Docket No.: **SA-510**
Exhibit No.: **9K**

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Excerpts from Boeing 737 Maintenance Training Manual and Maintenance Manual

INTRODUCTION

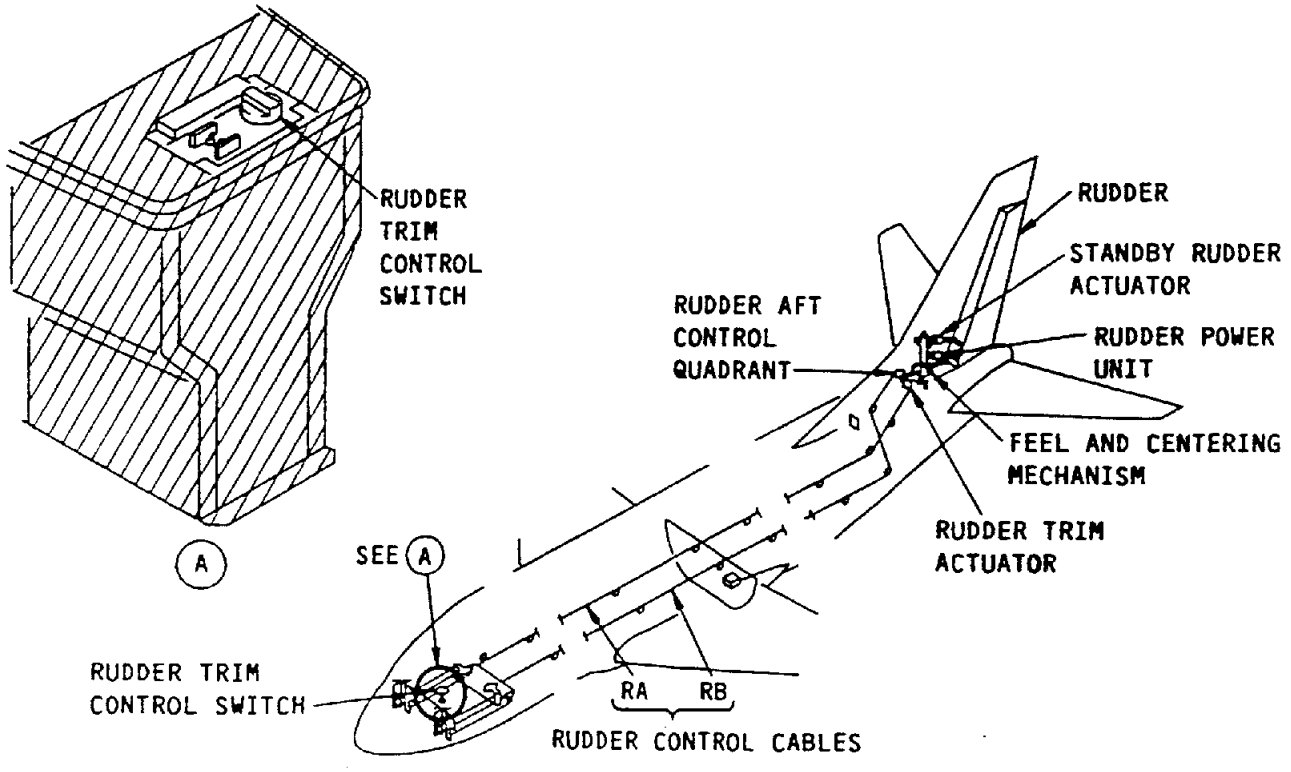
RUDDER

1. Purpose

   The rudder provides yaw control of the airplane around the vertical axis.

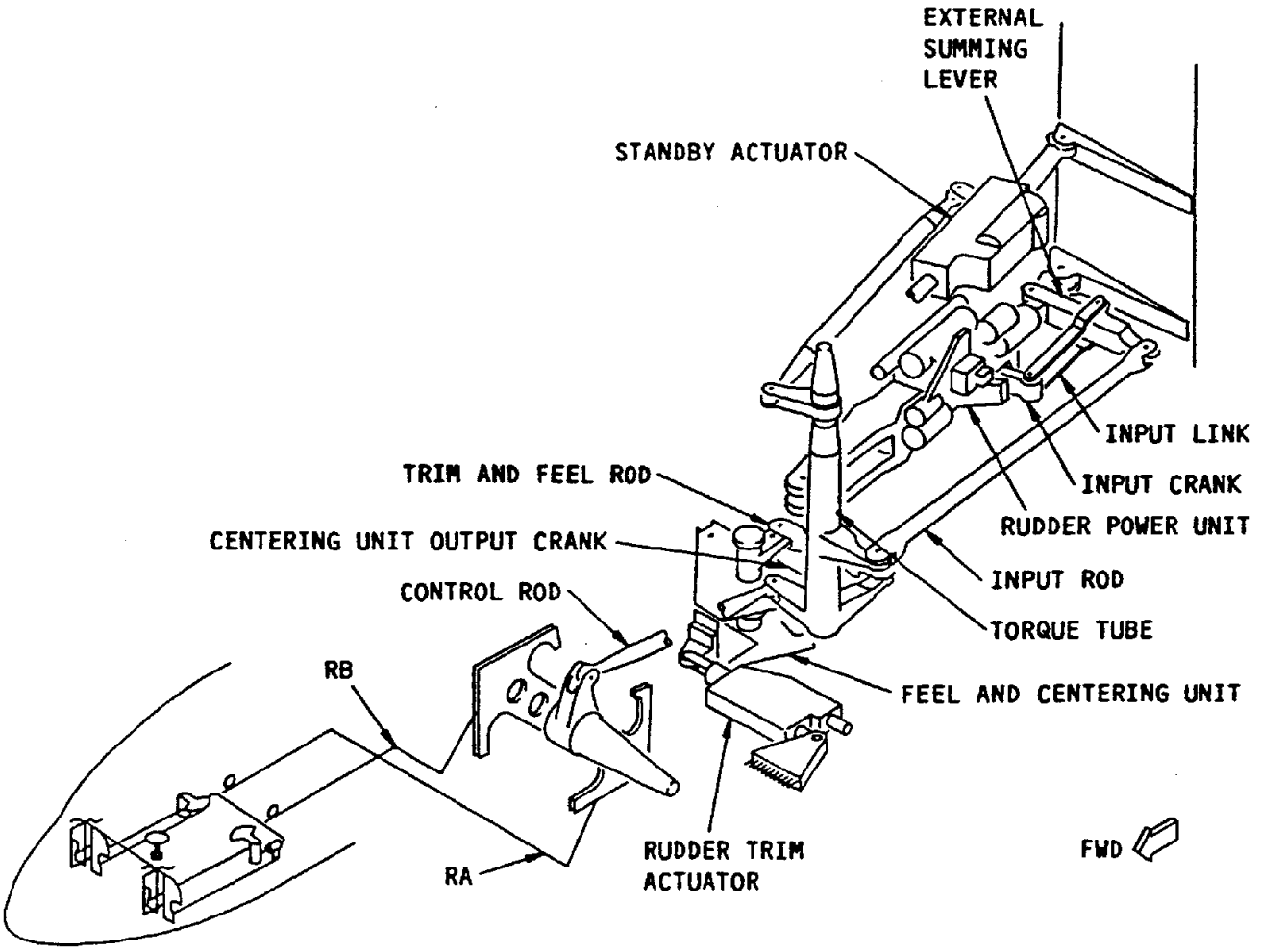
2. System Description

   A single conventional rudder without tab is powered by a main power control unit supplied by hydraulic systems A and B. A separate power control unit supplied by the standby system provides backup power. Any one of the three hydraulic systems will provide effective rudder control. The power control units are actuated by cables operated from either the captains or first officers rudder pedals. Rudder trim is accomplished by operating a trim control switch on the aisle stand that inputs to the power control units via an electric actuator mounted on the feel and centering mechanism.



RUDDER

131272



RUDDER SYSTEM

130966

COMPONENT FUNCTIONAL DESCRIPTION

RUDDER PEDAL ASSEMBLY

1. Purpose

   The captain and first officer are each provided with a pair of rudder pedals used for controlling the airplane about the vertical axis.

2. Location

   The rudder pedals are located below the captain's and first officer's instrument panels. Rudder pedal support and quadrant assemblies are in the lower nose compartment.

3. Physical Description

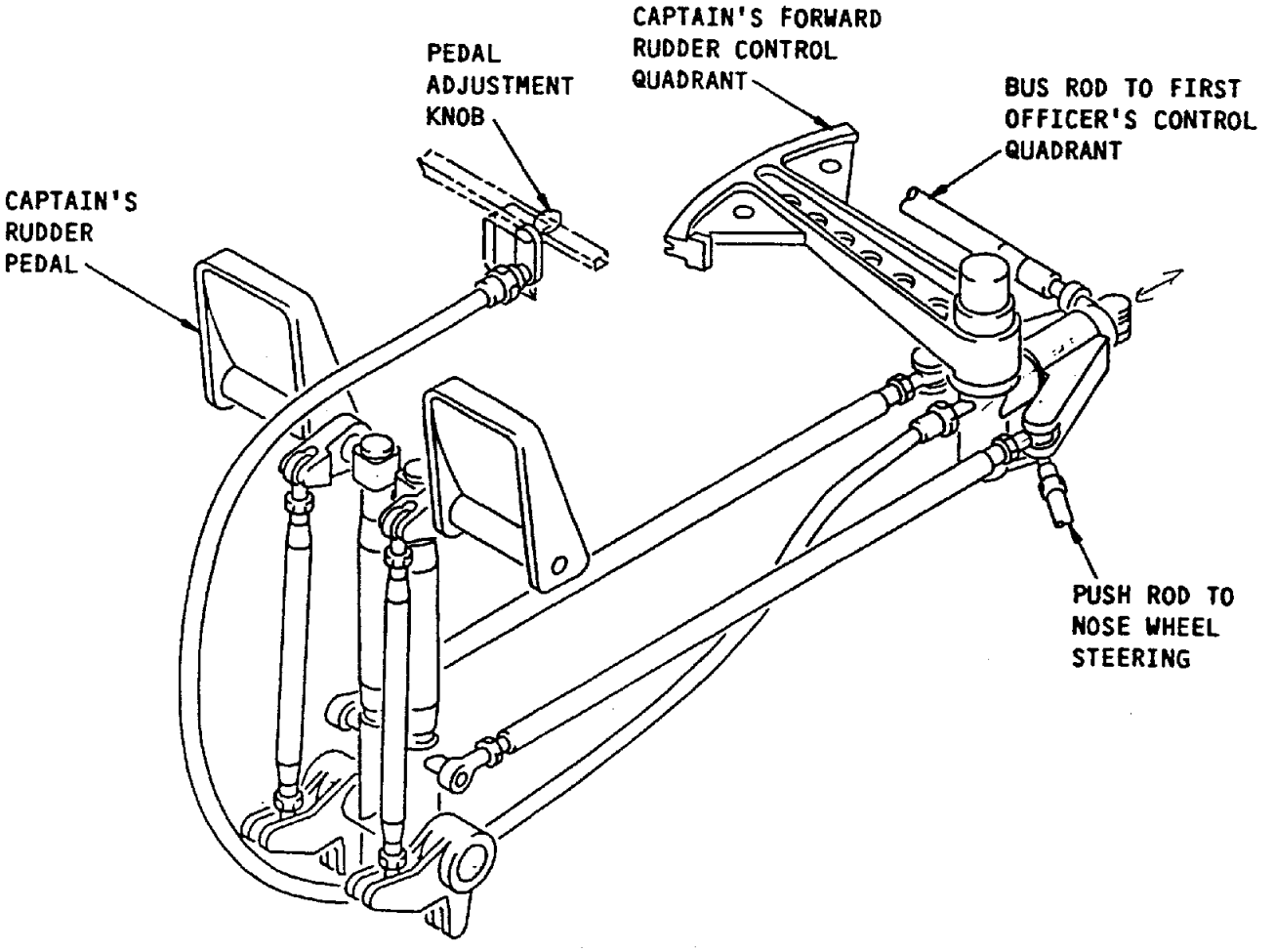
   Each pair of pedals consist of right and left pedals mounted on a shaft. The pedal shaft is attached to the upper end of the pedal arm assembly. The lower end of the pedal arm assembly is mounted on a support shaft attached to structure below the floor.

   Fore and aft movement of the pedals is transmitted by two pushrods to a jackshaft yoke. The rotary motion of the yoke is passed to the forward quadrant by means of the jackshaft. Both sets of control pedals respond equally because they are bussed together by means of a pushrod connecting the two jackshaft assemblies.

4. Control

   Each set of rudder pedals can be adjusted independently by means of a rudder pedal adjust knob located on the instrument panel, forward of the control wheel. The knob must be pulled aft to permit crank rotation.

   Rotation of the crank operates a flexshaft to drive a jackscrew which moves the yoke fore and aft. Rudder pedal adjustment crank and crank handle stops are installed to prevent the rudder pedal adjustment screw from being backdriven by heavy foot pressure applied simultaneously to both rudder pedals.



RUDDER PEDAL ASSEMBLY

130942

COMPONENT FUNCTIONAL DESCRIPTION

AFT RUDDER CONTROL COMPONENTS

1. Purpose

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

2. Location

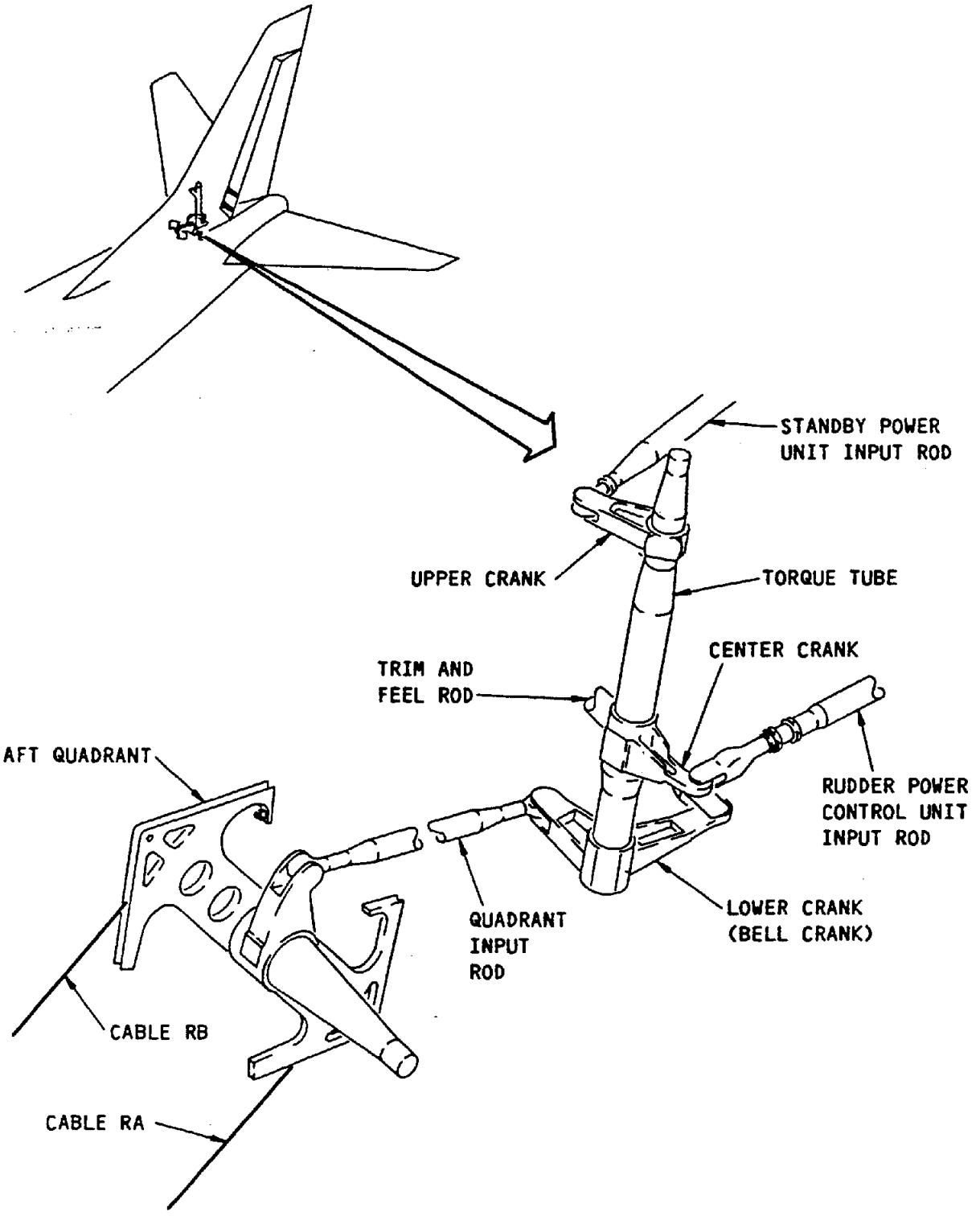
   The aft rudder control components are mounted in the vertical stabilizer forward of the power control units.

3. Physical Description

   The aft control components consist of a cable quadrant and a torque tube that provides a dual load path for rudder control linkage inputs. These cranks are bolted to the tube. The lower crank is connected to the input rod from the aft control quadrant and to the feel and centering mechanism. The center crank is connected to the main rudder power control unit input linkage. The upper crank is connected to the standby power control unit input linkage.

4. Operation

   Rudder pedal input through cables actuates the aft control quadrant which rotates the torque tube via an input rod. This results in a simultaneous input to the main power control unit, standby power control unit, and the feel and centering unit. Rudder trim is input through the feel an centering unit which rotates the torque tube. Trim inputs to both power control units simultaneous with driving the aft control quadrant to position the rudder pedals.



AFT RUDDER CONTROL COMPONENT

130944

COMPONENT FUNCTIONAL DESCRIPTION

MAIN RUDDER POWER CONTROL UNIT

1. Purpose

   The main rudder power control unit moves the rudder right or left when actuated by rudder pedal input, rudder trim input, or yaw damper input and provides wind gust snubbing when the airplane is parked.

2. Location

   The unit is located in the vertical fin. The body is fixed to fin structure and the piston head to the rudder.

3. Physical Description

   The main power control unit is a single tandem actuator with two pistons on a single rod. The unit contains two separate chambers for the two hydraulic systems, two bypass valves, and a dual control valve operated by an internal input crank. The internal crank is operated by an external input crank that is driven by an external summing lever connected to the input rod from the torque tube.

   Yaw damper components incorporated in the main power unit include a solenoid operated shutoff valve, a transfer valve, a yaw damper actuating piston, and a rate sensor.

4. Power

   Normal operation of the main power control unit is by both hydraulic systems A and B. Either system acting alone will provide full rudder control.

5. Control

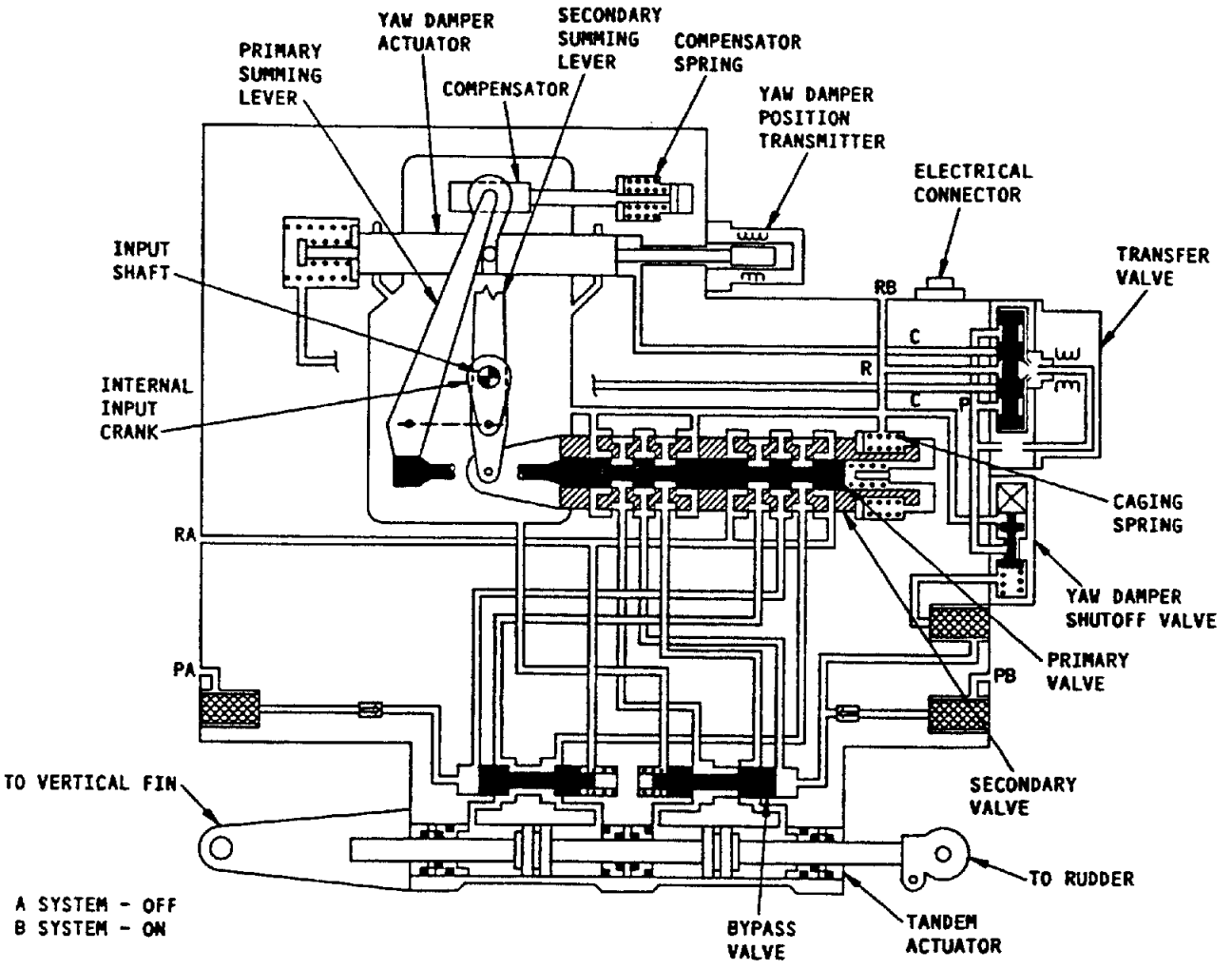
   Hydraulic power from an operating system opens a bypass valve and is delivered to the control valve. When a system is off the bypass valve is spring-loaded to bypass. Both sides of the piston are connected to either line from the control valve to prevent a hydraulic lock.

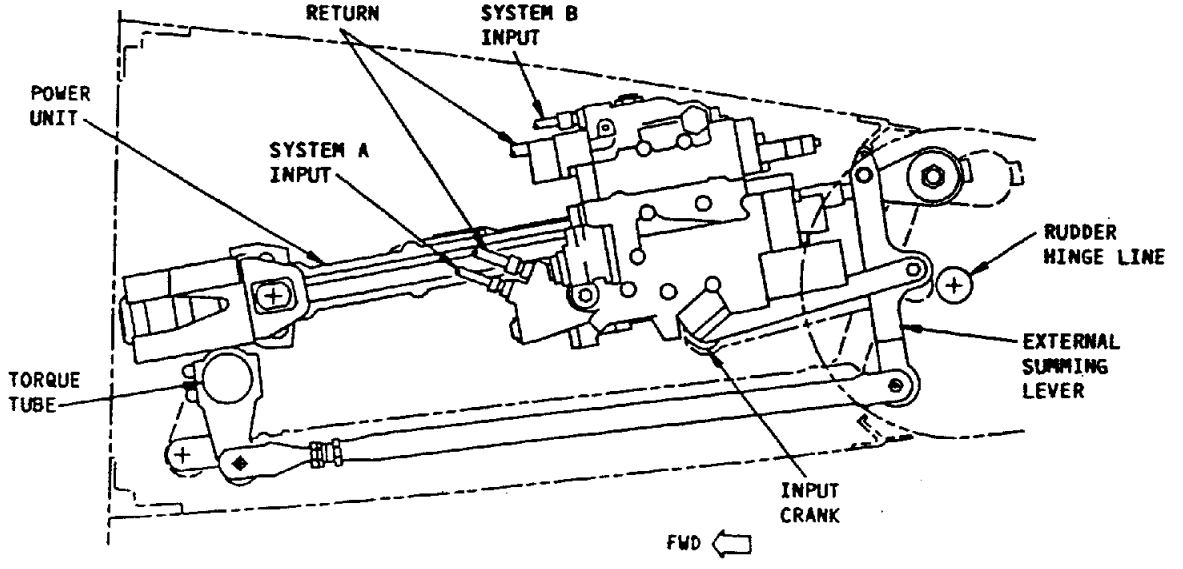
COMPONENT FUNCTIONAL DESCRIPTION

6. Operation

Input from the rudder pedals or rudder trim causes the torque tube to drive an input rod that positions the power unit input crank through the external summing lever. The external crank actuates the internal crank to position the control valve which ports hydraulic pressure to one side of the actuating pistons. The piston strokes to position the rudder. The external summing lever is carried by the piston to return the external crank to neutral and stop the rudder at the desired position.

The amount of control valve movement is also governed by yaw damper input. Pilot input and yaw damper input are summed algebraically by the summing levers connected to the primary and secondary control valves. Pressure from the transfer valve drives the yaw damper actuator to position the control valve via the summing levers. Yaw damper is limited to 3° left or right rudder movement.





MAIN RUDDER POWER CONTROL UNIT

130892

COMPONENT FUNCTIONAL DESCRIPTION

RUDDER FEEL AND CENTERING MECHANISM

1. Purpose

   The rudder feel and centering mechanism provides artificial feel to the rudder pedals, centers the rudder, and transmits trim inputs to the aft control components.

2. Location

   The feel and centering unit is located below the rudder power unit in the vertical fin.

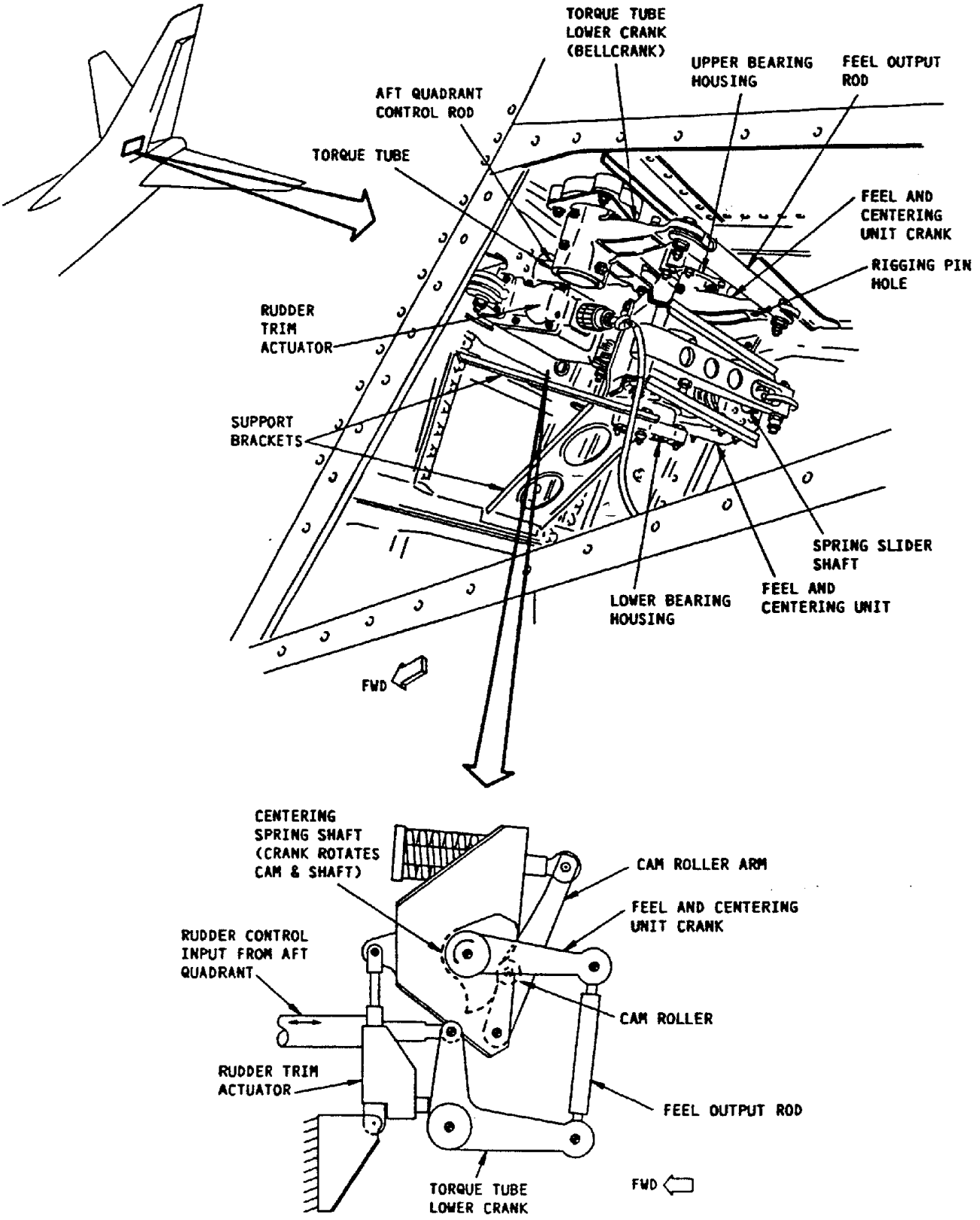
3. Physical Description

   The feel and centering unit consists of a support shaft, a feel and centering crank, two frames, an arm and roller, a spring assembly, and a cam. The support shaft is bearing mounted on structure. The feel and centering crank is fixed to the support shaft and is connected through the trim and feel rod to the lower crank on the torque tube. The two frames are bearing mounted on the support shaft. The arm and roller and the spring assembly attach to and rotate with the two frames. The cam is fixed to and rotates with the support shaft. The rudder trim actuator is connected to the forward side of the two frames.

4. Operation

   When the rudder pedals are displaced, the torque tube rotates causing offset of the trim and feel rod and, in turn, rotation of the feel and centering crank, the support shaft, and the cam. As the cam rotates, the arm and roller are displaced out of the detent position to compress the spring assembly and provide artificial feel.

   Rudder trim input through the rudder trim actuator rotates the two frames with the arm and roller and spring assembly. The force of the spring assembly holds the arm and roller in the cam detent and causes the cam to rotate. Rotation of the cam causes subsequent motion of the support shaft, the feel and centering crank, the trim and feel rod, the lower crank, and the torque tube. This causes input to the rudder power unit to position the rudder and, at the same time, the lower crank causes input to the rudder control system to position the rudder pedals.



RUDDER FEEL AND CENTERING MECHANISM

130982

COMPONENT FUNCTIONAL DESCRIPTION

RUDDER TRIM SYSTEM

1. Purpose

   The rudder trim system provides a means of positioning the rudder for directional trim of the airplane.

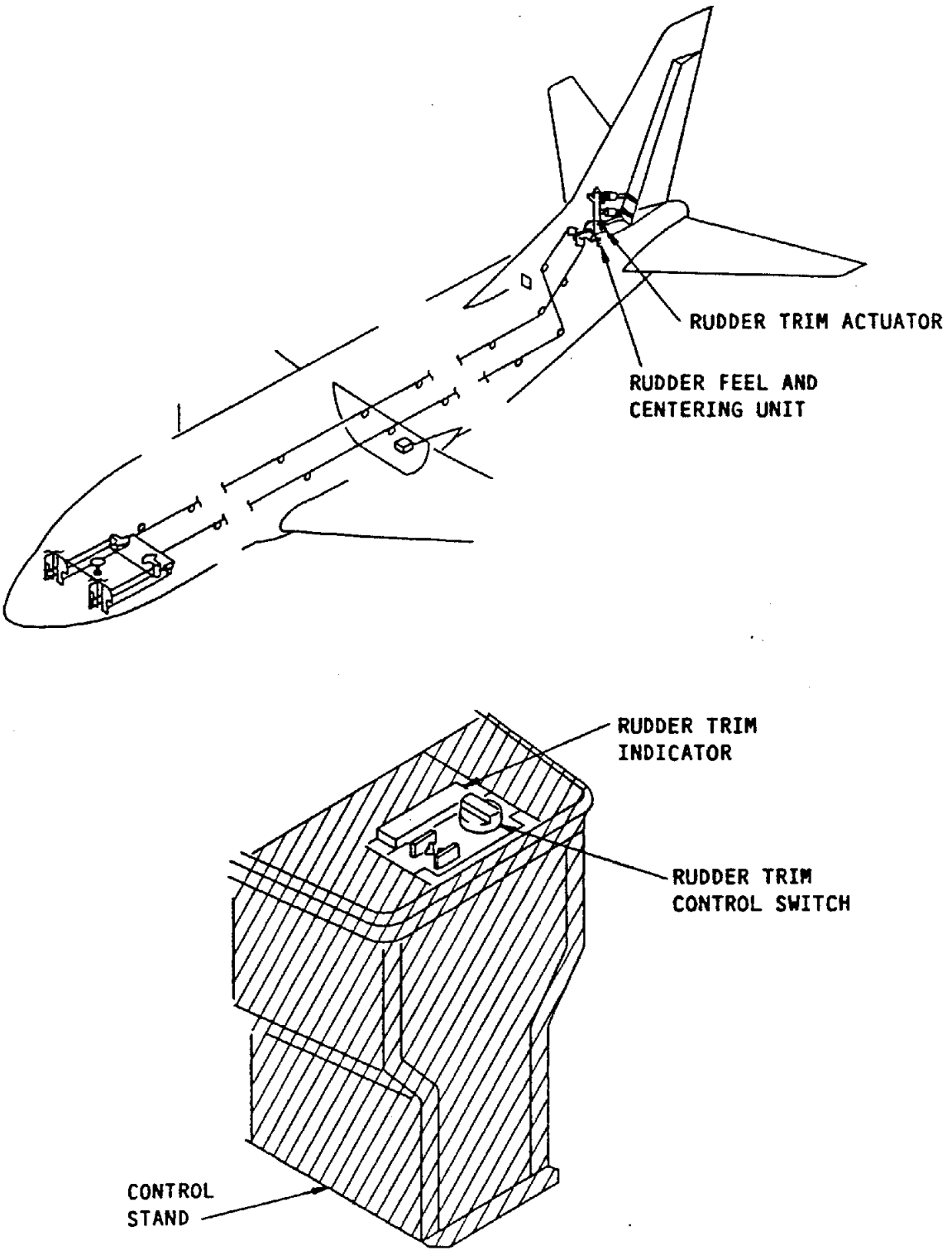
2. Location

   The rudder trim actuator is mounted between vertical fin structure and the case of the rudder feel and centering mechanism.

   The rudder trim control switch and rudder trim indicator are installed on the aft section of the pilot's control stand.

3. Physical Description/Features

   The rudder trim actuator consists of an acme screw driver ram, coupled to a motor-brake and position sensor (RVDT) through a gear reduction, and limit switches enclosed by an aluminum housing. The motor drive is controlled by the rudder trim switch or by activation of an internal limit switch.



RUDDER TRIM SYSTEM

130971

COMPONENT FUNCTIONAL DESCRIPTION

RUDDER TRIM

1. Power

   The rudder trim actuator motor is powered by 115 volts ac from transfer bus 1. The rudder trim indicating system is powered by 28 volts ac from transfer bus 1.

2. Control

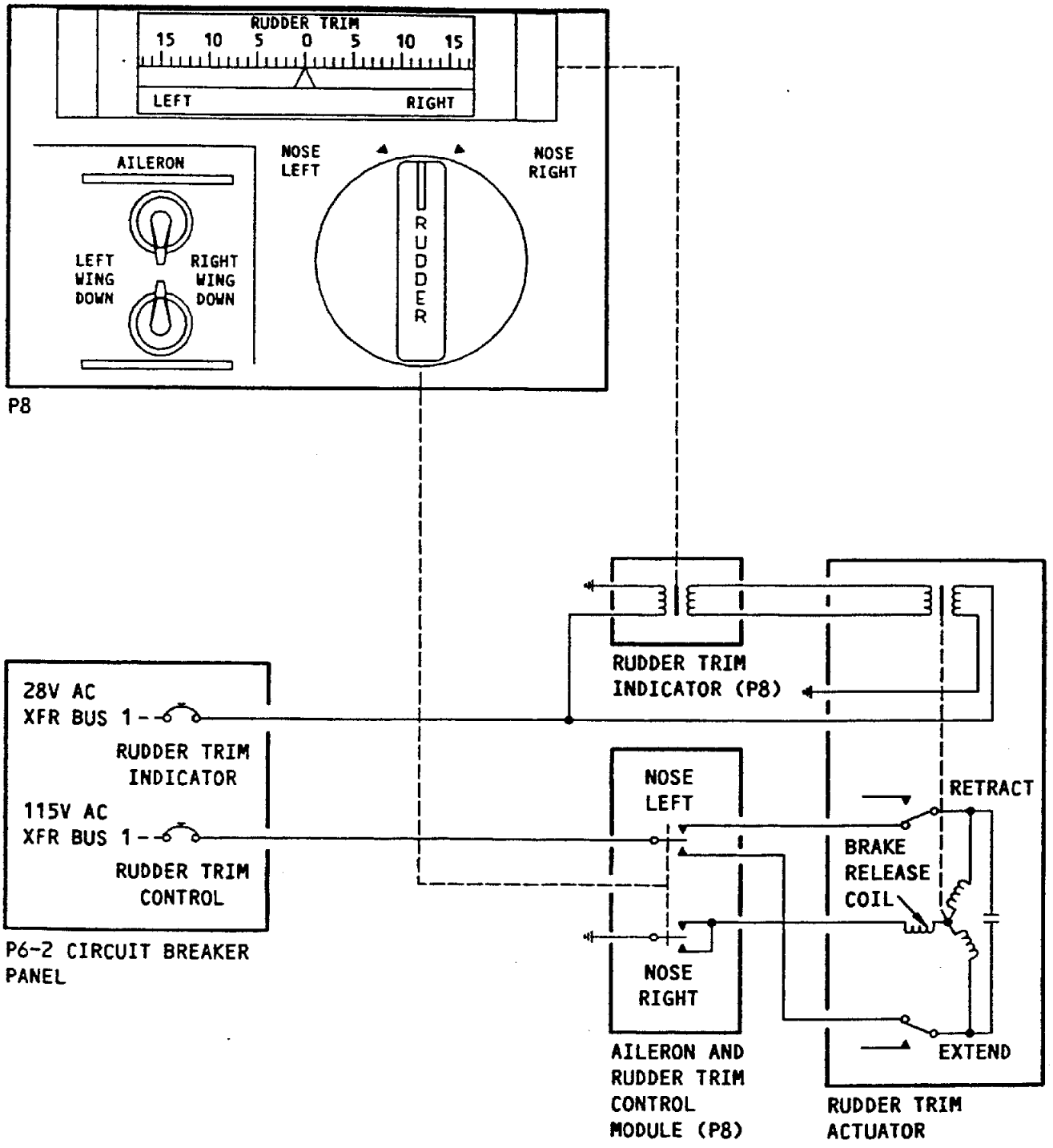
   Operation of the rudder trim switch actuates a pair of contacts. Control power is applied through the upper set of contacts and the appropriate set of limit switches to the motor and brake and to ground through the lower contacts. The electromagnetic brake prevents actuator overrun and internal mechanical stops prevent overtravel in case of limit switch malfunction.

3. Operation

   Trim commands from the trim switch cause the actuator to extend or retract which rotates the feel and centering mechanism. This drives the power unit input rods to position the rudder to a new neutral if hydraulic power is available. The pedals are positioned to a new neutral position corresponding to rudder position.

4. Monitor

   The rudder trim indicator is driven electrically by a rotary variable differential transformer (RVDT) in the actuator. It is graduated up to 17 units left and right to display up to the 16° maximum left and right rudder movement by the trim system. Loss of power to the indicator causes a black tape to cover the pointer and an off flag to appear at the left of the dial.



RUDDER TRIM

130989

COMPONENT FUNCTIONAL DESCRIPTION

STANDBY RUDDER ACTUATOR

1. Purpose

   The standby rudder actuator provides standby hydraulic pressure to operate the rudder when either system A, system B, or both are not available.

2. Location

   The standby rudder actuator is located above the main power control unit in the vertical fin.

3. Physical Description

   The actuator consists of a bypass valve, control valve, and the actuating cylinder. The piston rod is attached to fin structure and the opposite end of the actuator housing is attached to the rudder.

4. Power

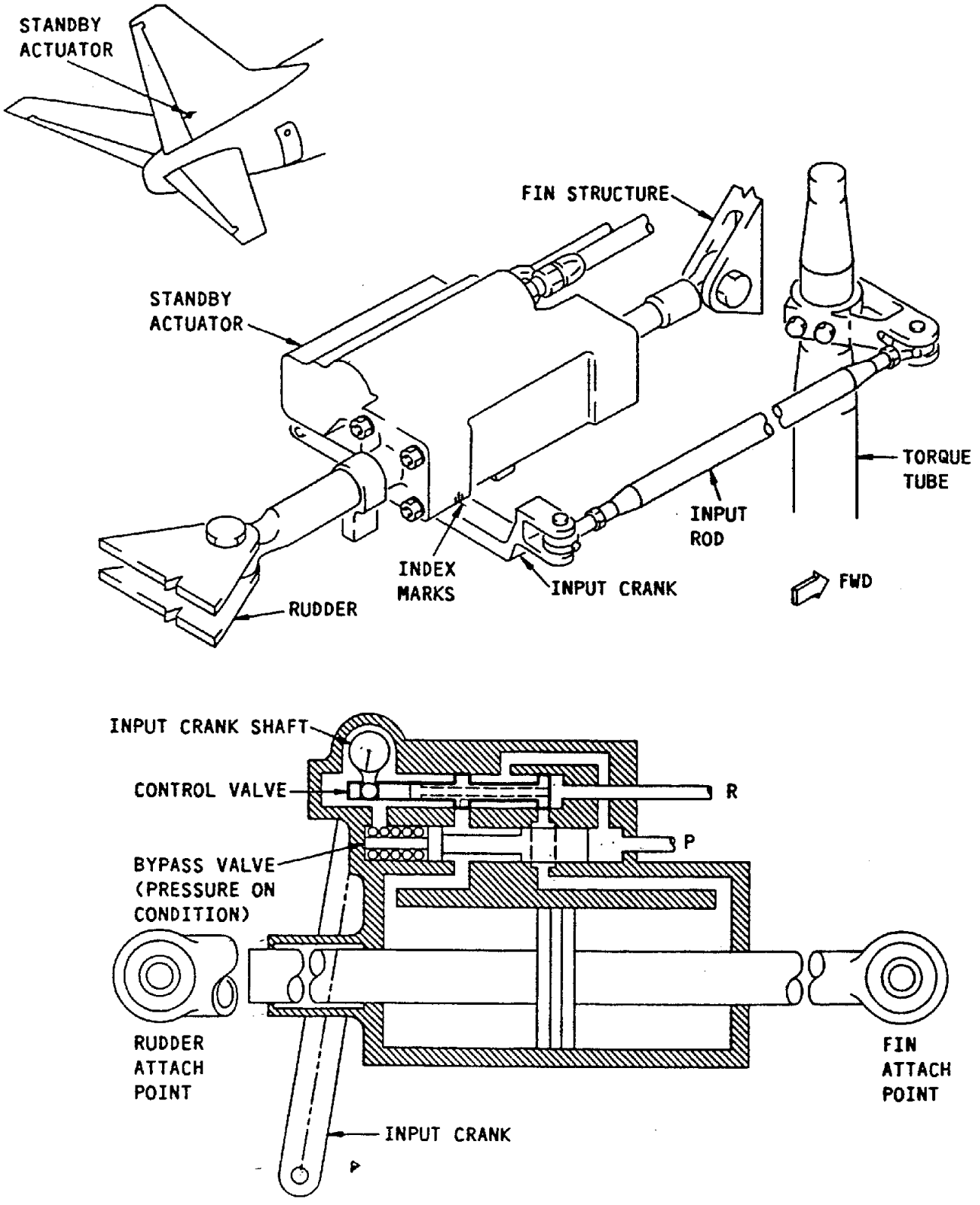
   The standby actuator is not normally powered. When selected by the A or B flight control switches or automatic operation, the actuator is powered through the standby rudder shutoff valve. At least one side of the main power control unit is not powered when the standby actuator is powered. No more than two hydraulic systems can be used to operate the rudder.

5. Control

   Inputs form the rudder pedals or trim actuator are simultaneous to the main power control unit and to the standby actuator. The bypass valve is in the bypass position when standby pressure is not available. This connects both piston chambers to the same port of the control valve to prevent a hydraulic lock.

6. Operation

   When standby rudder operation is activated, standby pressure opens the bypas valve and connects the actuator chambers to separate control valve ports. Control inputs, operating the external crank, position the control valve to apply pressure in one chamber and open the other to return. The actuator housing strokes on the piston to position the rudder and null the control valve.



STANDBY RUDDER ACTUATOR

130972

COMPONENT FUNCTIONAL DESCRIPTION

STANDBY RUDDER SHUTOFF VALVE

1. Purpose

   The standby rudder shutoff valve controls hydraulic pressure to the standby actuator.

2. Location

   The valve is mounted in the standby module on the aft wall of the main gear wheel well.

3. Physical Description

   The valve is an electrically operated spool and sleeve contained in a cartridge that fits into a cavity in the standby module. The electric motor is splined to a cam which converts rotary motor action into linear spool action in the sleeve.

4. Power

   The valve is electrically operated by 28 volts dc supplied by the battery bus.

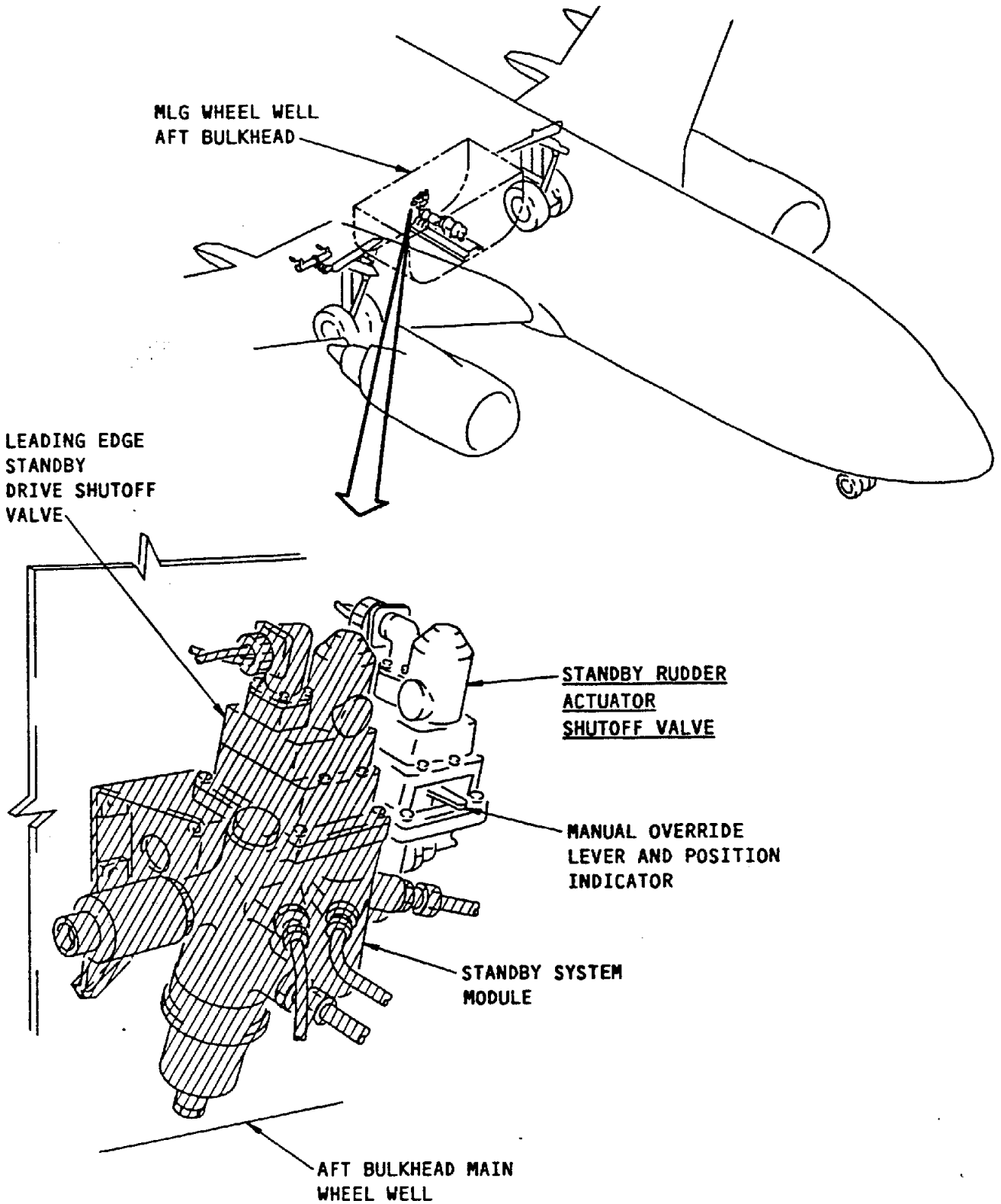
5. Control

   Operation of the standby rudder shutoff valve electrically is by either the Flight Control A or B switches on the overhead panel. The valve is closed when both switches are ON or OFF. Moving either to STBY RUD applies power to open the valve and allow standby pressure to the standby rudder actuator.

   The valve can also be opened automatically whenever low pressure is detected at either flight control low pressure switch, the trailing edge flags are not up, and the airplane is either in the air or on the ground with wheelspeed above 60 knots.

6. Monitor

   The valve is equipped with a manual override lever and position indicator. The lever is at position 1 when the valve is closed and position 2 when open. This lever can be used to manually position the valve when electrical power is off.



STANDBY RUDDER SHUTOFF VALVE

150973

OPERATION

RUDDER HYDRAULIC SYSTEM

1. Operation/Control Sequence

   Control inputs to the rudder hydraulic power units are from either pilot's rudder pedals or the trim control switch. Any input causes rotation of a torque tube in the vertical fin that results in simultaneous input to both the main and standby hydraulic power units. The pressurized power units deflect the rudder up to a maximum of 26° in either direction, 16° by trim.

2. Normal Sequence

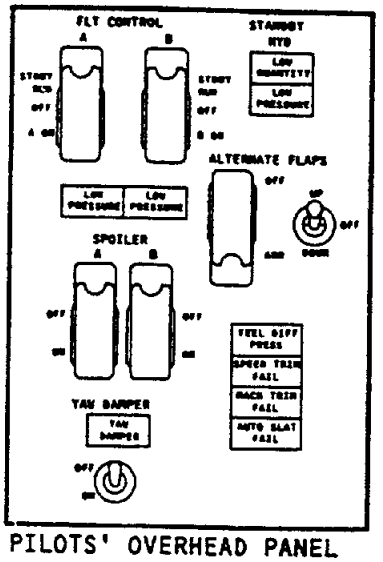
   Normal operation of the rudder is by hydraulic systems A and B applied to the dual tandem piston in the main power unit through shutoff valves in the respective flight control modules. These valves are controlled by the applicable flight control (A and B) switches on the pilot's overhead panel. The switches are normally guarded ON. When positioned OFF the respective valve closes, blocking system pressure to the aileron, elevator, and rudder. One system can move the rudder full travel but at approximately half the normal rate.

   Manually operated isolation valves can selectively isolate the rudder from either primary hydraulic system for test purposes.

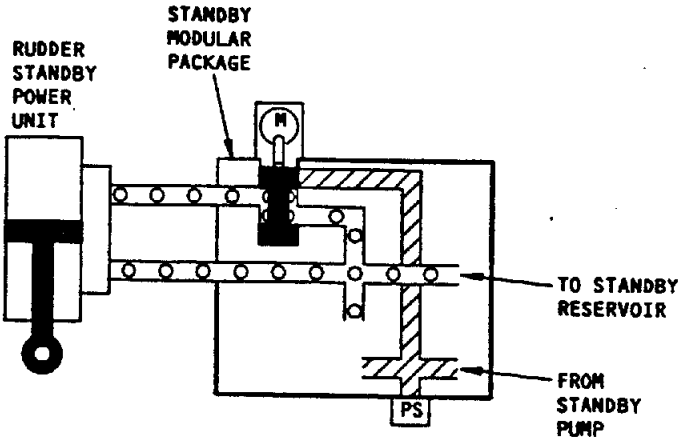
3. Backup Sequence

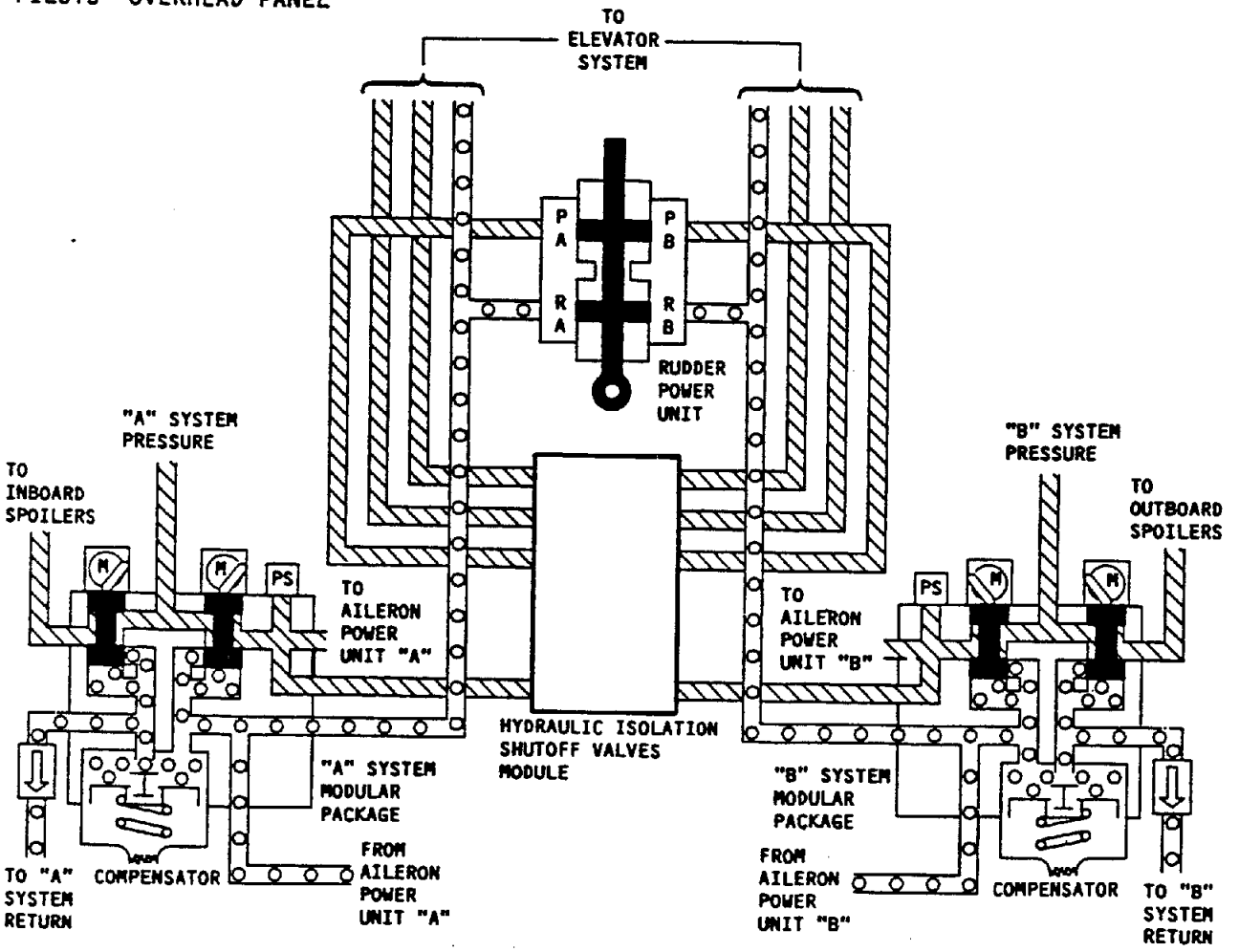
   Either or both primary hydraulic systems can be replaced by the standby power unit, pressurized by the standby hydraulic system through the standby rudder shutoff valve. This valve is operated by positioning either flight control switch (A or B) to STBY RUD. This closes the respective flight control shutoff valve so that no more than two systems operate the rudder at the same time.

   The standby rudder shutoff valve is automatically opened and the standby pump is started to pressurize the standby actuator whenever either primary flight control low pressure switch is low, the trailing edge flaps are not up, and the airplane is either in the air or on the ground with wheelspeed above 60 knots.



PILOTS' OVERHEAD PANEL



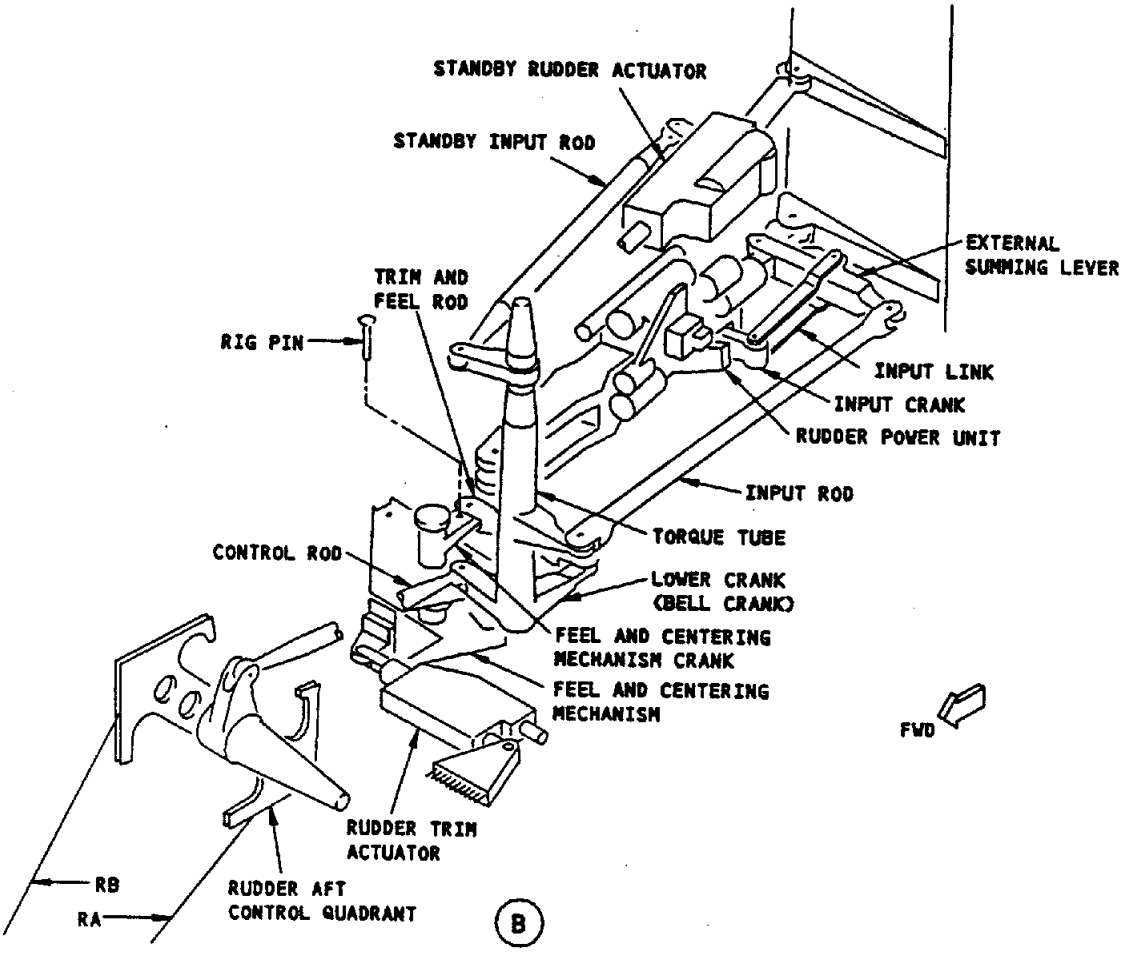


RUDDER HYDRAULIC SYSTEM

131273

RUDDER AND RUDDER TRIM CONTROL SYSTEM - DESCRIPTION AND OPERATION

1. General
   A. Yaw control of the airplane is provided by a single conventional rudder without tab. There are two separate hydraulic systems powering one main power control unit. Rudder control backup is provided by a standby power unit, which is driven by a third hydraulic system. Any one of the three hydraulic systems will provide effective rudder control. Rudder trim is accomplished by operating a trim control knob which repositions the rudder centering unit.
   B. The rudder control system is pedal operated by the captain or the first officer (Fig. 1). Pedal movement rotates the forward quadrants, which are cable connected to the aft quadrant. Rotation of the aft quadrant moves a control rod connected to a torque tube. Rotation of the torque tube moves a crank connected to the rudder power control unit linkage (Fig. 2). This admits hydraulic fluid to the actuating cylinder, which moves the rudder.
   C. Rudder trim is initiated by the rudder trim knob located on the aisle stand (Fig. 3). The rudder trim knob activates arming and control switches which direct electrical input to the rudder trim actuator motor. Rotating the trim knob arms the trim motor circuit and selects either the extend mode for left rudder trim or the retract mode for right trim. Extension or retraction of the trim actuator jackscrew causes the feel unit frames to rotate. This moves linkages which rotate the torque tube, causing rudder power control unit input.
   D. Rudder feel is provided by a rudder feel unit. The feel unit is connected to the rudder control torque tube, which connects through linkage and cables to the rudder pedals (Fig. 4).
   E. The rudder is fully power operated through the entire travel. The rudder power control unit is hydraulically operated by hydraulic systems A and B simultaneously. The A and B systems can be independently activated by switches located on the overhead panel. Either of the A and B switches can be used to activate the standby hydraulic system and supply pressure to the standby actuator. The standby hydraulic system is automatically activated in the event of the loss of the A or B hydraulic system on takeoff.



Rudder Control System Component Location
Figure 1 (Sheet 2)

F. To maintain system B hydraulic pressure to the elevator system in case of a rudder system hydraulic leak, the system B pressure line to the rudder PCU has a fuse (not on all airplanes) located in the aft stabilizer compartment, and the system B return line from the rudder has a check valve (not on all airplanes) located in the space above the stabilizer center section.

G. System A and system B pressure is supplied by engine-driven hydraulic pumps on each engine and electric motor driven hydraulic pumps (one for each system). A and B flight control hydraulic modular units are identical in components and operation. Pressurized hudraulic fluid flows through the modular unit which consists of a spoiler shutoff valve, a flight controls shutoff valve, low pressure warning switch, compensator, and check valve. The flight controls shutoff valve controls the flow of hydraulic fluid to the ailerons, elevator, and rudder. When either the A or B flight control switch on the overhead panel is moved to STBY RUD, or if the automatic standby function is activated, the standby hydraulic system pump will start. The standby rudder actuator shutoff valve located in the standby hydraulic module will also open, porting hydraulic fluid to the standby actuator.

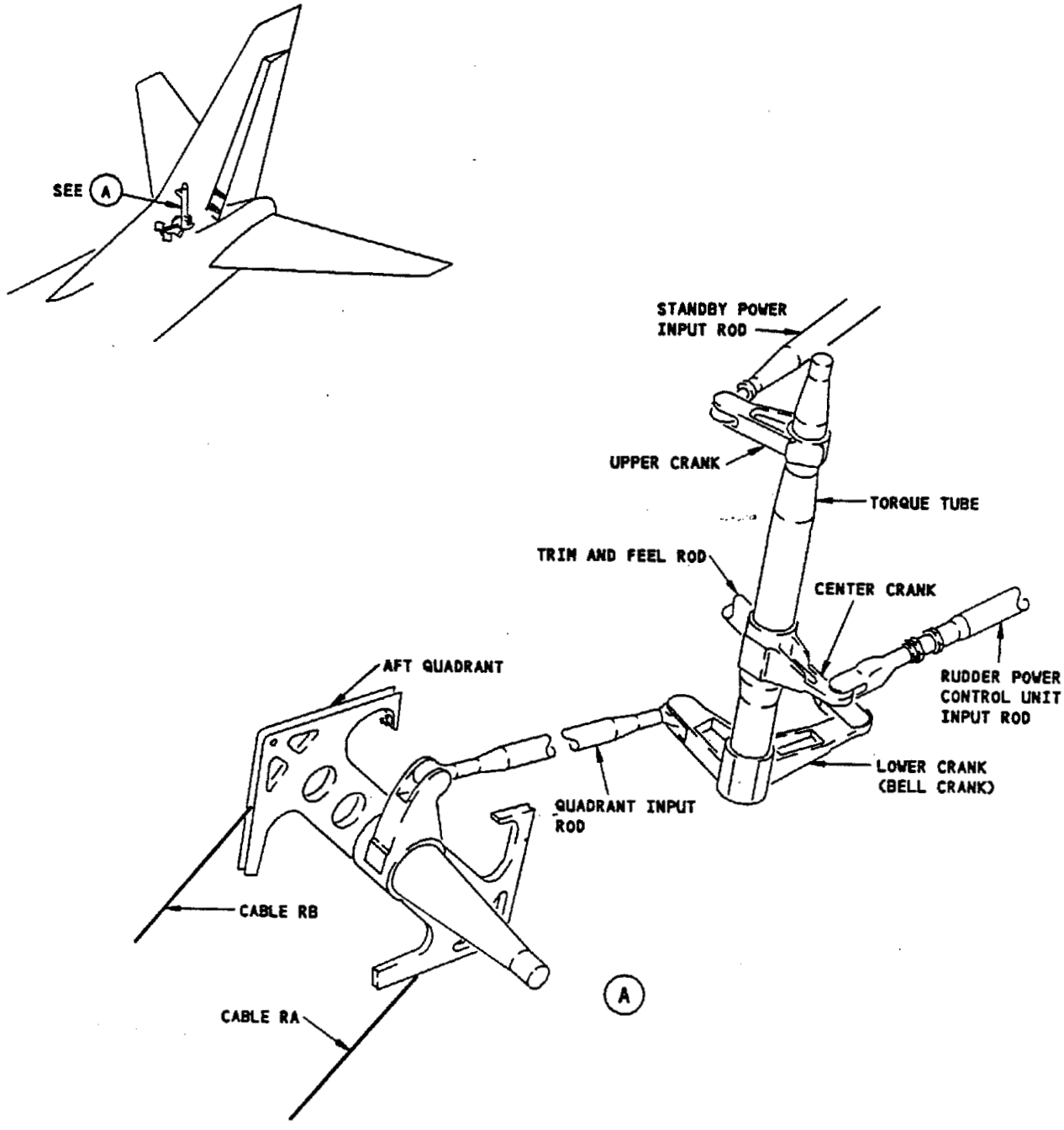
H. A rudder isolation shutoff valve is installed in the system A and the system B hydraulic lines between the respective system A and system B flight controls hydraulic modular units and the rudder power unit. The valve is part of the hydraulic isolation shutoff valve module, which consists of six hydraulic isolation valves. The valves are individually operated and provide a means of isolating individual hydraulic components for ground leakage and flow tests.

2. Rudder

A. The rudder provides yaw control for the airplane. The rudder is of graphite/composite construction. The skin is made of graphite reinforced epoxy. There is no rudder tab. There are seven rudder hinges, the bottom one being a thrust hinge. Balance weights are fastened to the rudder nose. The balance weights are made of tungsten. See Structural Repair Manual, Chapter 51, for rudder balancing. There is a body seal attached to the bottom rib of the rudder. The body seal is made of honeycomb nomex core material. This seals the gap between the rudder and the body.

3. Rudder Pedals

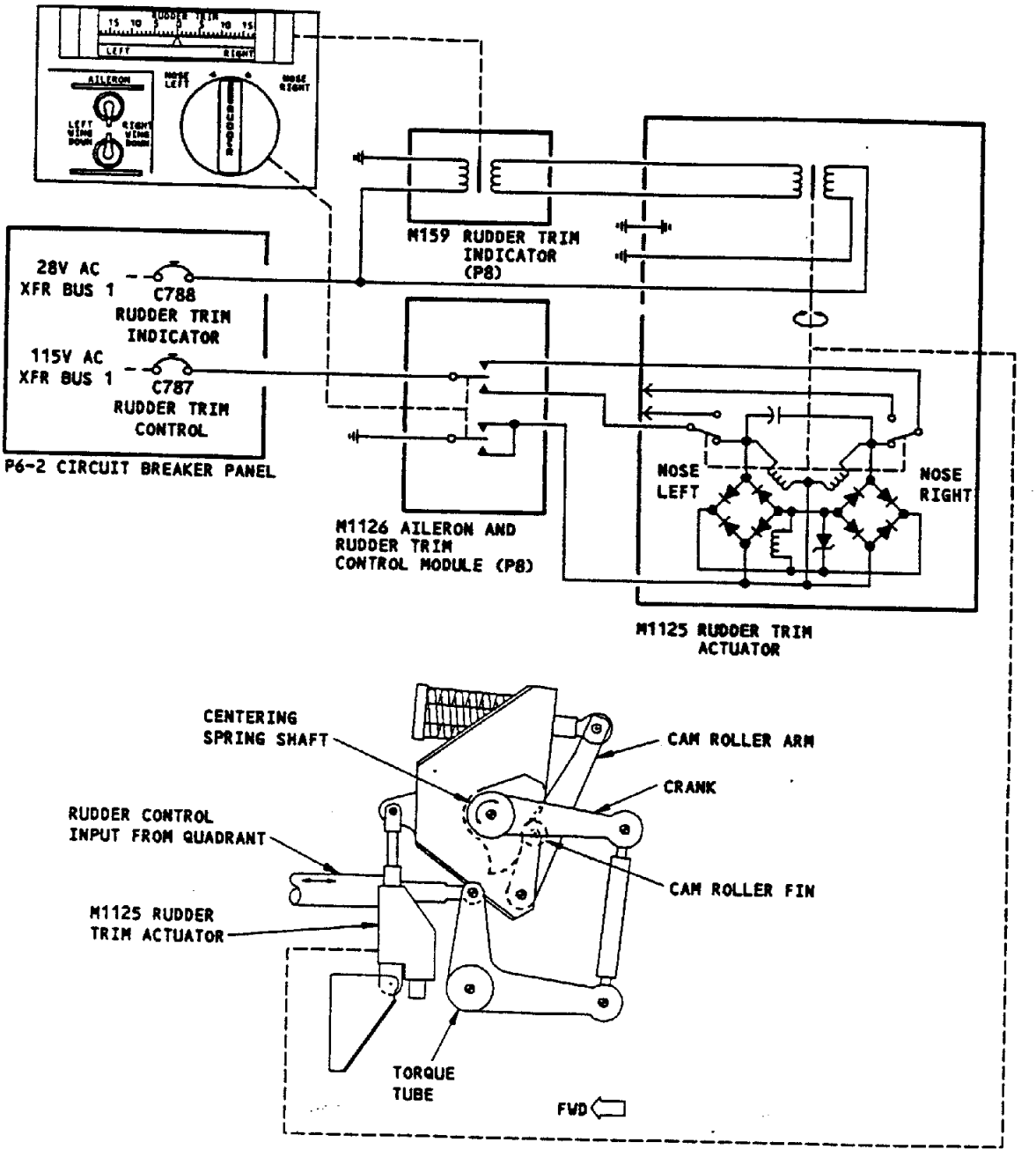
A. The captain and first officer are each provided with a pair of rudder pedals used for controlling the airplane about the vertical axis (Fig. 1). Each pair of pedals consist of right and left pedals mounted on a shaft. The pedal shaft is attached to the upper end of the pedal arm assembly. The lower end of the pedal arm assembly is mounted on a support shaft attached to the structure below the floor. The rudder pedals are located below the captain's and first officer's instrument panel. Rudder pedal support and quadrant assemblies are accessible through the lower nose compartment.



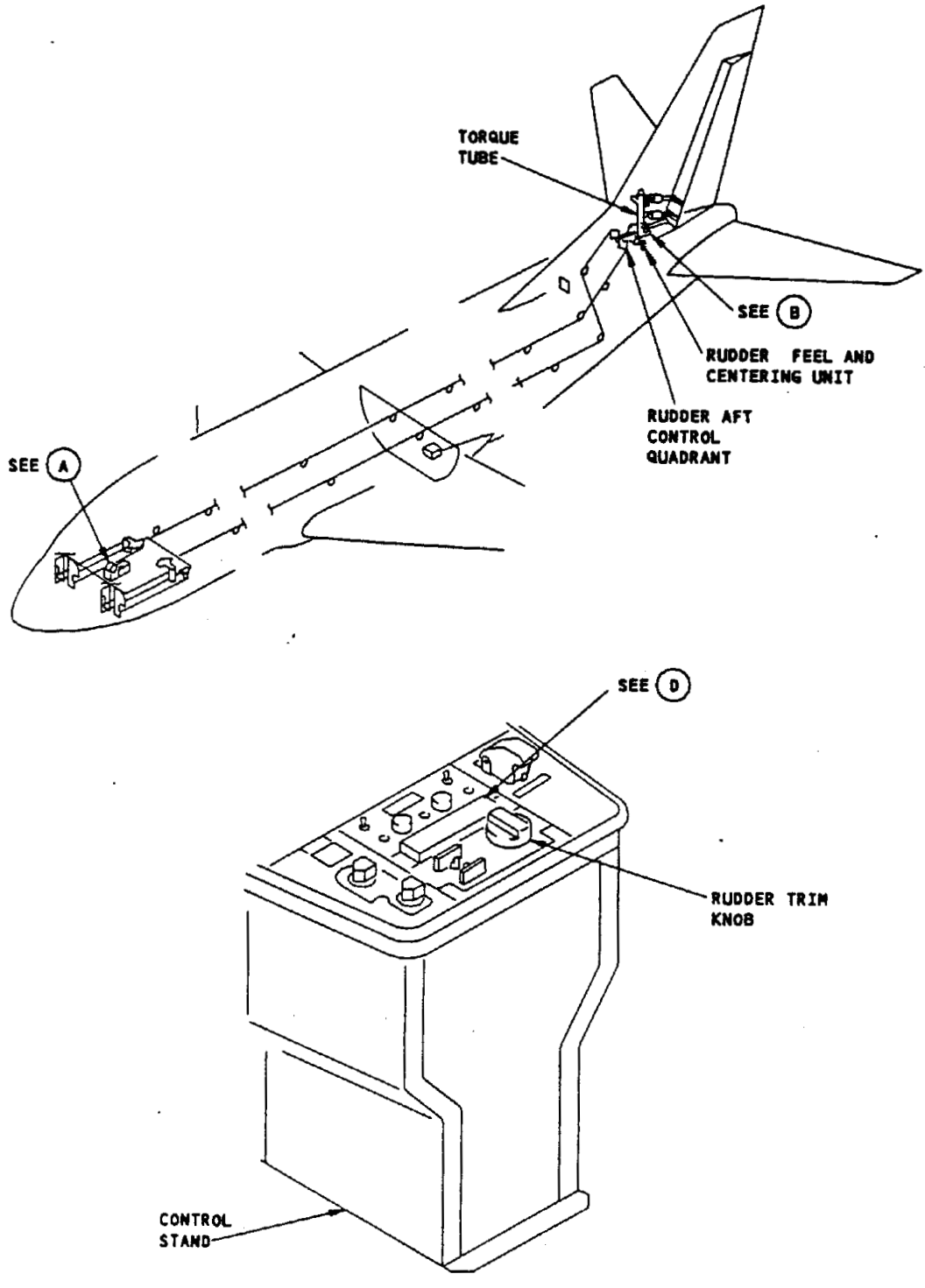
Rudder Aft Control Quadrant and Torque Tube
Figure 2

B. Fore and aft movement of the pedals is transmitted by the two pushrods to the jackshaft yoke. The rotary motion of the jackshaft yoke is passed to the forward quadrant by means of the jackshaft. The two sets of rudder pedals are bussed together by means of a bus pushrod connecting the two jackshaft assemblies. Toe pressure on the rudder pedals causes pedals to rotate about the shafts and initiate braking action.

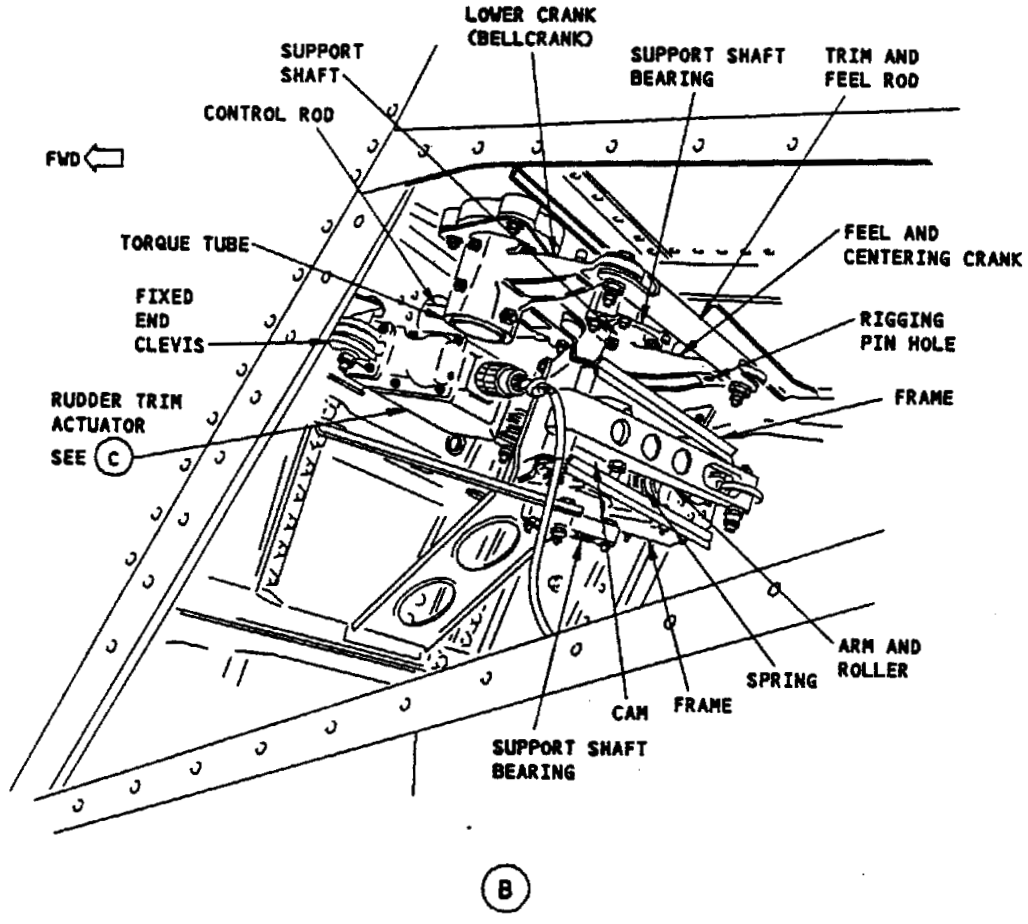
4. Rudder Pedal Adjustment Crank
   A. The two pairs of rudder pedals can be adjusted independently to suit the captain and first officer. This is accomplished by means of the rudder pedal adjust shaft (Fig. 1). The rudder pedal adjustment mechanism consists of an adjustment crank, adjustment shaft, a jackscrew, and pedal adjustment nut attached to the jackshaft assembly.
   B. The adjustment crank is located on the instrument panel forward of the control wheel. The crank is connected to a flexshaft routed forward under the instrument panel, then down under the floor, and aft to the universal joint in the rudder control jackshaft assembly. Rotation of the rudder pedal adjustment crank actuates the jackscrew which causes the yoke, containing the pedal adjustment nut, to move fore and aft.
   C. Rudder pedal adjustment crank and crank handle stops are installed to prevent the rudder pedal adjustment screw from being backdriven by heavy foot pressure simultaneously applied to both rudder pedals. The crank incorporates a spring-loaded pin within the knob. The stops are incorporated into the crank housing bearing retainer. Rotation of the crank handle is prevented in either direction beyond the stop blocks, by contact of the spring-loaded pin that protrudes from the crank handle. To permit crank rotation for rudder pedal adjustment, the knob must be pulled aft so the pin clears the stops.
5. Rudder Aft Control Quadrant
   A. The rudder aft control quadrant (Fig. 2) transmits the motion of the rudder control cables to the dual path torque tube. The assembly consists of a quadrant bolted to a shaft. The shaft is mounted horizontally in the vertical stabilizer.
   B. Rotation of the quadrant pushes or pulls the quadrant input rod attached to a crank on the rudder control torque tube.
6. Rudder Control Torque Tube
   A. The rudder control torque tube provides a dual load path for rudder control linkage inputs. The torque tube (Fig. 2) consists primarily of two aluminum tubes bonded and swaged together. A dual-load-path plug forms each end of the torque tube and is double riveted in place. The torque tube is mounted on two bearings retained by two nuts installed on each dual plug. The tube is mounted in a vertical position in the vertical fin. Three cranks are bolted to the tube. The lower crank is connected to the input rod from the aft control quadrant and to the feel and centering mechanism. The center crank is connected to the main rudder power control unit linkage. The upper crank is connected to the standby power unit control linkage. The cranks are of dual construction with the two halves bonded and riveted together.
   B. Rudder pedal input causes the torque tube and cranks to rotate. This provides input to the rudder power unit, the feel and centering unit, and the standby actuator.

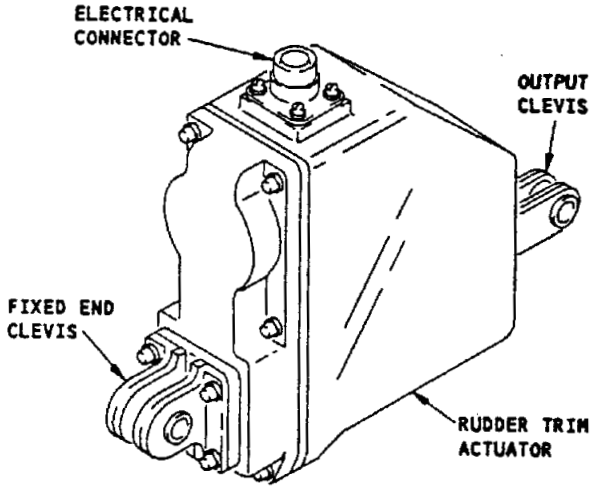


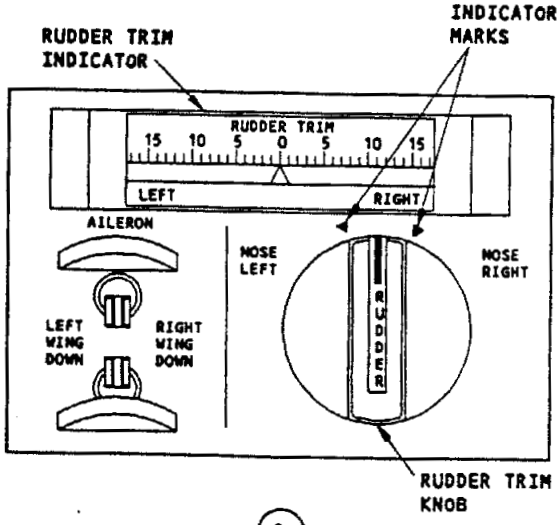
Rudder Trim Control System Schematic
Figure 3



Rudder Trim and Feel System
Figure 4 (Sheet 1)



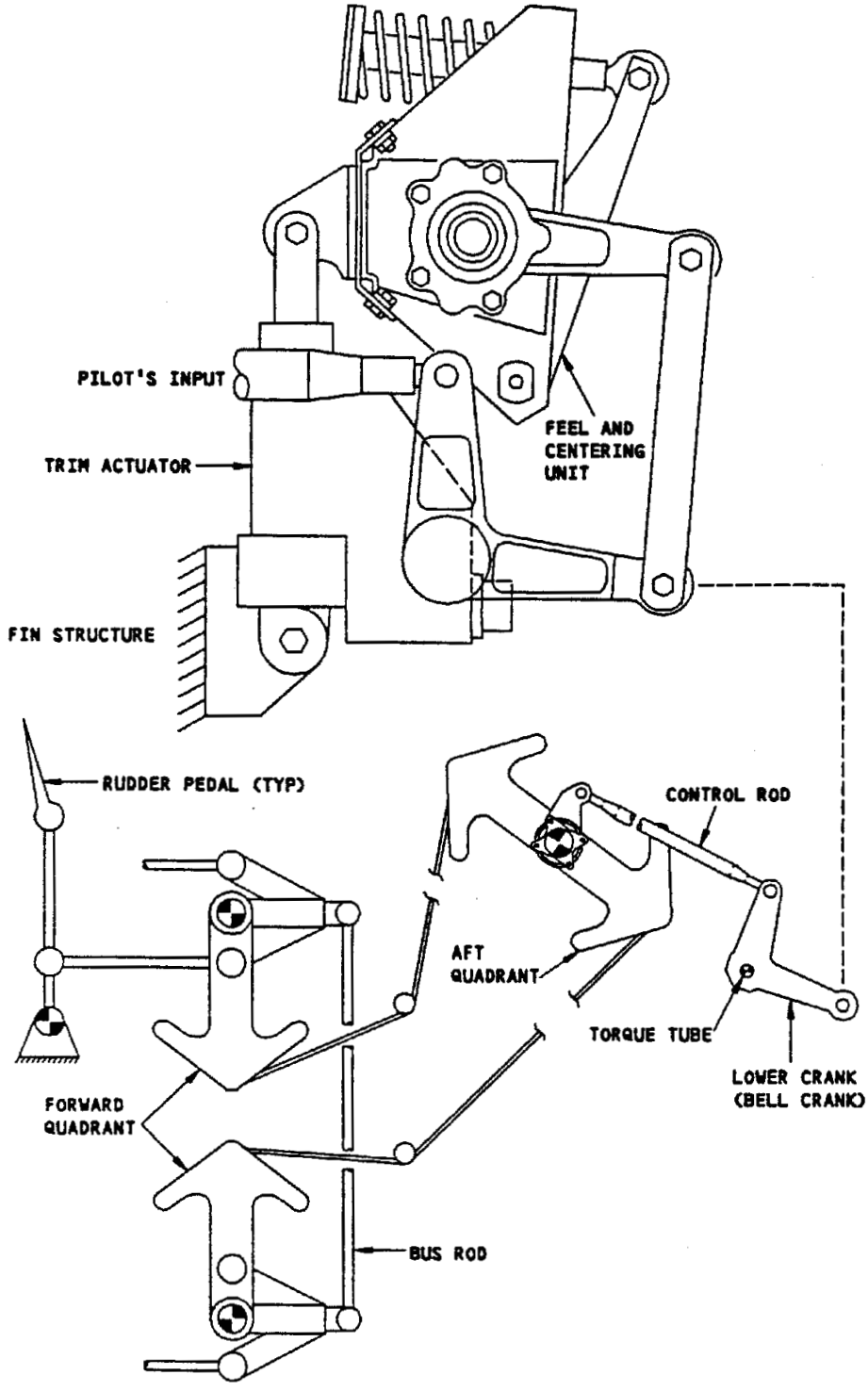




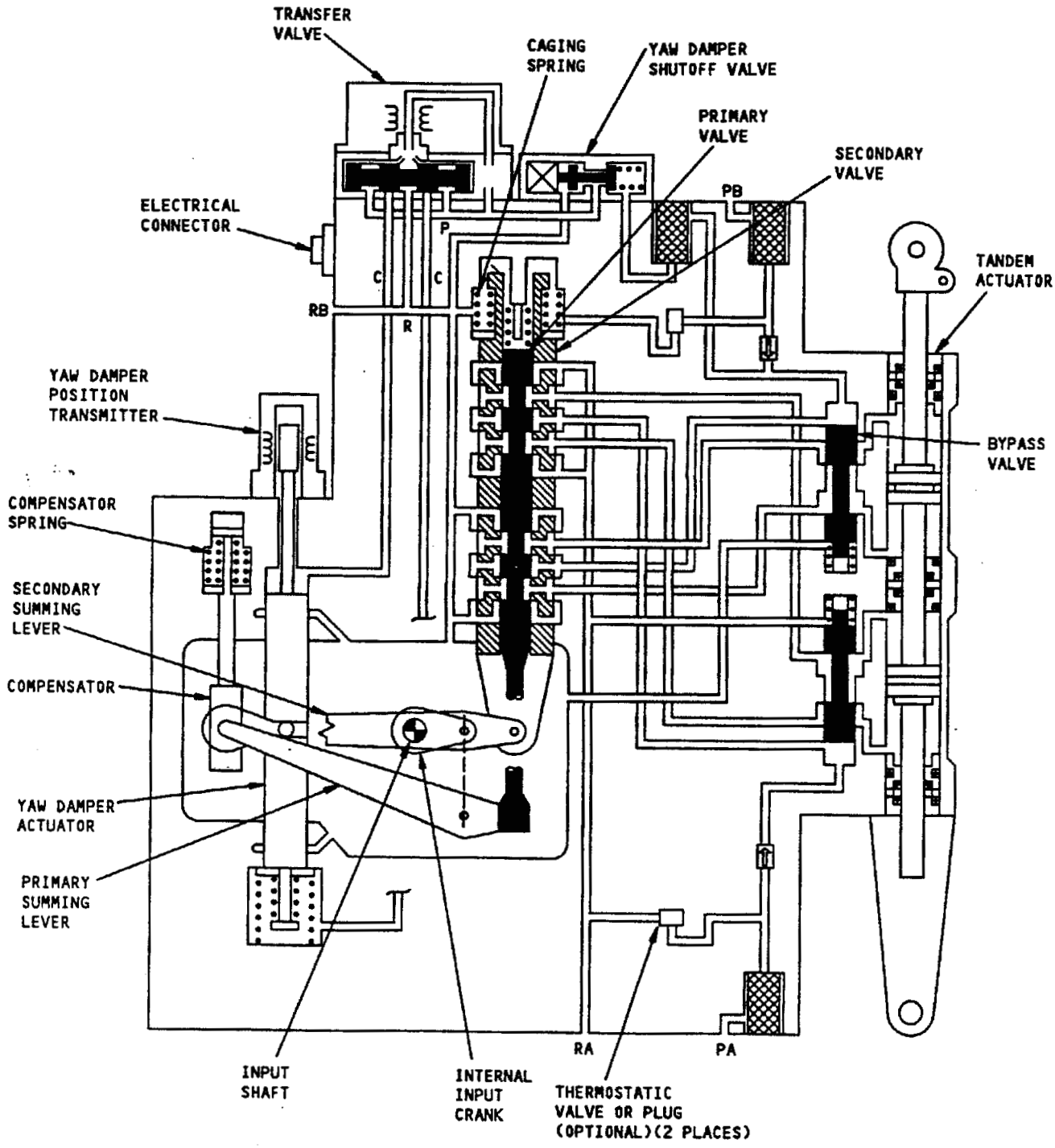
Rudder Trim and Feel System
Figure 4 (Sheet 2)

7. Rudder Trim Control Mechanism
   A. The rudder trim control mechanism provides a means for controlling the directional trim of the airplane and indicates the units of rudder trim (Fig. 4). The control mechanism consists of a rudder trim knob and rudder trim indicator on the aft end of the control stand.
   B. The trim indicator is driven electrically by a transmitter in the rudder trim actuator on the feel and centering mechanism. The indicator shows up to 17 units of left or right trim. Each unit represents approximately one degree of rudder trim. The indicator is located on panel P8 next to the rudder trim knob and is powered by 115 volts ac from bus XFR BUS-1. The RUDDER TRIM control circuit breaker is located on circuit breaker panel P6.
   C. The rudder trim knob is located on center console panel P8 and activates arming and control switches which direct electrical input to the rudder trim actuator motor. The knob is spring-loaded to return to neutral. The RUDDER TRIM circuit breaker is located on circuit breaker panel P6.
8. Rudder Trim Actuator
   A. The rudder trim actuator consists of an acme screw driven ram, coupled to a motor-brake and position sensor (RVDT) through a gear reduction, and limit switches enclosed by an aluminum housing. The motor drive is controlled by the rudder trim knob or by activation of an internal limit switch. An electromagnetic brake prevents actuator overrun and internal mechanical stops prevent overtravel in case of a limit switch malfunction.
   B. Trim commands from the trim knob cause the actuator to extend or retract, which rotates the feel and centering mechanism. This provides a new zero force pedal position corresponding to the trimmed rudder position. The actuator provides the ground point for the feel and centering mechanism.

9. Rudder Feel and Centering Mechanism (Fig. 5)
   A. The rudder feel and centering mechanism consists of the feel and centering unit which provides artificial feel to the pilots' pedals and centers the rudder. The feel and centering unit is located below the rudder power unit in the vertical fin (Fig. 4). The feel and centering unit has a support shaft, a feel and centering crank, two frames, an arm and roller with a spring assembly, and a cam. The support shaft is bearing mounted on structure. The feel and centering crank is fixed to the support shaft and is connected through the trim and feel rod to the lower crank on the torque tube. The two frames are bearing mounted on the support shaft. The arm and roller and the spring assembly attach to and rotate with the two frames. The cam is fixed to and rotates with the support shaft. The rod end of the rudder trim actuator is supported by a fitting on the forward end of the two frames. When the rudder pedals are displaced, the torque tube rotates causing offset of the trim and feel rod and in turn rotation of the feel and centering crank, the support shaft, and the cam. As the cam rotates, the arm and roller are displaced out of the detent position to extend the spring assembly and provide artificial feel. Rudder trim input through the rudder trim actuator rotates the two frames with the arm and roller and spring assembly. The force of the spring assembly holds the arm and roller in the cam detent and causes the cam to rotate. Rotation of the cam causes subsequent motion of the support shaft, the feel and centering crank, the trim and feel rod, the lower crank and the torque tube which then causes input to the rudder power unit, repositioning the rudder. At the same time, the lower crank causes input to the rudder control system with movement of the pilots' pedals.
10. Rudder Power Control Unit (Fig. 6)
   A. The rudder power control unit moves the rudder right or left when actuated by rudder pedal input and provides wind gust snubbing when the airplane is parked. The unit is located in the vertical fin (Fig. 1). The body is fixed to fin structure and the power head to the rudder. The control unit is separately powered by hydraulic systems A and B. Either system acting alone will provide full rudder control.
   B. Power control unit yaw damper function is to minimize dutch roll during manually and automatically controlled flight. The yaw damper provides rudder displacement proportional to the yaw rate, and opposing the yaw direction of the airplane. The yaw damper input is in series with the pilots' input and is not felt at the rudder pedals.
   C. Pilots' input by rudder pedals is transmitted through cables and linkages to the power control unit input crank. The input crank rotates and moves the control valve which ports hydraulic pressure to the actuating cylinder. The amount of control valve movement is also governed by the yaw damper input. The pilots' input and yaw damper input are combined algebraically by the summing levers, which connect to the the primary and secondary control valves. The power control unit piston rod end is attached to the rudder. Extension or retraction of the rod moves the rudder left or right. An external summing lever attached to the actuating piston provides feedback to return the control valve to neutral and to stop the rudder at the desired position.

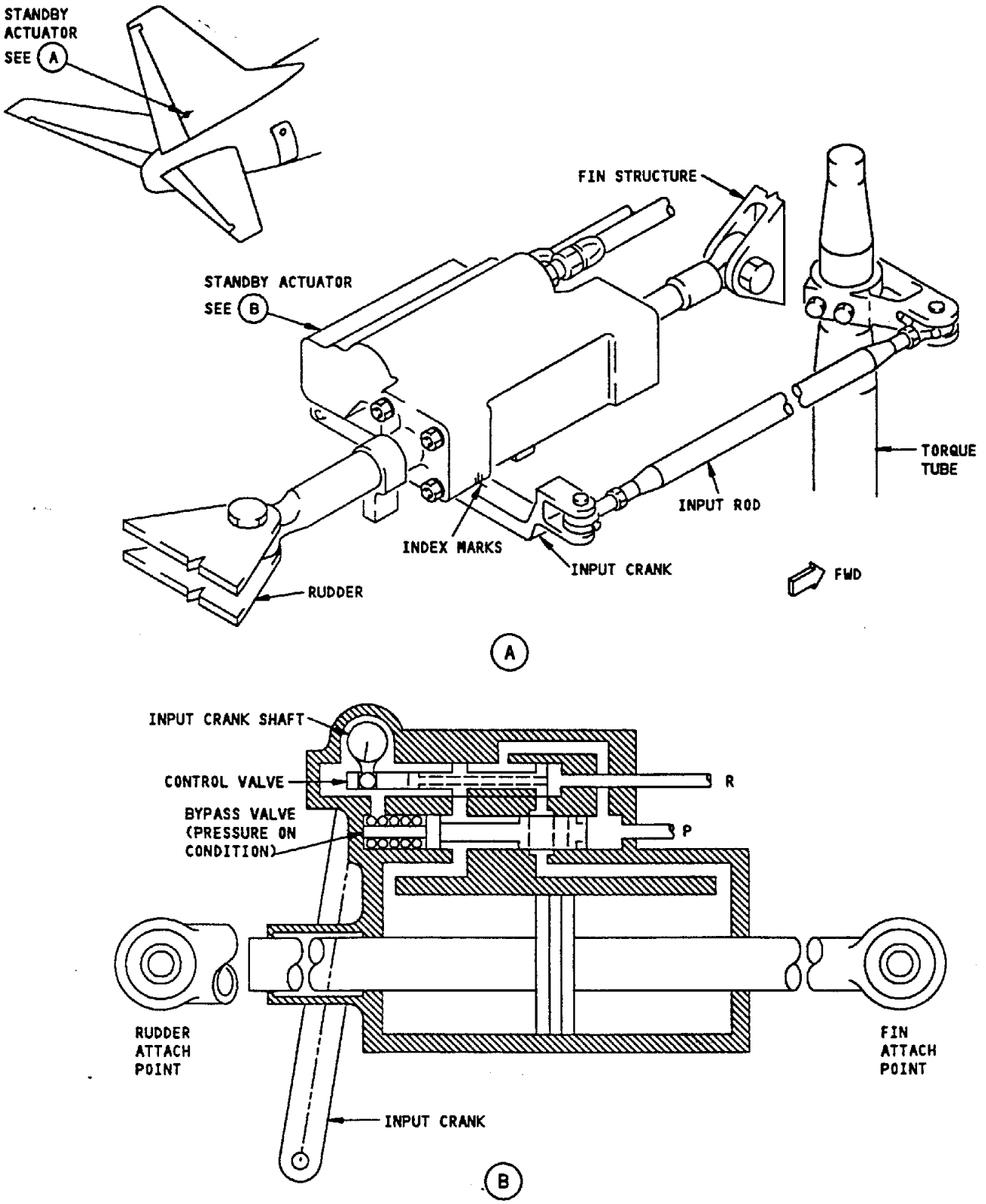


Rudder Feel and Centering Mechanism Schematic
Figure 5



Rudder Power Control Unit Schematic
Figure 6

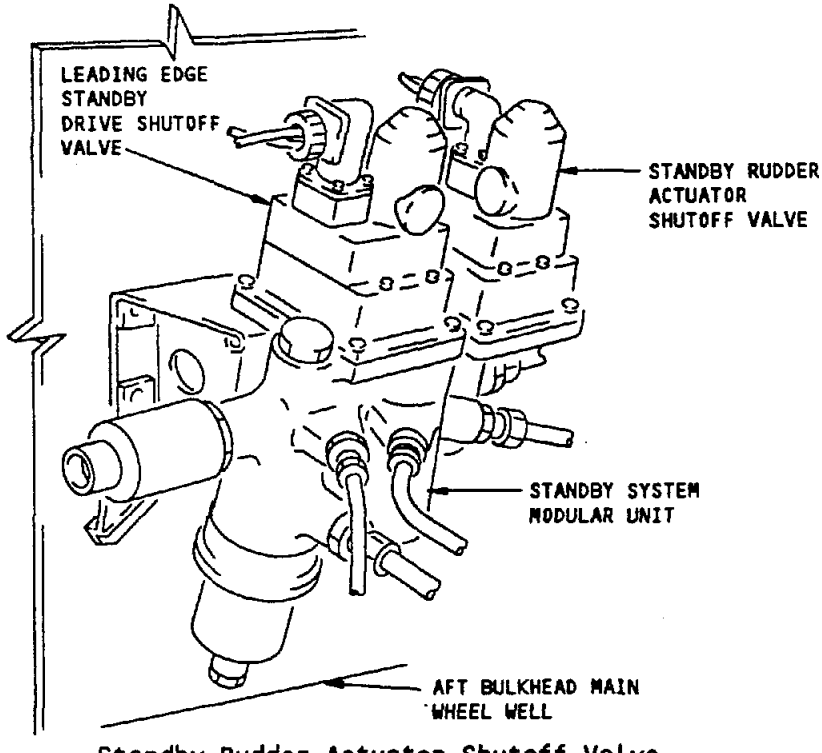
11. Standby Rudder Actuator Shutoff Valve
    A. The standby rudder actuator shutoff valve is located on the aft bulkhead of the main wheel well (Fig. 8). The unit is mounted on the standby system modular unit by four bolts. The valve is electrically operated from a 28-volt dc source, and consists of a motor spool sleeve and cartridge. The cartridge containing the spool and sleeve fits into a cavity in the modular package. The electric motor is splined to a cam which converts rotary motor action into linear spool travel in the sleeve. The valve is equipped with a manual override lever and position indicator. The manual override allows the valve to be positioned with electrical power off. The valve is on when the lever is in position 1, and off when the lever is in position 2.
12. Standby Rudder Actuator
    A. The standby rudder actuator (Fig. 7) positions the rudder when hydraulic system A and B are not available. The actuator consists of a bypass valve, control valve, and the actuating cylinder. Standby hydraulic power for the standby actuator is controlled by system A and B switches on the overhead flight controls panel or by activation of the automatic standby function.
    B. Hydraulic pressure supplied from the standby system operates the actuator. Rotation of the input crank will position the control valve to port fluid to the actuating cylinder.
13. Operation
    A. The rudder control system is operated by two sets of pedals, one for each pilot. Pedal movement is transmitted to forward quadrants and jackshafts by rods. The two forward quadrants are interconnected by a bus rod. Cables transmit forward quadrant motion to the aft quadrant located in the vertical fin. Rotation of the aft quadrant in turn causes rotation of the rudder control torque tube.
    B. The rudder control torque tube, when rotated, provides simultaneous input to the rudder power control unit, the standby rudder actuator, and to the rudder feel and centering mechanism. In normal operation, the power control unit is powered by hydraulic systems A and B (Fig. 9). Control input to the power unit occurs when a torque tube-mounted crank rotates. The crank is connected by a rod to the input linkage of the power unit. As the input linkage moves, the control valve opens and ports hydraulic fluid to the actuator cylinder. The actuating piston then moves and causes rudder deflection. Nominal rudder travel is 26 degrees in both directions.
    C. If hydraulic systems A and B are not available to power the rudder, standby power may be turned on, and the rudder operated with the standby actuator. Rudder pedal input positions a servovalve in the actuator which ports fluid to the actuating piston. Movement of the piston closes off the ports when desired rudder travel is reached. The rudder will also operate automatically on standby power when all of these conditions occur: system A or B hydraulic pressure drops below 1200 psi, the flaps are extended, and the wheel speed is greater than 60 knots or the airplane is in the air.



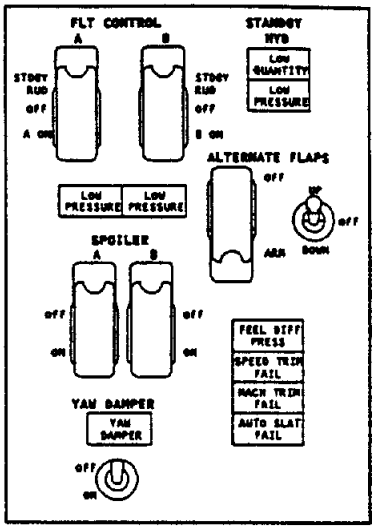
Rudder Standby Actuator
Figure 7

D. In addition to operating the rudder power unit and the standby actuator, the torque tube moves the centering cam in the feel and centering mechanism. When the cam shaft is rotated, the spring-loaded cam follower is displaced.

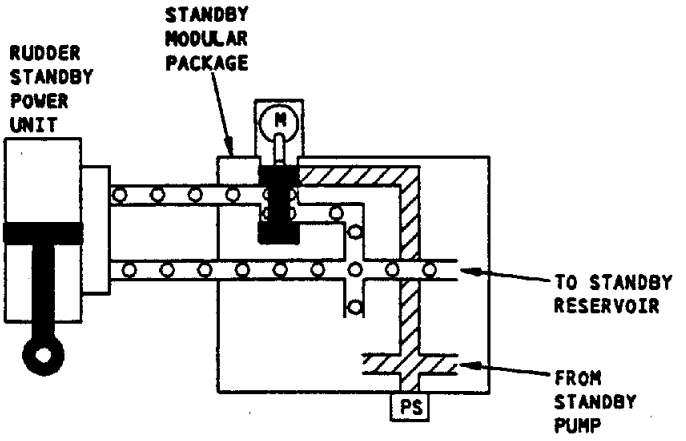
E. If rudder trim is adjusted with the power control unit depressurized, the drag of the unpowered rudder system will allow the system to remain out of center. This will force the rudder feel and centering mechanism cam follower out of the cam detent. Then when hydraulic power is applied, the rudder trim control knob and rudder will rapidly move to the newly trimmed position.



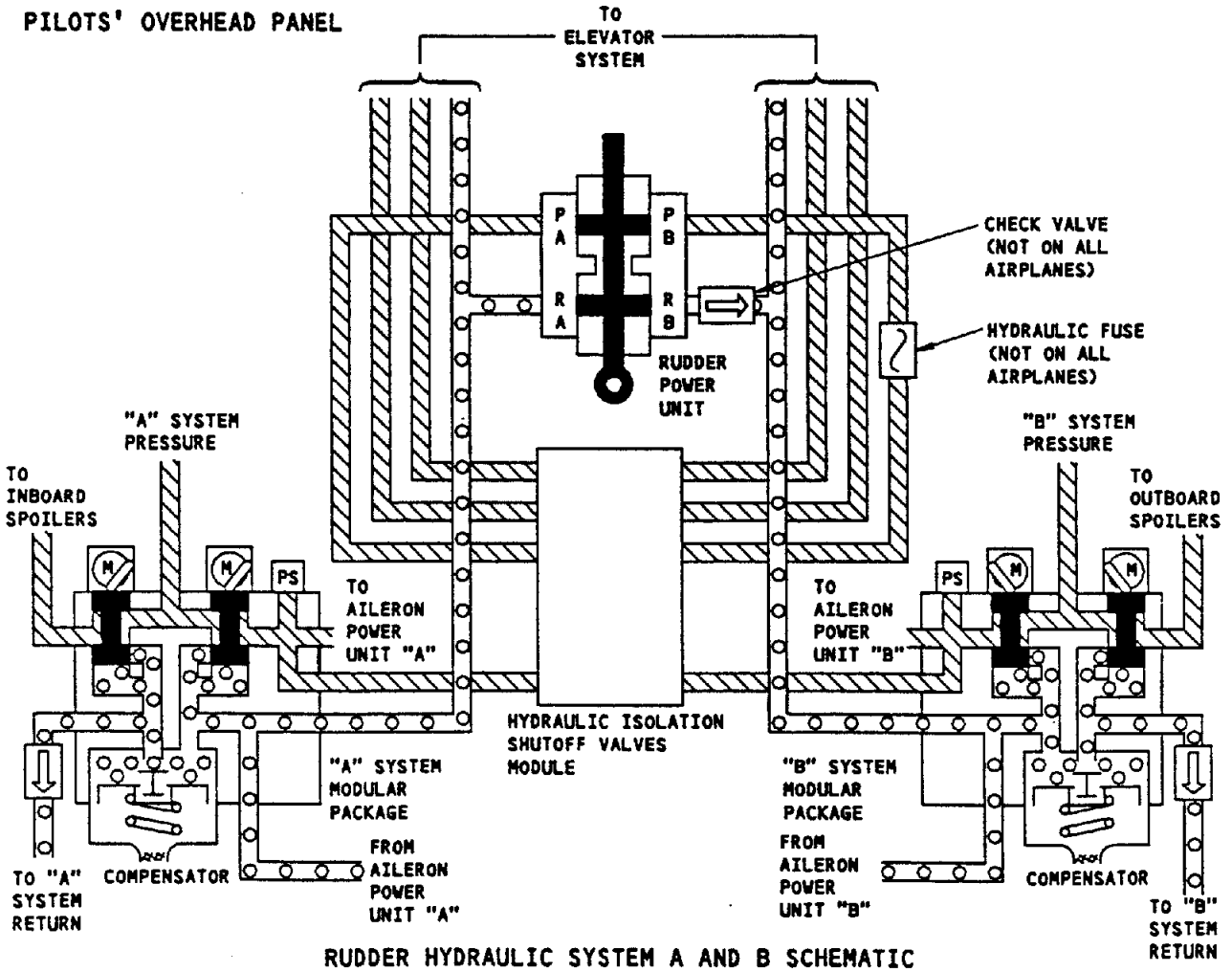
Standby Rudder Actuator Shutoff Valve
Figure 8



PILOTS' OVERHEAD PANEL



RUDDER STANDBY SYSTEM SCHEMATIC



RUDDER HYDRAULIC SYSTEM A AND B SCHEMATIC

Rudder Hydraulic System Schematic
Figure 9