Agenda (2/3)

- Module 4 – Design requirements and Safety process
  - 4-1 Requirements
  - 4-2 Safety process
- Module 5 – Aircraft power systems
  - 5-1 Hydraulic power systems
  - 5-2 Electric power systems
- Module 6 – Aircraft Control systems Architectures
  - **6-1 Hydro Mechanical Systems**
  - 6-2 Fly by wire systems
  - 6-3 Fly by wire systems new generation
  - 6-4 A320 FAL Visit

General definitions

Primary Flight Control system

- Includes all the elements between the stick and the flight surfaces necessary to control the attitude, the trajectory and the speed of the aircraft in manual piloting mode.
- The Primary Flight Control system is made up of:
  - the piloting devices : stick, rudder bar, trim commands ,
  - the devices necessary to transmit and handle the flight crew orders :
    - steering systems and cables in case of mechanical flight controls ,
    - computers and wirings in case of fly by wire flight controls ,
  - the actuators or servo commands which allow to move and set the flight surfaces to the right position

General definitions

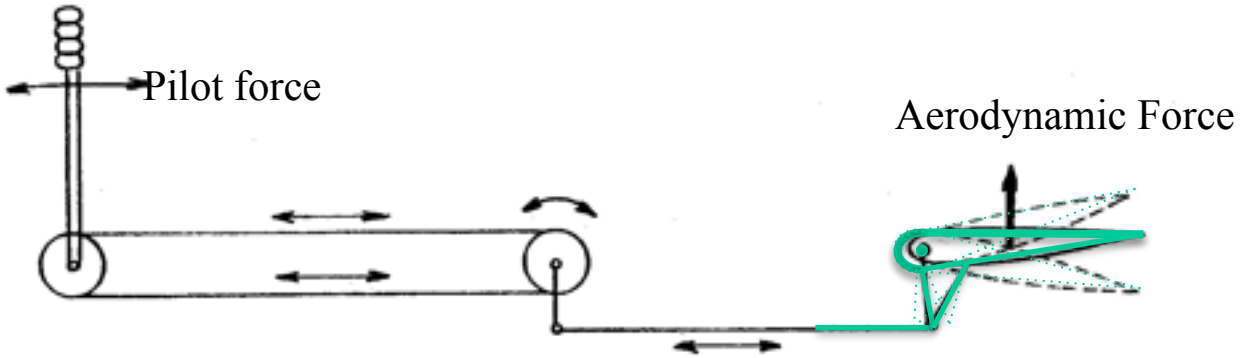
Secondary Flight Control system

The Secondary Flight Control system is made up of all the

- elements necessary to control the lift of the aircraft:
  - Control of the slats
  - Control of the flaps
  - Control of the Spoiler

- Remark:Computerizations of flight control systems allows new functionalities of the classical control surfaces and consequentially to a mix of “primary and secondary”

Mechanical control systems, Basic principle

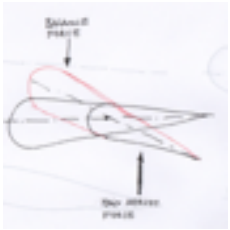


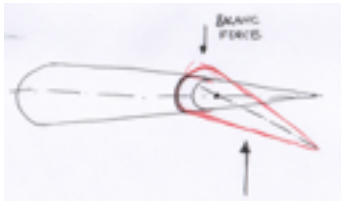
- Pilot forces and aerodynamic forces are balanced
- Pilot forces (and displacements) are limited and therefore Aerodynamic forces should not exceed a certain limit
- Regulation CS 25.143 (b1) provide the acceptable force values
- If the design of the aircraft requires control surface deflections which results in aerodynamic forces in exceed of the allowable maximum limits features must be invented to reduce the surface hinge moment
-

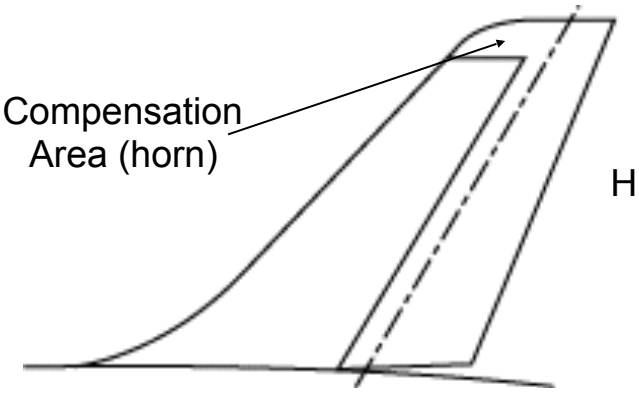
A/C Axis	Normal	Max
Pitch	10	75
Roll	5	50
Yaw	20	150

Mechanical control systems, Basic principle

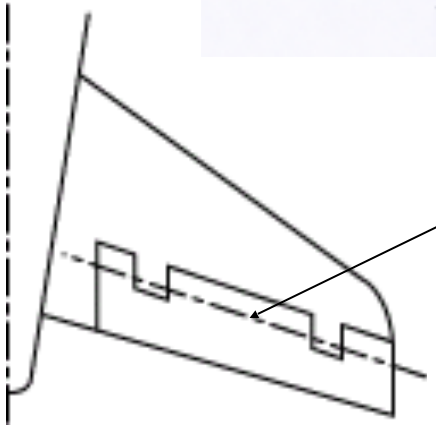
Hinge moment reduction achieved by cropped surface design





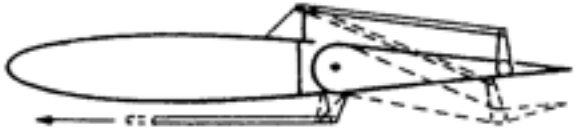


Aerodynamic
Hinge moment relief
devices

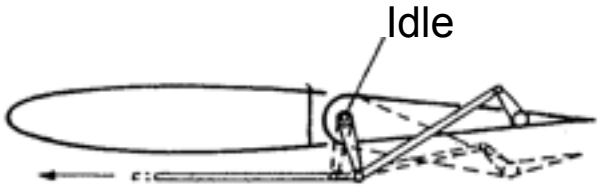


Mechanical control systems, Tabs

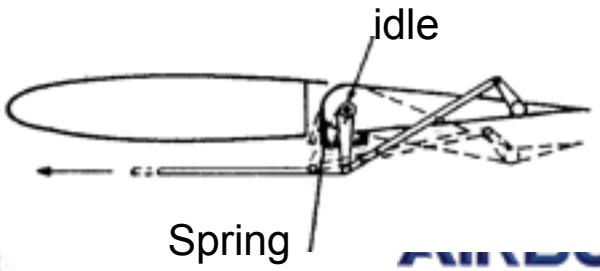
Aerodynamic amplifier for reducing forces needed to move control surfaces



Automatic tab

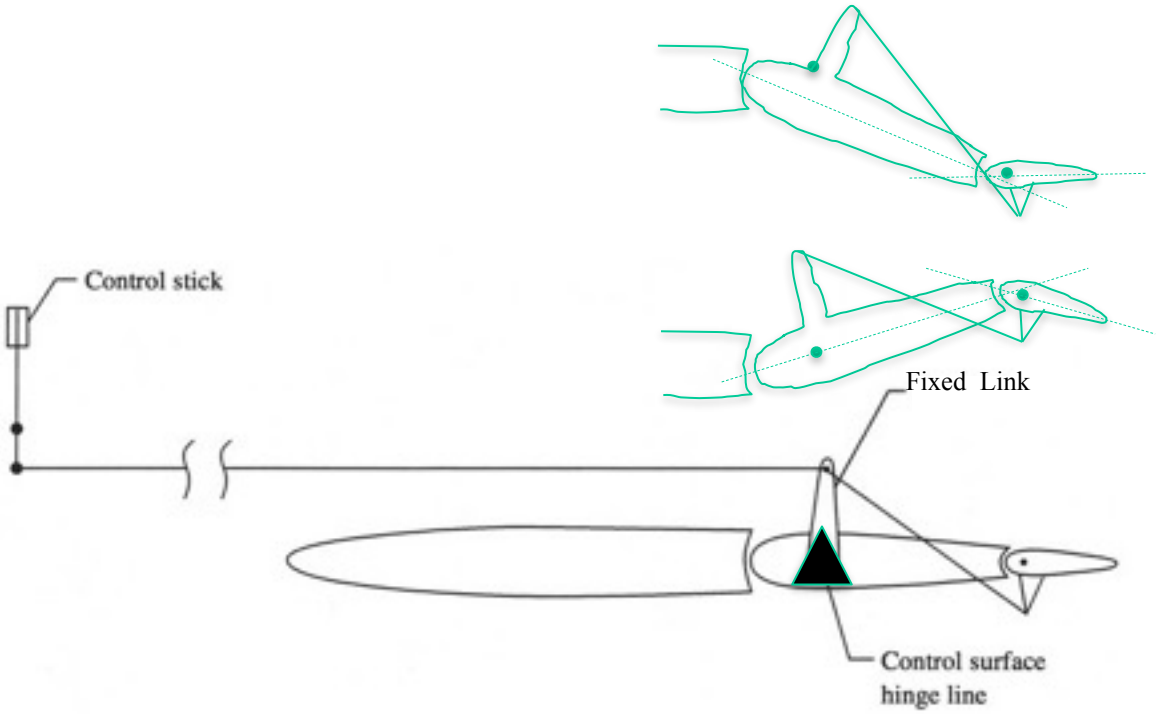


Servo tab



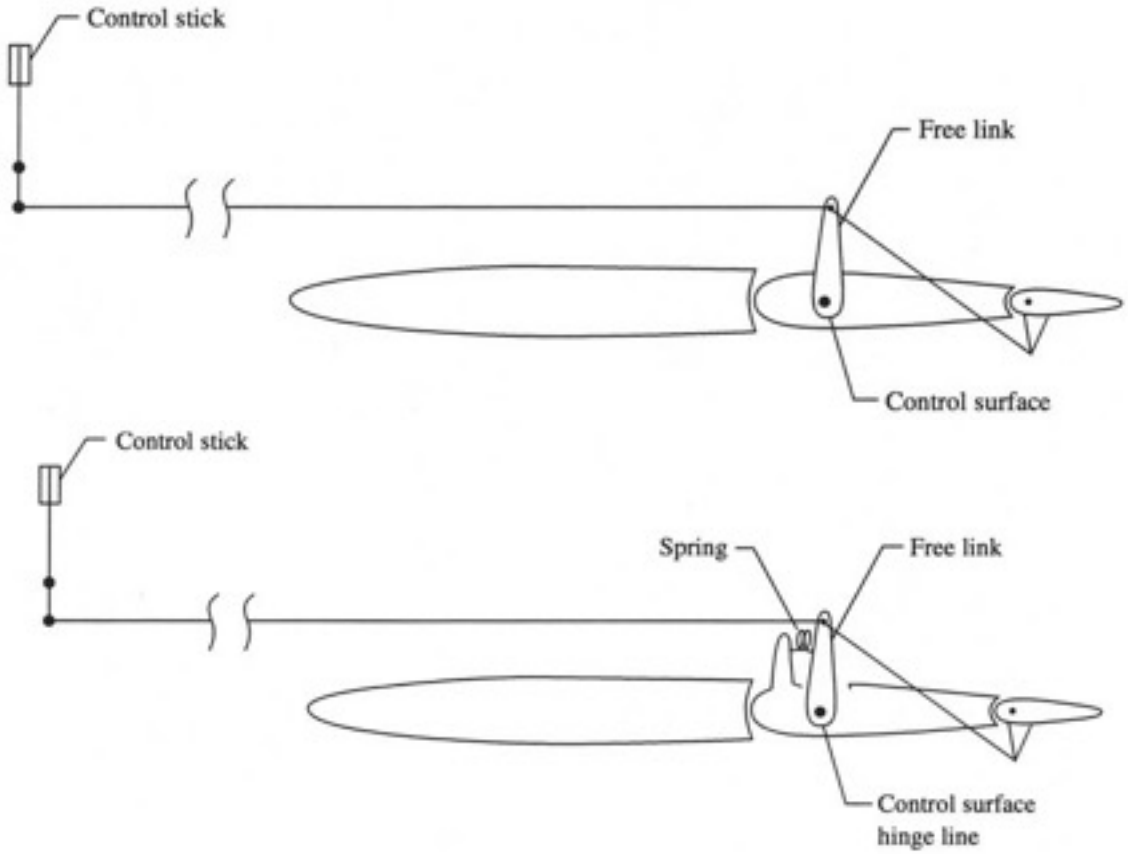
Spring tab

Hinge moment reduction devices



Automatic Tab

Hinge moment reduction devices

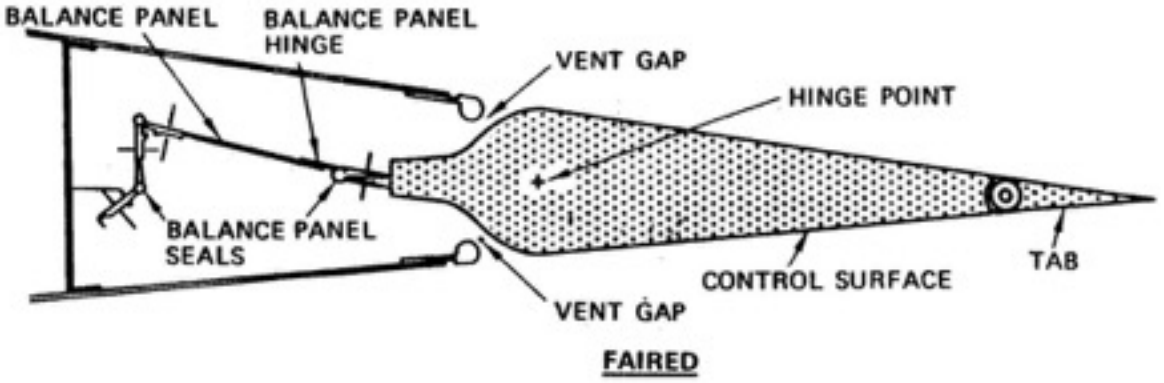


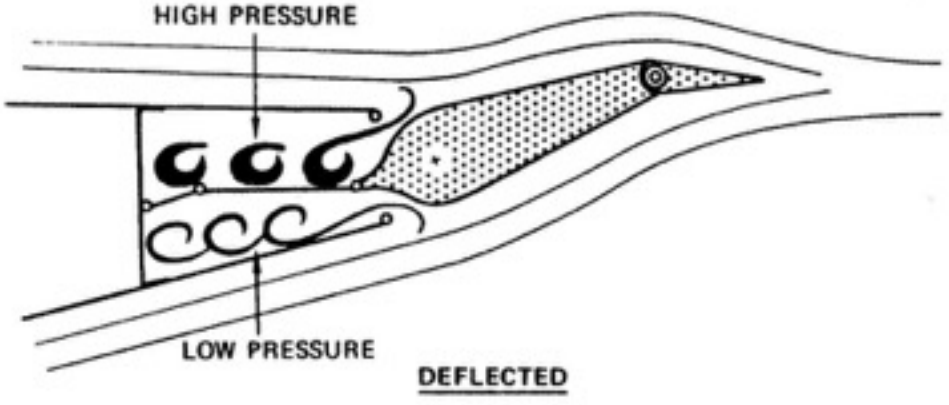
The tab acts as an Amplifier of the Pilot force

Servo Tab

Spring Tap

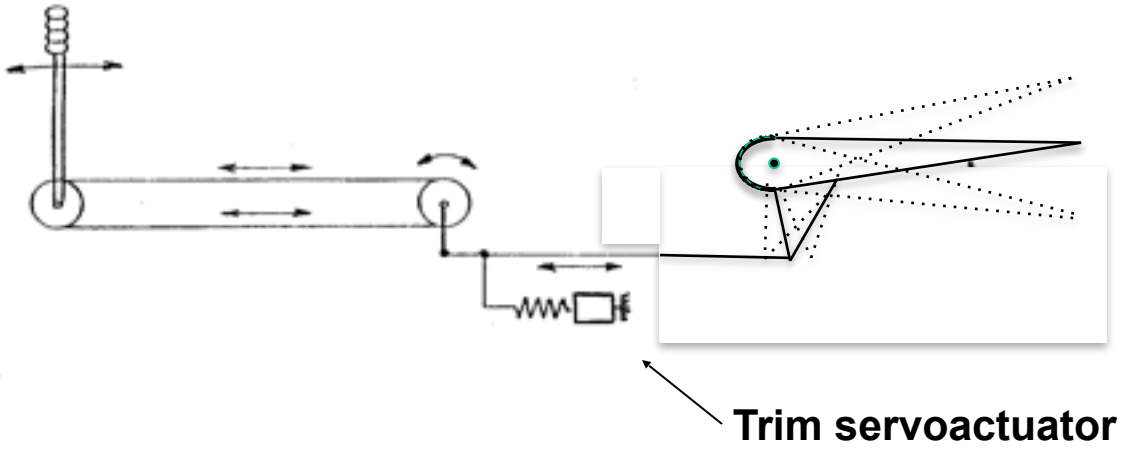
Mechanical control systems, Balance panel





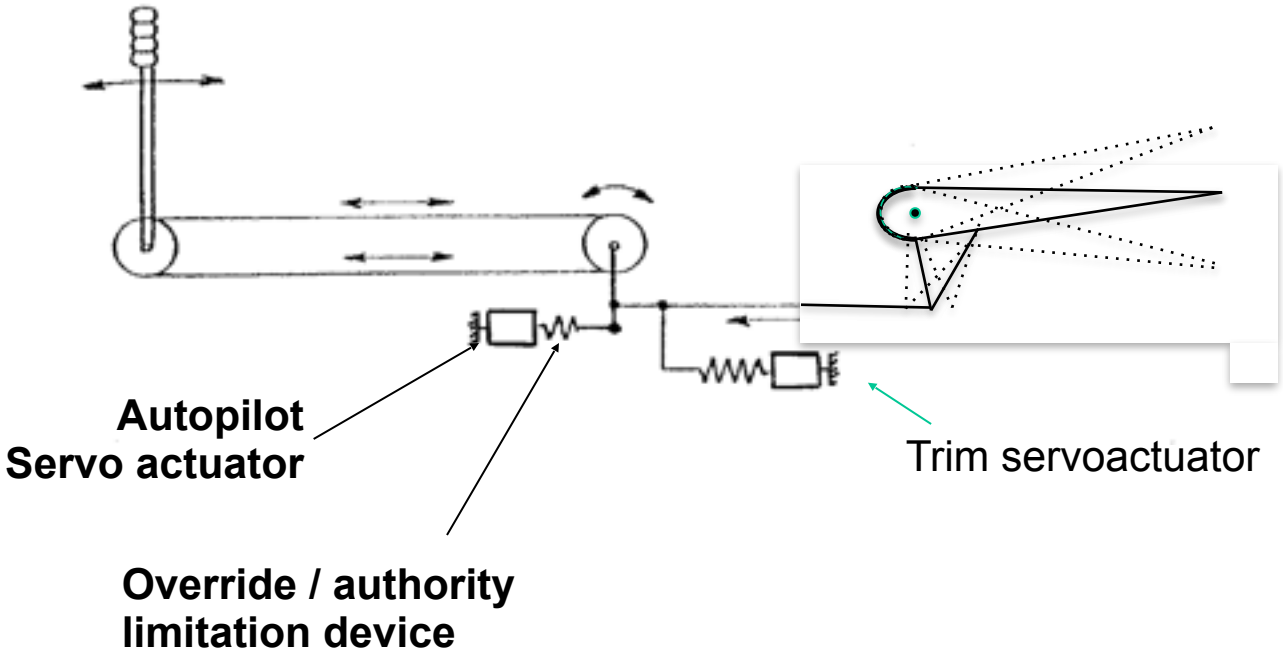
Mechanical control systems

- System architecture overview



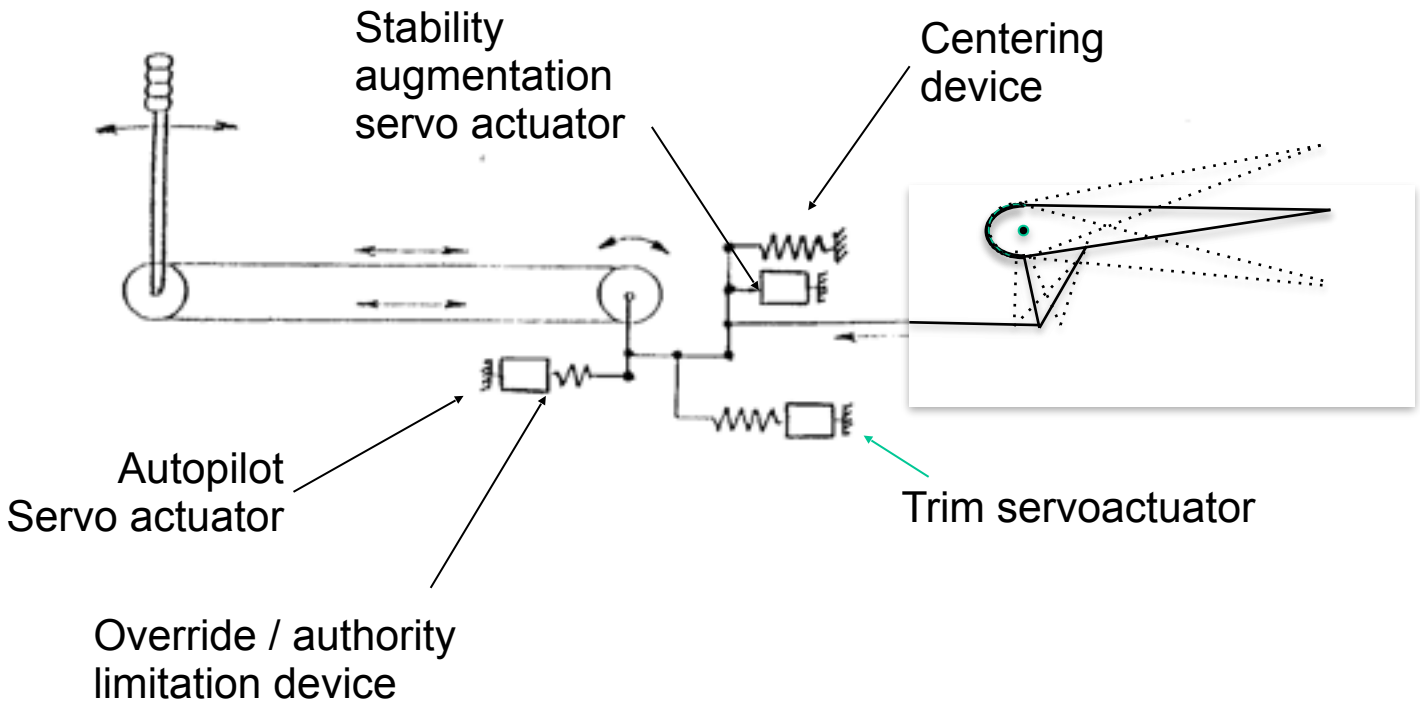
Mechanical control systems

- System architecture overview



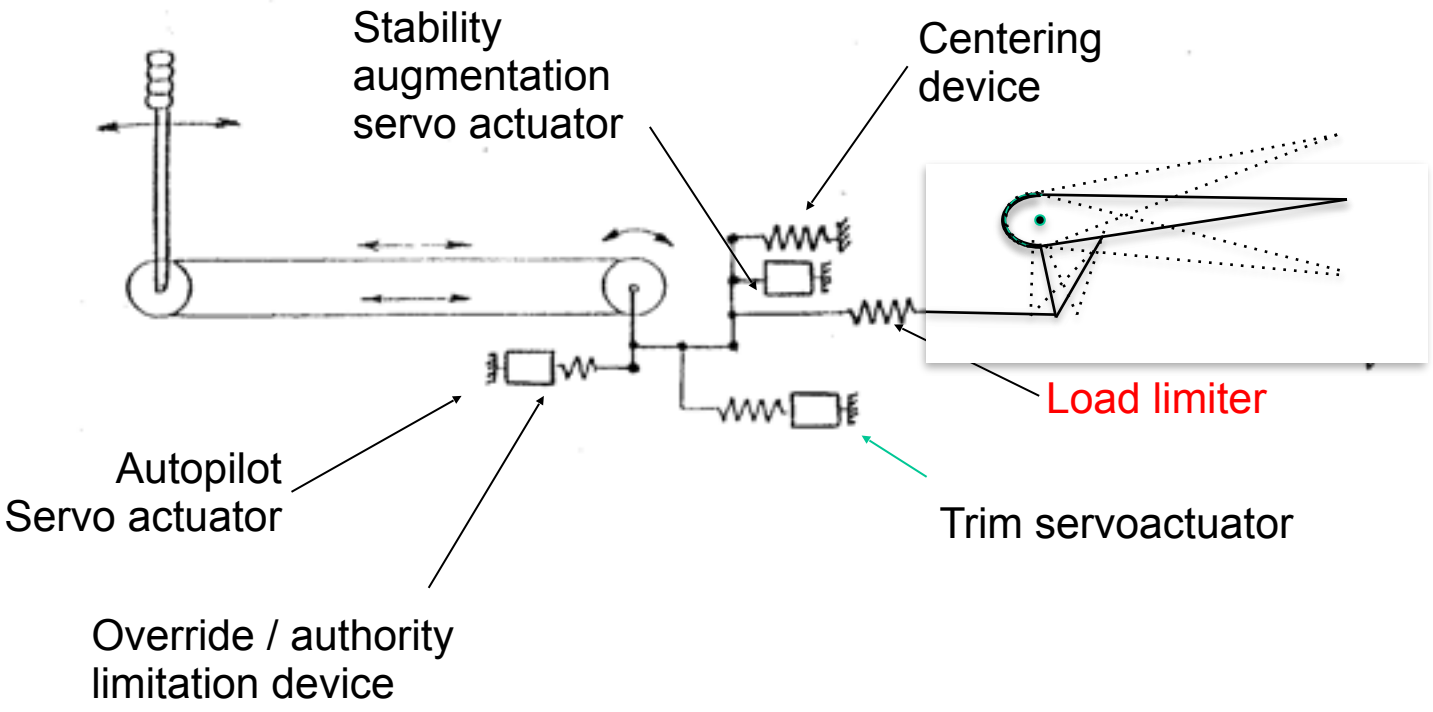
Mechanical control systems

- System architecture overview



Hydromechanical control systems

- System architecture overview

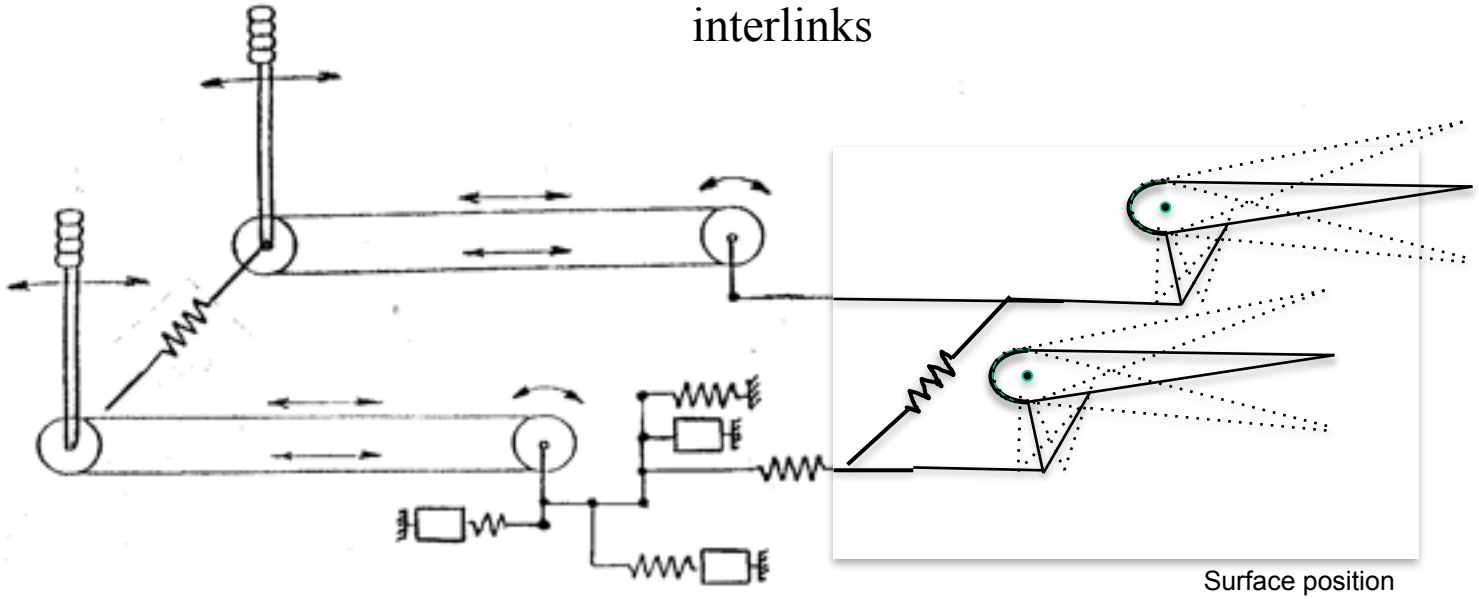


Hydromechanical control systems

- System architecture overview

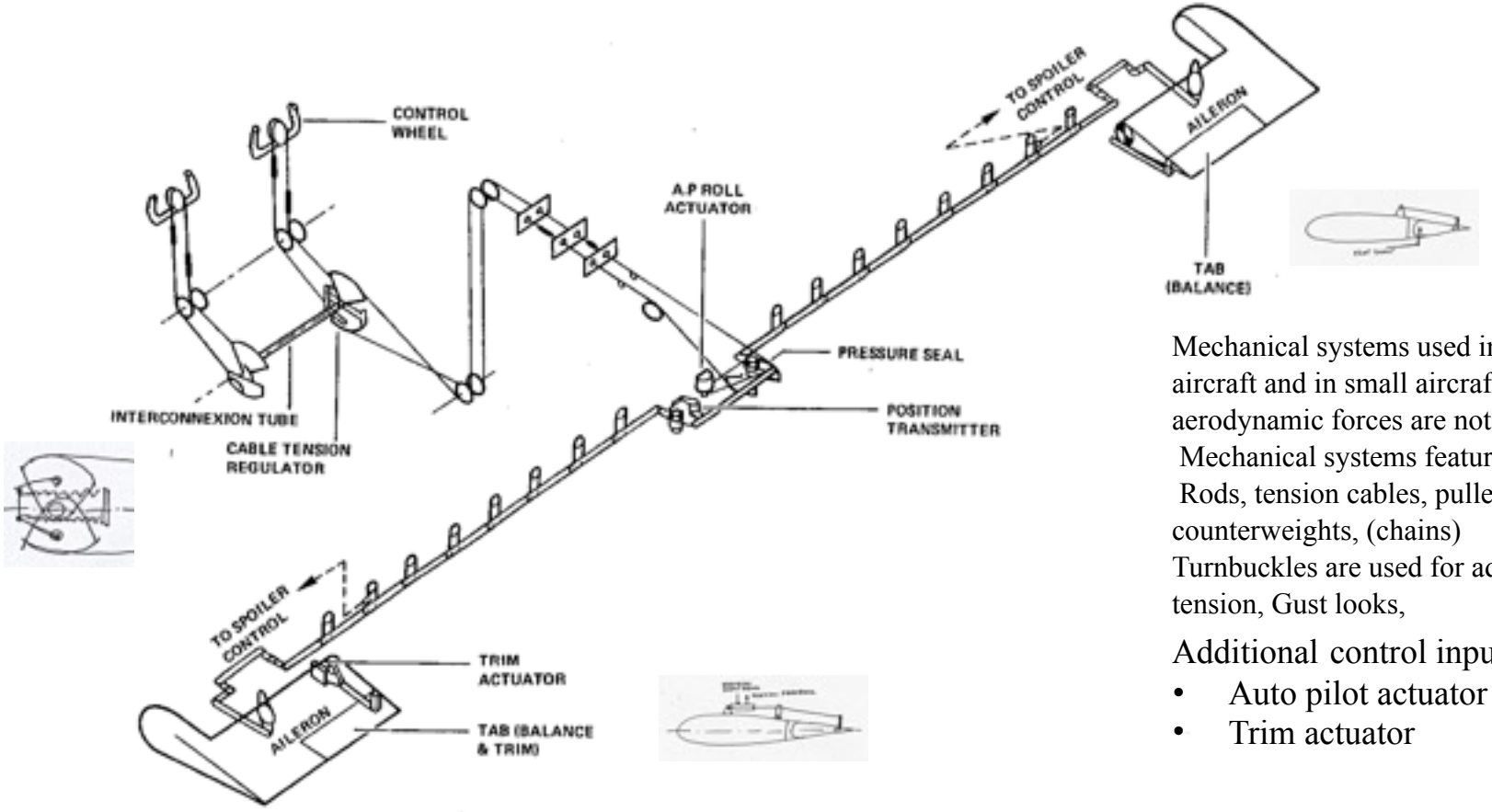
System is duplicated with mechanical interlinks

Pilot force transducers



Surface position transducers

Mechanical control systems, System architecture aileron control (ATR)



Mechanical systems used in early aircraft and in small aircraft where the aerodynamic forces are not excessive.

Mechanical systems features:

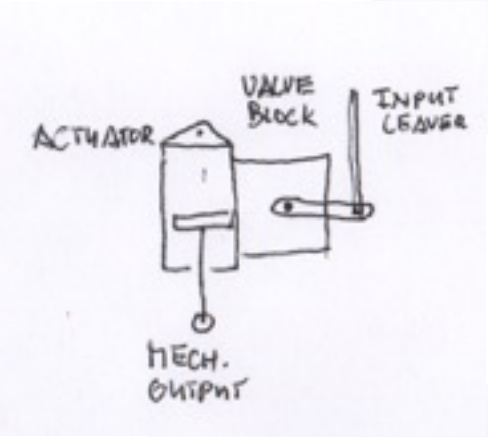
Rods, tension cables, pulleys, counterweights, (chains)

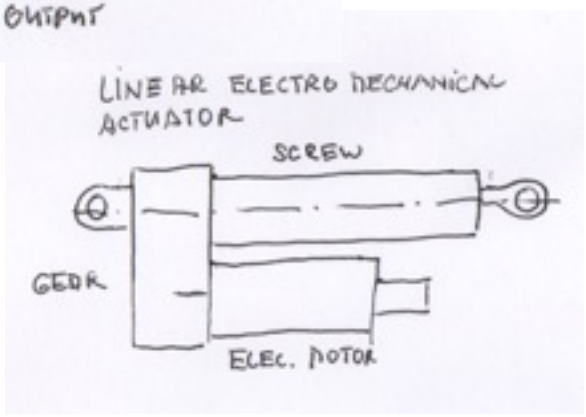
Turnbuckles are used for adjust cable tension, Gust looks,

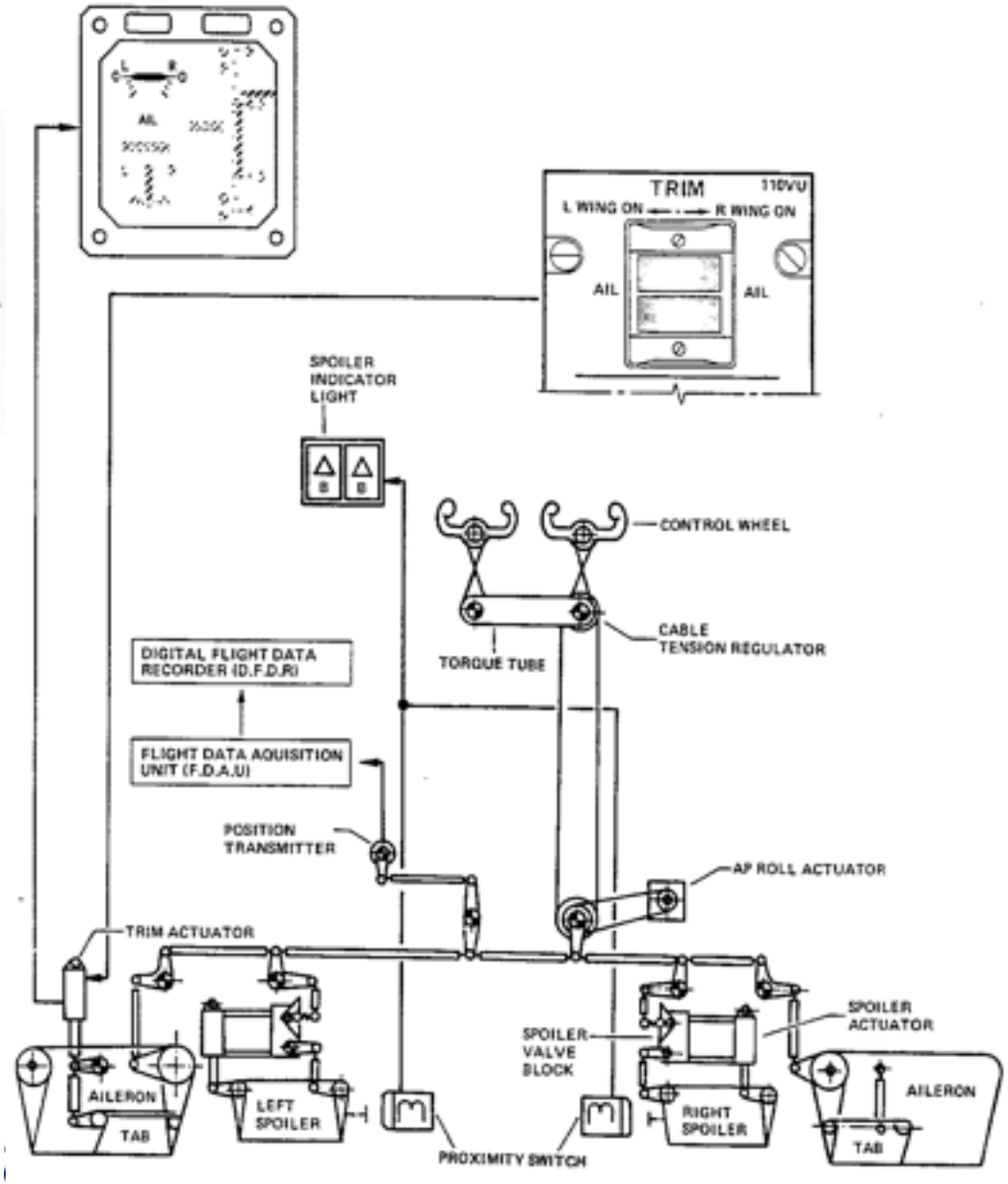
Additional control inputs are :

- Auto pilot actuator
- Trim actuator

Mechanical control systems, System architecture aileron control (ATR)

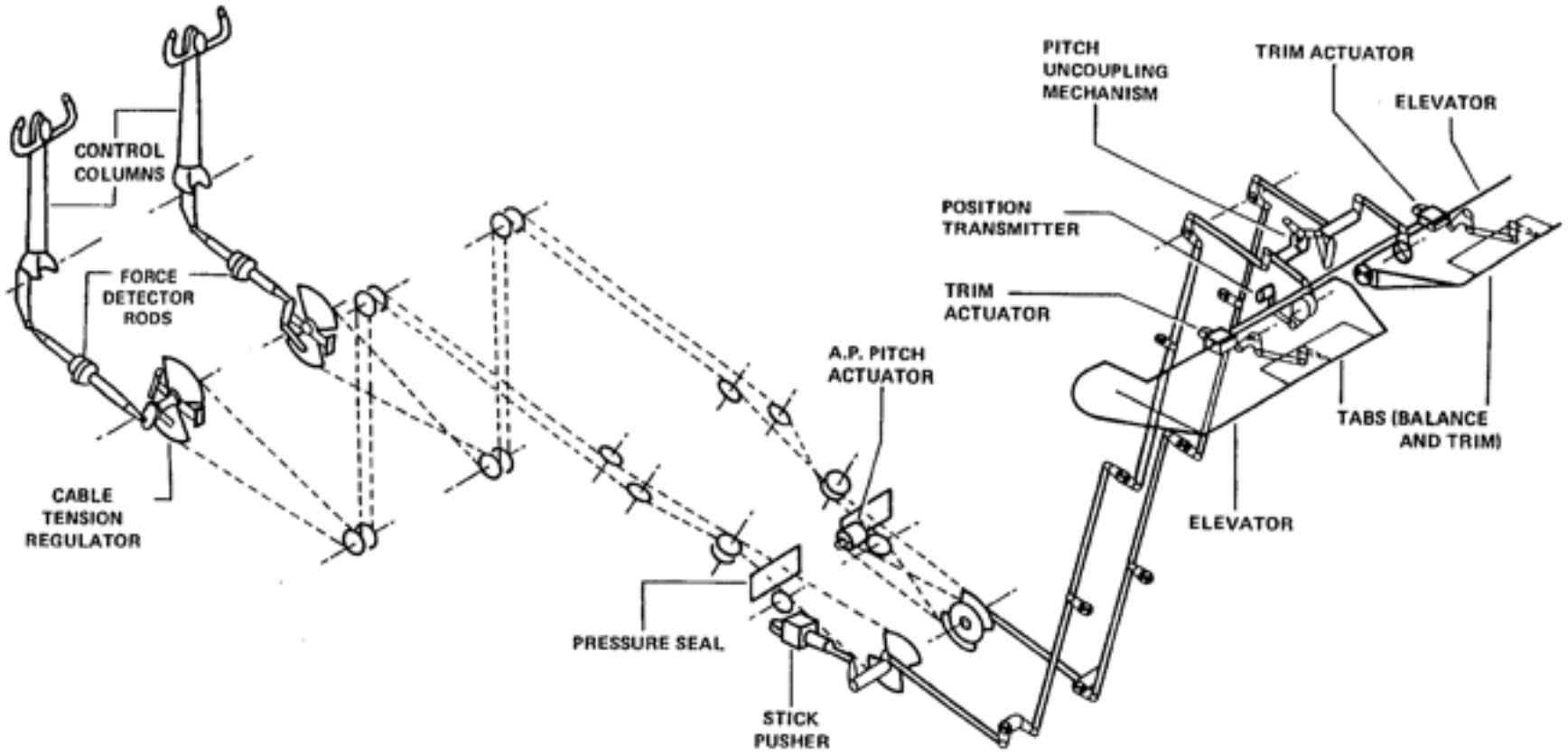






THALES

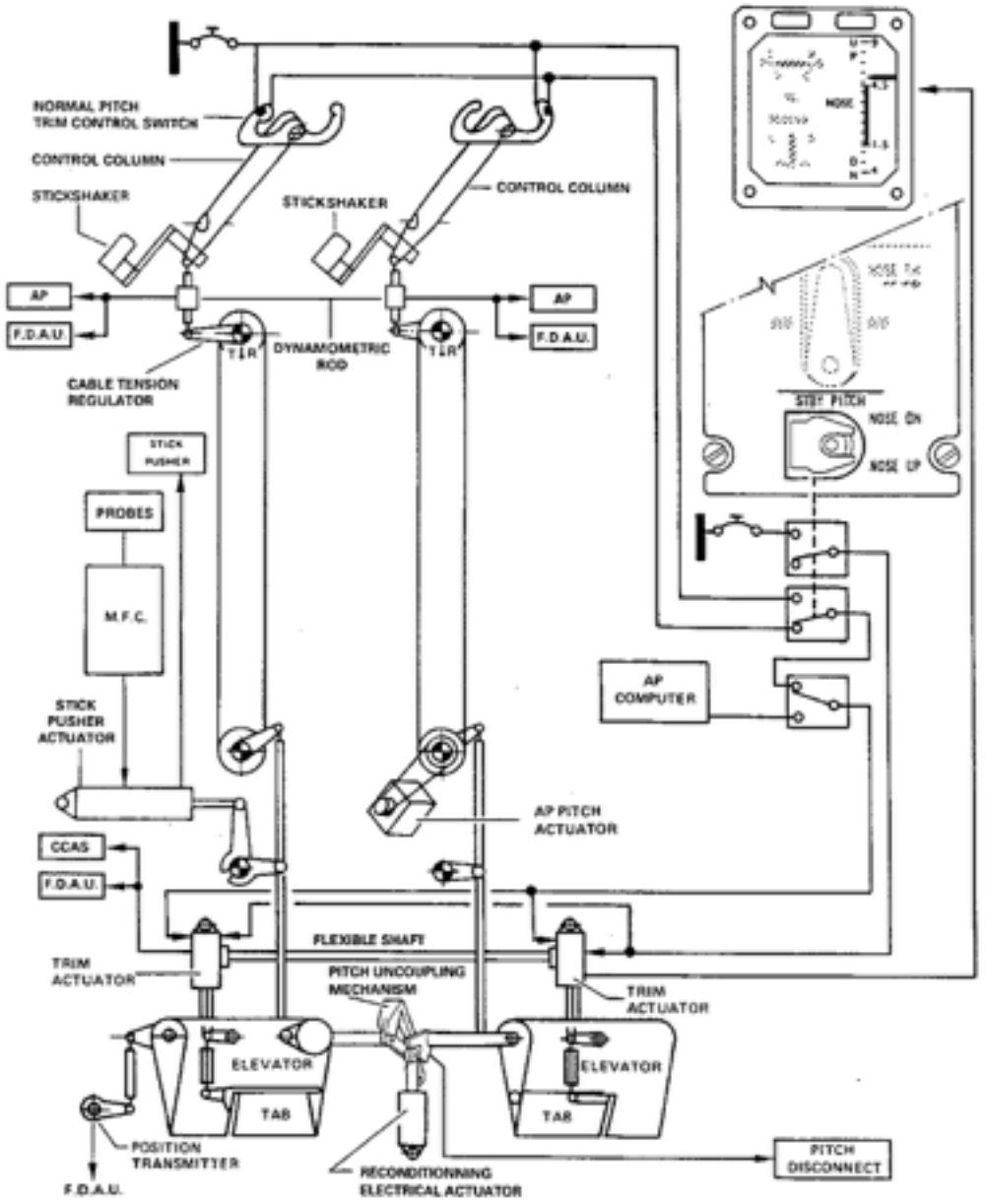
Mechanical control systems, System architecture, Elevator control (ATR)



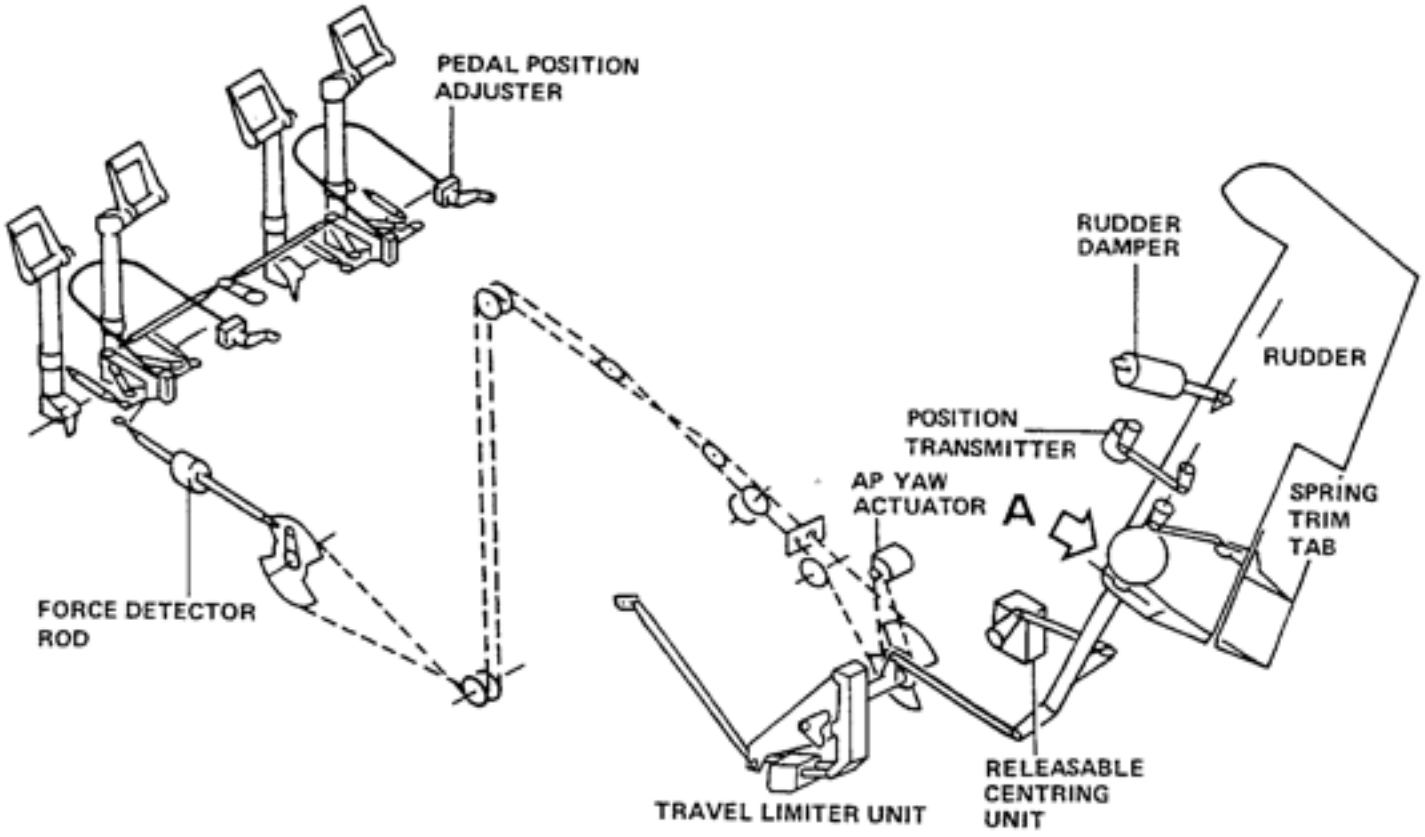
Mechanical control systems, System architecture, Elevator control (ATR)

Actuation devices

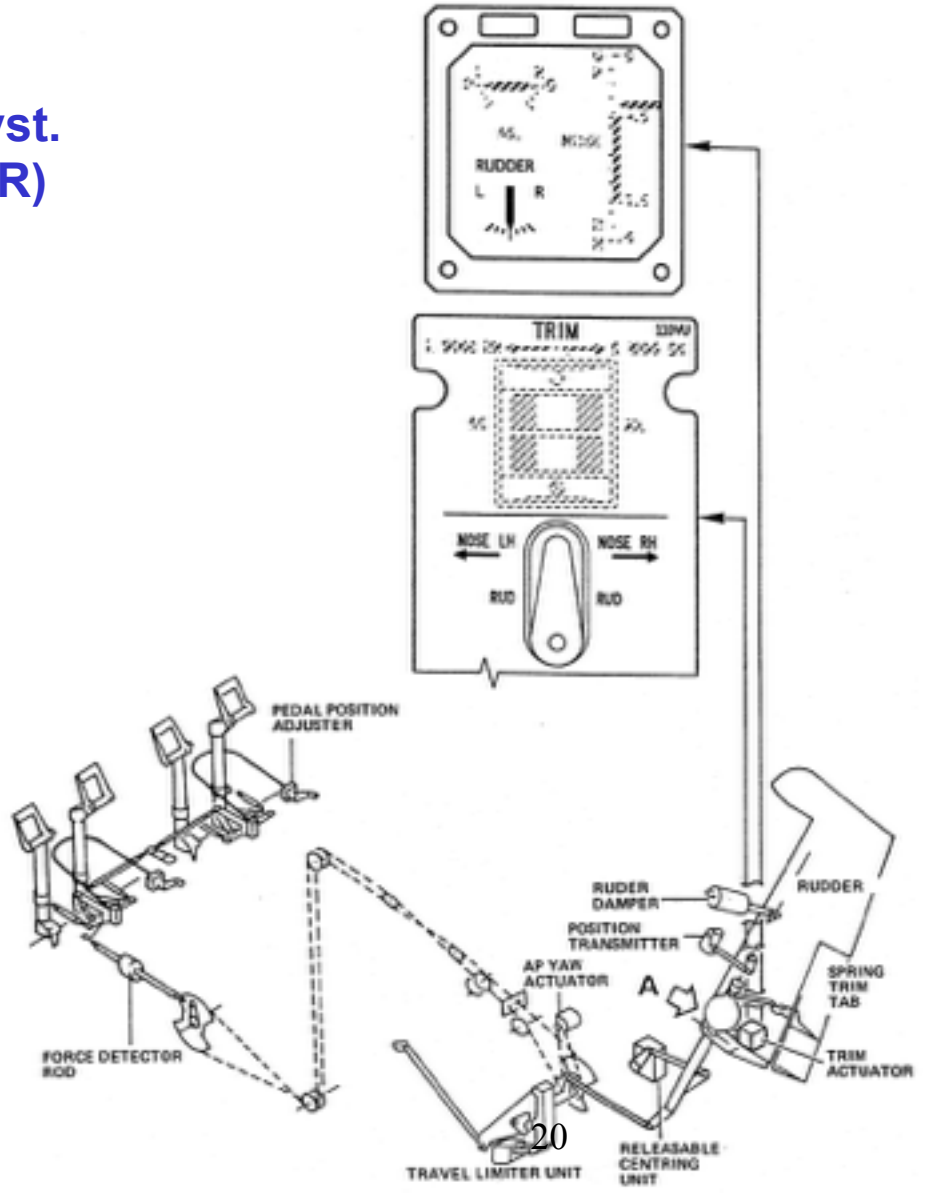
- Stick pusher actuator
- Reconditioning act.
- Trim actuator
- AP actuator



Mechanical control systems, Syst. Architecture Rudder control (ATR)



Mechanical control systems, Syst. Architecture Rudder control (ATR)

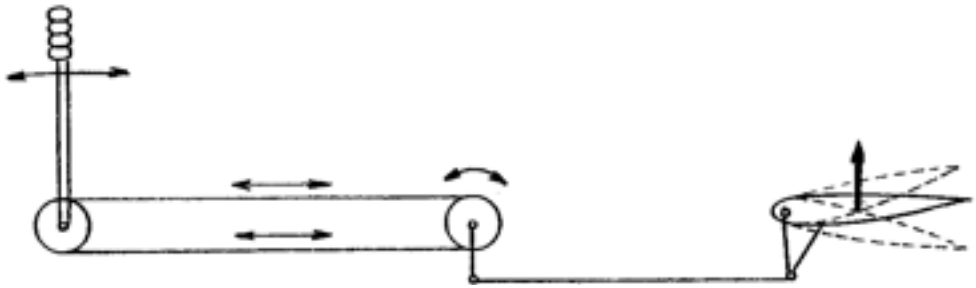


Outlines

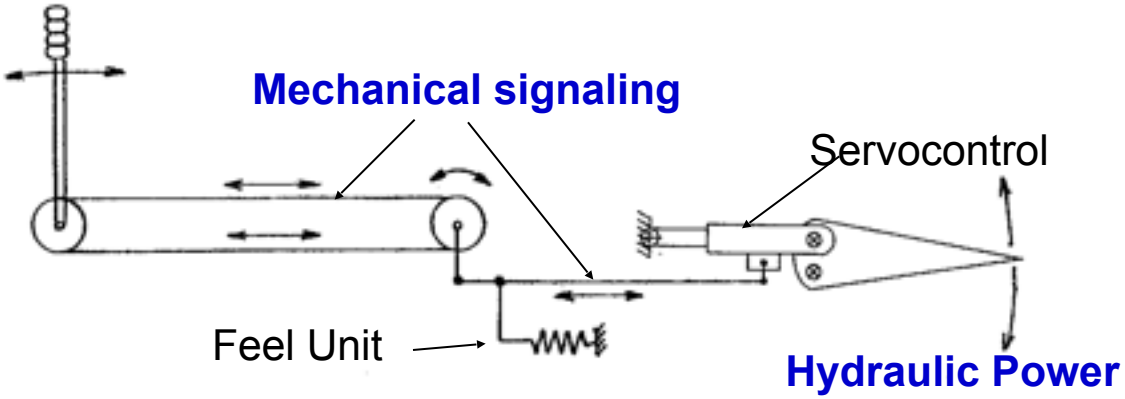
- Generals : Control surfaces & Cockpit controls
- Mechanical control systems (ATR)
- Hydromechanical control systems (A300/A310/B737 etc)
- First generation Fly by Wire systems (A320/A330/ A340/B777)
- New generation, hybrid power sources, full Fly By Wire systems (A380/others)
- Future trends, smart and more electric actuation

Hydromechanical control systems

- Basic principle



Fully mechanical system



Hydromechanical system

- Before we continue to review the hydraulically powered controls lets go through the principals of Hydraulics
- Section 5.1

Outlines

- Generals : Control surfaces & Cockpit controls
- Mechanical control systems (ATR)
- Hydromechanical control systems (A300/A310/B737 etc)
- First generation Fly by Wire systems (A320/A330/ A340/B777)
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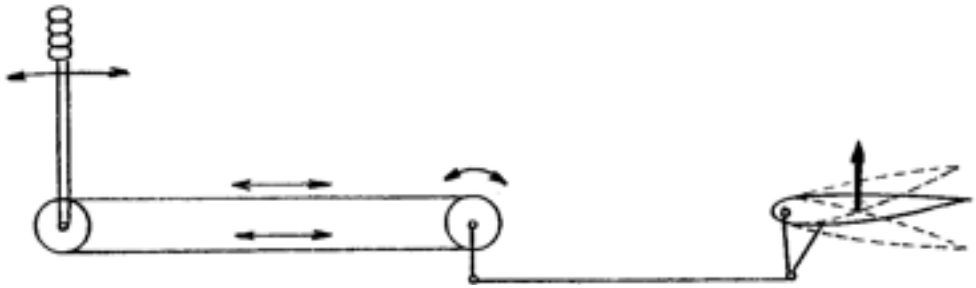
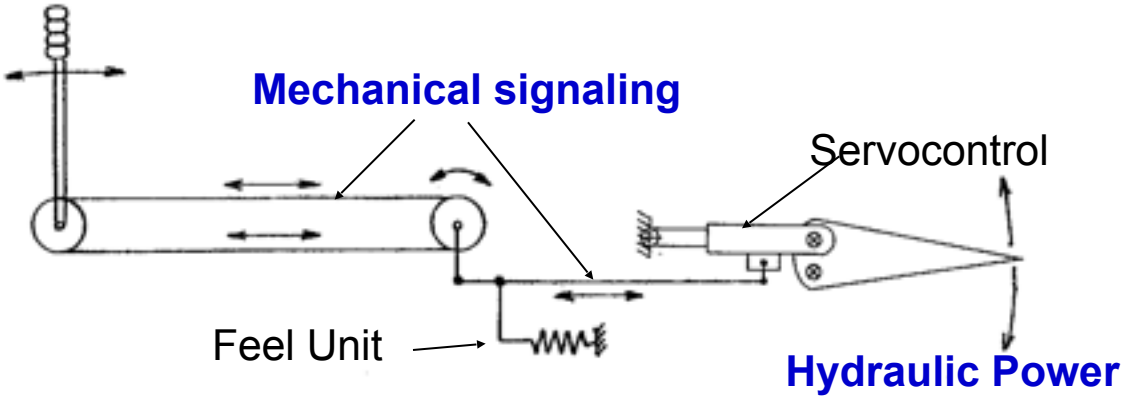
Hydromechanical control systems

- Basic principle



Fully mechanical system

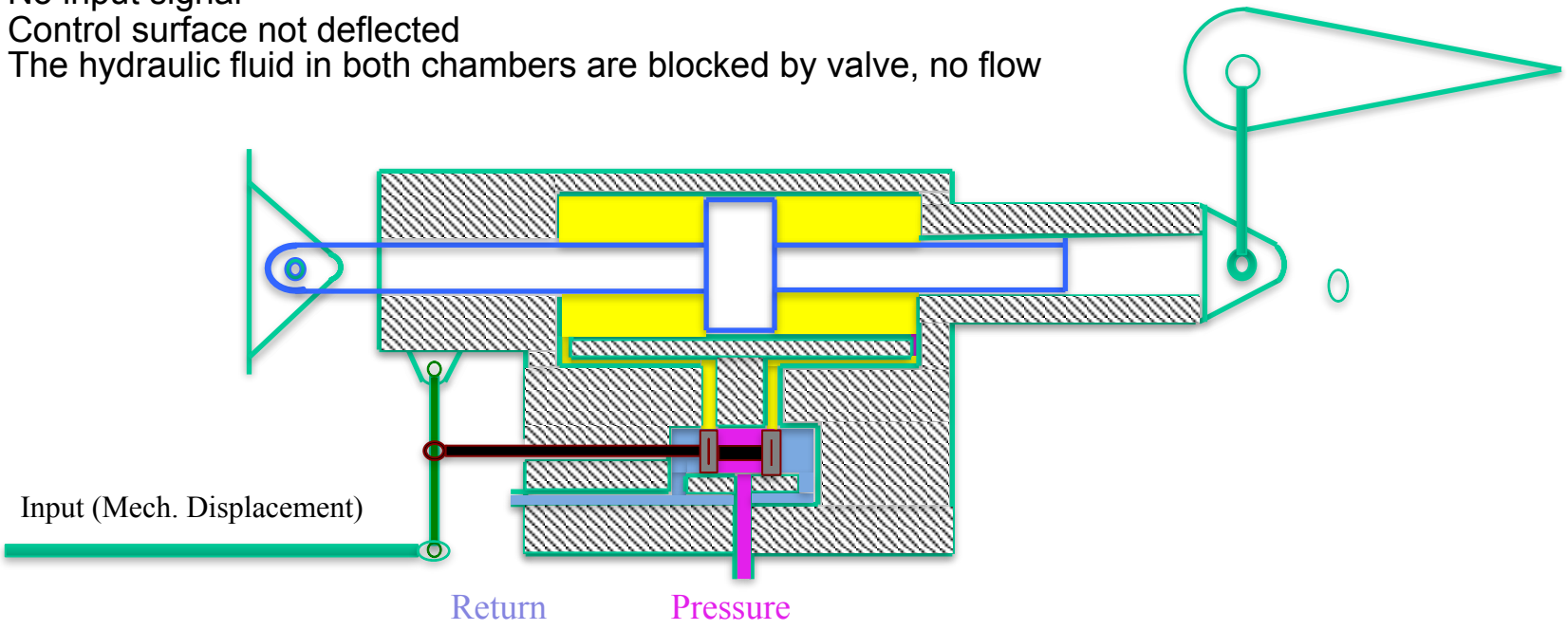


Hydromechanical system

Hydromechanical control systems

The hydraulic servocontrol, Basic principle of the control mechanism.
A typical catuator shown in neutral position

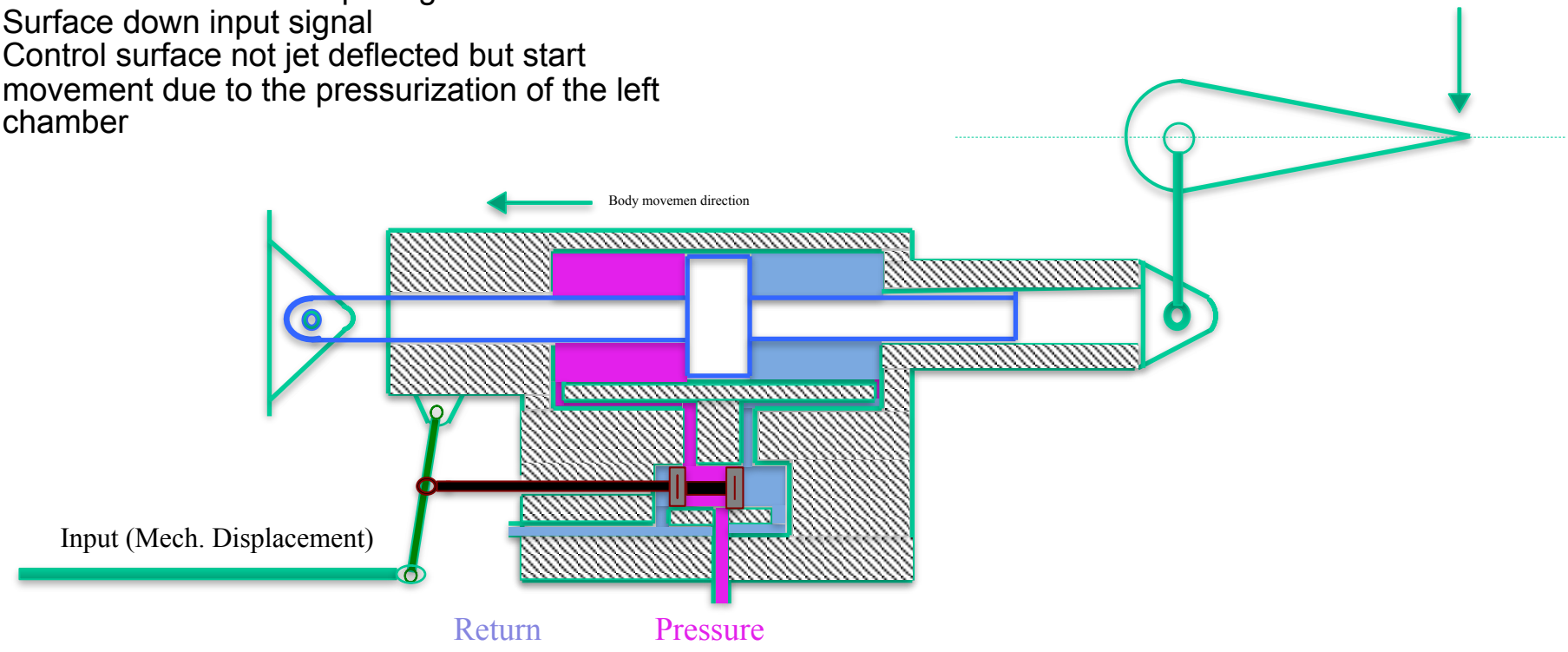
- No input signal
- Control surface not deflected
- The hydraulic fluid in both chambers are blocked by valve, no flow



Hydromechanical control systems

The hydraulic servo control, Basic principle
The actuator received an input signal

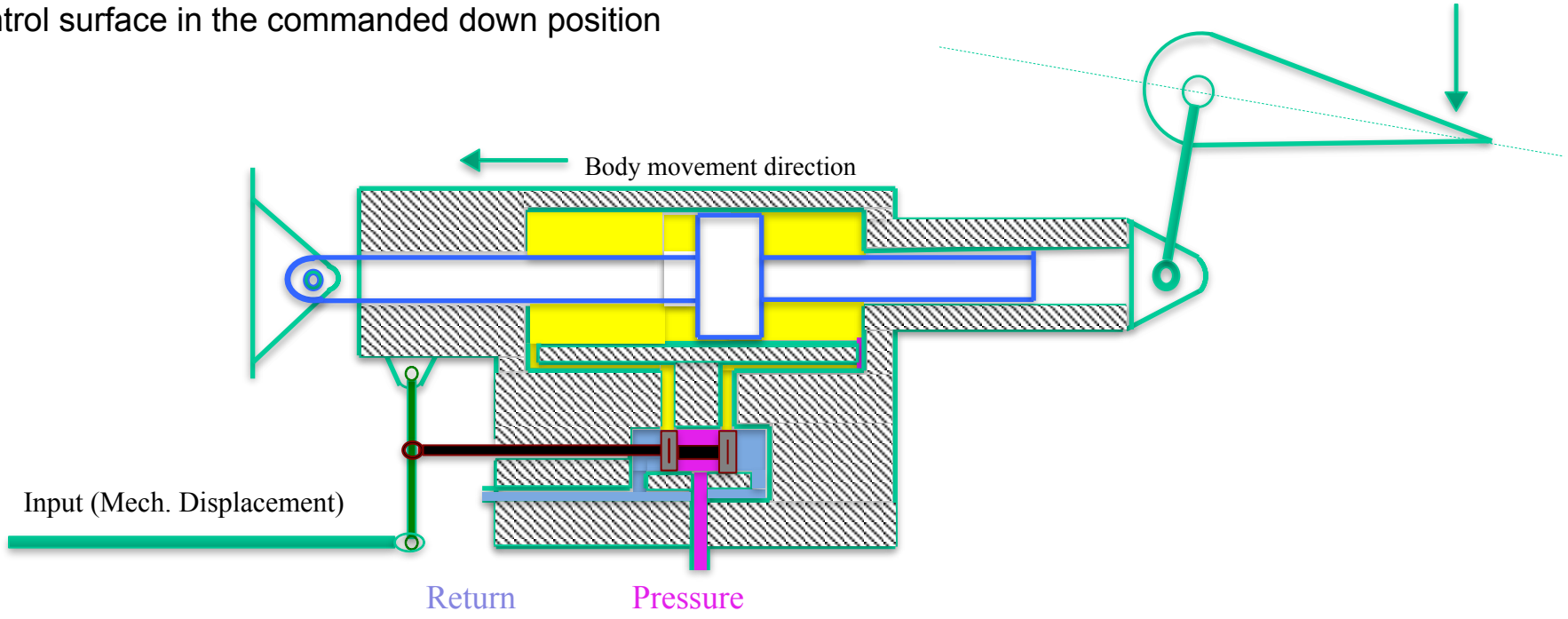
- Surface down input signal
- Control surface not jet deflected but start movement due to the pressurization of the left chamber



Hydromechanical control systems

The hydraulic servo control, Basic principle

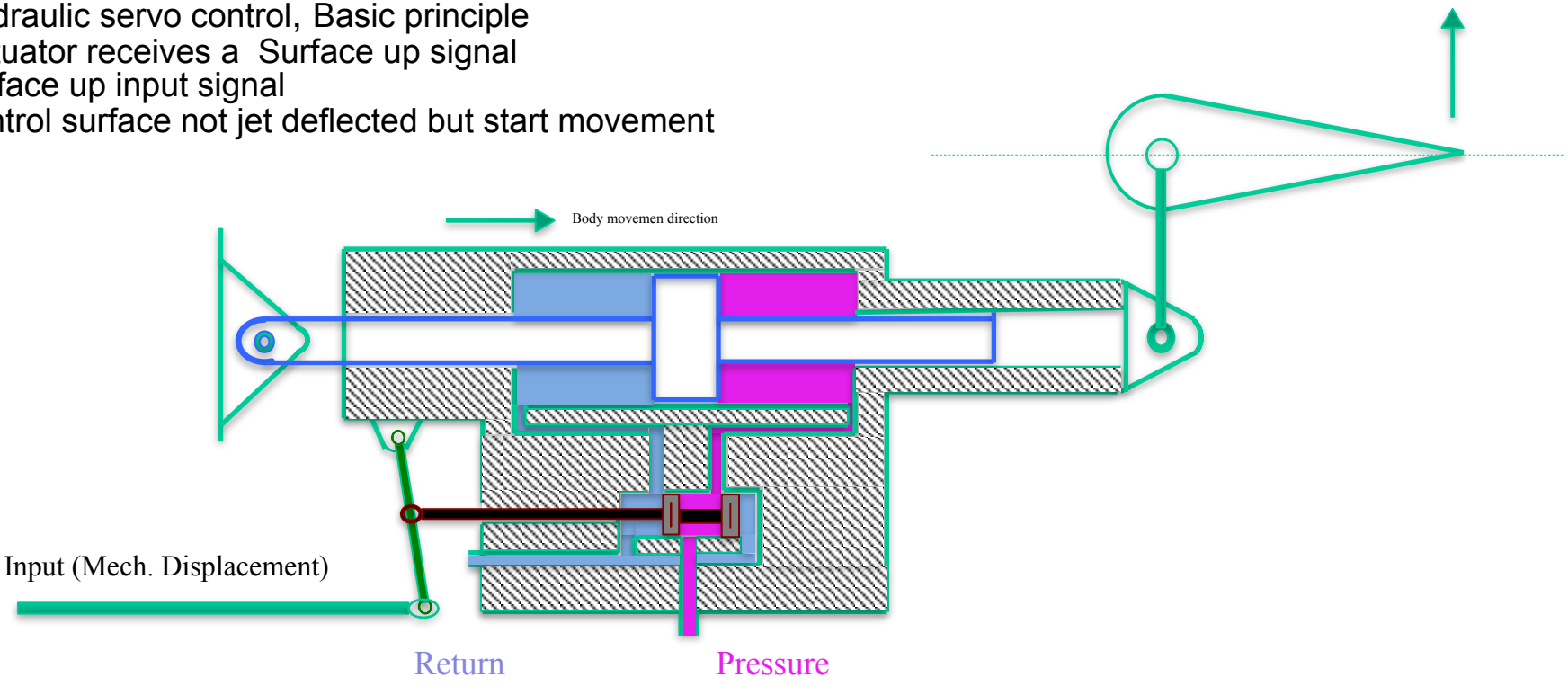
- Input leaver returns to neutral position
- Servo valve closed
- Control surface in the commanded down position



Hydromechanical control systems

The hydraulic servo control, Basic principle
The actuator receives a Surface up signal

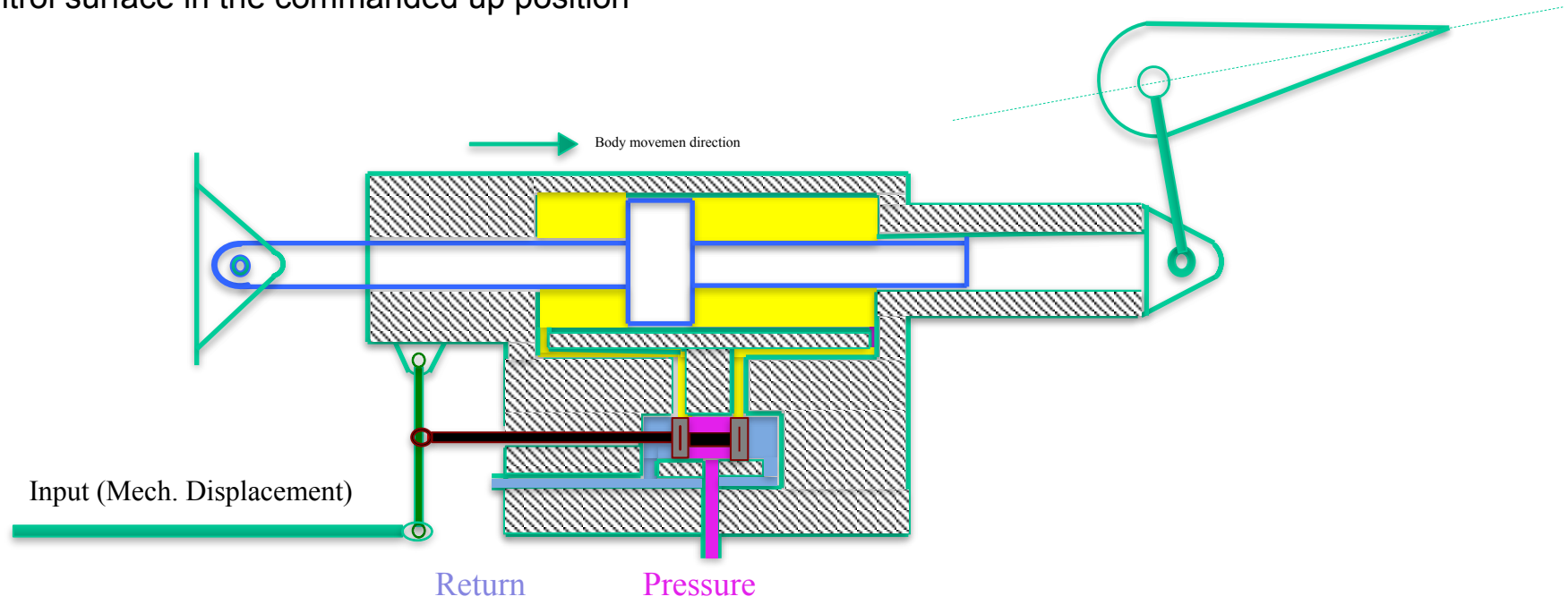
- Surface up input signal
- Control surface not jet deflected but start movement



Hydromechanical control systems,

The hydraulic servo control, Basic principle

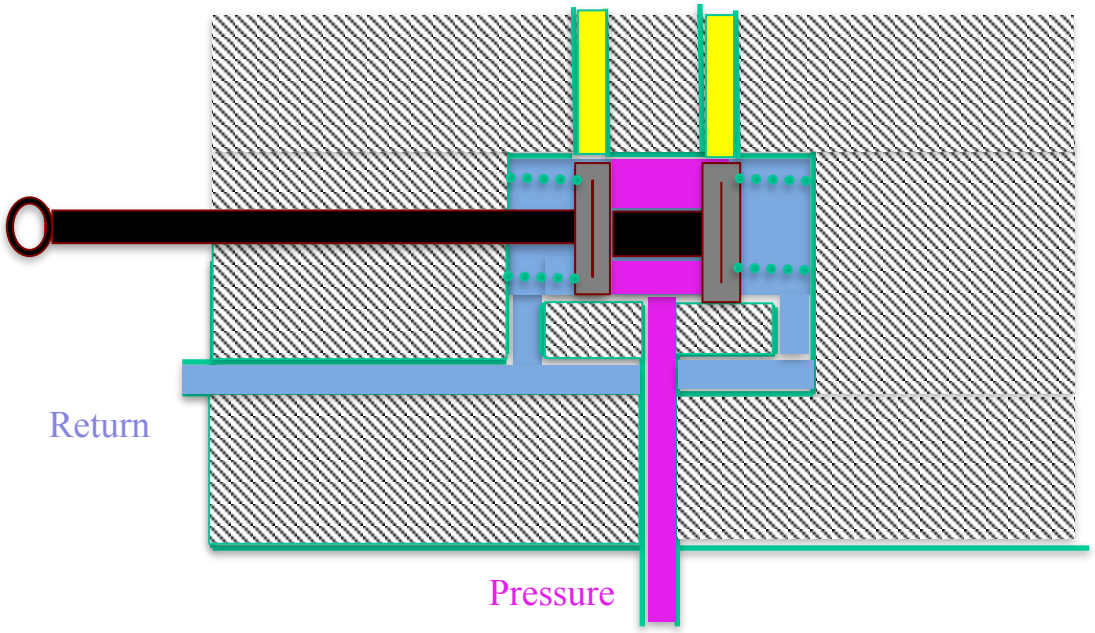
- Input leaver returns to neutral position
- Servo valve closed
- Control surface in the commanded up position



Hydromechanical control systems

Servo valve features

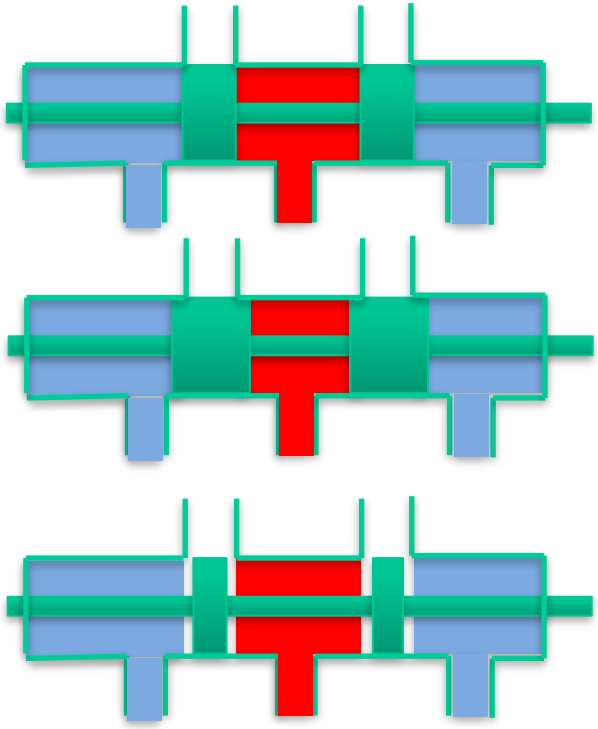
- Spool centering mechanism
  - Centered by mechanical Springs or by hydraulic pressure



Hydromechanical control systems

Servo valve features

- The size of the “valve piston” influence the dynamic behavior of the actuator



Neutral, immediate reaction to input signal

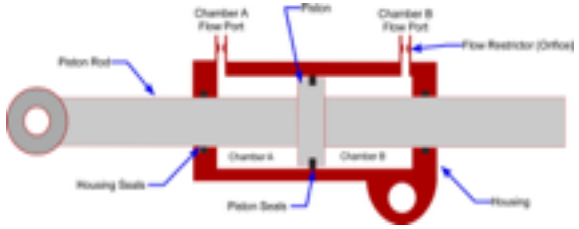
Overlapping, delayed reaction to input signal

Underlapping, accelerated reaction to input signal

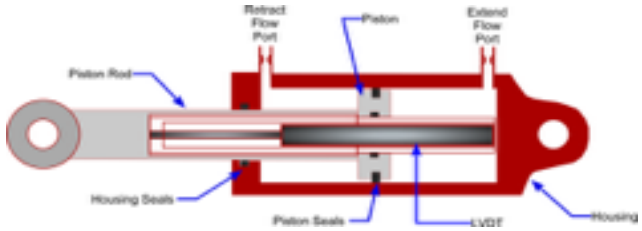
Hydromechanical control systems

Actuator features

- There are an infinite number of actuator design available for the different number of applications, a few typical ones are shown



Linear unbalanced actuator

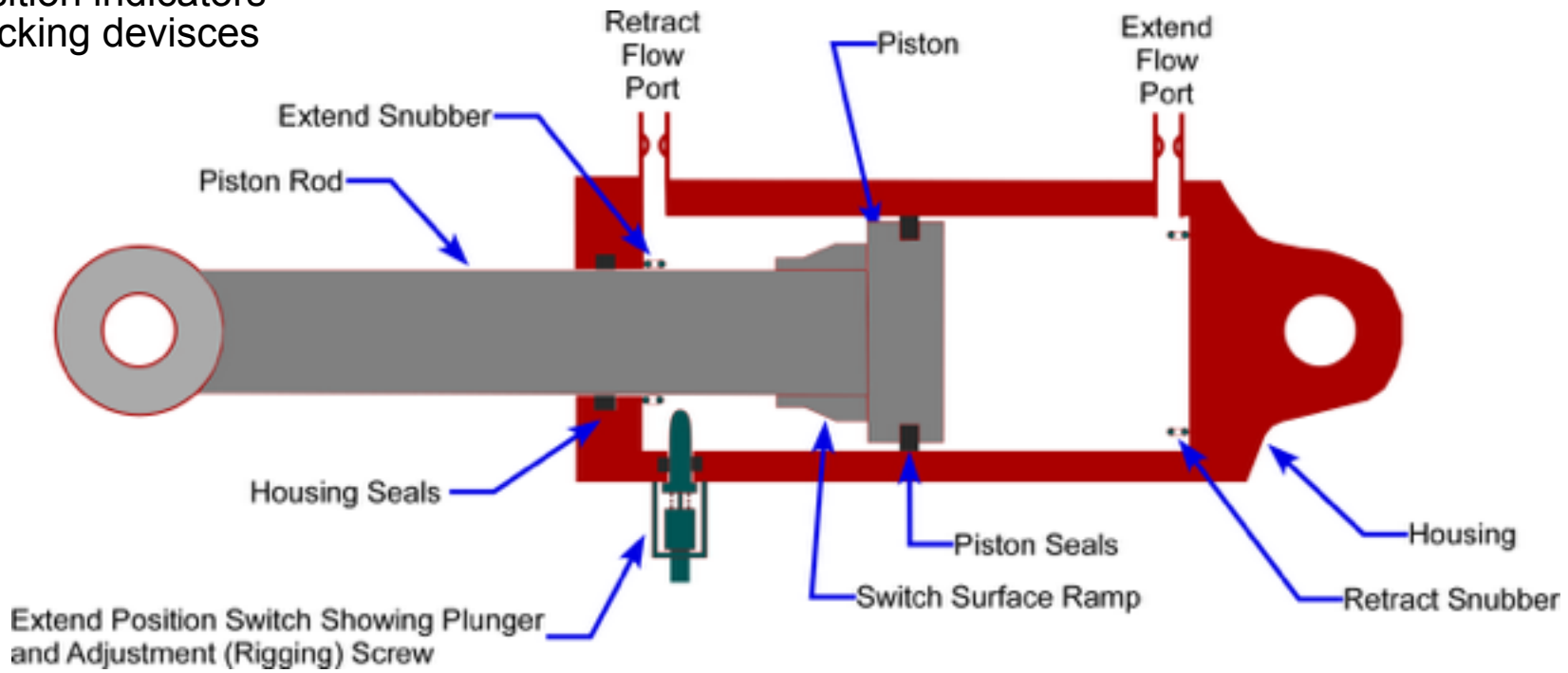


Balanced actuator with integrated position transcducer

Tandem design, act with double hydraulic system and double control valve

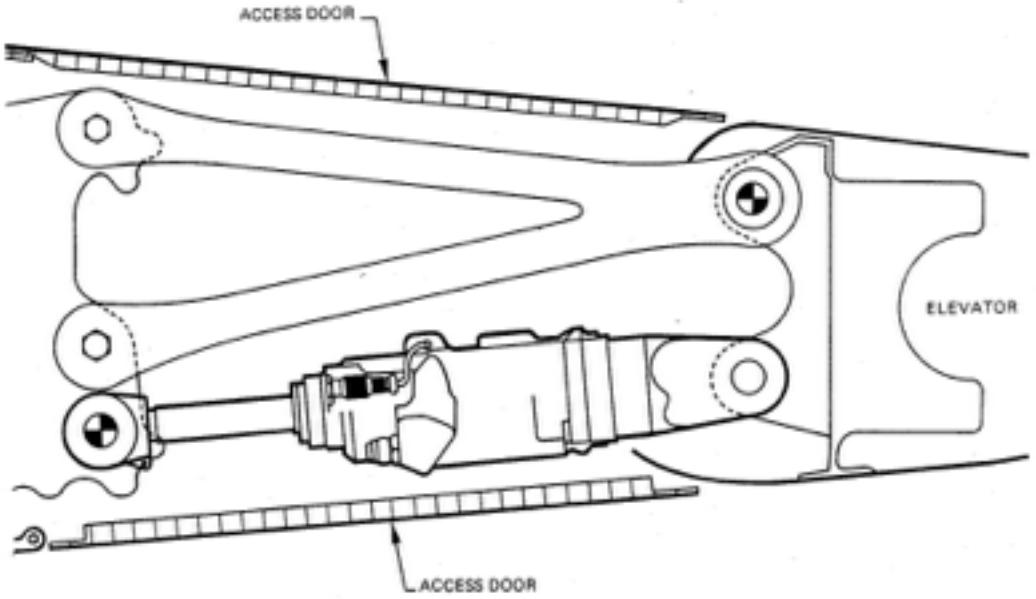
Hydromechanical control systems

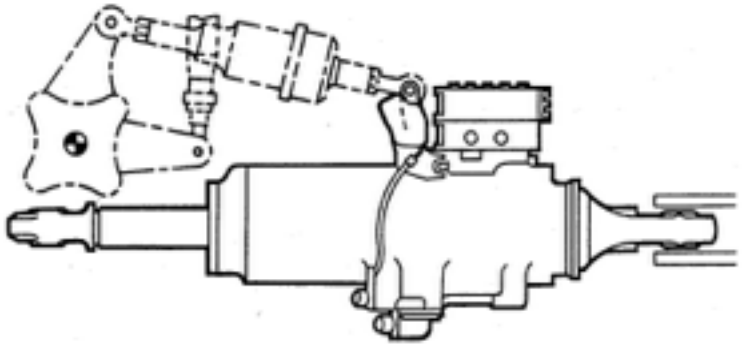
Actuator features
- Seals
- End position damping devices
- Position indicators
- Blocking devisces



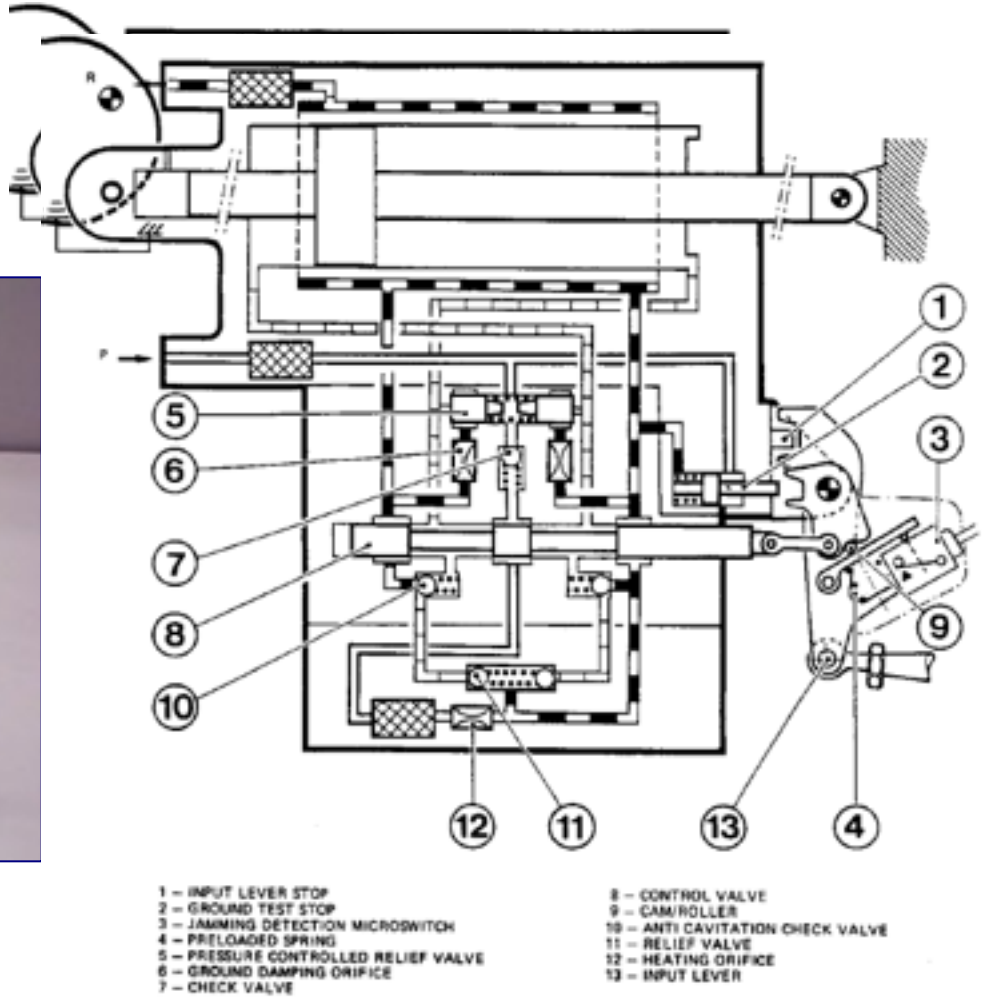
Hydromechanical control systems

- Key component: The hydraulic servocontrol



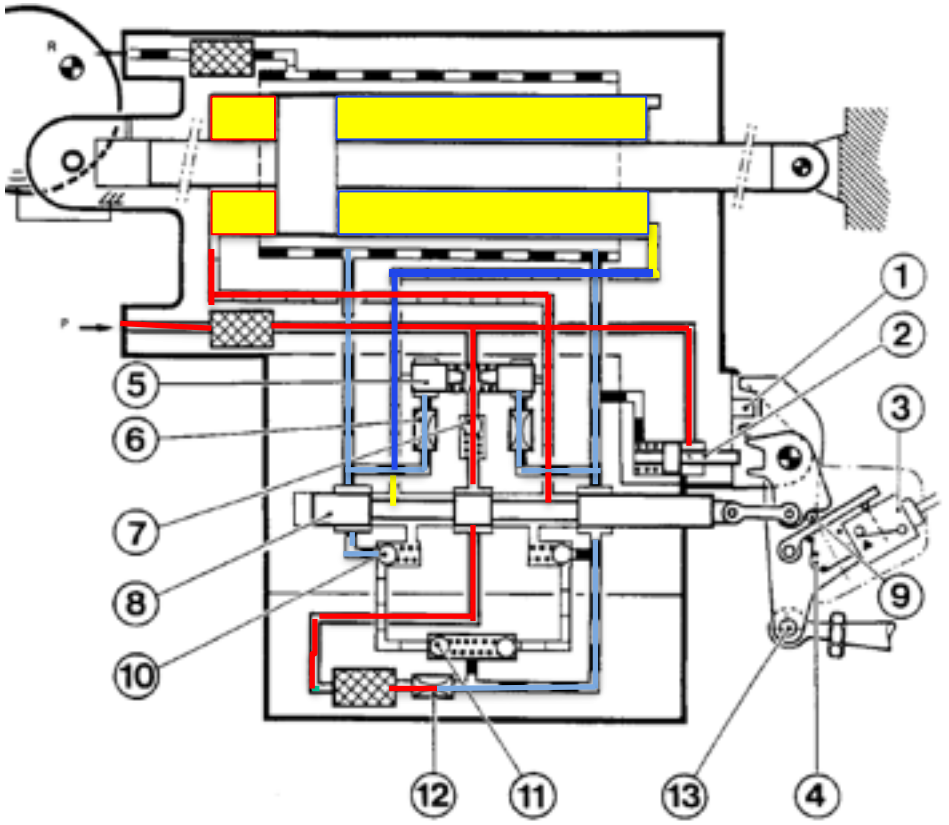


A300-600 Rudder servocontrol



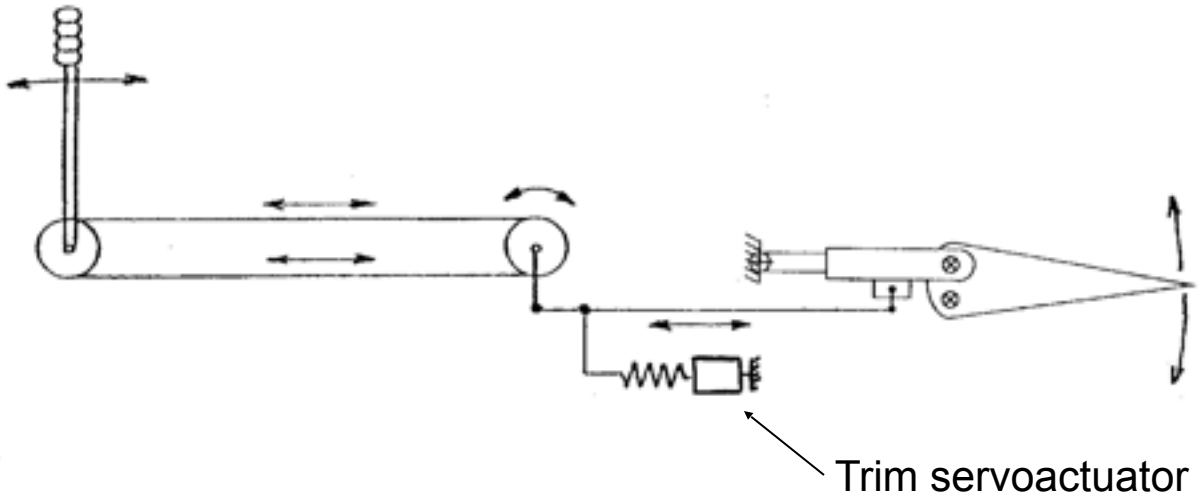
Hydromechanical control systems,

1. Input lever stop
2. Ground test stop
3. Jamming detection switch
4. Preloaded spring
5. Pressure control relive valve
6. Ground damping orifice
7. Check valve
8. Control valve
9. Cam /roler
10. Anti cavitation check valve
11. Relive valve
12. Heating orifice
13. Input lever



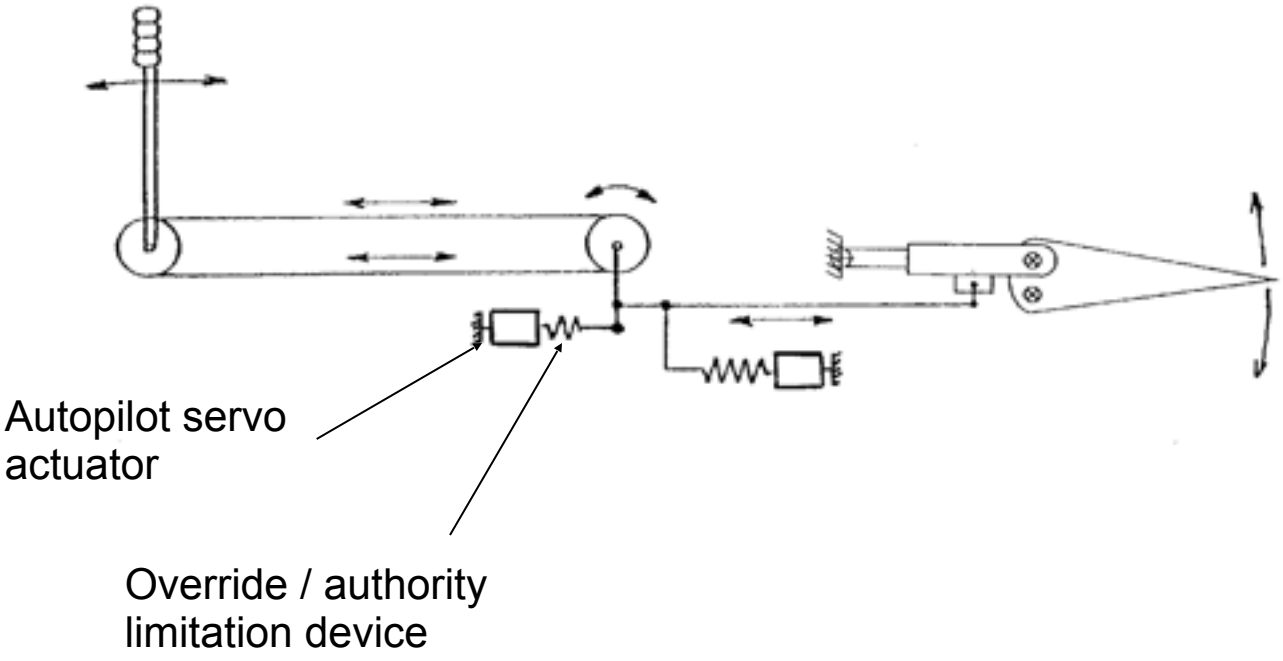
Hydromechanical control systems

- System architecture overview



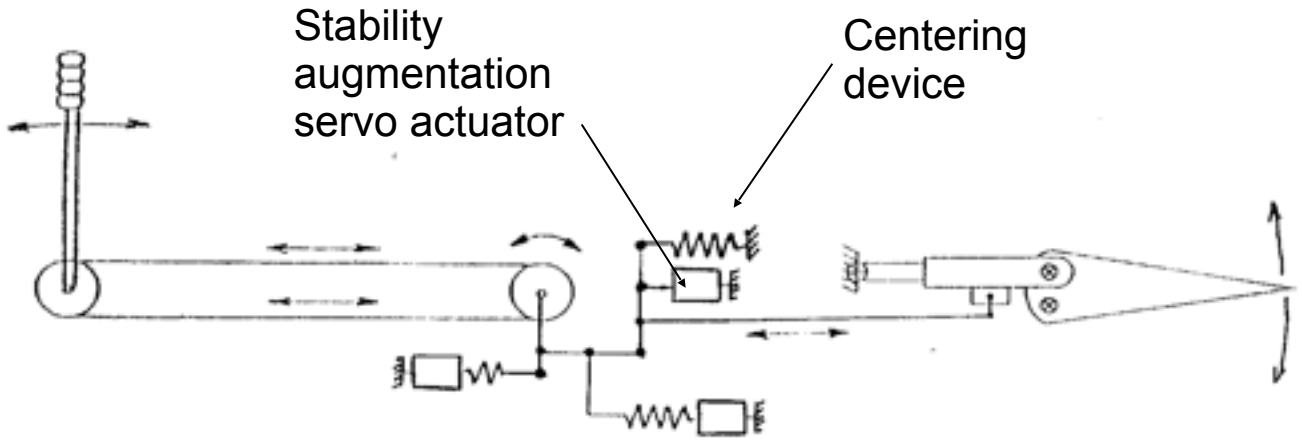
Hydromechanical control systems

- System architecture overview



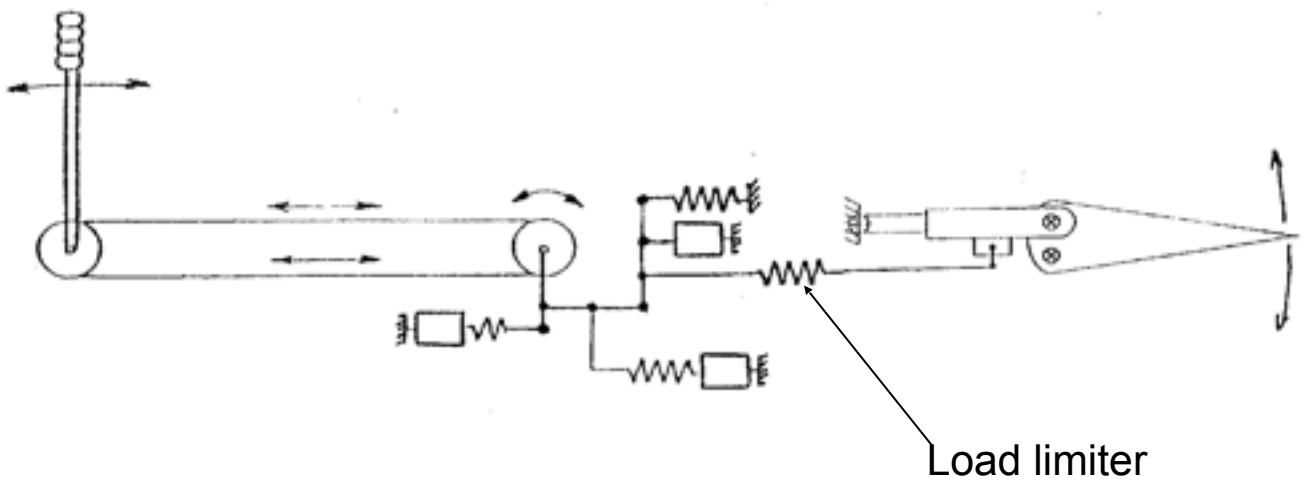
Hydromechanical control systems

- System architecture overview



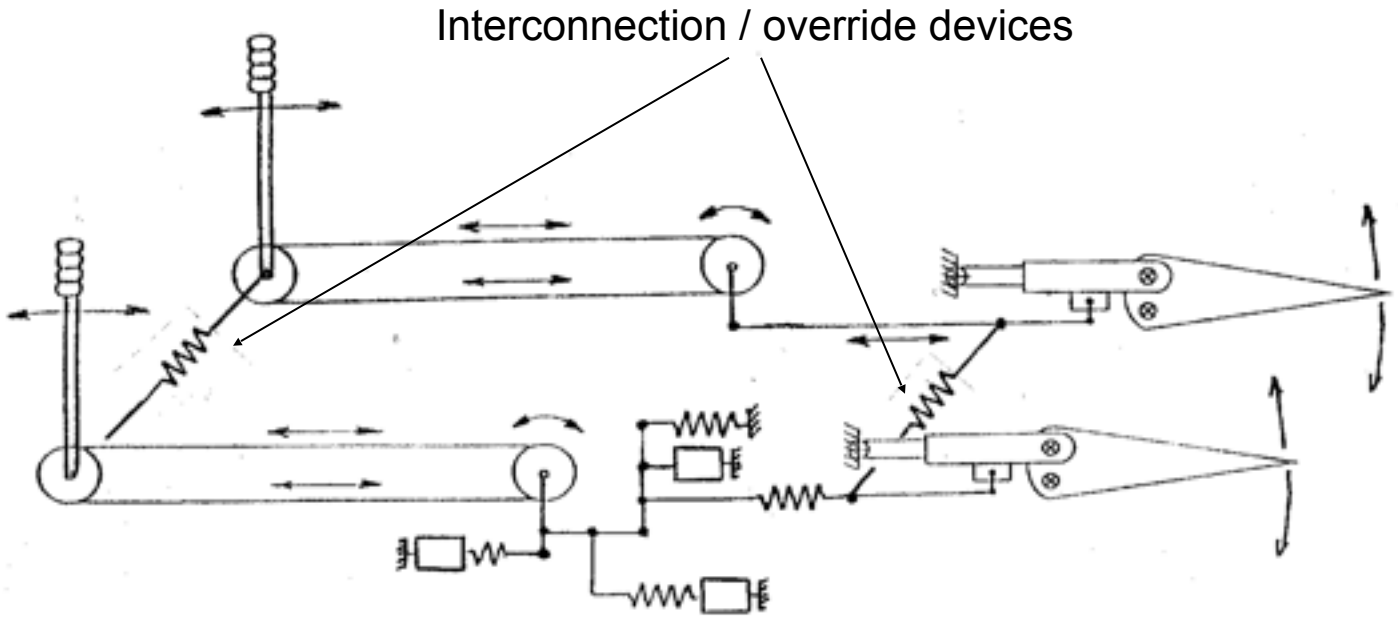
Hydromechanical control systems

- System architecture overview



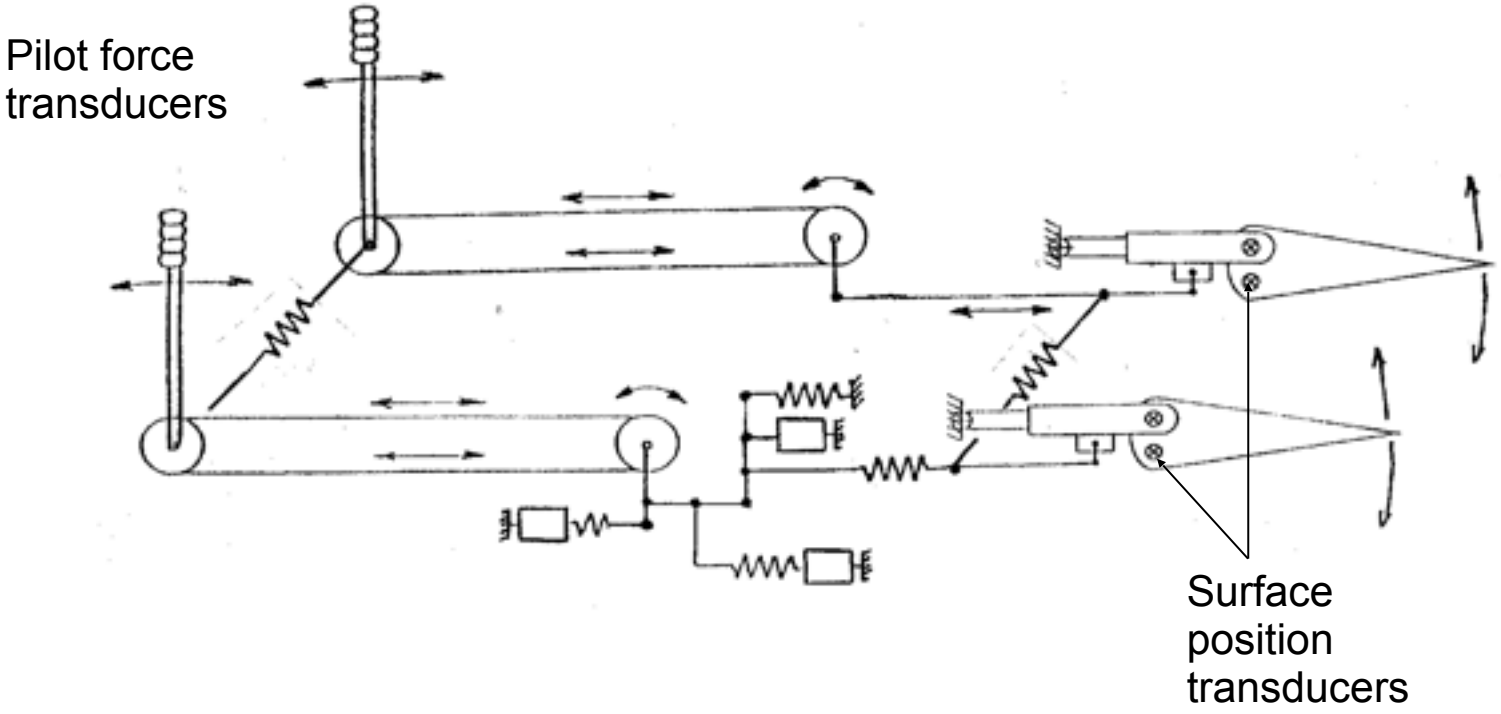
Hydromechanical control systems

- System architecture overview



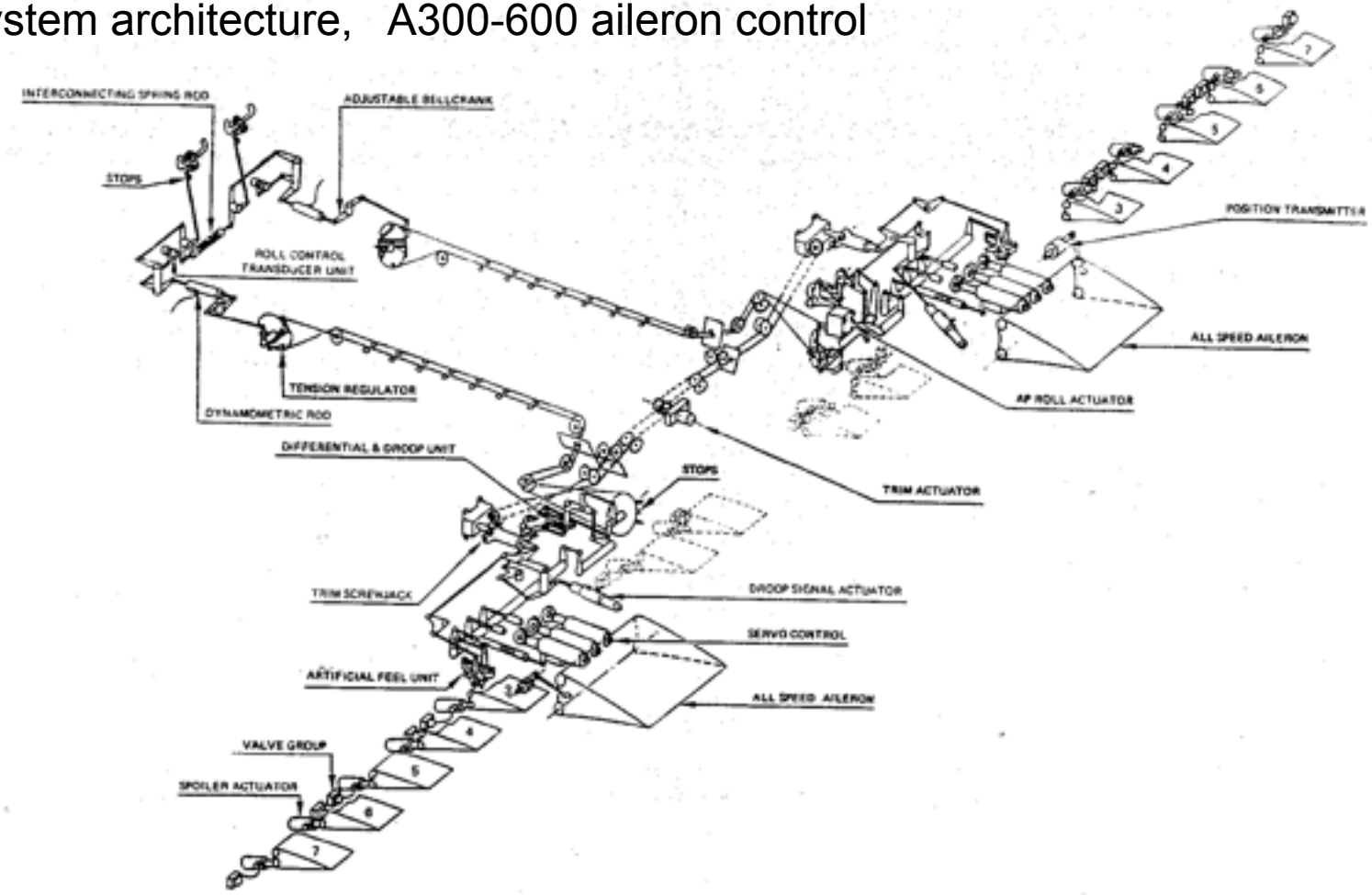
Hydromechanical control systems

- System architecture overview

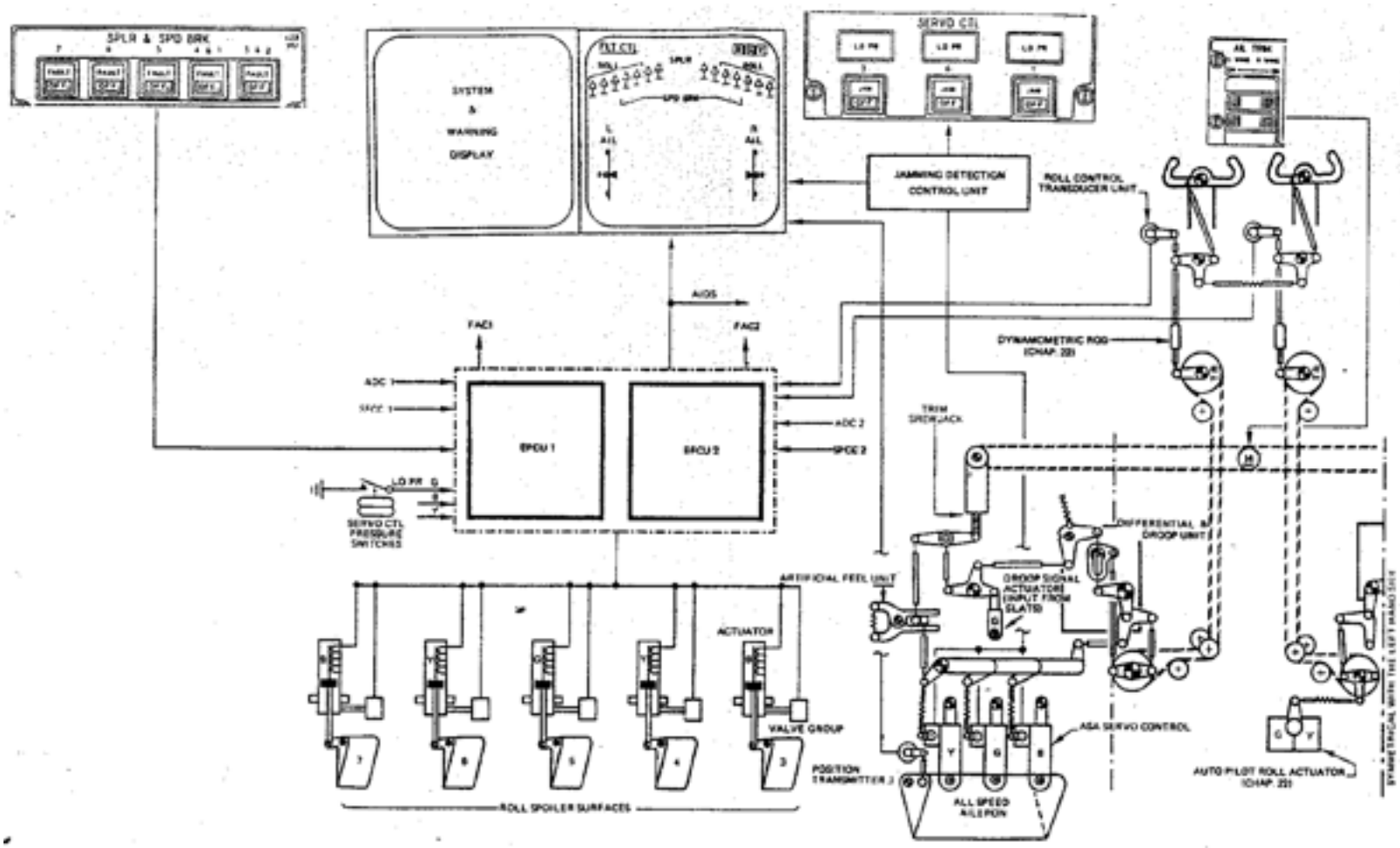


Hydromechanical control systems

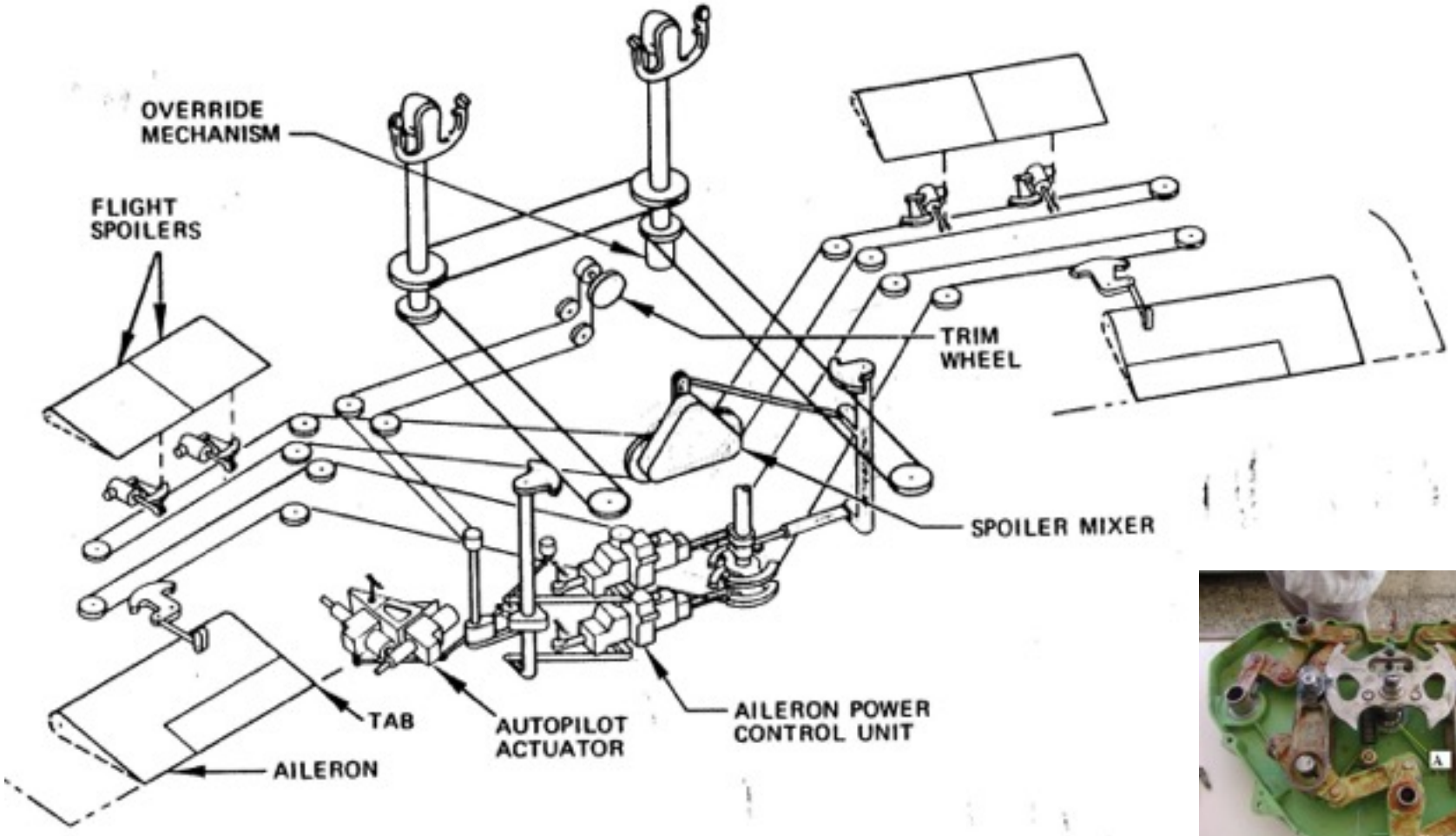
- System architecture, A300-600 aileron control



- System architecture, A300-600 aileron control
-

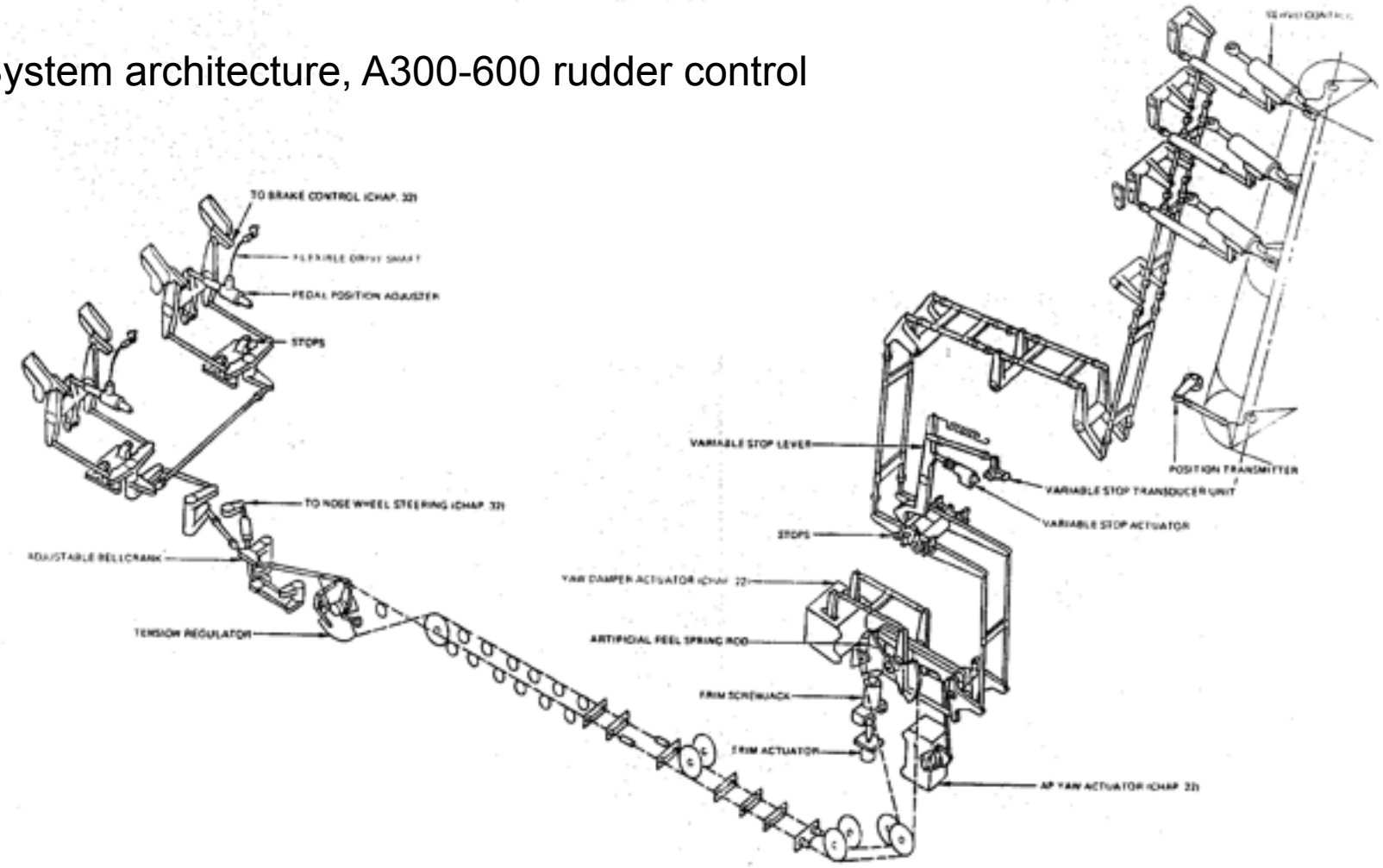


- System architecture, B737 aileron control

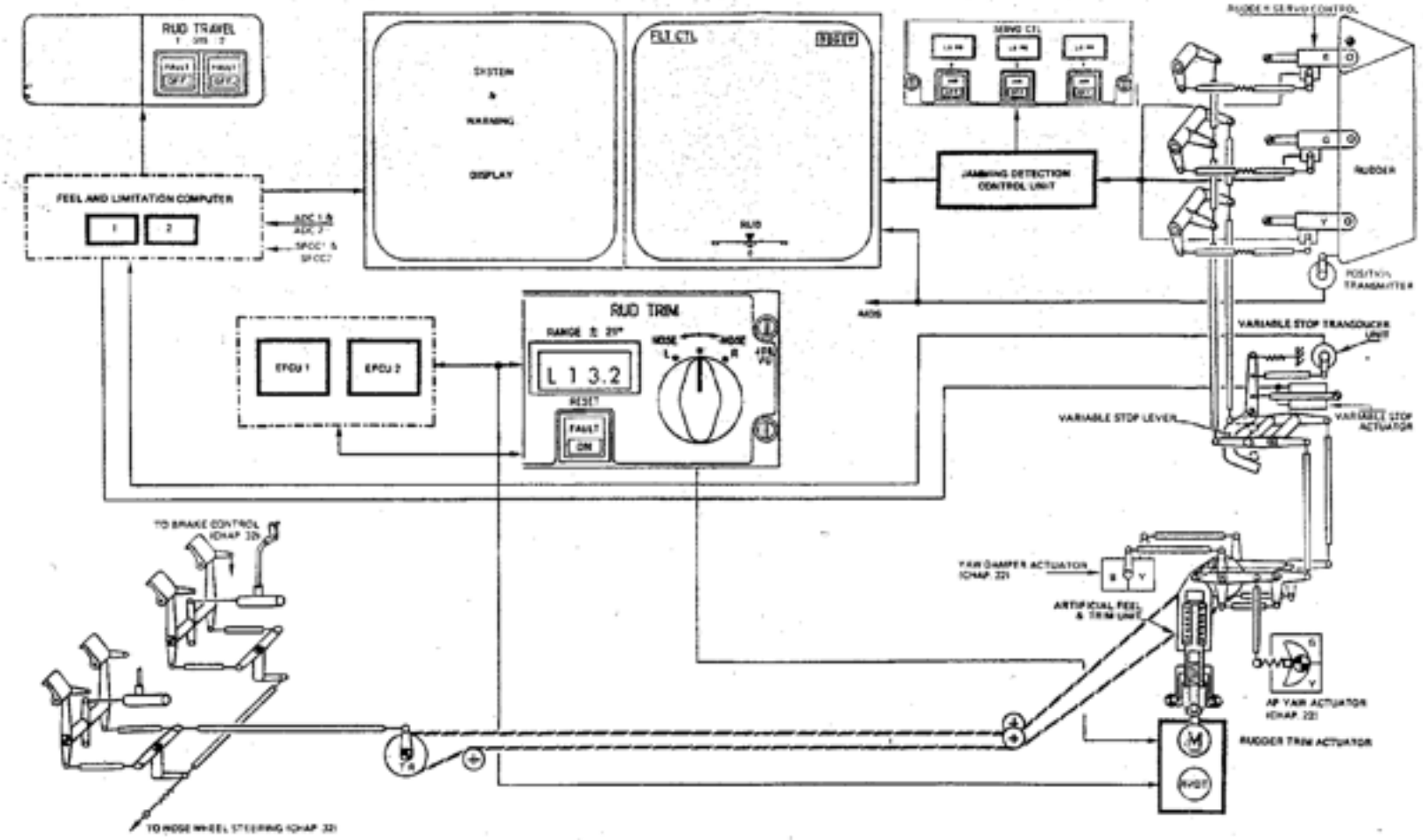


A300-600 rudder control

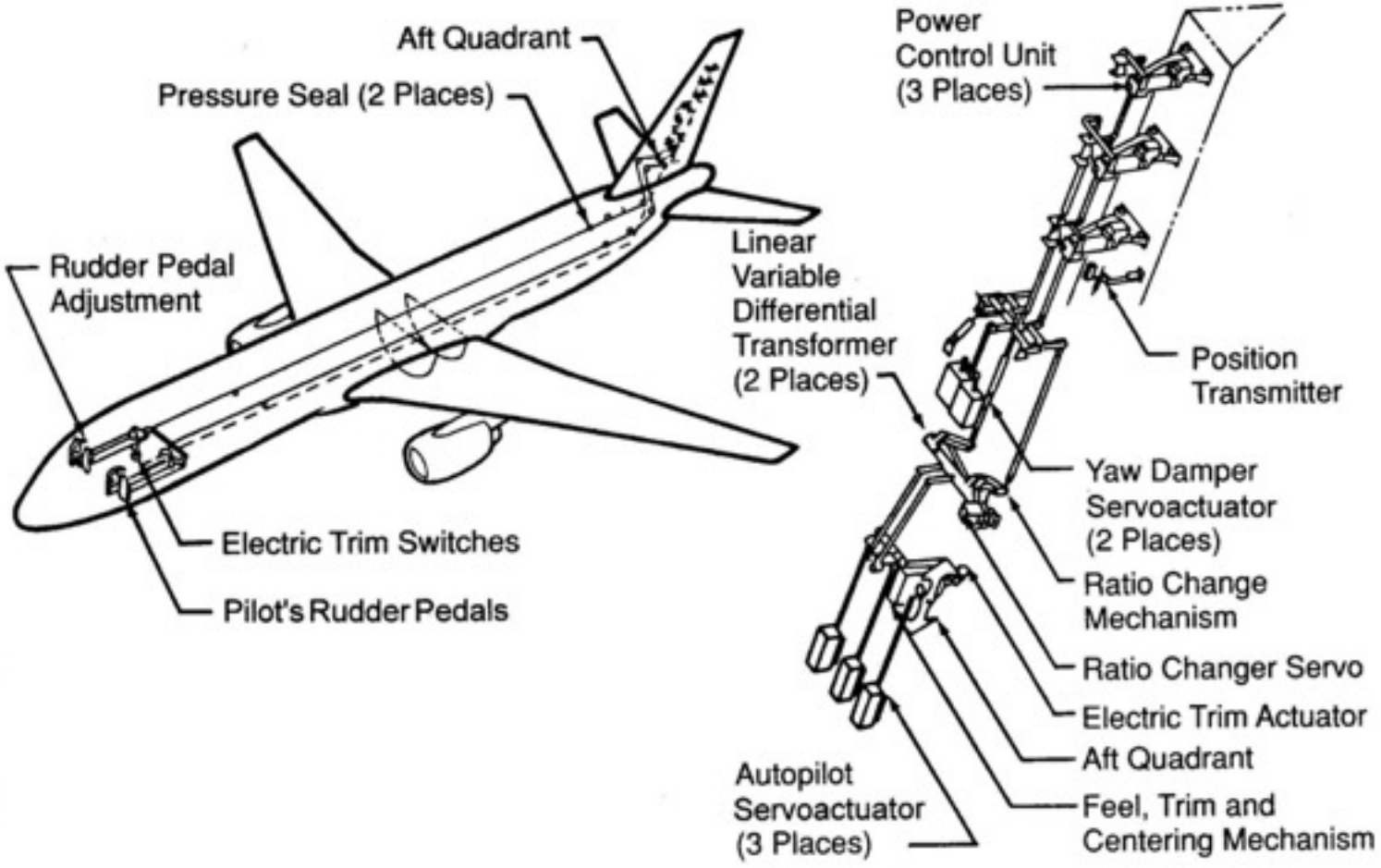
System architecture, A300-600 rudder control



- System architecture, A300-600 rudder control

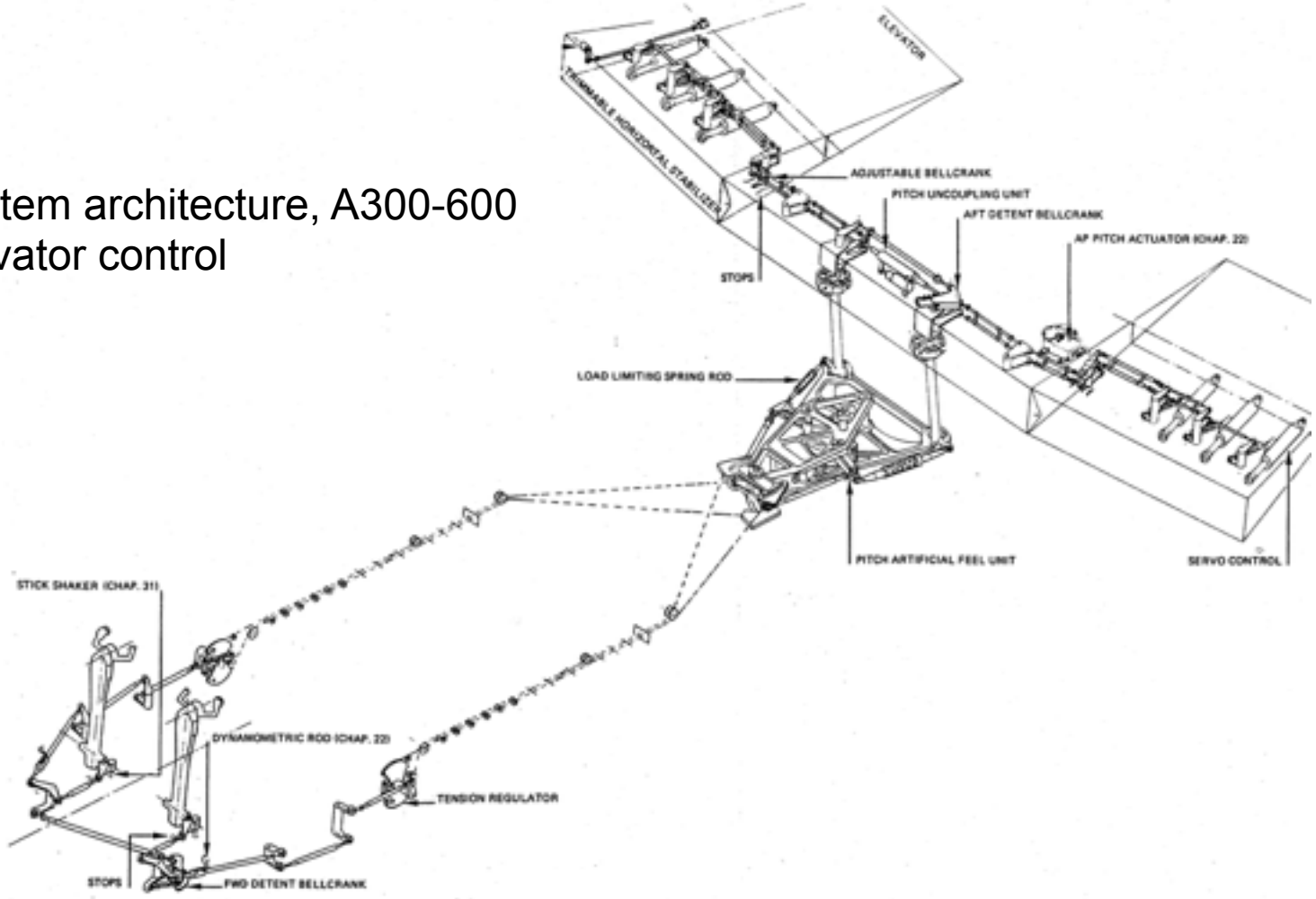


System architecture, B757 rudder control

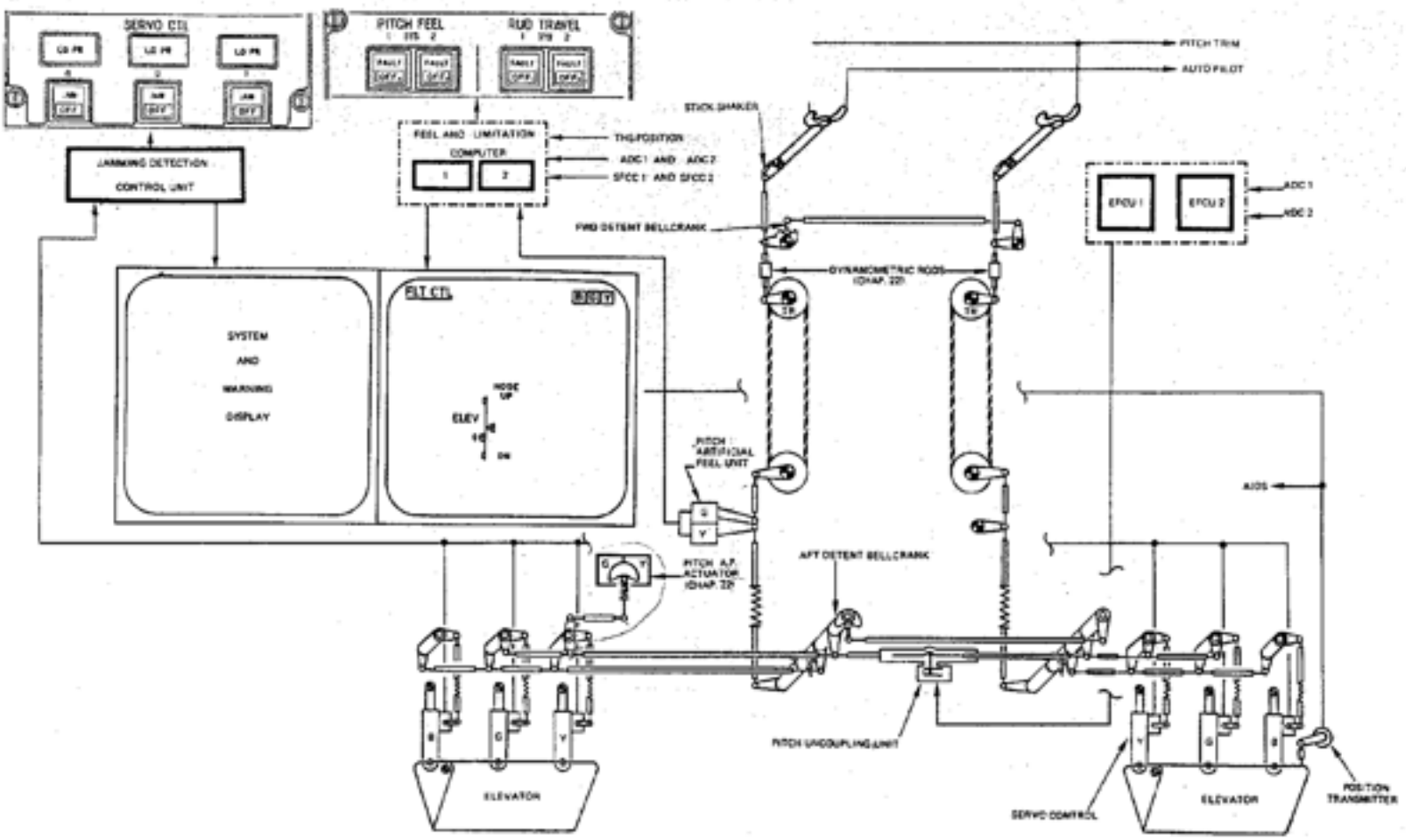


Hydromechanical control systems

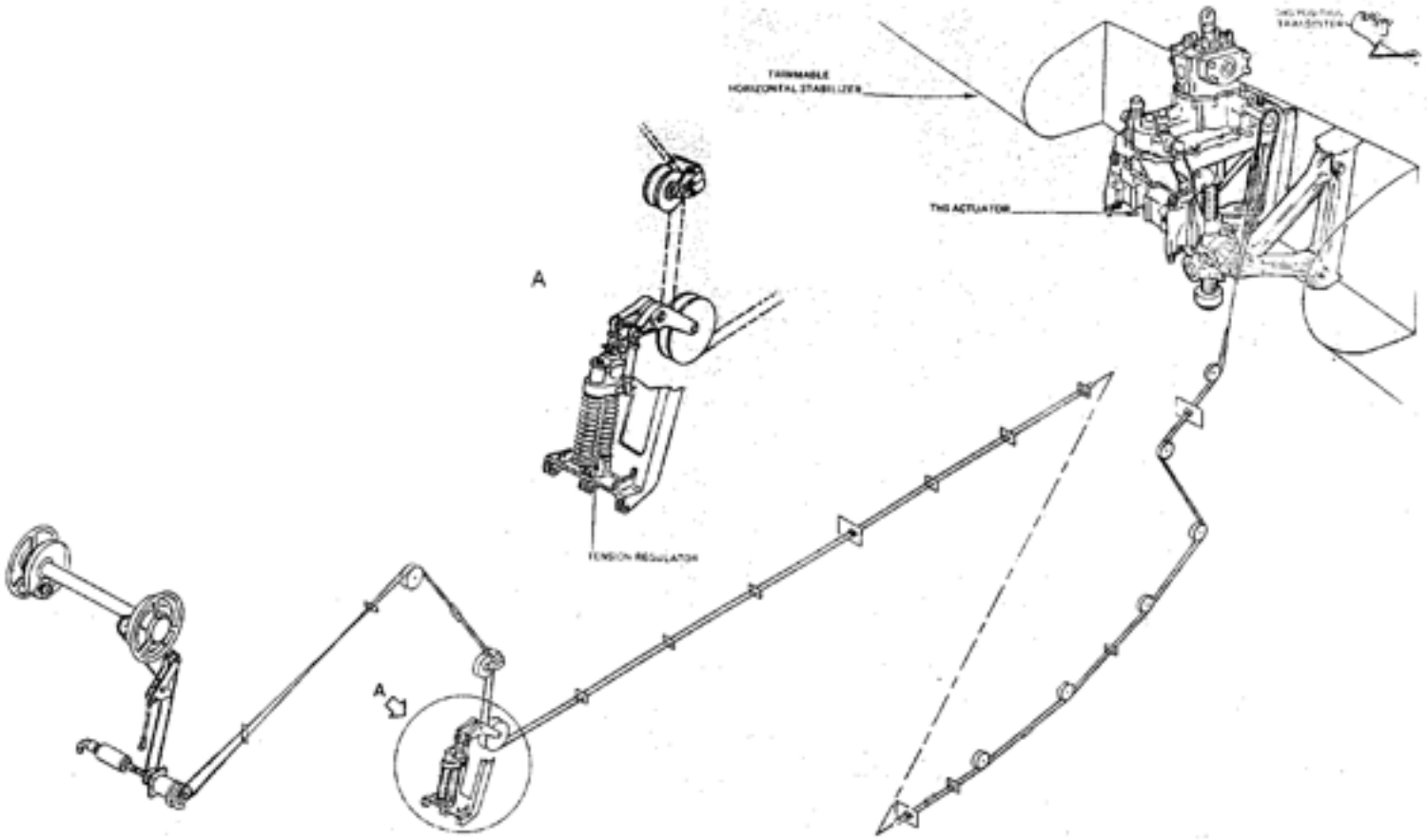
System architecture, A300-600
Elevator control



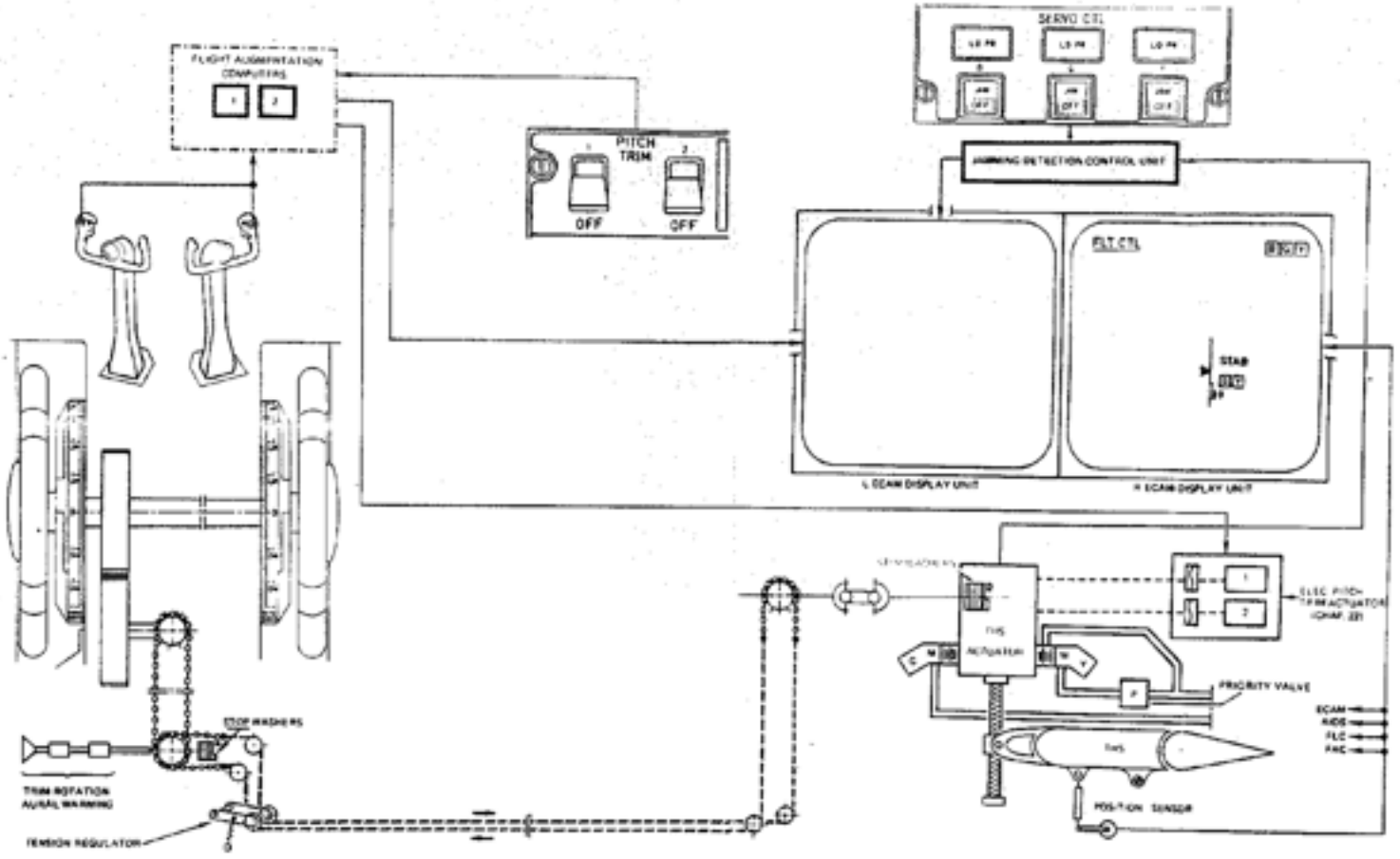
System architecture, A300-600 elevator control



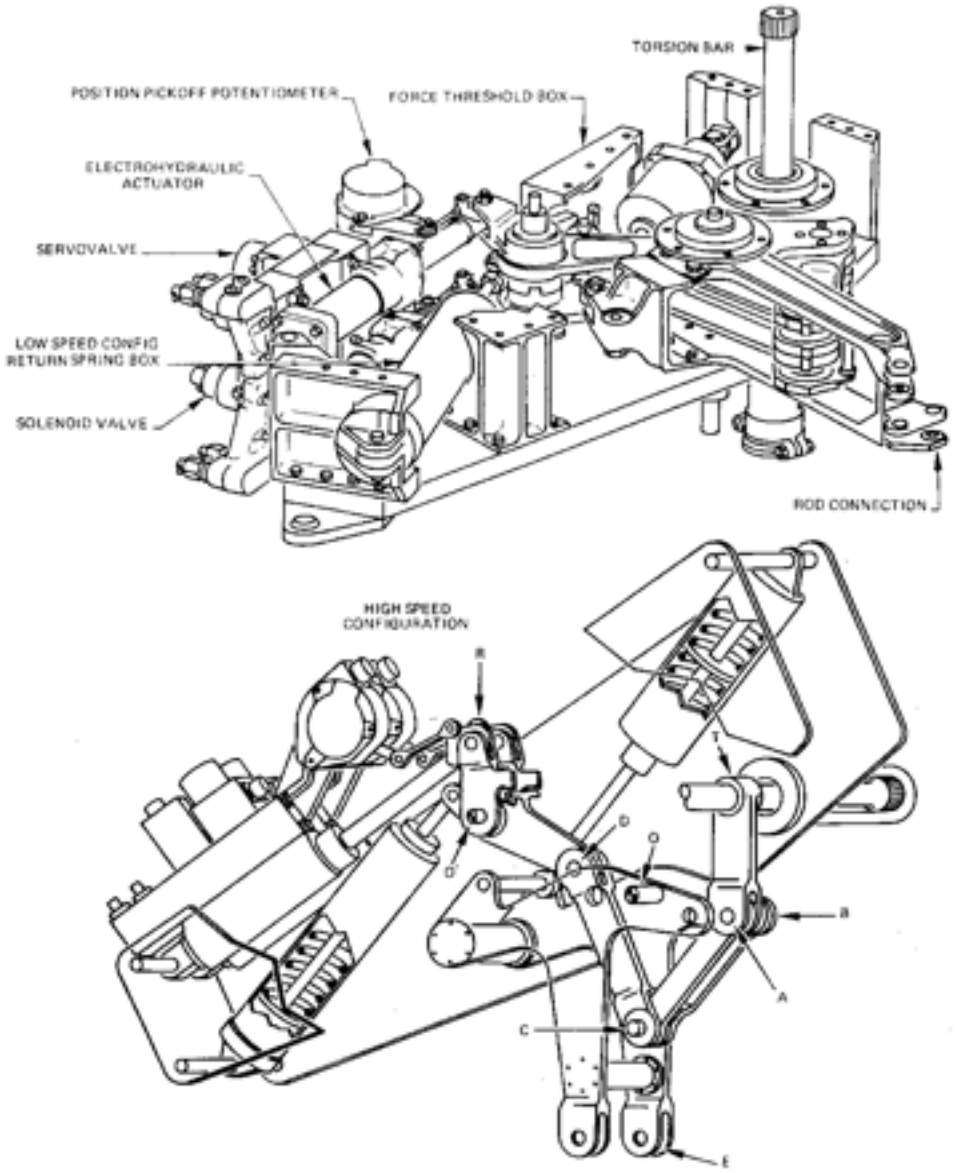
A300-600 horizontal stabilizer control



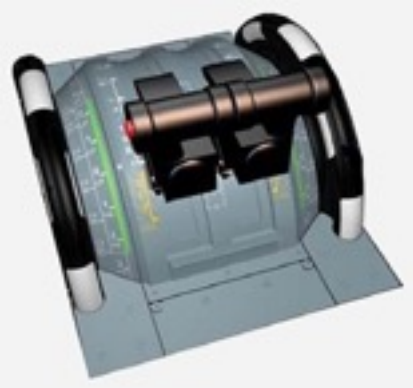
System architecture, A300-600 horizontal stabilizer control

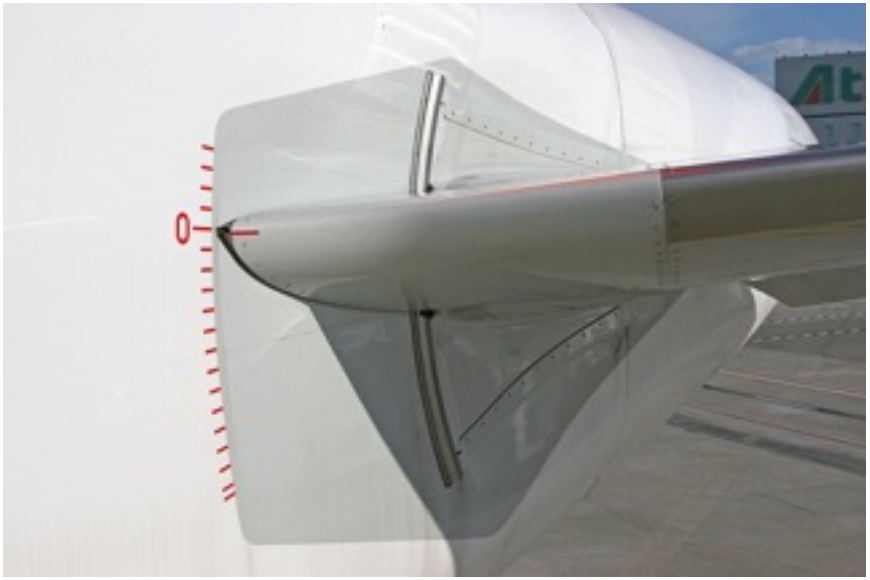


- Pitch Feel Unit
  A300/A310

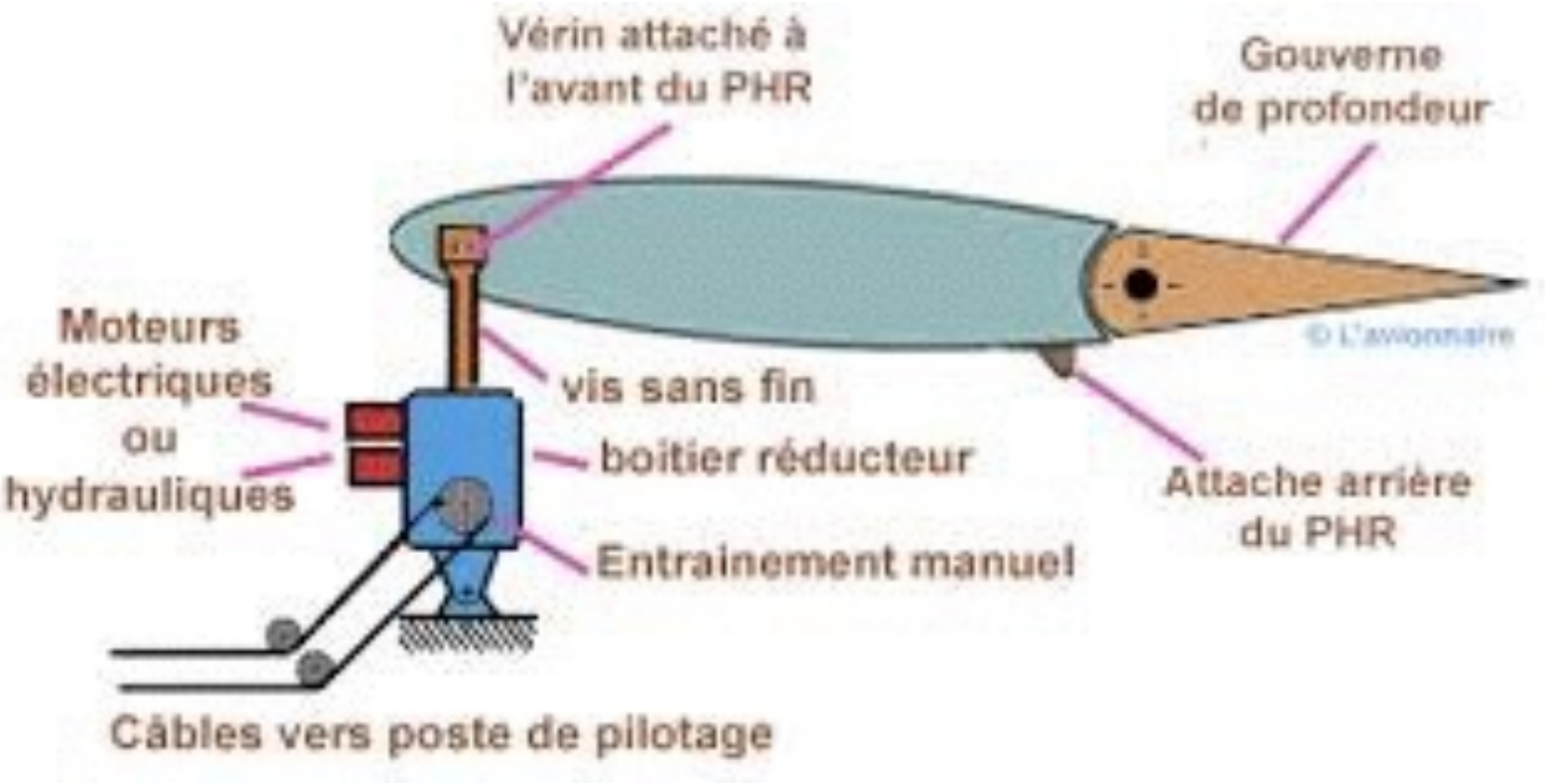


Trimable horizontal Stabilizer Actuator

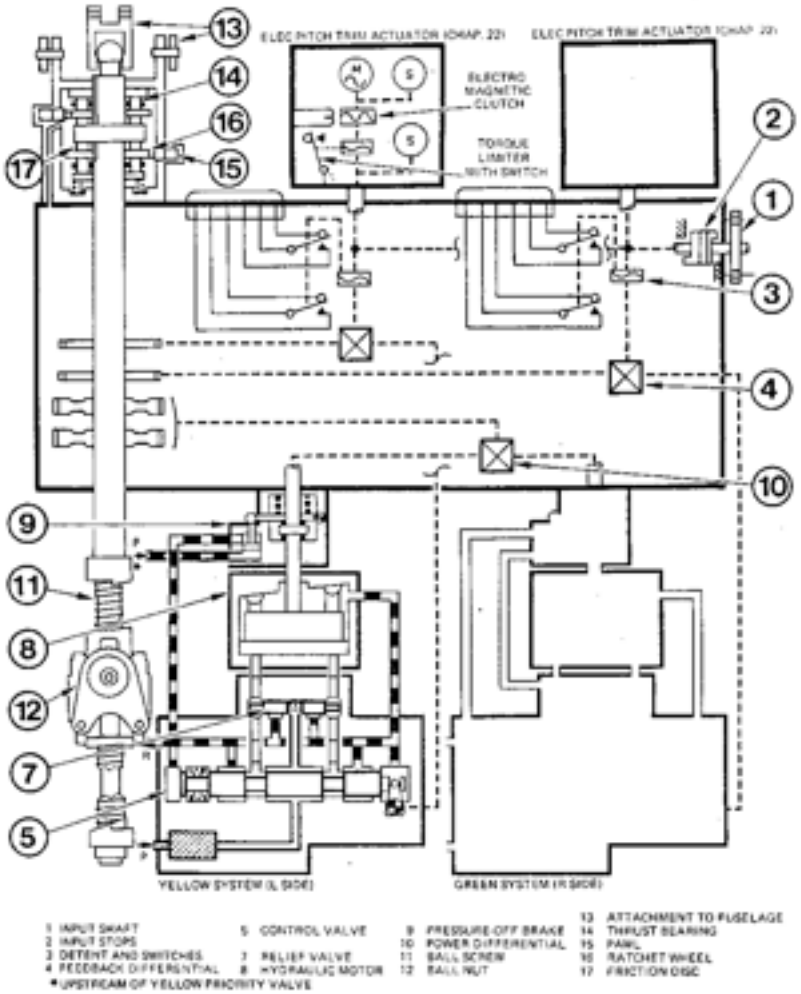


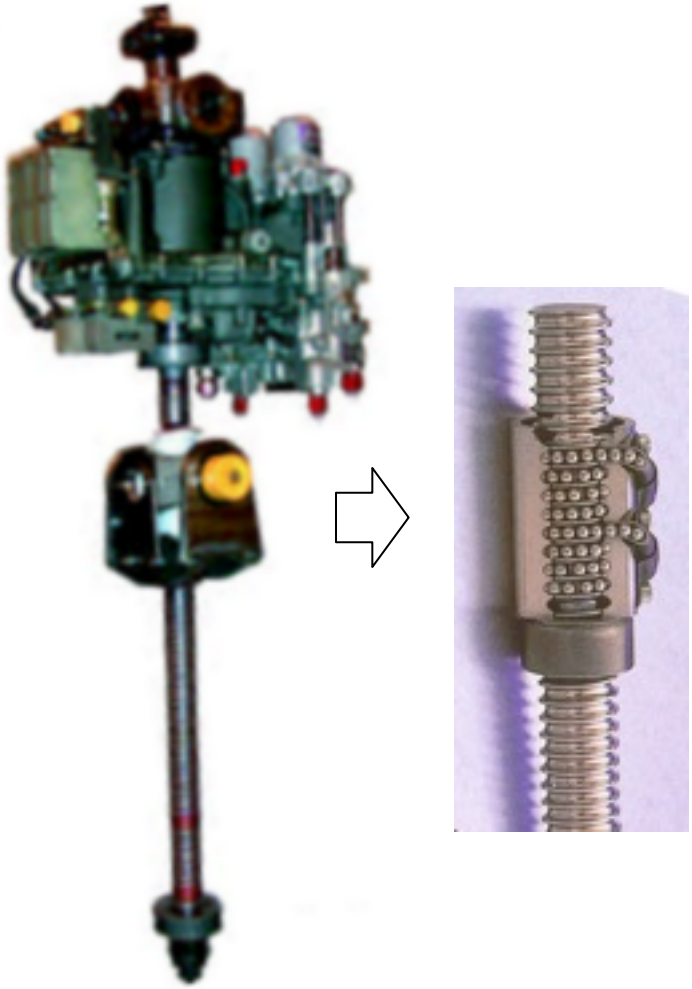


The Principal of THS actuation



THSA A300/A310 Trimmable Horizontal Stabilizer Actuator





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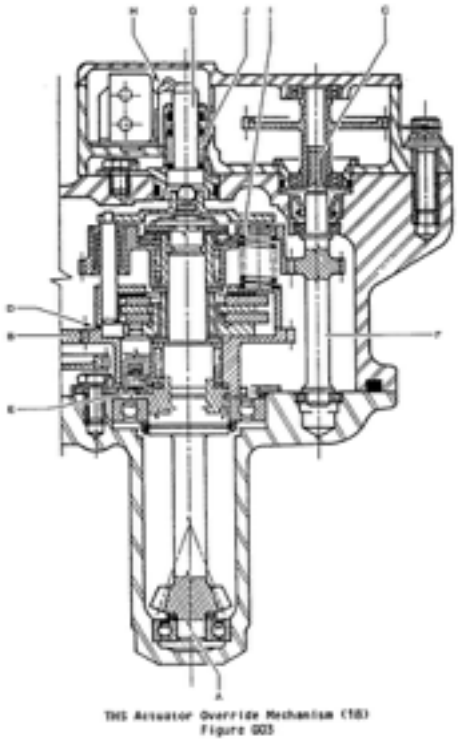


Override mechanism deletion (18)

1 INPUT SHAFT
2 INPUT STOPS
3 DETENT AND SWITCHES
4 FEEDBACK DIFFERENTIAL
5 CONTROL VALVE
6 PRESSURE MAINTAINING VALVE
7 BRAKE CONTROL VALVE
8 HYDRAULIC MOTOR
9 PRESSURE OFF BRAKE
10 POWER DIFFERENTIAL
11 BALL SCREW
12 BALL NUT
13 ATTACHMENT TO FUSELAGE
14 THRUST BEARING
15 PAWL
16 RATCHET WHEEL
17 FRICTION DISC
18 SERVO ACTUATOR
19 BRAKE CONTROL DIFFERENTIAL
20 TRANSDUCERS
21 TRANSDUCERS
22 PITCH TRIM ACTUACTOR:
-ELECTRICAL MOTORS
-CONTROL ELECTRONIC
-ELECTROMAGNETIC CLUTCHES
-MICRO SWITCHES

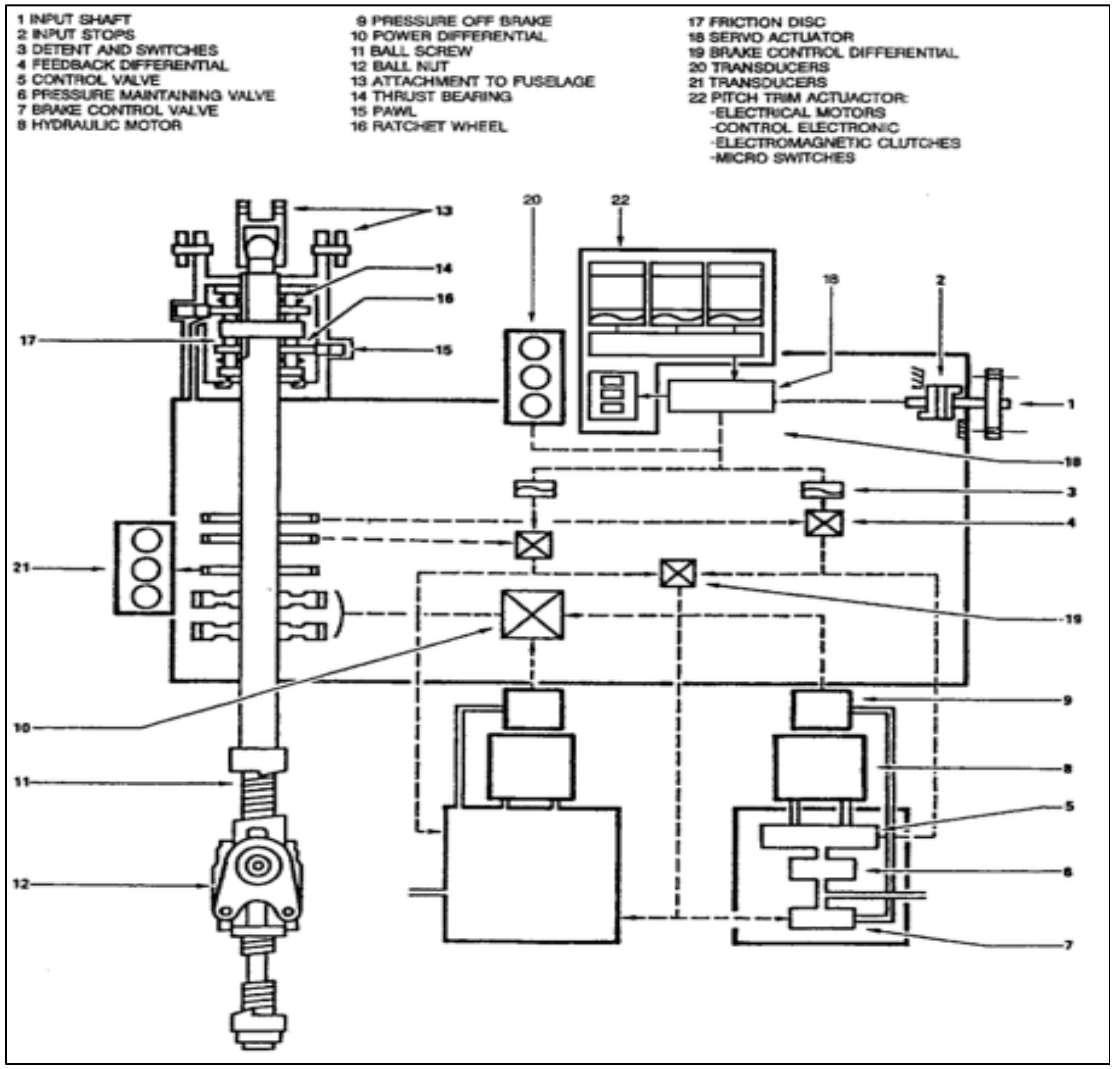
Electrical Motors input

Mechanical input deletion

Hydraulic blocks and motors

THALES

A320 THSA principal



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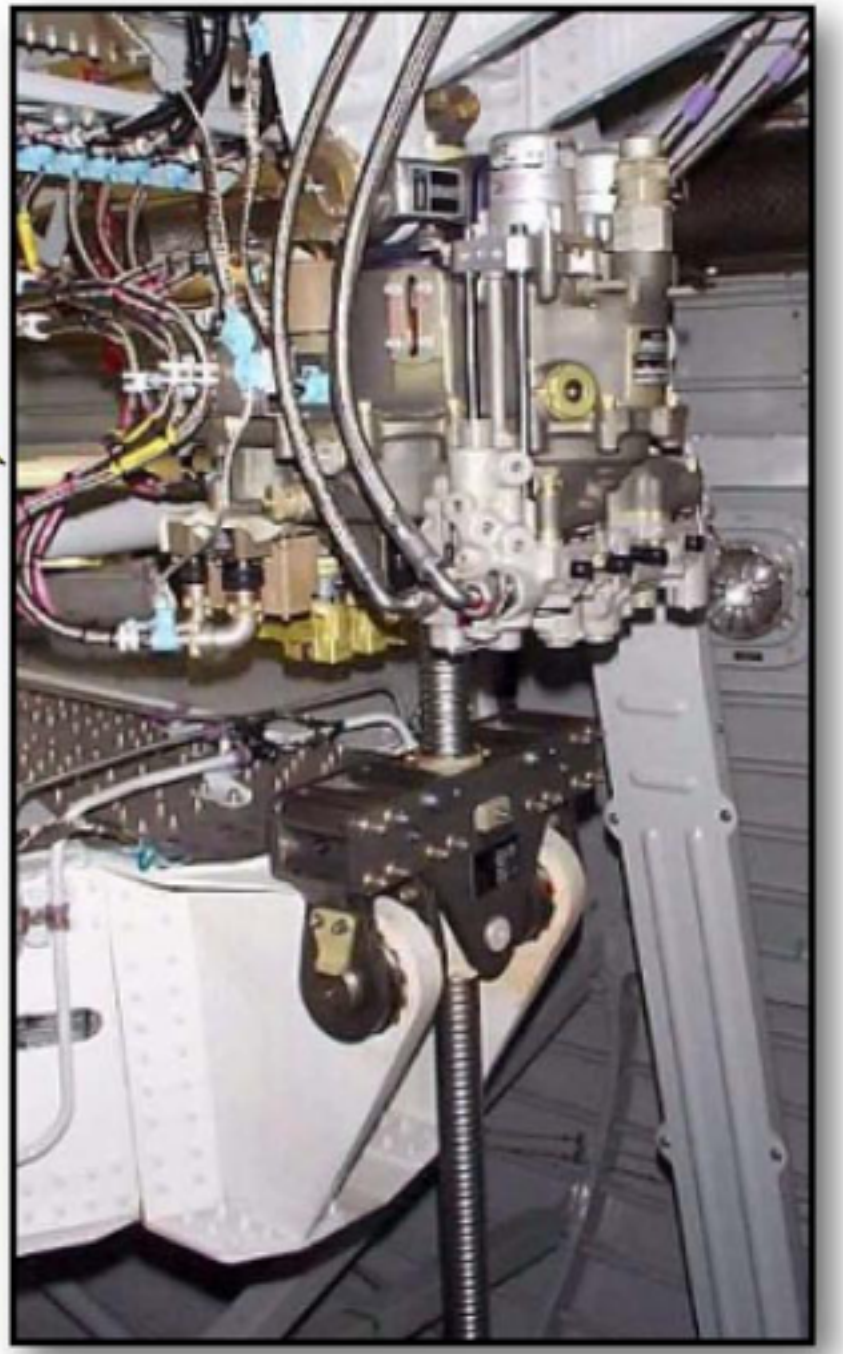
A320 THSA Installation



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THALES

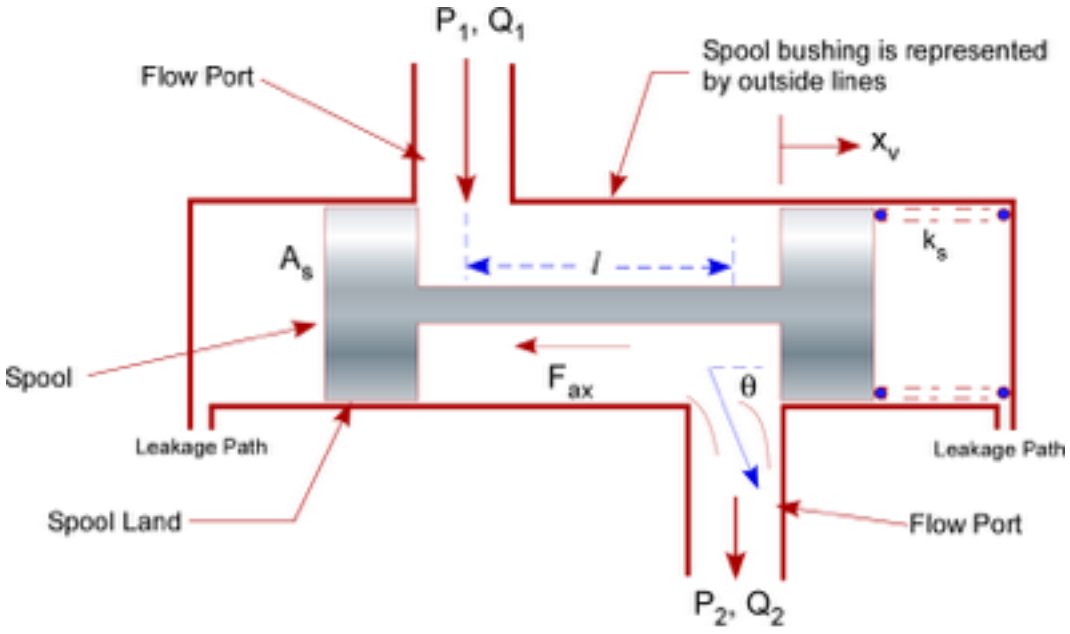
End of section, thank you

Back up,

End of section , Thank you

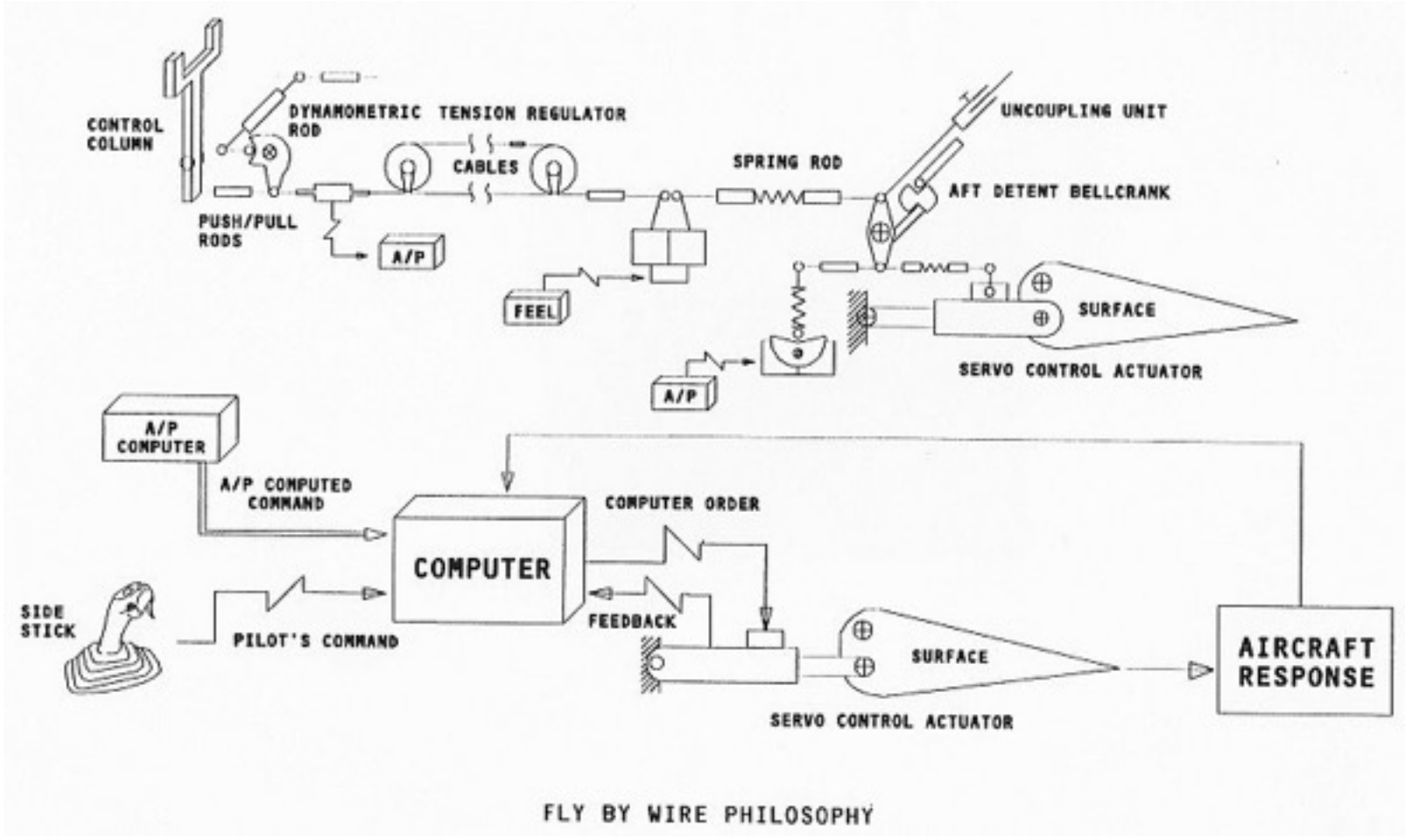
BACK UP

Servo principal



A_s	Area of the spool	A_v	Port flow area
x_v	Spool position	P_1	Inlet pressure
P_2	Outlet pressure	Q_1	Inlet flow rate
Q_2	Outlet flow rate	F_{ax}	Flow force (static and dynamic)
θ	Jet flow angle	l	Distance between ports

Comparison: Hydro mechanical versus FBW



THSA universal test rig

Picture: Sal aerospace Engineering


AIRBUS A320
A320