1. GENERAL.

Primary flight controls in roll is conventional mechanical systems. Pitch and yaw control is a "fly–by–wire" system with hydraulic servos.

A one–piece flap is mounted on each wing. Each flap is driven by an hydraulic actuator.

Roll trim is performed by tabs on ailerons. Pitch trim is performed by changing elevator neutral position. Yaw trim is accomplished by a pedal force cam unit which biases the neutral setting of the pedals commanding a rudder deflection.

2. MAIN COMPONENTS AND SUBSYSTEMS.

2. 1. Elevators.

The elevators are servo operated.

Left and Right control columns are mechanically interconnected via a disconnect unit. Apart from the interconnect, Left and Right sides are independent.

To create forces in the elevator system a break–out and stick force unit is installed. The break–out function gives a slight resist force when moving the control column out of trimmed position. Trimmed position is always the same control column position (neutral position).

A control column command is sensed by the dual Linear Voltage Differential Transformers (LVDT's) which in turn send analog signals to the Powered Elevator Control Units (PECU's) which via control logic and the two mode valves control the dual elevator servos. For redundancy each PECU consists of two Servo Actuator Channels (SAC's).

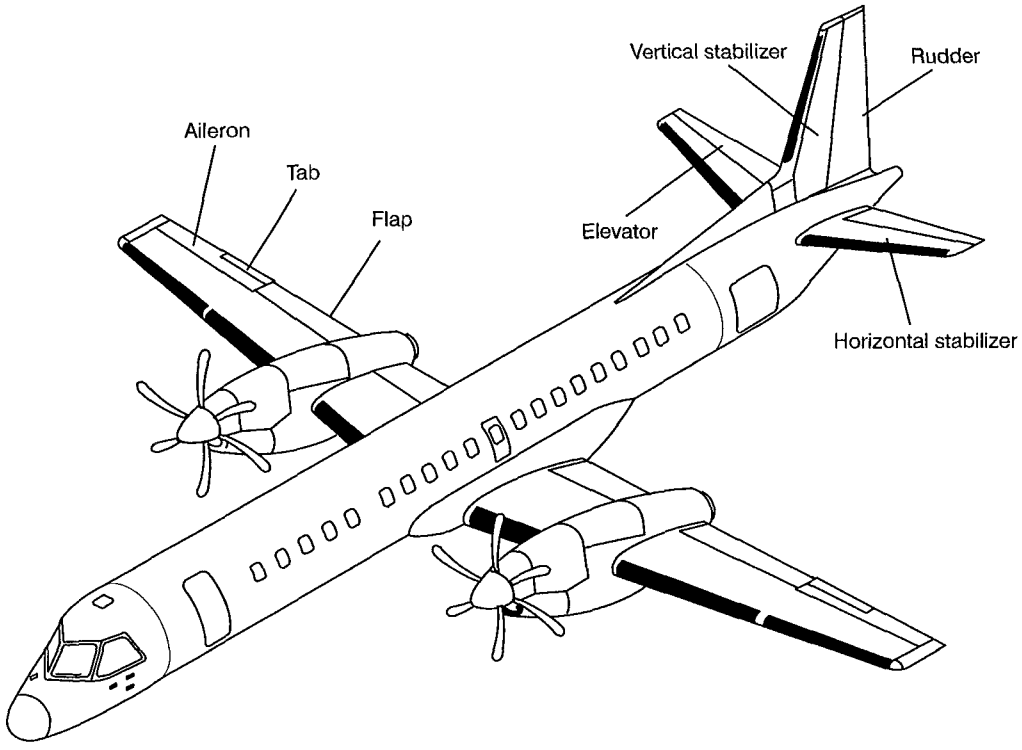


FIG.1. Flight control surfaces.

The PECU modifies the analog signals from the control column with digital stability augmentation input for the following functions:

- Stick–to–Elevator Gearing vs KIAS (higher stickforce with higher speed and lower force with lower speed).
- Electronic speed stability "DOWNSPRING" (elevator down command for a speed decrease and elevator up command for a speed increase to restore trimmed condition).
- Electronic "BOBWEIGHT" (increased stickforce with increased g–load).
- Trimrate vs KIAS (slower trim rate at higher speed and higher trim rate at lower speed).
- Flap movement trim bias (there is no stick force or change in stick position for flap extension/retraction).

At power–up the elevator system goes through a Preflight Built In Test (PBIT) to verify proper function. Part of the test is an end–to–end deflection of the elevators to confirm correct travel. Left and Right PBIT is totally independent and elevator deflection may not be synchrone during test. The control columns do not move during PBIT. The PBIT takes 35 sec and once phased there is a Continuous Built In Test (CBIT) function monitoring the system. The first part of the PBIT is a test of the internal logic which typically results in the Elevator test being completed when the end–to–end travel part of the elevator PBIT starts. If only one engine is shut down during a short turnaround, the elevator system stays active, however, after restarting the engine a new PBIT is performed (both GEN on line).

L and/or R ELEVATOR TEST ON status message will illuminate during PBIT as a verification of the ongoing test.

PBIT requires the following:

- Weight on wheel
- L and R GEN on line
- Indicated speed (KIAS) below 40 kt
  - ° If indicated speed exceeds 40 kt the system goes direct into CBIT
  - ° If for any reason the engines are started and the GENs on line with GPU connected, the PBIT for Left system will not start until the GPU is disconnected. If not disconnected within 1 minutes, L ELEVATOR TEST Master Caution will come on.
  - ° If for any reason the PBIT is not started at power up, L or R ELEVATOR TEST Master Caution comes on. A manual restart of the PBIT can be performed with the test switch. If the PBIT starts, the Master Caution goes out.
  - ° If for any reason L and/or R engine driven GEN has dropped off line or been turned off and thereafter been reset on line, a new ELEVATOR PBIT is activated on affected side, if aircraft is on ground. In flight this test is inhibited. After landing when IAS decreases below 40 kt, L and/or R ELEVATOR TEST master caution will be generated as a result of an inhibited test. A PBIT will not take place. This master caution is latched but can be removed by doing a new PBIT.

If CBIT is not active within 2 minutes after Prop RPM on both engines exceeds 750 and weight is on wheel, L and R ELEVATOR TEST Master Caution come on.

Should one side's control column become jammed the other side's Column can control the aircraft by applying excessive force to the control column and then disconnecting the two by pulling the PITCH disconnect handle in the cockpit; this separates the two columns permanently. If the handle is not pulled, the disconnect function is automatically reset when the excessive control force is no longer applied. If the handle has been pulled, disconnection is permanent and the system can only be reset on the ground.

When the control columns are disconnected the left pilot has control of the left elevator and the right pilot of the right elevator. The pilot whose elevator channel is free maintains sufficient control of the aircraft. The MAIN PITCH trim still works on both elevator surfaces.

If elevator split exceeds a triggering limit (speed dependant) ELEVATOR SPLIT MASTER WARNING will be generated.

If the left control column is jammed, no stick pusher movement is available; see chapter 17/5.

Should the extreme improbability of a total failure of the PECS system occur, there is an Emergency Pitch Trim System (EPTS) that enables control of the aircraft. The EPTS is designed for a continued safe flight to give time to reset the basic system. The elevator has a natural free floating tendency resulting in a nose down command should the PECS system fail. The automatic function of the EPTS locks the elevator in present position. After activating the system by setting the ELEVATOR EMER TRIM switch to ACTIVE position the elevator can be moved by trimming via the normal pitch trim switch on the control wheel.

The EPTS only work on an elevator control surface after both SACs in one PECU sense a failure. EPTS shall only be used in case of a total PECS failure (L+R ELEVATOR INOP).

The autopilot elevator servo drive is mechanically connected to the right control column, see chapter 3.

The elevator control system has the following modes of operation:

– Normal:
  - Both PECUs with the four SACs and all four servos are active.

– Degraded:
  - Reduction in redundancy down to the level of one SAC controlling one servo in active mode, remaining servos in damped mode. The side with no servo active is controlled by the EPTS.

– EPTS mode (L+R ELEVATOR INOP):
  - All SACs and servos inoperative. Aircraft controlled by the EPTS. The mode is a temporary mode to control aircraft until normal system function is restored.

– Fully damped mode:
  - Gustlock mode. Unpowered aircraft. Damping function to avoid gust damage.

Elevator and control column position is indicated on EICAS synoptic page.

2. 2. Rudder.

The rudder is servo operated.

Each pair of rudder pedals is mechanically interconnected and Left and Right pilot pedals in turn interconnected via a disconnect unit.

To create forces in the rudder system a pedal force cam unit and a damper is installed.

A rudder pedal command is sensed by the Linear Voltage Differential Transformers (LVDT) which in turn send analog signals to the Rudder Control Units (RCU) which via control logic and the two mode valves control the rudder servos. Rudder deflection is limited as a function of speed by a logic in the RCUs.

At power–up of the system the Rudder system goes trough a Preflight Built In Test (PBIT) to verify proper function. Part of the test is an end–to–end deflection of the rudder to confirm correct travel. The rudder pedals do not move during PBIT. The PBIT takes 20 sec and once phased there is a Continuously Built In Test (CBIT) function monitoring the system. The first part of the PBIT is a test of the internal logic followed by the rudder travel test. RUDDER TEST ON status message will illuminate during PBIT as a verification of the ongoing test.

NOTE
With modified Rudder Control Units (RCU P/N 7U7750–3) the PBIT will take approximately 25 to 60 seconds. If the PBIT takes more than 40 s (which is the test time window in EICAS) RUDDER TEST FAULT caution will come on. The caution will be extinguished when the PBIT is successfully passed. If the caution remains on after 60 s a rudder test fault has occurred.

PBIT requires the following to be initiated:

– Weight on wheel

– L and R GEN on line

– Indicated speed (KIAS) below 40 kt.

  - If indicated speed exceeds 40 kt the system goes direct into CBIT.
  - If for any reason the PBIT is not started at power–up, RUDDER TEST FAULT Master Caution comes on. A manual restart of the PBIT can be performed with the test switch. If the PBIT starts, the Master Caution goes away. If CBIT is not active within 2 minutes after Prop RPM on both engines exceeds 750 and weight is on wheel RUDDER TEST FAULT Master Caution is activated.

Should one side's pedals become jammed the other side's pedals can control the rudder after pulling the yaw disconnect handle. When the handle has been pulled, disconnection is permanent and the system can only be reset on the ground. After disconnection half rudder authority is available.

– If left pedals are jammed there are still artificial forces but undamped in the right pedals after disconnection.

– If right pedals are jammed there are no artificial forces, only the damper in the left pedals after disconnection.

The yaw damper and the autopilot are part of the logic in the RCUs.

The rudder control system has three modes of operation:

– Normal:
  - Both RCUs and both servos active.

– Degraded:
  - One RCU controlling both servos in active mode.
  - Two RCUs controlling one servo in active mode and one in damped mode.
  - One RCU controlling one servo in active mode and one in damped mode.

– Fully damped (same as gust lock):
  - No RCU active and both servos in damped mode.

Rudder and pedal position is indicated on EICAS synoptic page.

2. 3. Ailerons.

The left and right aileron control channels are mechanically interconnected.

Applicable to a/c <u>without</u> mod 5791 (Aileron Variable Gearing Vortex Generators).

To reduce roll control forces at large flap settings there is a flap–controlled aileron variable gearing. The gearing starts changing from a flap angle of 27 degrees to give equal wheel forces at Flaps 35 and Flaps 20.

Applicable to a/c <u>with</u> mod 5791 (Aileron Variable Gearing Vortex Generators).

To increase aileron effectiveness at low speeds, vortex generators (VGs) are installed on the upper and lower surfaces of the aileron leading edge. To reduce roll forces for flaps 20 and 35 a variable gearing is installed. The variable gearing starts at 17 degrees flaps.

Applicable to all aircraft.

A centering spring unit is installed in each control system.

The autopilot aileron servo drive is mechanically linked to the right aileron channel.

Should one of the control channels become jammed, the other channel can be controlled by applying excessive force to the control wheel, or disconnected by

pulling the roll disconnect handle in the cockpit which separates the two channels from each other. If the handle is not pulled, the disconnect function is automatically reset when the excessive control force is no longer applied. If the handle has been pulled, disconnection is permanent and the system can only be reset on the ground.

When the control channels are disconnected the left pilot has control of the left aileron and right pilot of the right aileron; the pilot whose aileron channel is free maintains sufficient control of the aircraft.

A torsion spring is mounted on each aileron in order to limit up–float of the aileron if an open failure should occur.

Aileron position is indicated on EICAS synoptic page.

2. 4. Flaps.

There is a single, slotted flap on each wing. The flaps are mechanically interconnected and are operated by hydraulic power and controlled with a handle on the center pedestal.

To prevent flap damage due to excessive air loads, a blow–back protection is incorporated in the hydraulic system.

A flap interconnect unit prevents excessive flaps split.

Flap position is indicated on both primary and secondary EICAS.

Automatic Flap Retraction system (AFR) Mod No 5786.

The purpose with the AFR system is to reduce the landing distance at single engine landings. With the AFR system the flaps will automatically retract to flaps 15 with double retraction rate compared with normal flap retraction, provided that the following conditions are met:

– Flap handle at 20 or 35 position.

– Actual flaps position at 20 or 35.

– Landing gear down and locked.

– Wheel speed both inboard and outboard more than 25 kts.

After AFR activation a blue "A" will be indicated before the flap position indication figure on PED page. The flap handle will remain in its pre–set position (20 or 35).

The system is reset by moving the flap handle to flaps 15 position, thereafter the handle can be moved to a higher or lower value and the flaps will follow. The system is also reset at electrical power down.

2. 5. Gust lock.

The gust lock is controlled with a handle on the center pedestal in the cockpit. The system locks the ailerons, control wheel and control column mechanically.

The rudder and elevators are prevented from gust damage by the hydraulic system being in damped mode when not active.

With the gust lock engaged, power lever movement is limited to prevent the aircraft from taking off with the controls locked.

Should any disconnection occur in the gust lock control link system, the system fails in the disengaged position.

2. 6. Trim systems.

Main roll trim is accomplished by operating the ROLL trim switches to actuate the left aileron trim tab.

Standby roll trim is accomplished by operating the STBY ROLL trim switches to actuate the right aileron trim tab.

Yaw trim is accomplished by operating the YAW trim switches to command the yaw trim actuator which in turn controls the Pedal Force Cam Unit. The Pedal Force Cam Unit biases the neutral setting of the pedals. The pedal movement is sensed by the LVDTs which will trim the rudder trough the RCUs.

All these switches are located in the trim panel on the center pedestal in the cockpit.

MAIN PITCH trim is accomplished by operating the trim switches on either control wheel. With MAIN PITCH trim both elevator surfaces are used for trimming. Because of the flap movement trim bias it is a must to set takeoff trim at correct takeoff flap setting. Changing flap setting after setting trim results in wrong trim setting.

In case of malfunction in the main pitch trim system, standby pitch trim is accomplished by operating the STBY PITCH trim switches on the center pedestal. With the STBY PITCH trim, only right elevator is used for trimming. If Left and Right elevator control surface split exceeds approximately 3 degrees, ELEVATOR SPLIT Master Caution is generated. The STBY PITCH trim shall only be used in case of failure in the normal trim system.

All trim switches are dual switches to prevent runaway trim, and must be operated together.

A common trim position indicator is located on both primary and secondary .

2.7. Yaw Damper and rudder autotrim (for detailed information see chapter 3 Autoflight).

The aircraft is equipped with a full envelope Yaw Damper and yaw autotrim controlled by the YD lever on the Autopilot control panel. The autotrim is an augmentation system to increase comfort and reduce pilot workload.

The autotrim function is deactivated on ground (weight on wheel), and if rudder pedal deflection exceeds 5 degrees from trimmed position, to allow decrabbing during crosswind landings. Once deactivated, the deflection must be brought back to within 3 degrees of trimmed position to be reactivated. The trimrate from the autotrim system is 75% of the trimrate from manual trimming, and is thus not fully capable of compensating for asymmetric thrust at low airspeed. Neither is it intended nor certified to handle yaw control following an engine failure at low speed.

Max autotrim authority is 80% of rudder pedal authority at speed below 128 KIAS. At speed above 128 KIAS the rudder limiter starts to restrict rudder authority so at higher speed autotrim and pedal authority will gradually be the same.

The Yaw Damper is a series Yaw Damper which means it works around commanded rudder position and is not fed back to the rudder pedals. At large rudder commands (rudder pedal deflection more than 15 degrees from trimmed position) the YD disconnects. Once disconnected, the deflection must be brought back to within 12 degrees of trimmed position to be reconnected.

3. CONTROLS AND INDICATORS.

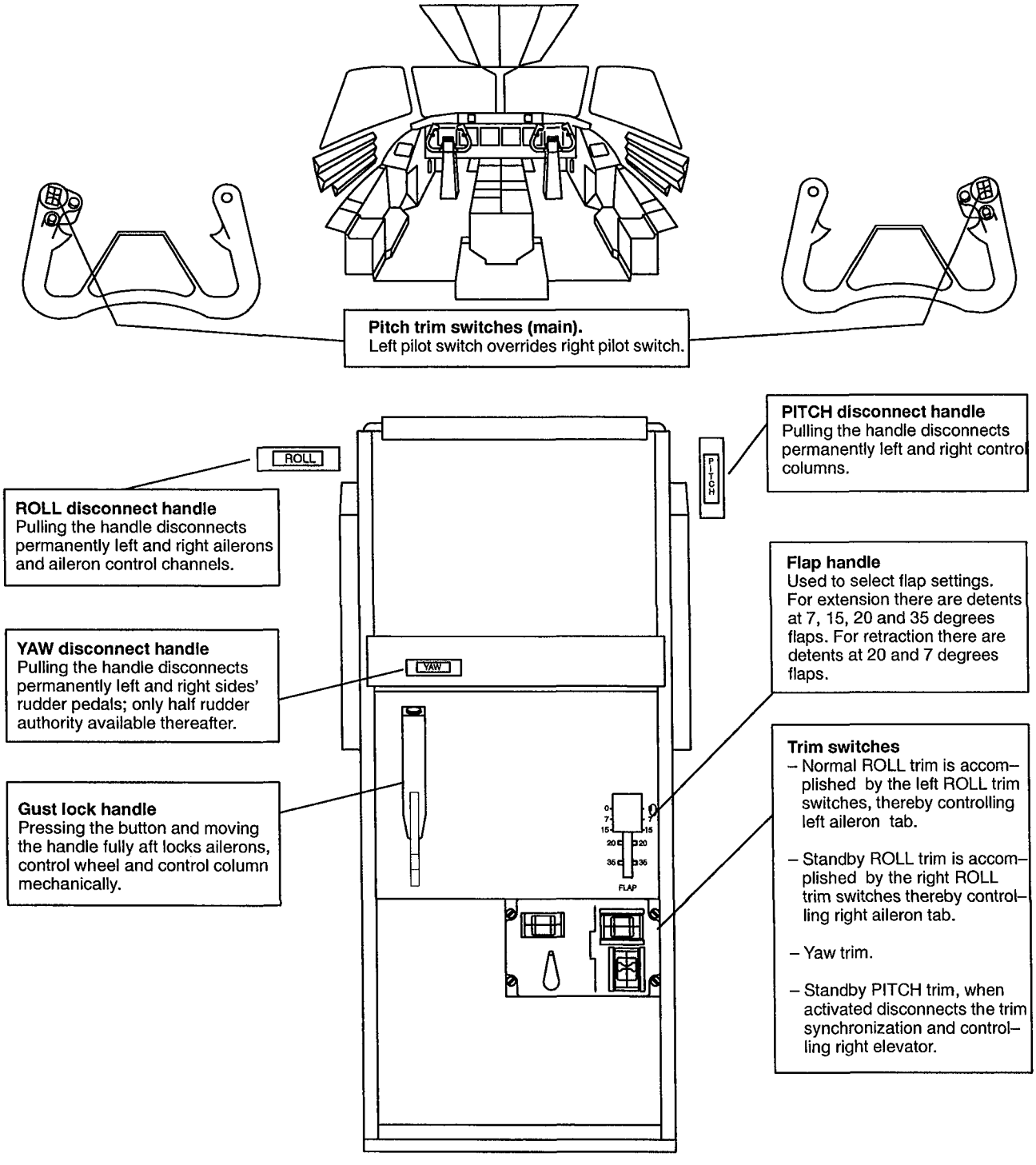


FIG.2. Flight controls.

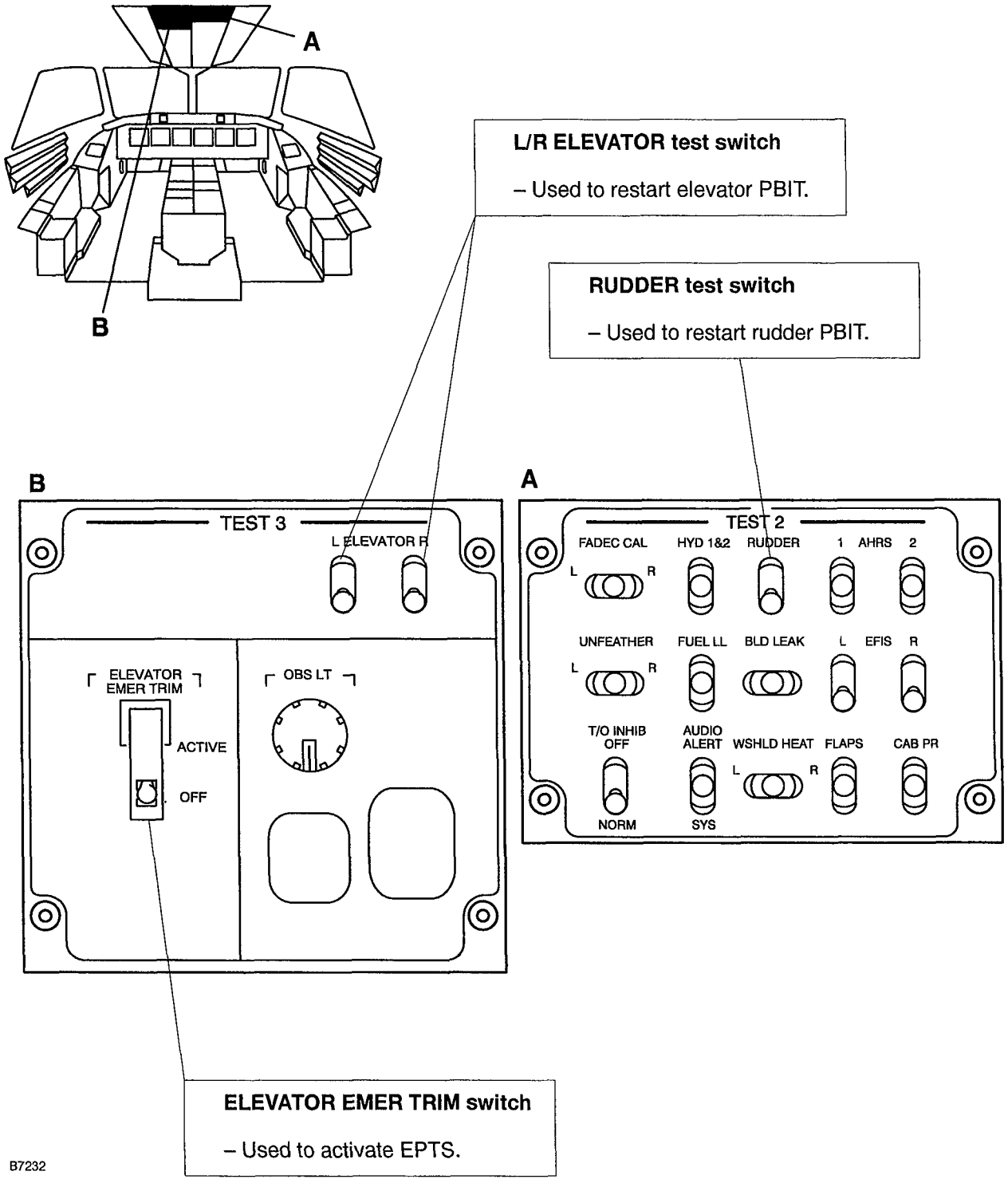
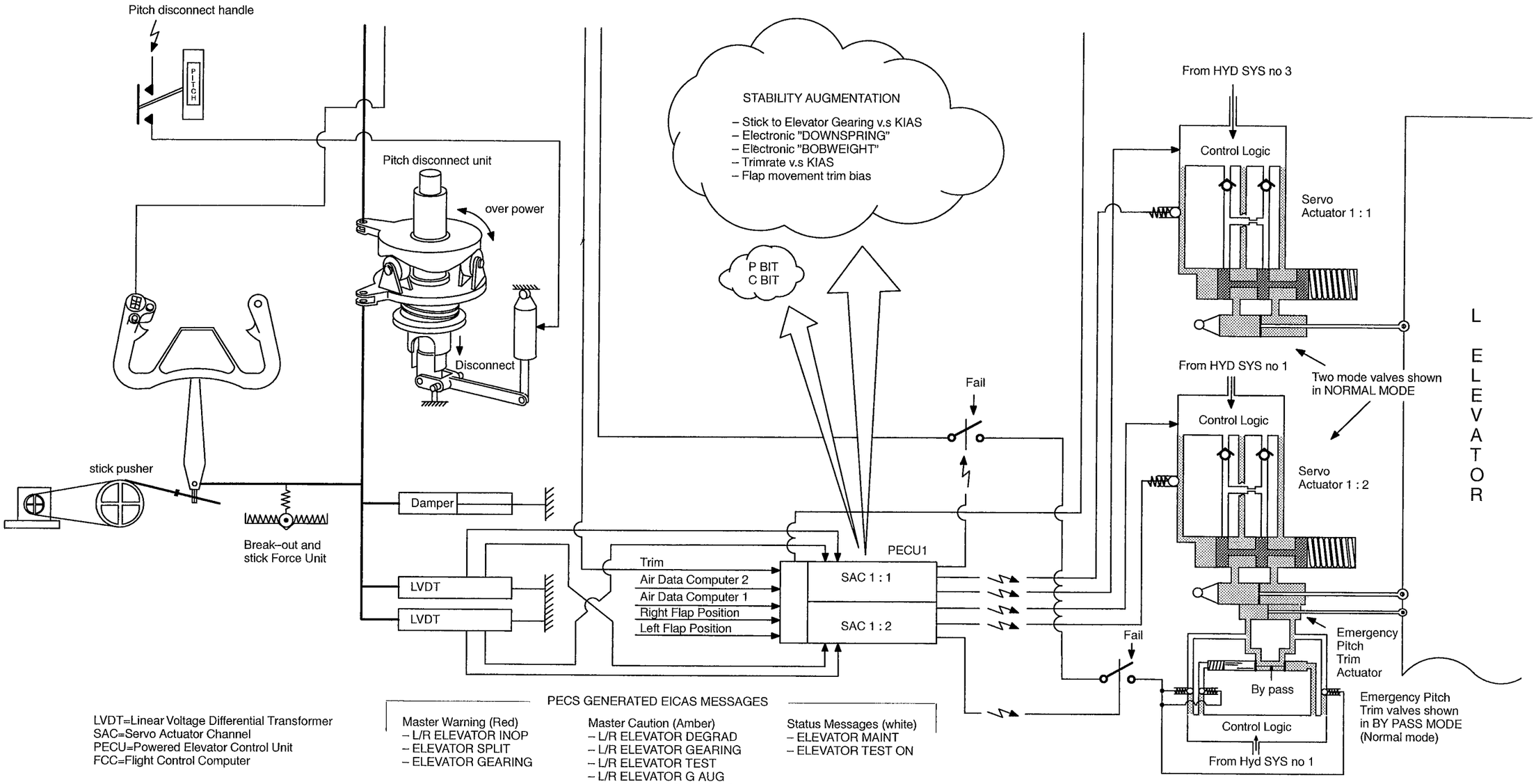


FIG.3. Flight control switches.



LVDT=Linear Voltage Differential Transformer
SAC=Servo Actuator Channel
PECU=Powered Elevator Control Unit
FCC=Flight Control Computer

PECS GENERATED EICAS MESSAGES

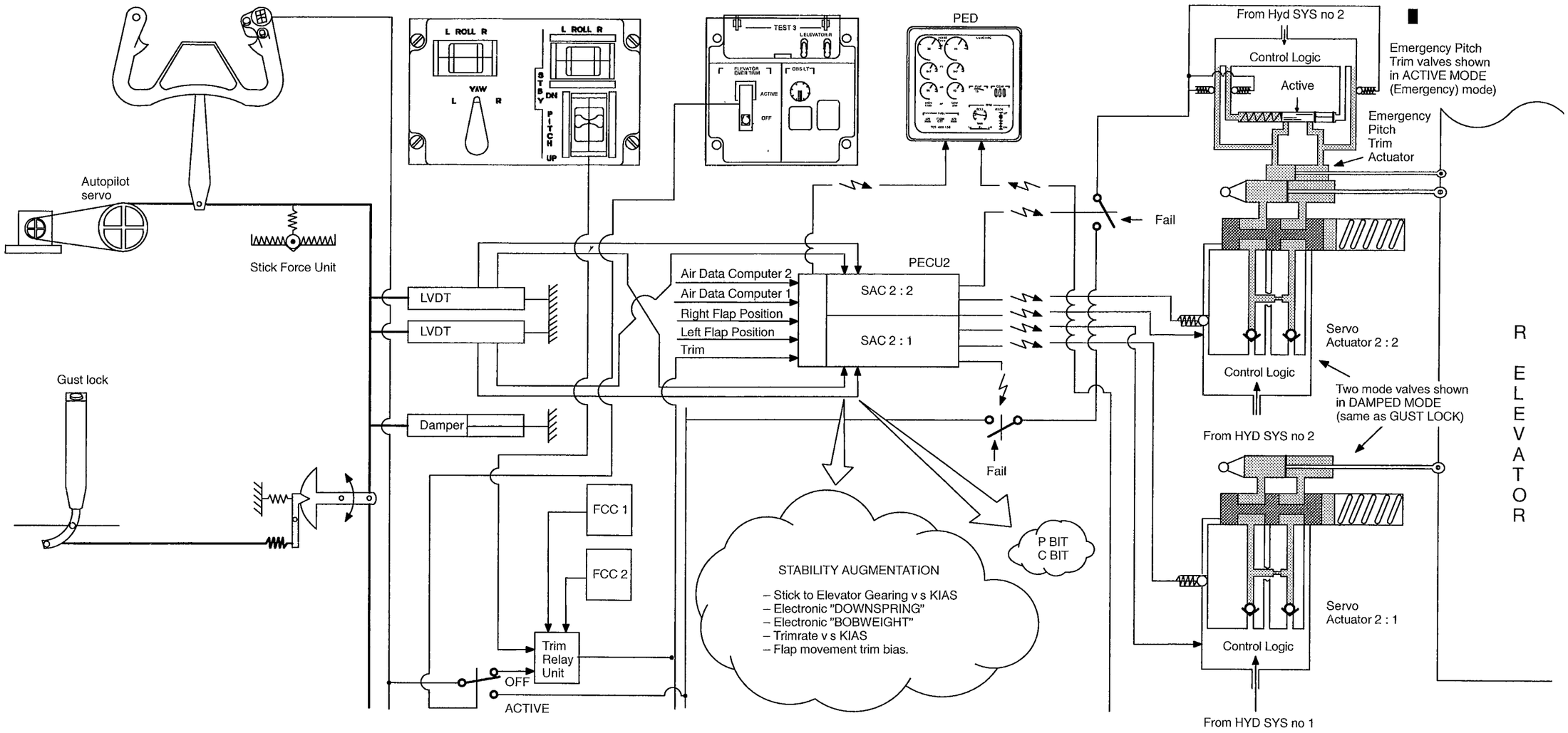
Master Warning (Red)
– L/R ELEVATOR INOP
– ELEVATOR SPLIT
– ELEVATOR GEARING

Master Caution (Amber)
– L/R ELEVATOR DEGRAD
– L/R ELEVATOR GEARING
– L/R ELEVATOR TEST
– L/R ELEVATOR G AUG
– L/R ELEVATOR IAS AUG
– L/R ELEVATOR FLAP TRM
– L/R ELEVATOR TRIM + AUG
– ELEVATOR TRIM SPLIT
– ELEVATOR IDENT FAIL
– L/R ELEVATOR MAINT

Status Messages (white)
– ELEVATOR MAINT
– ELEVATOR TEST ON

B6722

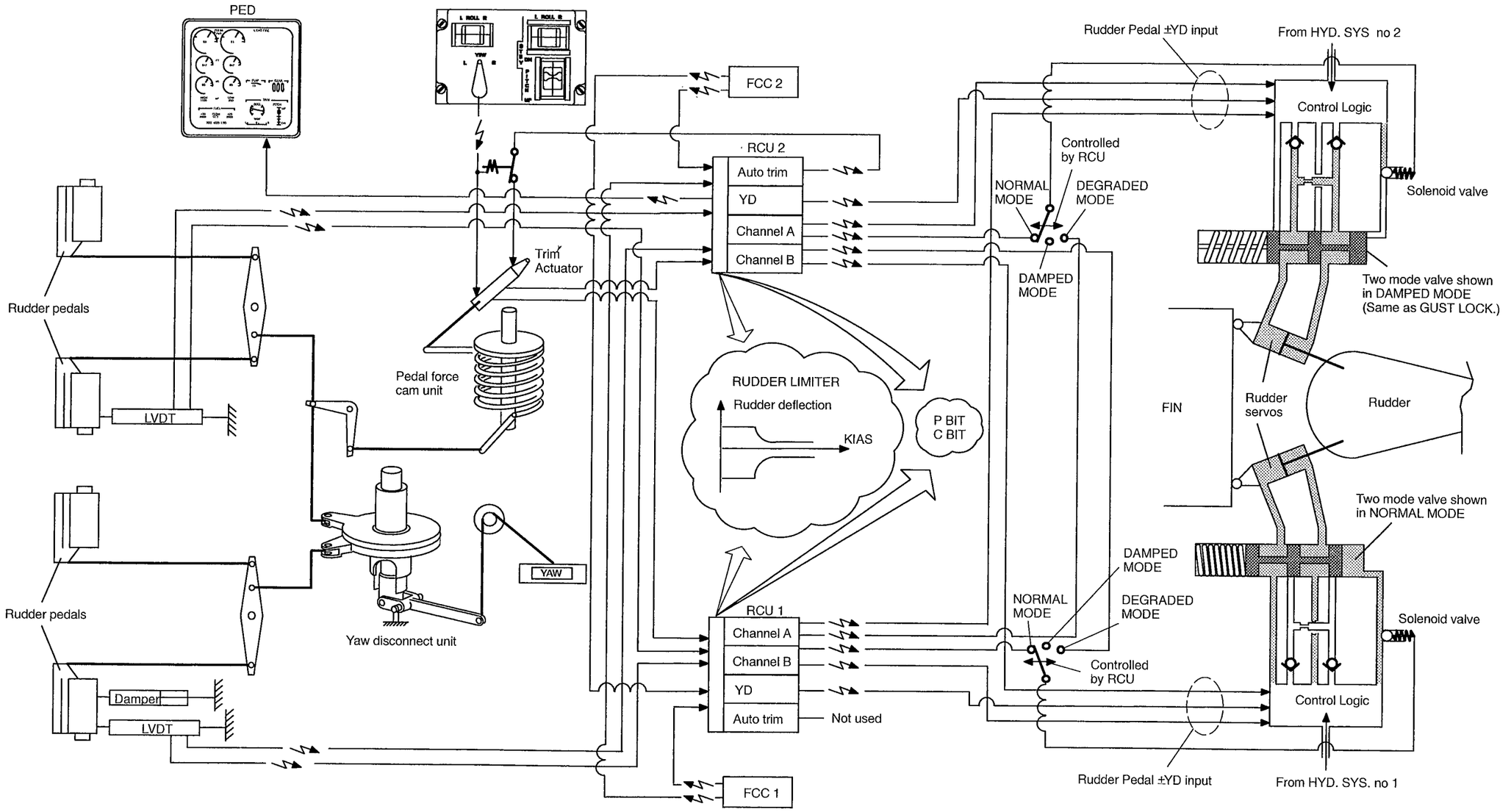
FIG. 4. Elevator system (L side).



LVDT=Linear Voltage Differential Transformer
SAC=Servo Actuator Channel
PECU=Powered Elevator Control Unit
FCC=Flight Control Computer

B6732

FIG. 5. Elevator system (R side).



LVDT= Linear Voltage Differential Transformer
PBIT = Preflight Built In Test
CBIT = Continuous Built In Test
RCU = Rudder Control Unit
YD = Yaw Damper
FCC = Flight Control Computer

RCU GENERATED EICAS MESSAGES.

Master Warning (Red)
– RUDDER INOP
– RUDDER LIMIT INOP

Master Caution (Amber)
– YAW AUTO TRIM INOP
– RUDDER TEST FAULT
– PEDAL MISCOMPARE
– PEDAL DEFLECTION
– RUDDER CTL 1 FAULT
– RUDDER CTL 2 FAULT
– RUDDER 1 FAULT
– RUDDER 2 FAULT

Status Messages (white)
– PEDAL SENSOR FAULT
– RUDDER MAINT
– RUDDER TEST ON

B7254

FIG. 6. Rudder system.

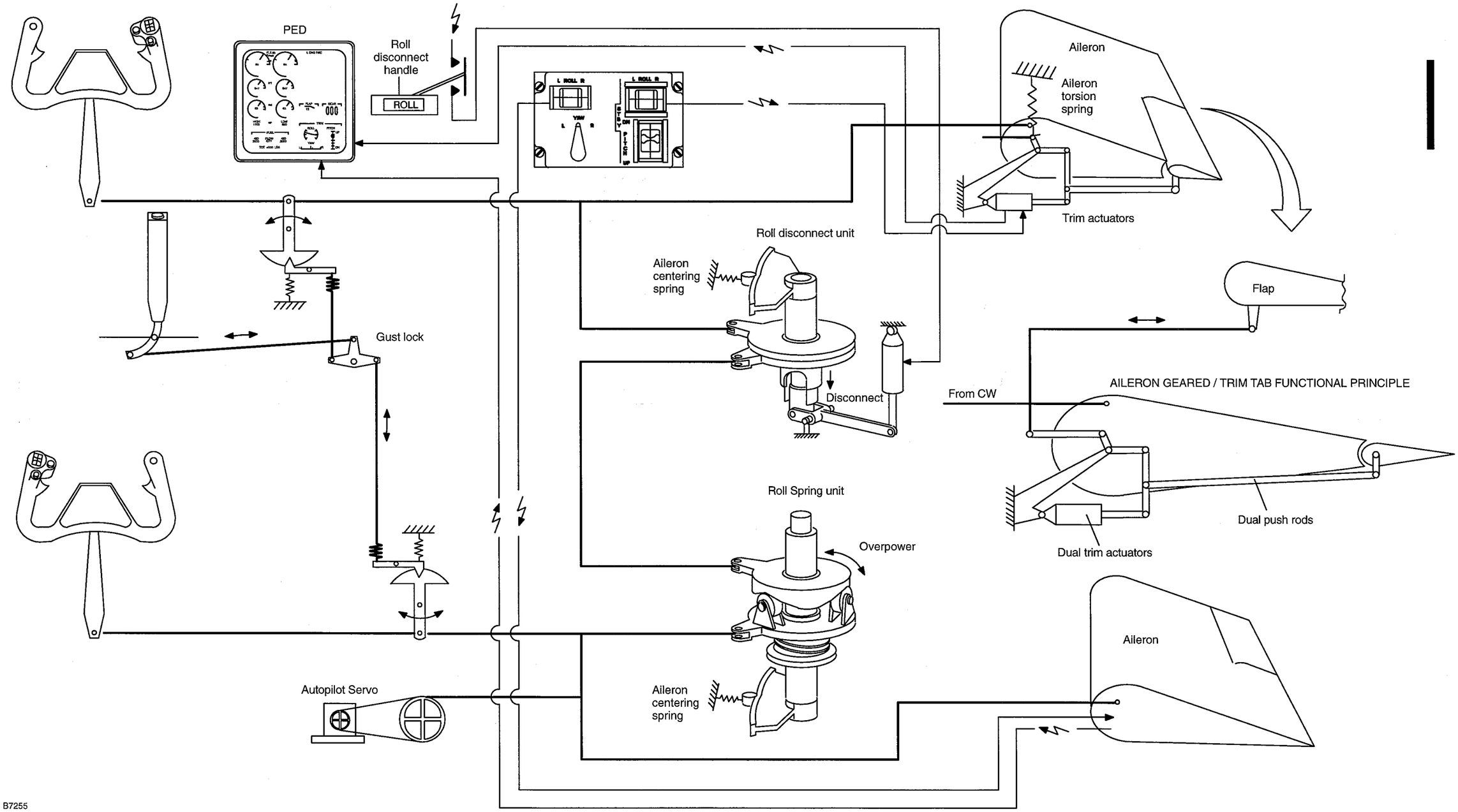
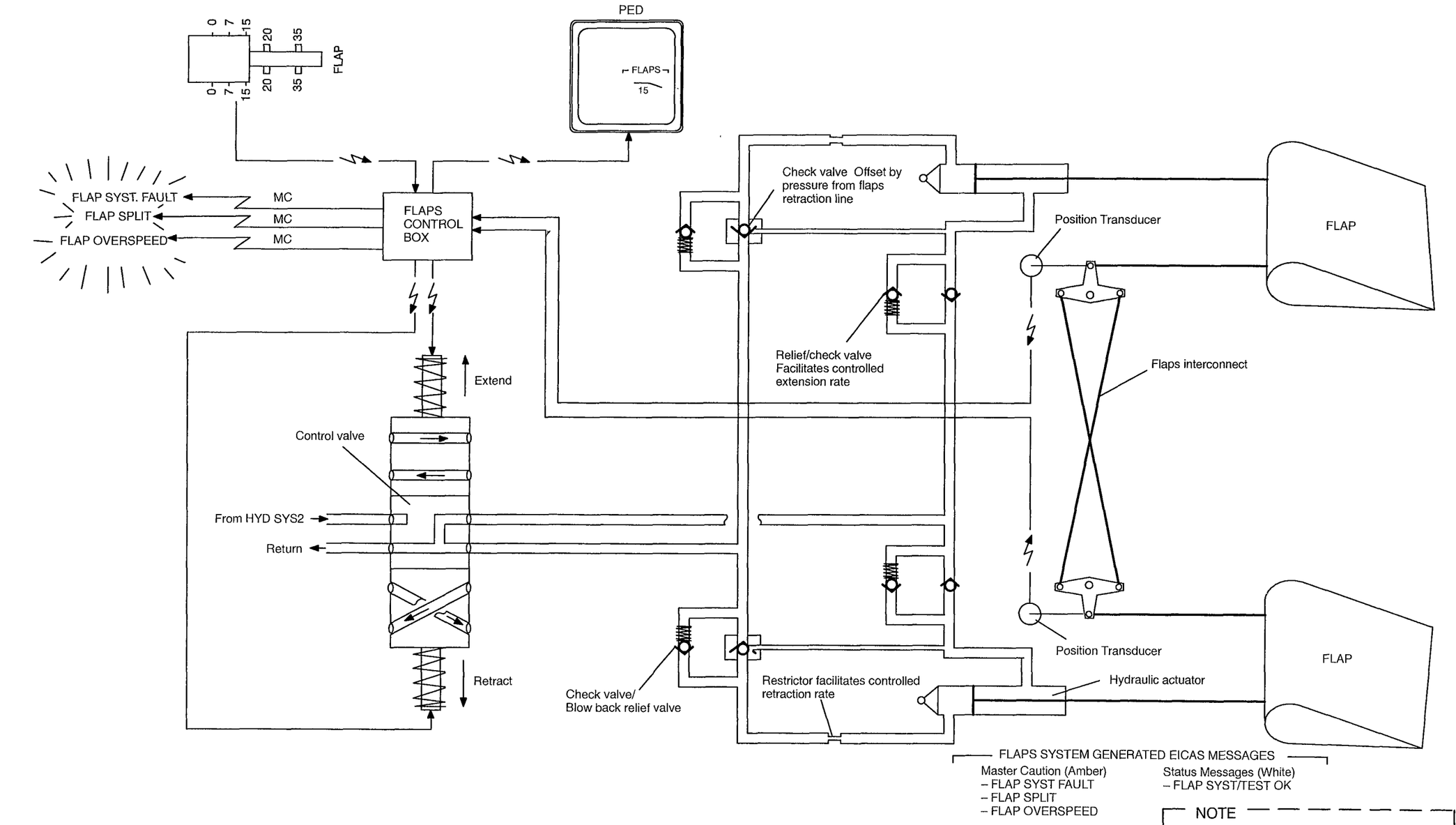


FIG. 7. Aileron system.



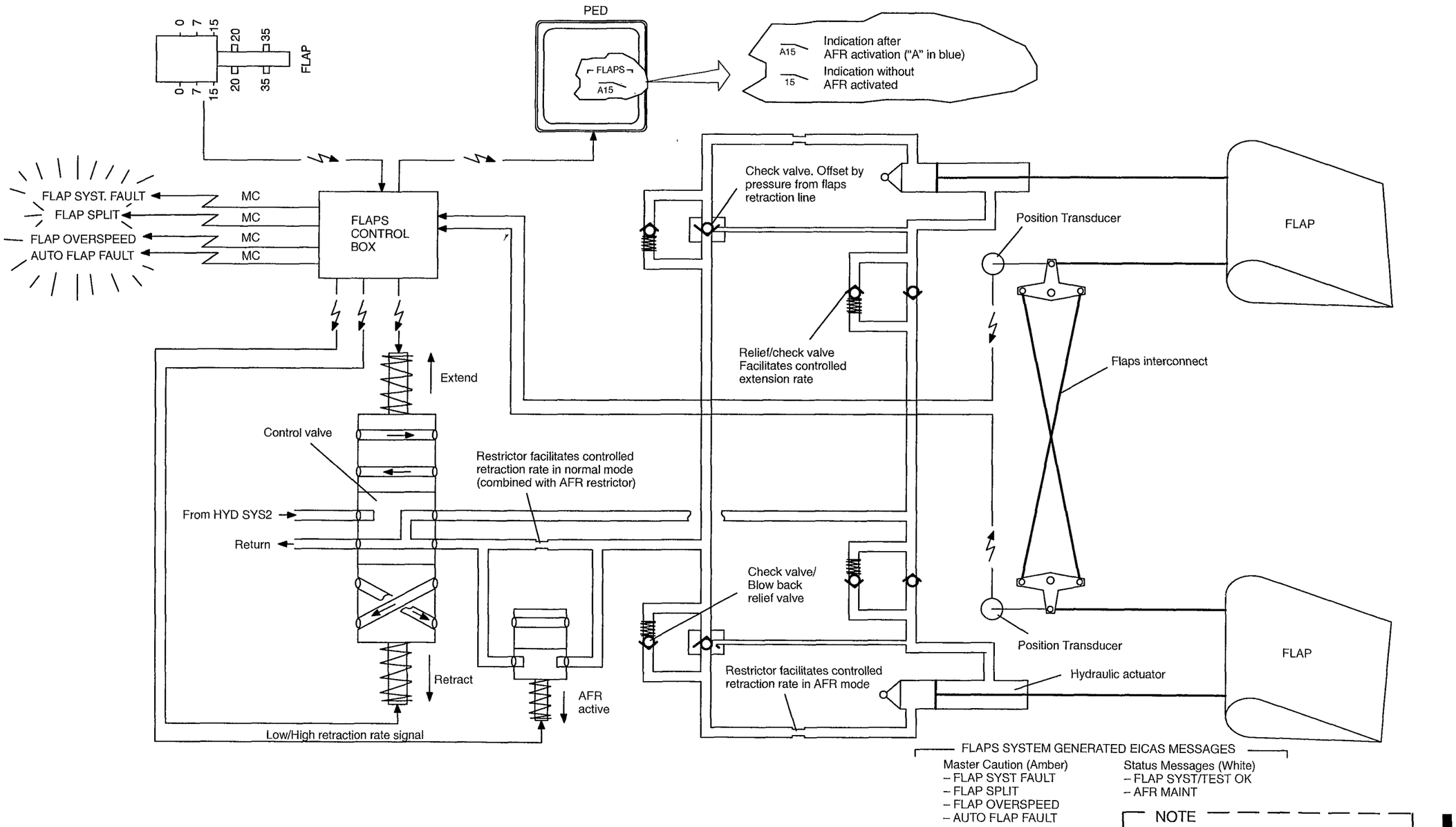
B10232

NOTE

With Mod. No. 6225 installed, the "FLAP SYS/TEST OK" message is replaced by a flap test lamp (green) on the overhead panel.

FIG. 8. Flaps system.

Without AFR system.



B10231

NOTE

With Mod. No. 6225 installed, the "FLAP SYS/TEST OK" message is replaced by a flap test lamp (green) on the overhead panel.

FIG. 8. Flaps system.

With AFR system.

4. ELECTRICAL POWER SUPPLY.

Flap control	L BAT BUS	G–8	FLAP CTL
Yaw trim	R BAT BUS	N–6	TRIMS YAW
Pitch and Roll Trim (main)	L BAT BUS	G–5	TRIM PITCH ROLL
Picht and Roll Trim (stby)	R BAT BUS	N–5	TRIM STBY PITCH ROLL
Pitch/Roll Disconnect	L BAT BUS	G–6	PITCH ROLL DISC
EPTS	R HOT BAT BUS	N–10	ELEVATOR EMER TRIM
RCU no 1	L MAIN /BAT BUS	G–7	RUDDER CTL 1
RCU no 2	R BAT BUS	N–7	RUDDER CTL 2
SAC 1:1	L BAT BUS	G–10	ELEVATOR L CTL 1
SAC 1:2	EMER BUS	N–9	ELEVATOR L CTL 2
SAC 1:2 backup	L BAT BUS	G–11	ELEVATOR L CTL 2 BACK UP
SAC 2:1	EMER BUS	G–9	ELEVATOR R CTL 1
SAC 2:2	R BAT BUS	N–8	ELEVATOR R CTL 2