actuator keep the flap locked in the selected position. The electronic monitoring of the flaps minimize flap asymmetry in case of drive line failure and minimize non-selected flap movement.

Flap Drive

There are four flap actuators installed on each wing, two actuators per flap. The flap actuators move the flap surfaces to a selected position and lock the selected position against the aerodynamic forces on the flap surfaces, through bi-directional no-backs in each actuator.

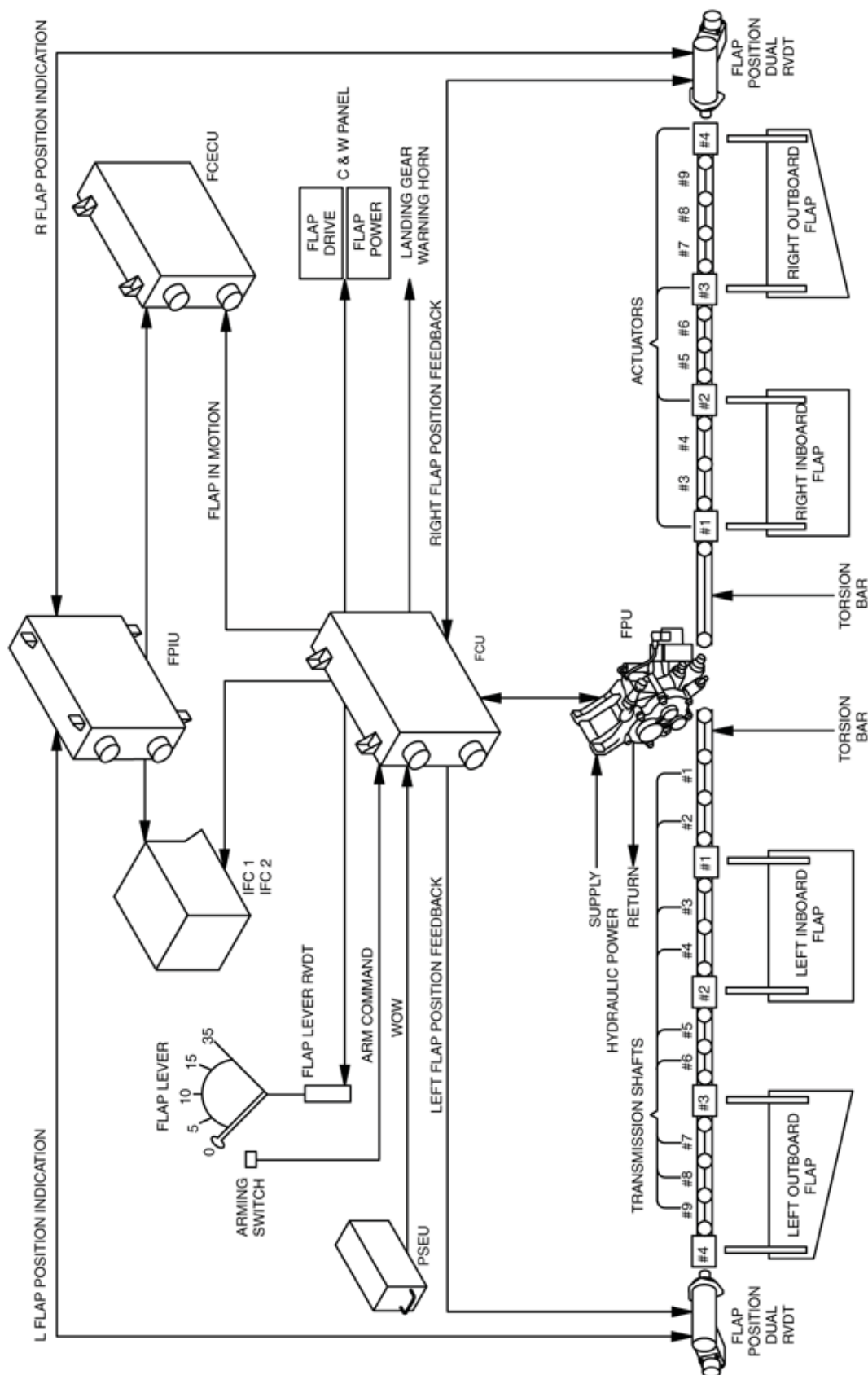


Figure 12.8-23 Flap System Schematic

Non-Normal Operation

If during flap extension or retraction a flap failure occurs, either the FLAP POWER or the FLAP DRIVE caution light will come on.

If the FLAP POWER caution light comes on a flap failure has occurred. The flaps will lock in the last position reached prior to failure. All further flap movements will be inhibited.

If the FLAP DRIVE caution light turns on this is a flap fault indication. The flaps may still be operable in some instances with reduced performance. The fault is automatically reset if the condition goes away.

Flap Position Indication Unit (FPIU)

The FPIU supplies flap position data to the flight deck and to other aeroplane systems for indication and monitoring purposes. The flap position indication system has two functions:

- Supplies indication of the current flap position to the copilot's MFD.
- Monitors flaps position during flap deployment and signals position data to the FCU, FCECU, IFC, ADU.

12.8.7 Gust Locks

Ailerons

The aileron gust lock system locks the aileron control surfaces in the neutral position when the copilot's hand wheel is in the neutral position (Figure 12.8-18). The aileron control system is a mechanically operated system. Gust protection for the ailerons is supplied by a gust lock mechanism operated by a CONTROL LOCK lever from the flight deck. The CONTROL LOCK lever is located on the power quadrant ahead of the power levers (Figure 12.8-16). It is spring loaded to the forward OFF position while a trigger under the CONTROL LOCK lever locks it in the aft ON position.

When the CONTROL LOCK lever is ON position, the ailerons lock in neutral position. The power levers will move only as far as the CONTROL LOCK lever. If a gust lock cable fails, the gust lock mechanism fails safe to the unlocked position.

To unlock the aileron gust lock, the CONTROL LOCK lever must be pulled aft and the trigger under the gust lock lever squeezed to release it. The CONTROL LOCK lever can then be moved forward to the OFF position.

Rudder and Elevators

The Rudder and the Elevator Control Systems are hydraulically powered flight control systems. Gust lock protection for these two systems is provided by retained hydraulic pressure in the flight control actuators. The retained pressure provides stiffness to the flight control surface, which resists movement from external forces.

12.8.8 Stall Protection System

The Stall Protection System (SPS) operation mode is divided into:

- Pre-flight
- In-flight

Pre-Flight Test: A stall warning test should be conducted daily. The STALL WARN toggle switch located on the pilot side console is set to the TEST1 and then to the TEST2 position to test the two Stall Protection Modules (SPM1, SPM2). The switch must be held in the appropriate position for more than 10 seconds.

In-Flight Operational Mode: The Stall Protection System (SPS) operates when the airspeed and above ground altitude are near their lower limits.

Each Stall Protection Module (SPS1, SPM2) (Figure 12.8-24) uses the following parameters to calculate when the aeroplane is near a stall condition:

- Angle of attack data
- Flap position
- Mach number
- Engine torque
- Icing status

Two Stall Protection Modules (SPM1, SPM2) are used to calculate the stick pusher operating angle. It uses the parameters that follow:

- Angle of attack
- Flap position
- Mach number
- Power lever angle
- Condition lever angle
- Icing status

The Stall Protection Modules calculate when to start and cancel the stick shakers and stick pusher operation. When the Stall Protection Modules operate their related stick shakers, a signal to the Automatic Flight Control System (AFCS) disengages the autopilot. In addition, a signal to the Ground Proximity Warning System (GWPS) prevents the PULL UP audible alerts. For the stick pusher calculations, each Stall Protection Module (SPM1, SPM2) uses the average of the two Angle Of Attack (AOA1, AOA2) inputs.

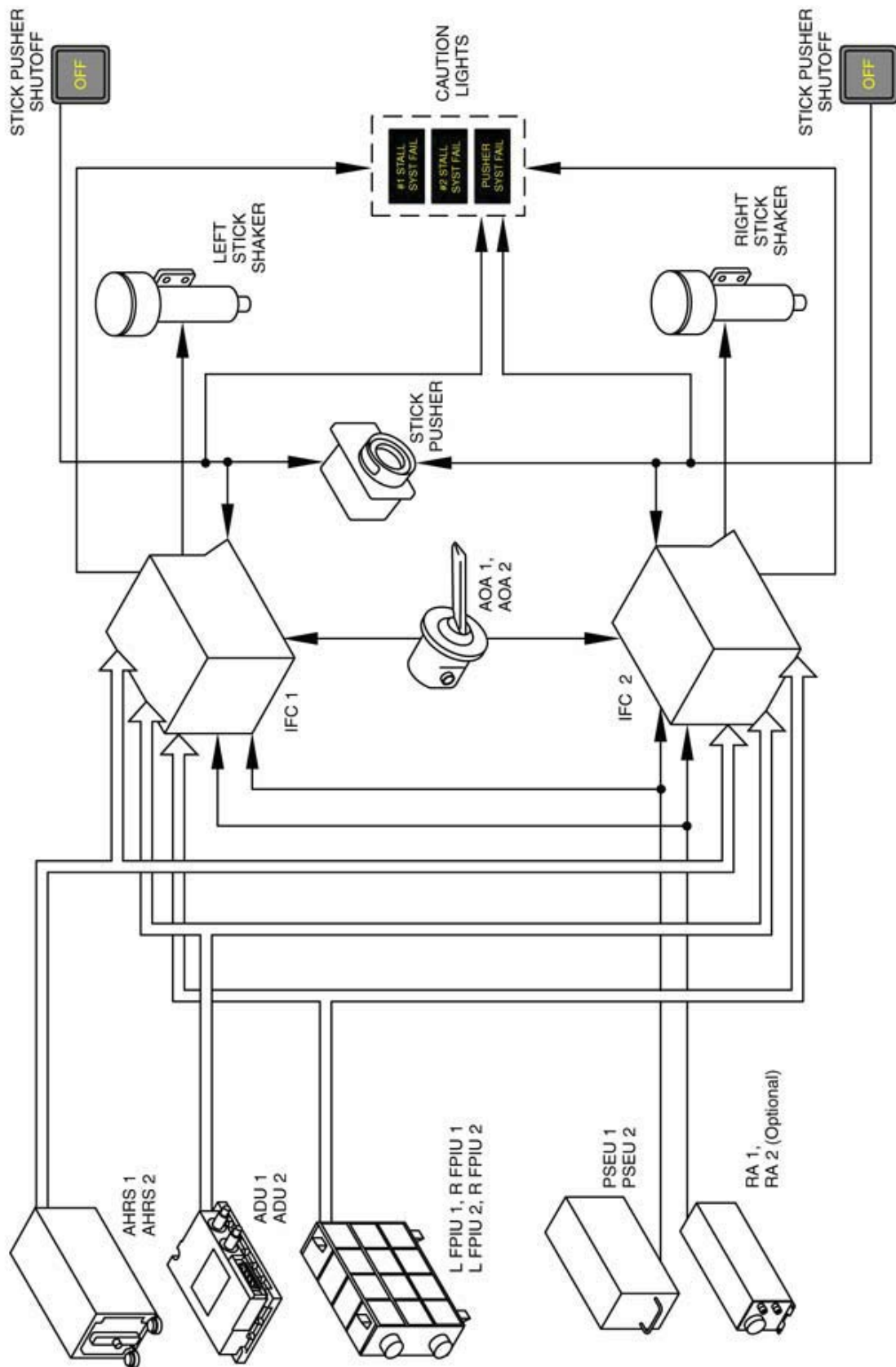


Figure 12.8-24 Stall Warning / Stick Pusher Schematic

The stick pusher will not operate if:

- SPM self-monitoring is not valid.
- Pre-flight test failure detected affecting the stick pusher. Includes WOW input discrepancy and RA inhibit failures as well as stick pusher interface failures.
- Pre-flight test failure detected affecting stall warning. Includes caution light failures as well as stick shaker failures.
- Failure of one AOA vane. Includes range check, trigonometry check, excitation failure, and AOA vane heater failure in flight.
- AOA discrepancy detected.
- Failure of both AOA vanes. Includes range check, trigonometry check, excitation failure, and AOA vane heater failure in flight.
- Failure of one stick shaker.
- Failure of both stick shakers, or one stick shaker and the opposite SPM.
- Stick pusher failed. Includes failures detected by the stick pusher actuator (FAIL signal), discrepancy between push command and command feedback, and discrepancy between push command and stick pusher actuator PUSH feedback signal.
- Stick pusher manually inhibited by shut off (release) switch.
- Stick pusher inhibited by AOA synthetic monitoring.
- Failure of both flap position inputs.
- Failure of both mach inputs.
- Propeller de-icing discrete discrepancy between SPMs (post modsum 4Q126089, reference speeds switch).
- Failure of both engine torque inputs.
- Both shakers not commanded or aeroplane not in flight for >50 m secs and pusher criteria met.

If an AOA transducer is not being heated, the Stall Protection Modules will not use its input.

The stall firing angle of the stick shaker and stick pusher is set to a relatively lower angle of attack when in icing conditions. When the INCR speeds selector is turned INCR, the Stall Protection System (SPS) changes its calculations because of the reduced performance limits of the aeroplane. The Engine Display (ED) of the Electronic Instrument System (EIS) shows an INCR REF SPEEDS message.

The stick pusher operates when the conditions that follow are correct:

- Calibrated airspeed is less than 215 knots
- Above Ground Level (AGL) altitude is more than 200 feet
- Stick pusher SHUT OFF annunciator switch is not pushed to the OFF position

When the aeroplane is near a stall condition, the stall protection system stick shakers causes the control columns to vibrate. In addition to this tactile warning, the stick shaker motor and the rattling of the mechanism on the control column creates a loud noise.

When one stick shaker is operating, its vibration is transmitted through the torque tubes and the push/pull rod to the other control column.

The stick pusher will move the control columns to decrease the angle of attack of the aeroplane when the aeroplane is in a stall condition. The pilots can override the stick pusher clutch by applying an opposite breakout 36 kilogram-force (kgf) (80 lbf) to the control column. After breakout, a 30 kilograms-force (kgf) (66 lbf) is needed to continue to override the clutch.

The stick pusher OFF switchlight can also be pushed to turn off the stick pusher.

If one stick pusher SHUT OFF switchlight or the other is pushed and latched, the OFF caption will illuminate on both annunciator switchlights. The stick pusher actuator will be shut off.

When both switchlights are deselected again, pusher is released and the OFF captions in the two switchlights extinguish.

Malfunctions of the Stall Protection System (SPS) are shown with caution lights.

The stall protection system malfunctions are shown with the caution lights that follow:

- #1 STALL SYST FAIL
- #2 STALL SYST FAIL
- PUSHER SYST FAIL

The #1 STALL SYST FAIL and #2 STALL SYST FAIL caution lights come on immediately in flight when malfunctions that prevent stick shaker and stick pusher operation are sensed.

Malfunctions of non-critical parameters, or stick shaker motors malfunction, are not shown in flight. The #1 STALL SYST FAIL or #2 STALL SYST FAIL caution light will come on 30 seconds after the aeroplane has landed.

Any of the conditions that follow will cause the PUSHER SYST FAIL caution light to come on:

- SPM self-monitoring is not valid.
- Pre-flight test failure detected affecting the stick pusher. Includes WOW input discrepancy and RA inhibit failures as well as stick pusher interface failures.
- Pre-flight test failure detected affecting stall warning. Includes caution light failures as well as stick shaker failures.
- Failure of one AOA vane. Includes range check, trigonometry check, excitation failure, and AOA vane heater failure in flight.
- AOA discrepancy detected.
- Failure of both AOA vanes. Includes range check, trigonometry check, excitation failure, and AOA vane heater failure in flight.
- Failure of one stick shaker.
- Failure of both stick shakers, or one stick shaker and the opposite SPM.
- Stick pusher failed. Includes failures detected by the stick pusher actuator (FAIL signal), discrepancy between push command and command feedback, and discrepancy between push command and stick pusher actuator PUSH feedback signal.
- Stick pusher manually inhibited by shut off (release) switch.
- Stick pusher inhibited by AOA synthetic monitoring.
- Failure of both flap position inputs.
- Failure of both mach inputs.
- Propeller de-icing discrete discrepancy between SPMs.
- Failure of both engine torque inputs.
- Both shakers not commanded or aeroplane not in flight for >50 m secs and pusher criteria met.

The PUSHER SYST FAIL caution light comes on when a stick pusher SHUT OFF switchlight selection is made. The PUSHER SYST FAIL light will go out when the two stick pusher SHUT OFF switchlights are not set and no malfunctions exist.

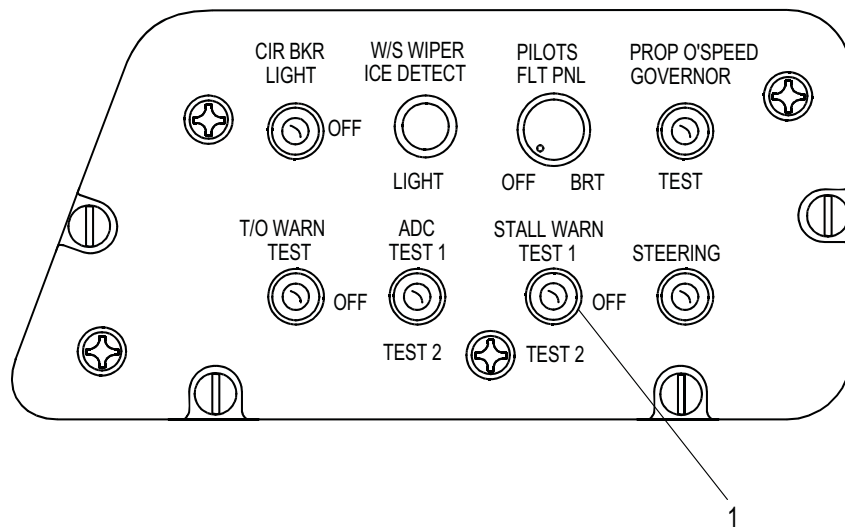
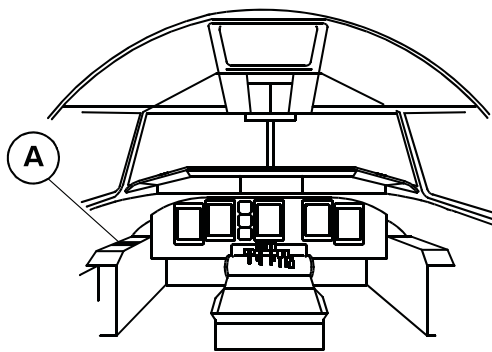


Figure 12.8-25 Stall Warning Test Switch

STALL WARNING CALLOUTS

1. STALL WARNING TEST SWITCH

(three position momentary test spring loaded to centre OFF)

Stall Warning Test..... Test 1 and Release

Observe:

- Stick Shaker Activates.
- # 1 STALL SYST FAIL and PUSHER SYST FAIL Caution lights illuminate (approx 8 sec).
- # 1 STALL SYST FAIL and PUSHER SYST FAIL Caution lights out and stick shaker off.
- Repeat with Stall Warning test switch at TEST 2.