Section - III
SYSTEMS DESCRIPTION

Sub-section 6
FLIGHT CONTROLS

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GENERAL

The aileron, elevator and rudder are primary controls operated manually by cable-activated circuits from dual ram's-horn type control columns and adjustable rudder pedals.

Trim tabs are installed on the rudder, elevator and left aileron. The elevator trim tab may also be operated by a servo motor which is controlled by the pilot using the electric trim switches or by the autopilot and mach trim system.

The airbrakes, powered by the main hydraulic system, are selected by the AIRBRAKE selector lever, which is labelled SHUT and OPEN with an infinite selection of intermediate positions. A third position, labelled DUMP, is available after lifting the selector lever through a baulk at the OPEN position.

Wing flaps, which are hydraulically powered, are installed at the wing trailing edge. Labelled selection positions are 0° (UP), 15°, 25° and 45° (FULLY DOWN). A lift dump position at 75° is available via the airbrake DUMP selection.

Emergency lowering is available via the auxiliary hydraulic system. A flap position indication is displayed on the Copilot's Multifunction Display (MFD). A rudder bias system, powered by engine bleed air, automatically applies opposite rudder to counteract the effect of asymmetric thrust resulting from a single engine failure. A stall warning (stick shake) and identification system (stick push) is also provided. (Refer to Sub-section 7 STALL WARNING/IDENTIFICATION)

Internal gust locks are provided to lock the control surfaces when the airplane is parked or moored. The internal gust locks are also linked to a throttle baulk which prevents both throttles being advanced beyond 60% N_1 when the gust locks are engaged. A single throttle can be advanced to full power, but the other throttle is then baulked at 55-60% N_1. The gust locks are rated for wind gusts of up to 80 knots.

PRIMARY CONTROLS

AILERON CONTROL SYSTEM (Figure 1)

Movement of the ram's-horn type handwheel on either control column operates the ailerons differentially. Each handwheel operates a lever at the bottom of the column through chains and cables.

A connecting rod interconnects the levers of each column. The left column lever is also connected to a pulley drum. From the pulley drum a combination of cables and tie-rods operate a pulley in each wing, which are connected to the aileron by levers and links. Each aileron control surface has a mass balance weight installed to prevent flutter and a horn balance to reduce the aerodynamic loads felt by the pilot.

Primary stops, located at the left and right aileron inboard hinges, limit the aileron range of movement. The stop bolt in the aileron hinge contacts a fixed stop in the wing structure and limits the upward movement of the aileron.

Downward movement of the aileron is halted when the primary stop of the opposite aileron takes effect. Secondary stops are located at the bottom of each control column.

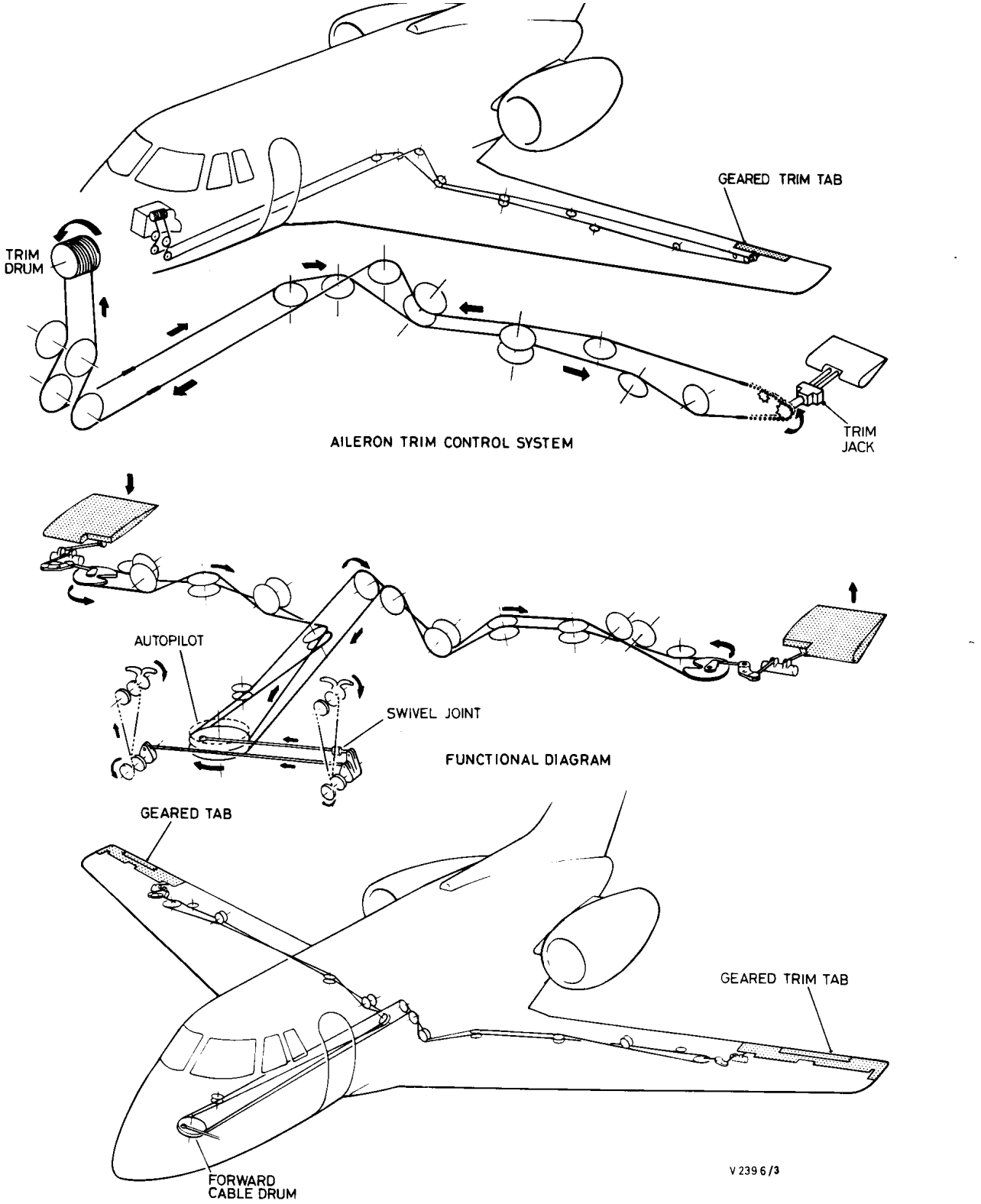
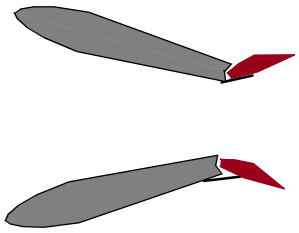


Figure 1
Aileron Control System

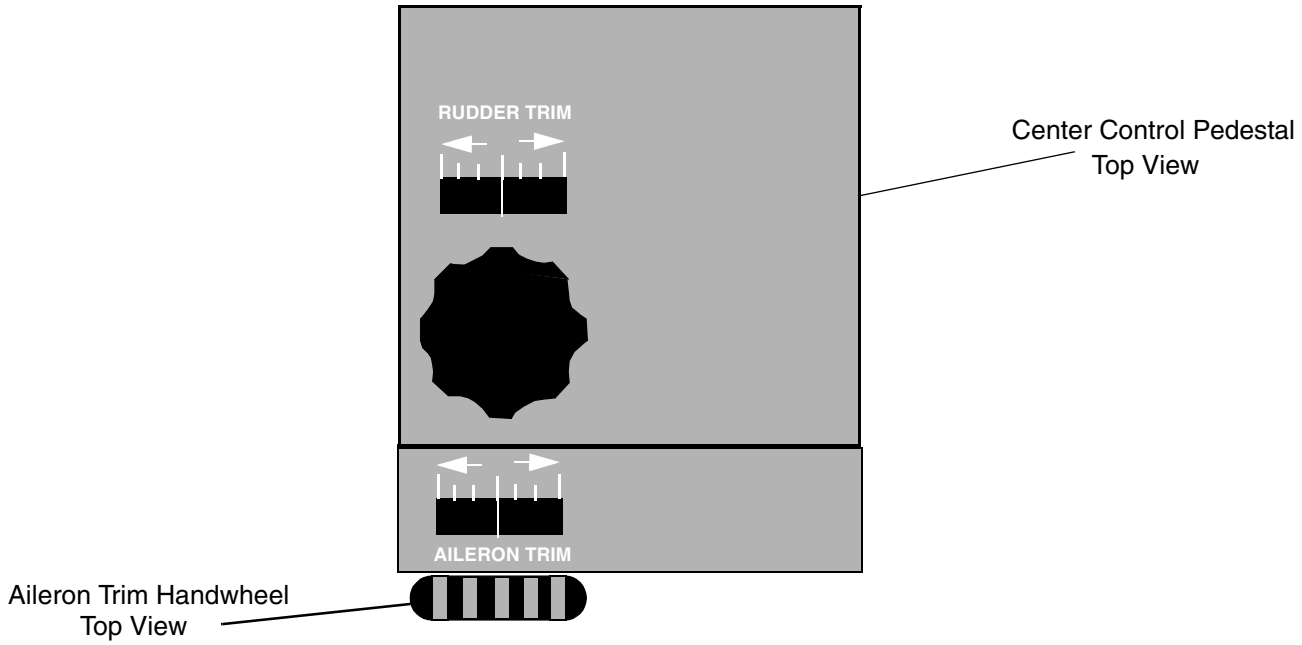
Aileron Geared and Trim Tabs

Each aileron has a servo-action geared tab mounted on its trailing edge. The tab is connected to the aileron by twin connecting rods, and moves in the opposite sense to the aileron to lighten the aerodynamic loads on the pilot's handwheel.The connecting rods for the left aileron tab are connected to a manually operated trim actuator.



Aileron Geared Tab Servo-action

The trim actuator is connected by a cable system to a trim handwheel mounted on the center control pedestal, immediately below the rudder trim handwheel.



Aileron Out-Of-Trim Warning

A warning of the aileron being out of trim for take-off is given by the illumination of the ELEV/AIL TRIM annunciator (on the MWS panel) if the following conditions apply:

- Aircraft weight is on wheels.
- Both engine thrust levers are advanced to more than approximately 60% N_1 power.
- Aileron trim is more than approximately 1 unit left or right.

MWS Panel Annunciator

RUDDER CONTROL SYSTEM (Figure 2)

The rudder is hinged from the rear of the vertical stabilizer and extends upwards from the rear cone of the fuselage to just below the under-surface of the horizontal stabilizer.

Movement of the rudder pedals is transmitted by connecting rods and a bell crank to a pulley drum under the flight compartment floor. Cables transmit the movement of the pulley drum to a quadrant installed at the bottom of the rudder torque tube. A spring strut connected to the lower portion of the rudder torque tube provides a centering force at the extreme travel. An autopilot servo motor is also connected to the base of the torque tube.

Primary stops are located at the rudder lower hinge to determine the range of movement in both directions. Secondary stops are located at each rudder pedal assembly.

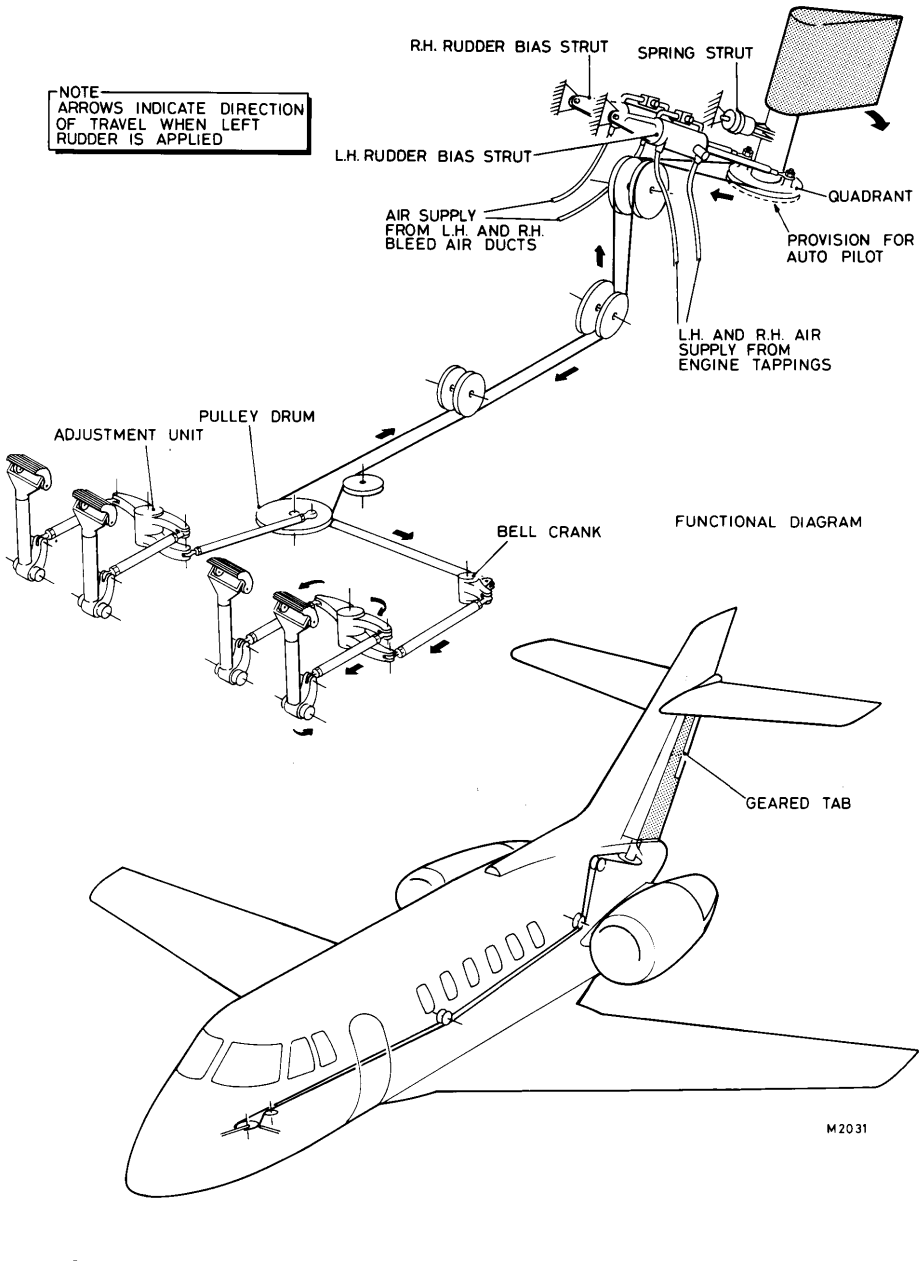


Figure 2
Rudder Control System

Rudder Geared and Trim Tabs (Figure 3)

Two separate tabs are hinged at the trailing edge of the rudder. The upper tab is linked to the rudder by a connecting rod, the lower tab is linked by rods to a screw trim actuator unit.

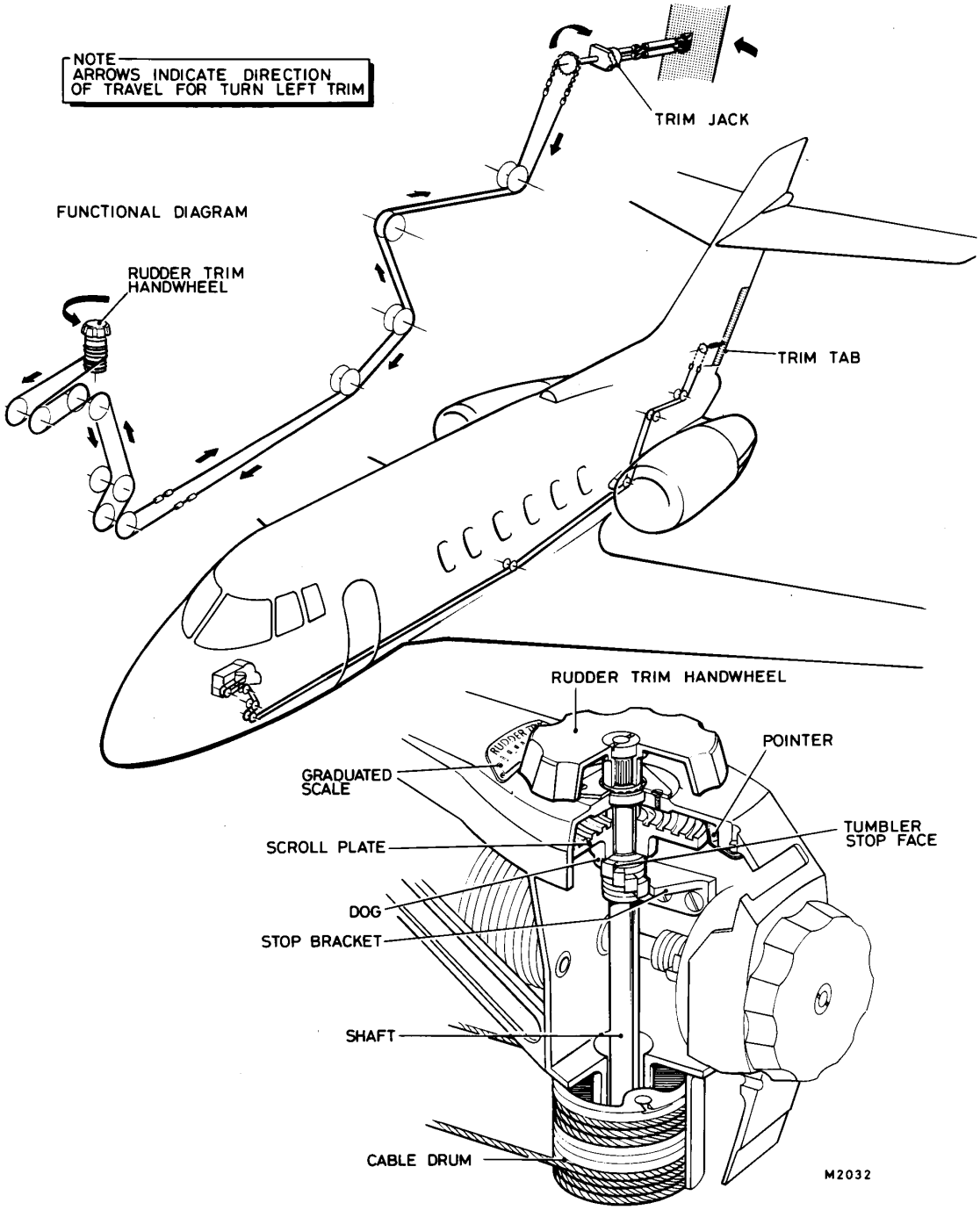
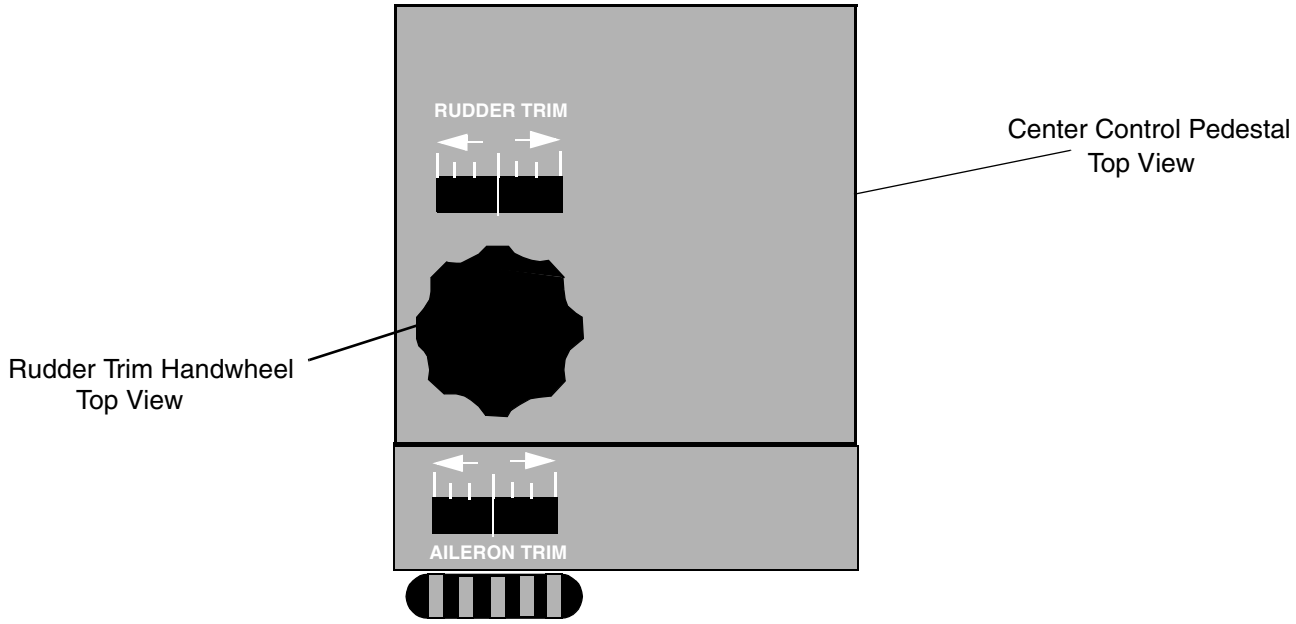


Figure 3
Rudder Trim System

Both tabs provide an anti-servo action while the position of the lower tab may be controlled manually by the rudder trim handwheel mounted on the center control pedestal, immediately above the aileron trim handwheel.



Rudder Bias System (Figure 4)

Two air powered struts are connected between the fuselage and the rudder torque tube quadrant to provide an automatic application of rudder bias to counteract asymmetric thrust caused by failure or malfunction of one engine.

The engine bleed air system is interconnected to the struts in such a manner that each engine supplies air to opposing sides of the strut pistons with a solenoid valve installed in each strut.

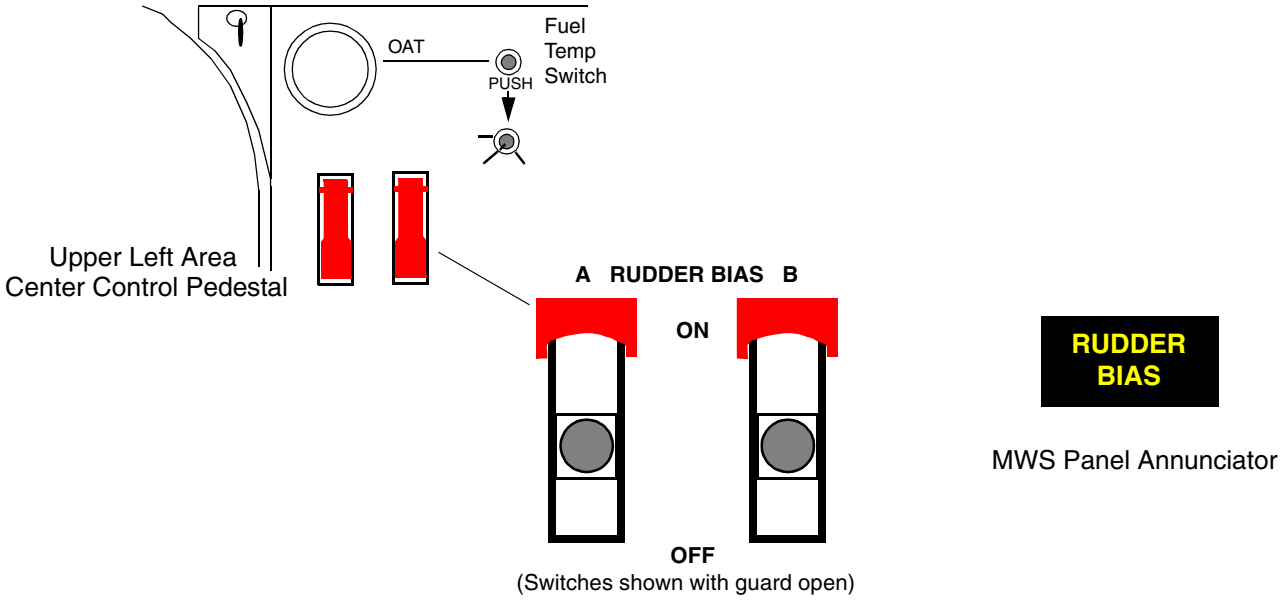
The solenoid valves are normally in the closed position when the RUDDER BIAS selector switches (A and B) are set to their ON positions. Accidental operation of the switches is prevented by a guard on each switch.

Should a leak occur in one supply line to a strut, the resulting loss of air would create an imbalance of forces which would bias the rudder to one side.

The rudder bias switches are located in the upper left area of the center control pedestal immediately above the elevator trim mechanical indication.

Selecting the RUDDER BIAS switch on the affected side to OFF, equalizes the pressures on both sides of the strut. The strut on the good side then maintains a balance of forces on the rudder.

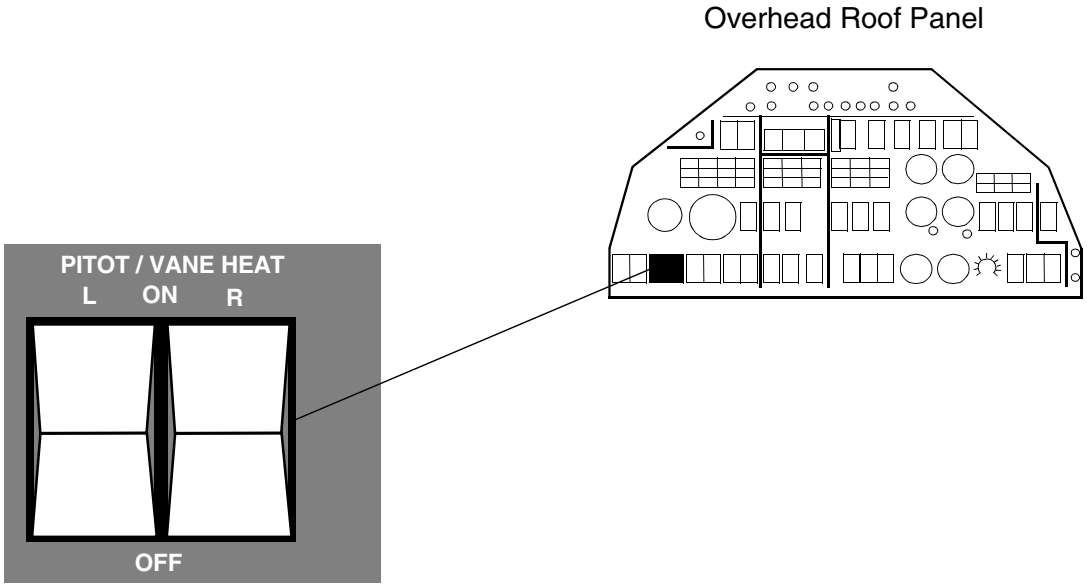
An amber MWS warning, RUDDER BIAS illuminates when either RUDDER BIAS switch (A or B) is set to the OFF position.



Electric Heating

An electric heater muff on each strut makes sure ice will not prevent operation of the strut or solenoid valve. Each muff has two elements which are supplied separately from the L and R PITOT/VANE HEAT switches on the overhead roof panel. Each switch controls the power supply to one heating element of each strut.

Pitot Vane Switch	*Busbar*	*Circuit Breaker*
Left	PS1	RUD BIAS HEAT LH > DA-D E/8
Right	PS2	RUD BIAS HEAT RH > DA-D F/8



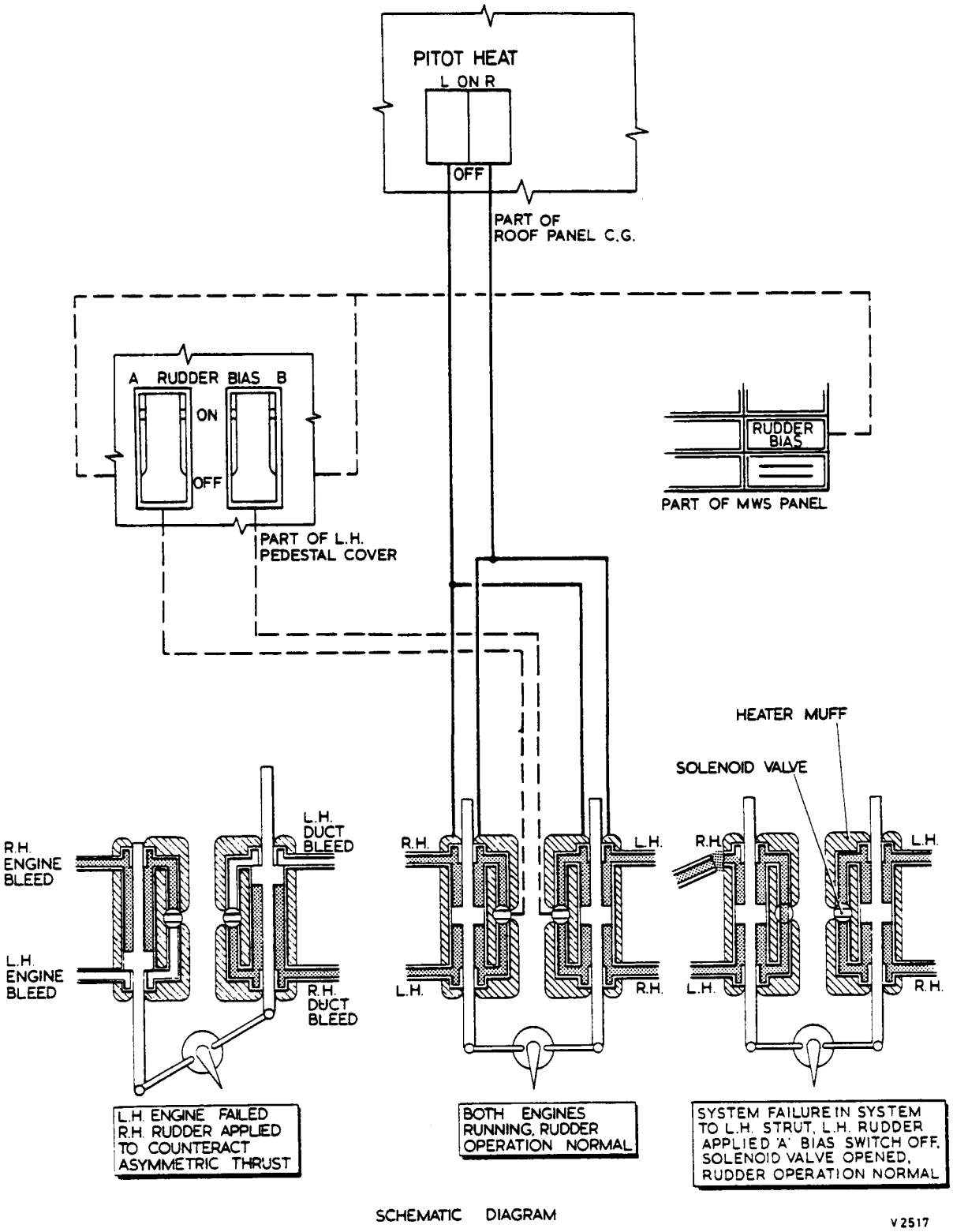


Figure 4
Rudder Bias System

ELEVATOR CONTROL SYSTEM (Figure 5)

The elevator control surfaces are hinged from the rear of the horizontal stabilizer and each is installed with a mass balance weight to prevent flutter and a horn balance to reduce the aerodynamic loads felt by the pilot. A spring and a g-weight are connected to the left control circuit to provide acceptable stick force characteristics.

A stick shaker motor is attached to each control column and is operated by the stall warning system. A stick pusher unit is connected to the elevator cable system to provide a positive push forward (pitch down) at the onset of stall identification. The cable circuit also provides an input for the autopilot servo unit.

Primary stops controlling the range of elevator movement are located on the middle hinge of each control surface. Secondary stops are located at the pulley drums under the flight compartment floor.

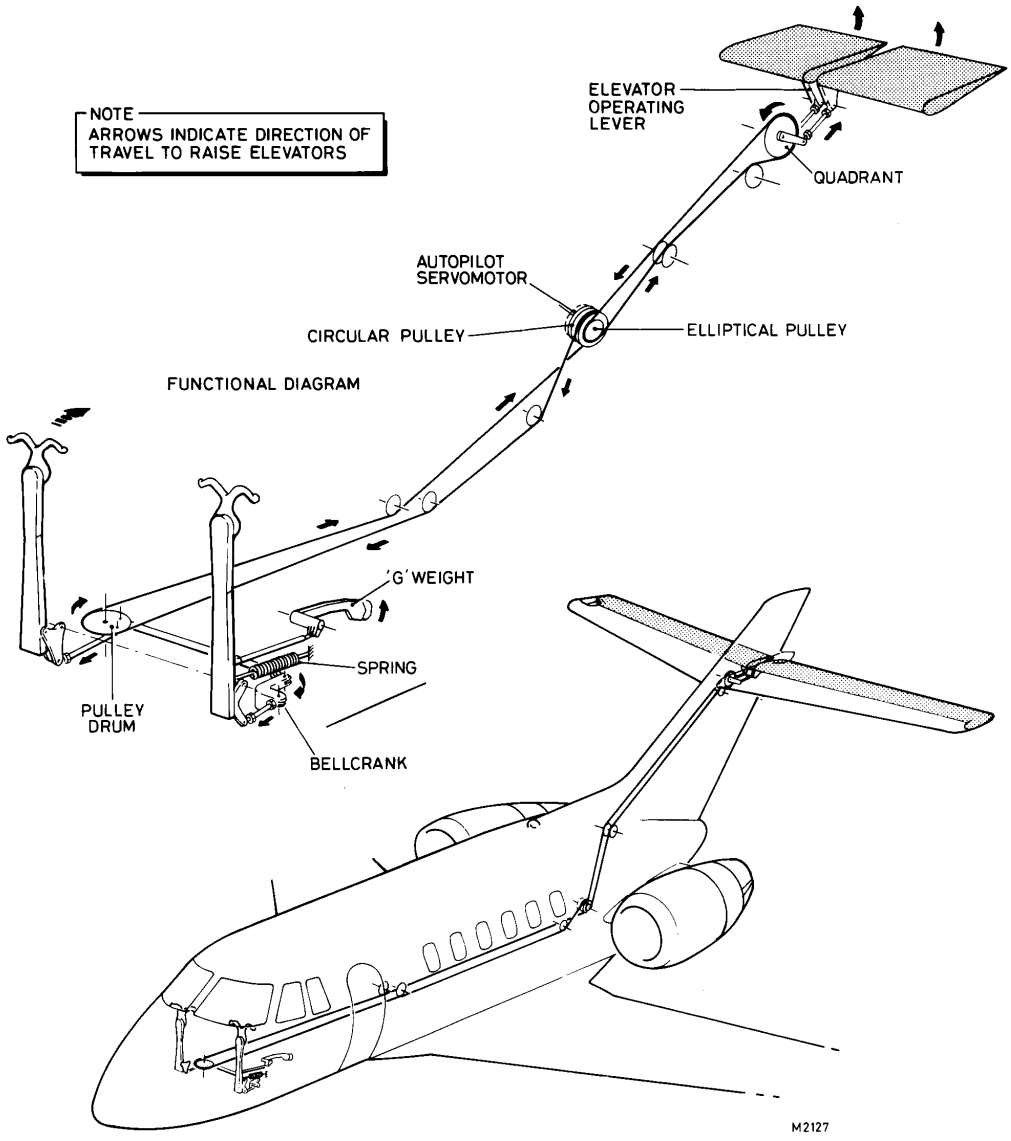


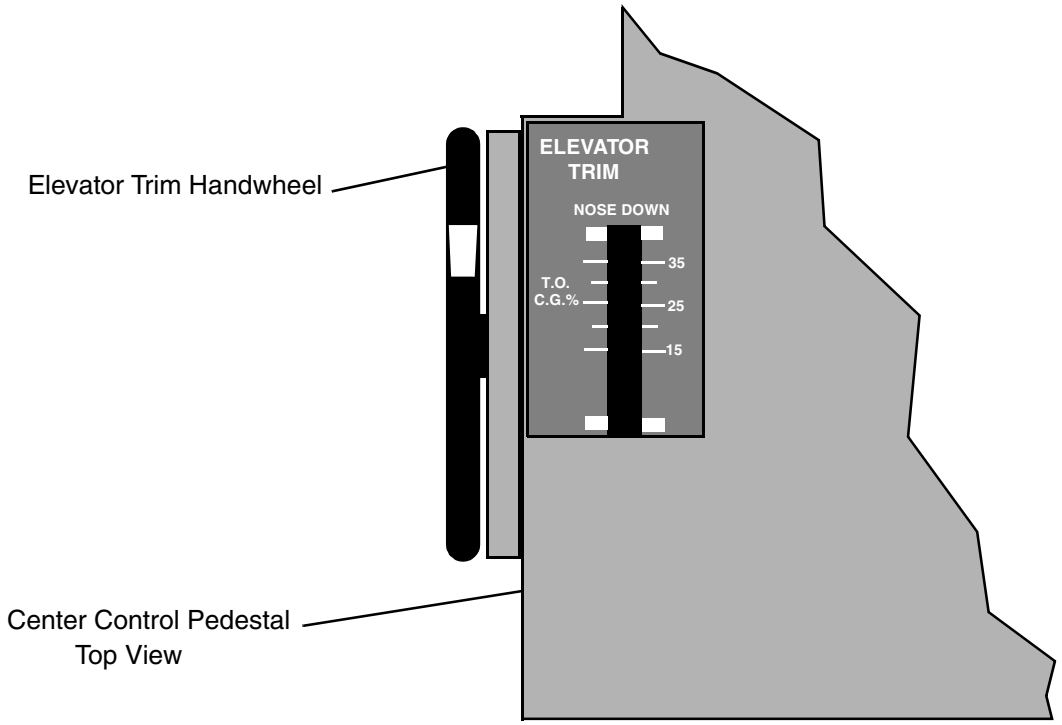
Figure 5
Elevator Control System

Elevator Trim System (Figure 6)

A trim tab is installed on each elevator and is manually controlled from an elevator trim handwheel, located on the left side of the central control pedestal.

Operation of the elevator moves the trim tab to give servo action. The autopilot servo motor is used to provide pitch trim, mach trim and electric trim functions. The pitch trim and electric trim functions are described more extensively in Sub-section 17 AVIONICS.

If necessary these functions can be overridden by arresting the movement of the elevator trim handwheel, which turns as the automatic system applies trim via the servo.



Elevator Out-Of-Trim Warning

A warning of the elevator being out of trim for takeoff is given by the illumination of the ELEV/AIL TRIM annunciator (on the MWS panel) if the following conditions apply:

- Aircraft weight is on wheels.
- Both engine thrust levers are advanced to more than approximately 60% N_1.
- The elevator trim is outside the "green" band.

ELEV/AIL TRIM MWS Panel Annunciator

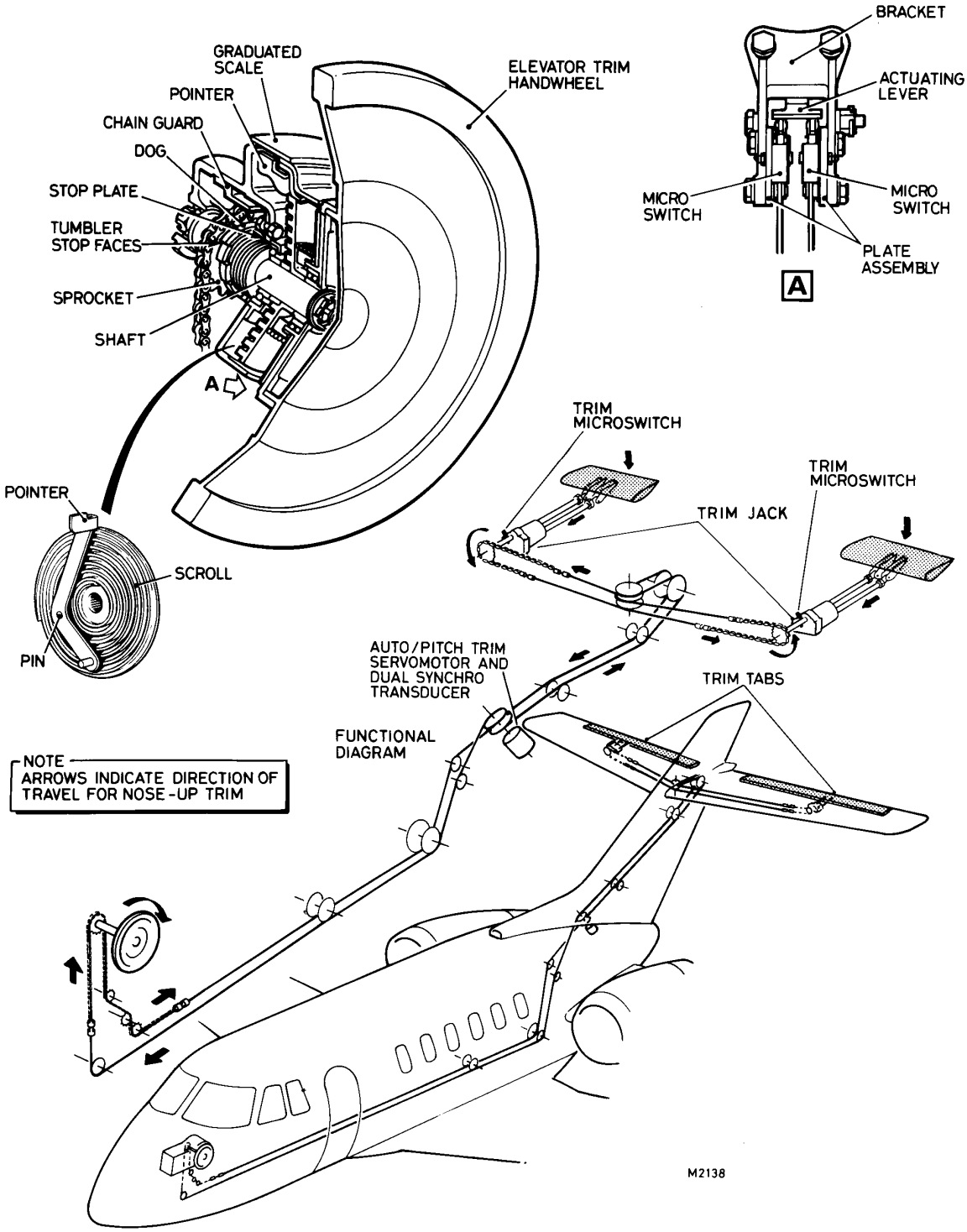


Figure 6
Elevator Trim System

Mach Trim

The Mach trim system is incorporated into the Integrated Avionics Processor System (IAPS) and uses the same pitch trim servomotor as the manual electric trim and the auto electric trim systems. The Mach trim system receives Mach number data from the air data computers and computes trim tab deflection to increase longitudinal stability at Mach numbers above 0.75 Mach when the autopilot is not engaged.

Faults which render the system inoperative (fail passive) will result in a warning given by the MACH TRIM FAIL annunciator coming on at the top right of the MWS panel.

MWS Panel Annunciator

The ELEV/AIL TRIM annunciator is powered from the PE busbar.

SECONDARY CONTROLS

FLAP SYSTEM

Interconnected slotted flaps are hydraulically powered from a single flap control unit and transmission shafting. The flap control unit is normally supplied from the main hydraulic system but an independent fluid supply from the auxiliary hydraulic system is available in the event of a main system failure.

Flap Control System (Figure 7)

The flap selector lever is connected by a cable to an input lever on the flap control unit. A spring strut and a spring drum in the cable run compensate for any movement lag. Movement of the input lever connects hydraulic pressure to operate a hydraulic motor in the flap control unit.

The motor drives the transmission shafting to move the flaps in the selected direction. The motor is stopped automatically should a control cable failure occur.

When the flaps reach the selected position, the hydraulic pressure is removed from the motor. Further movement of the flaps is arrested and they are locked at the required angle. Friction devices prevent the flaps moving away from the selected position in the event of hydraulic failure.

A synchronizing cable circuit is provided to prevent the occurrence of an asymmetric flap condition and should one flap cease to move, the synchronizing circuit isolates the hydraulic supply to the flap motor, the flaps stop moving and maintain the position attained at the moment of failure.

A flap servo baulk stops additional movement of the flap control unit input lever from the landing position. The baulk is released and the lever moved to the lift dump position by an interconnection with the airbrake control, when this is moved into the lift dump position.

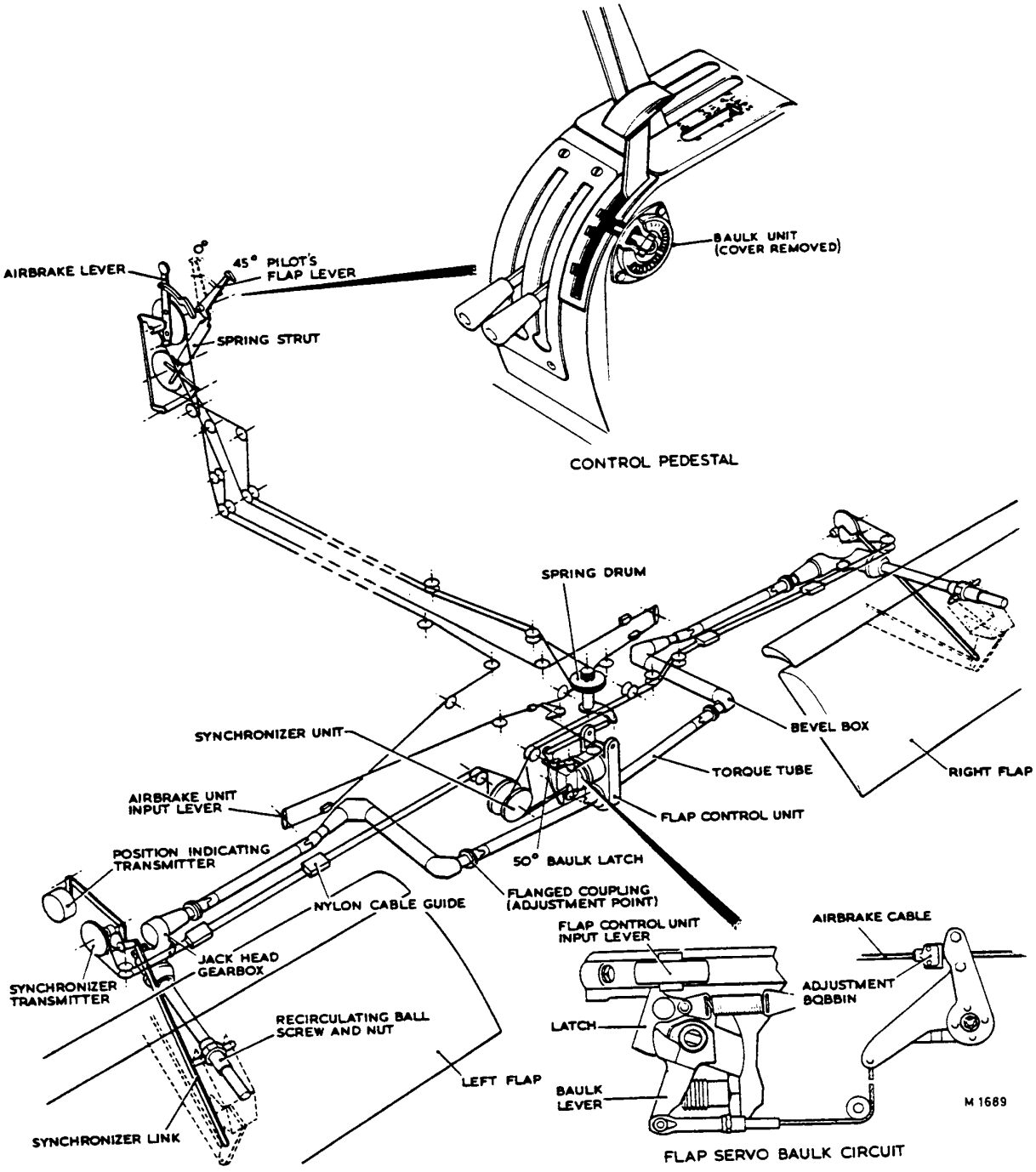
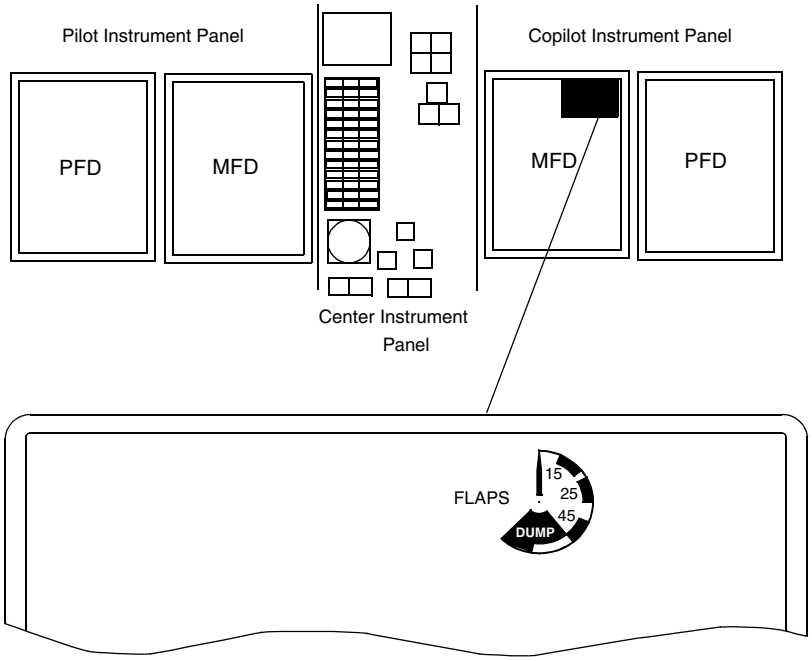


Figure 7
Flap Control System

Indications and Warnings

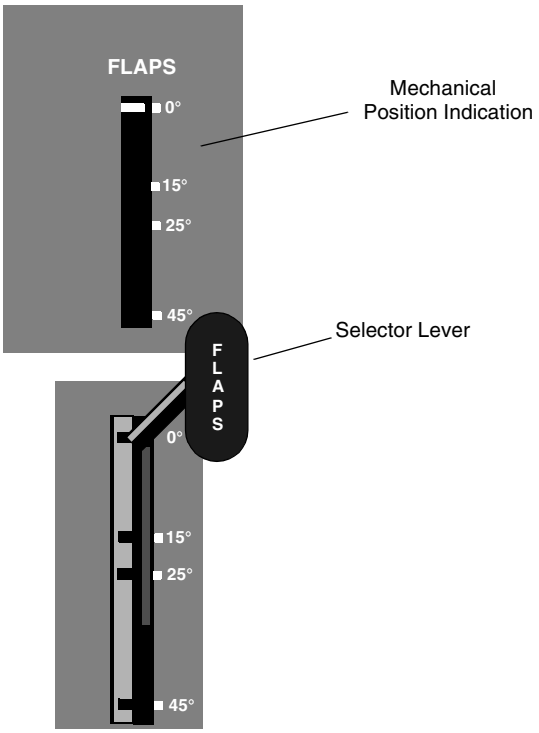
Flap position is displayed on the Copilot's Multifunction Display (MFD). This indication also provides the lift dump position.



A mechanical indication located adjacent to the thrust levers show the position of the flap selector lever and the flap positions are marked against the corresponding gates of the slot in which the lever moves.

A warning horn sounds if the flaps are selected to the 25° or 45° positions when the landing gear is not locked down. The flaps are controlled by a selector lever located on the right side of the center control pedestal. The lever moves in a gated slot which corresponds with the following flap positions:

- 0° ..... UP
- 15° .....TAKE-OFF
- 25° ..... APPROACH



A baulk, at the 15° slot, prevents inadvertent selection of the up, approach or landing positions. The baulk is released by pushing the selector lever into the 15° slot in the gate. Additional movement of the flaps downwards from the landing position to a lift dump position, is controlled by the airbrake selector lever.

Power Supplies

The flap position indication is powered from PS1(a) busbar via circuit breaker FLAP POS (M/7) on panel DA-D. The warning horn is powered from PE(a) busbar via circuit breaker HORN (K/1) on panel DA-D.

Emergency Operation

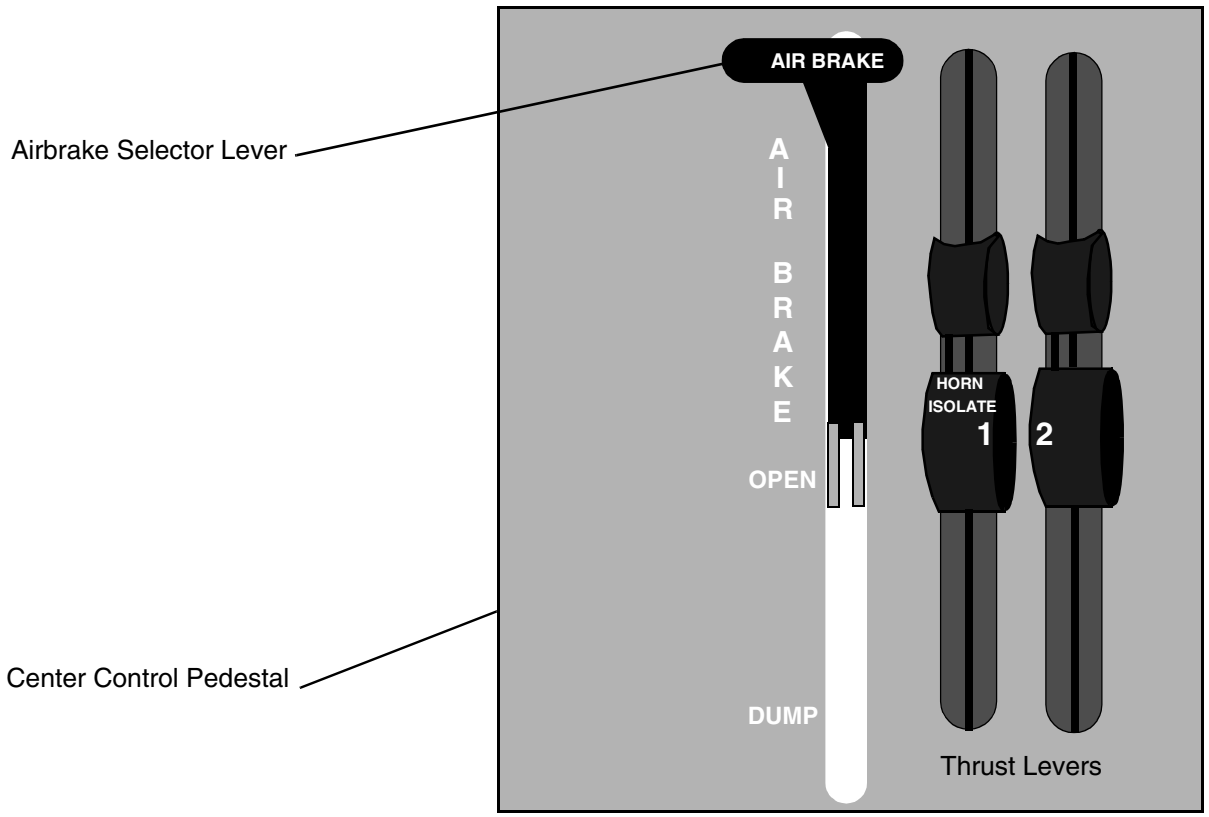
The flaps may be operated by means of the auxiliary hydraulic system. Using the auxiliary system the flaps can be lowered to any pre-set position from 0° to 45°. Lift dump and airbrakes are not available.

The emergency flap selection is made using the normal flap control lever. Position indication is still available as long as PS1(a) busbar is energized.

AIRBRAKE CONTROL SYSTEM (Figure 8)

A pair of airbrakes per wing are powered by the main hydraulic system. Of each pair, one airbrake extends from the wing upper surface, the other one from the wing lower surface.

Control of the airbrakes is by means of an AIRBRAKE selector lever located on the center control pedestal, immediately left of the thrust levers. The selector lever moves in a slot, which has a scale marked with three positions of SHUT, OPEN and DUMP. The normal (flight and ground) operating range is from the SHUT to the fully OPEN selections while intermediate positions are obtained by leaving the selector lever at the required setting within the range.



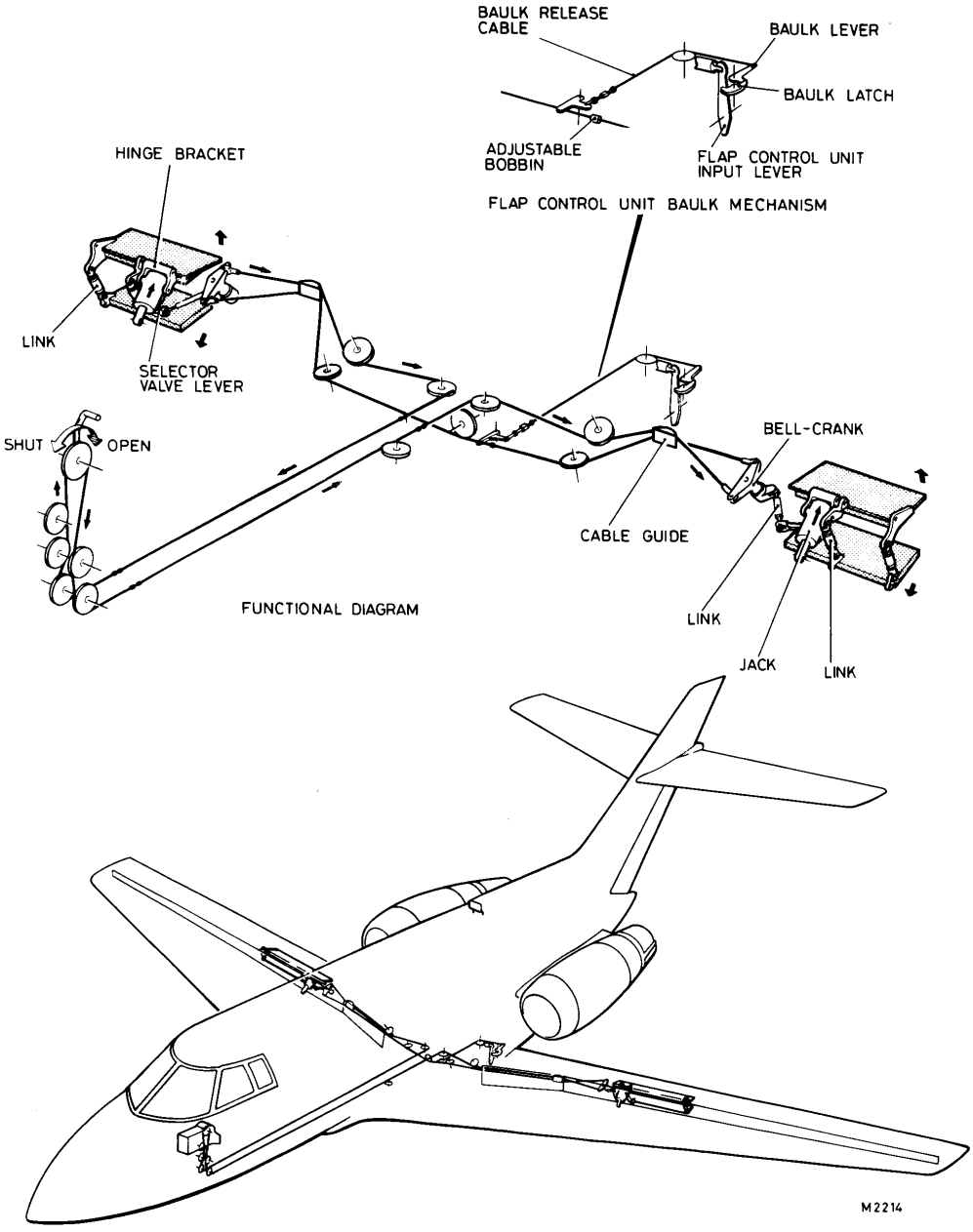


Figure 8
Airbrake Control System

A system of cables run from the AIRBRAKE selector lever to a hydraulic selector valve mounted on each airbrake actuator. Main hydraulic system pressure is utilized to operate the airbrakes through a hydraulic actuator in each wing. To allow for control system failure, the selector valve is biased to the SHUT position.

NOTE: There is no service available from the auxiliary hydraulic system for the airbrakes should the main hydraulic system fail.

Lift Dump

The AIRBRAKE selector is interconnected with the input lever to the flap control unit. Selection of airbrake between the SHUT and OPEN positions does not affect the flap position.

During the landing run, and the flaps selected to the 45° (Land) position, lifting the AIRBRAKE selector and then moving it rearwards into the DUMP position automatically lowers the flaps from the 45° setting to 75°, and also opens the airbrakes further to provide maximum drag.

Annunciations and Warnings

The airbrake system has a white, system status, annunciator on the MWS panel which illuminates when the airbrakes are extended from the SHUT position.

AIR BRAKE MWS Panel Annunciator

A warning horn sounds if all of the following conditions occur:

- The landing gear is down.
- Both thrust levers are advanced to more than 60% of N_1 power.
- The airbrakes are extended from the SHUT position.

Power Supplies

The AIR BRAKE annunciator is powered from PS2(a) busbar via circuit breaker AIRBRAKE (L/2) on panel DA-D.