CHAPTER 15
FLIGHT CONTROLS

INTRODUCTION

This chapter describes the flight controls of the Cessna Model 510 Citation Mustang. The aircraft has fixed and moveable surfaces that provide stability and control during flight. The primary flight controls are ailerons, rudder, and elevators. Secondary flight controls include trim devices, flaps, and speedbrakes. Control locks are also described.

GENERAL

The flight control systems consist of the control surfaces, trim control surfaces, trim indicating systems, and the related mechanical and electrical systems that control the airplane during flight.

The primary flight controls (elevators, ailerons, and rudder) directly control aircraft movement around the three axes of flight (pitch, roll, and yaw). They are manually actuated through cables by dual conventional control yokes and dual sets of rudder pedals in the cockpit. They can be immobilized by control locks when on the ground to prevent damage to the control surfaces and systems from wind gusts striking the aircraft.

The secondary flight controls include trim, flaps, and speedbrakes. Trim tabs, electrically or mechanically adjusted through controls on the cockpit pedestal or control yoke, assist flight control on all three axes. Mechanical elevator trim, adjusted through a cockpit pedestal wheel, is also provided.

Flaps and speedbrakes directly adjust airplane lift and drag. Both controls are electrically actuated. Flaps are operated by a handle on the cockpit pedestal. Speedbrakes are operated by a switch on the throttle.

All flight control surfaces are shown in Figure 15-1.

PRIMARY FLIGHT CONTROLS

DESCRIPTION

The primary flight controls (ailerons, rudder, and elevators) are manually operated by either the pilot or the copilot through a conventional control yoke and rudder pedal arrangement. Control inputs are transmitted to the control surfaces through cables, bellcranks, and pushrods. The rudder pedals also operate the nosewheel steering and wheel brakes (see Chapter 14—"Landing Gear and Brakes"). A flexible mechanical interconnect between the rudder and ailerons provides improved lateral stability.

The primary flight controls can also be controlled by the autopilot and yaw damper (see Chapter 16—"Avionics").

The rudder, both elevators, and the left aileron are each equipped with a trim tab that is electrically actuated from the cockpit. The elevator tabs can also be mechanically positioned by the pitch trim wheel on the control pedestal.

AILERON SYSTEM

Two ailerons (one on the outboard trailing edge of each wing) provide roll control. Neutral aileron position is 2° up. The ailerons are controlled through cables connected to the cockpit control yokes and the autopilot aileron electric servo. The control yoke rotates 70° in each direction to provide maximum aileron deflection.

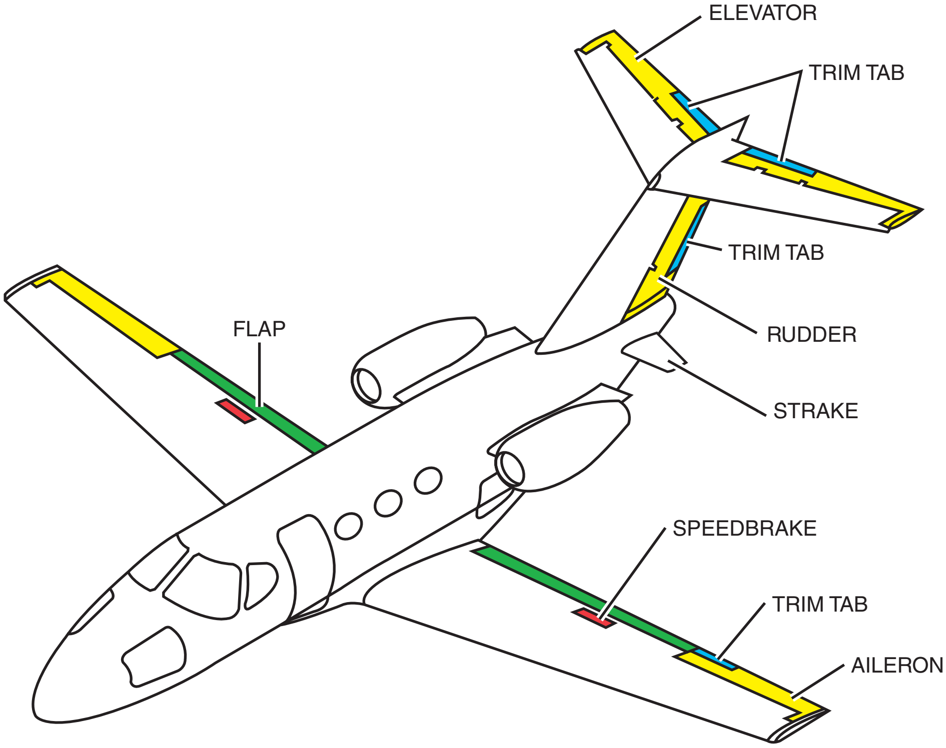

Figure 15-1. Flight Control Surfaces

Operation

When the pilot rotates the control yokes counterclockwise, the right aileron rotates down and the left aileron rotates up, causing the aircraft to roll left. By turning the control yokes clockwise, the opposite is true.

When the autopilot is operating, the autopilot roll servo provides inputs to the aileron control system. A single autopilot roll servo is mechanically connected to the aileron cable system. When the autopilot is engaged, the autopilot servo provides autopilot input to the aileron system in response to the automatic flight control system (AFCS) commands. Disengaging the autopilot can be accomplished by three normal means:

- The AP or YD button on the AFCS controller
- The AP TRIM DISC switch on either control yoke
- By commanding pitch trim

Either pilot can manually override the servo motor by applying force to the control yoke. For information on the AFCS (including autopilot), refer to Chapter 16—"Avionics."

Aileron-Rudder Interconnect

A flexible mechanical interconnect between rudder and ailerons provides improved lateral stability. Movement of the ailerons results in a comparable movement of the rudder (as sensed through the rudder pedals). If the pilot rolls the aircraft to the left, the interconnect also causes some rudder deflection (and resultant airplane yawing) to the left. Conversely, pressure on the rudder pedals and movement of the rudder results in a coordinated movement of the ailerons and control yoke.

In flight, to intentionally slip or skid/yaw the airplane, the pilot can override the interconnect by applying opposite forces to the control yoke and rudder pedals ("cross-controlling"). On the ground, the interconnect may cause some aileron and control yoke movement, as a coordinated response to rudder movements caused by the crew steering with the rudder pedals.

RUDDER SYSTEM

The rudder on the trailing edge of the vertical stabilizer provides yaw control. It moves as much as 35° left or right of center. It is controlled through cables connected to the cockpit control pedals and the autopilot yaw servo. The rudder is moved by fore and aft movement of the pedals.

The rudder pedals are floor-mounted and nonadjustable. The pedals are connected to the rudder through mechanical linkages and cables. Two separate rudder cable loops, routed differently, provide redundancy to protect against an engine rotor noncontainment (Figure 15-2).

Operation

Pressing either pilot rudder pedal (left or right) moves the rudder in that direction, which yaws the airplane that direction. Copilot controls work the same. Pilot and copilot pedals are mechanically linked so the pilot applying the greater force controls yawing, and controls the amount of pedal movement for both pilots. The rudder pedals also control nosewheel steering (refer to Chapter 14—"Landing Gear and Brakes.").

The single autopilot yaw servo is mechanically connected to the rudder. When the autopilot is engaged, the yaw servo provides input to the rudder system in response to the AFCS commands.

The yaw damper can be disengaged by:

- Pressing the YD button on the AFCS controller
- Pressing the AP TRIM DISC switch on either control yoke

Additionally, pilots can manually override the yaw servo motor by pushing the rudder pedals. For information on the AFCS (including autopilot), refer to Chapter 16—"Avionics."

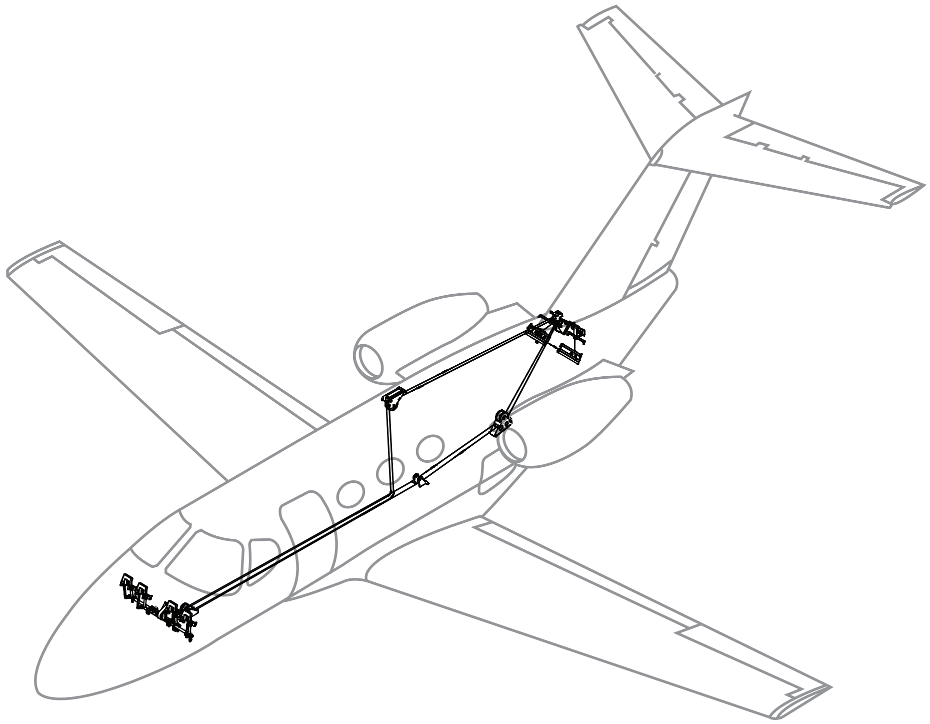

Figure 15-2. Rudder Control System Installation

ELEVATOR SYSTEM

The elevators are on the trailing edge of the horizontal stabilizer and provide longitudinal (pitch) control of the airplane. The elevators are mechanically controlled through cables by either pilot moving the control yoke fore and aft, or by the autopilot pitch servo.

The pitch system is a manual system consisting of conventional mechanical flight control components. A cable run from the pilot and copilot control yokes to a common elevator pulley provides output to the elevator surfaces. The aft elevator pulley is attached to each surface by a pushrod and horn. Motion from the aft elevator pulley is transmitted to the elevators by their respective pushrod.

In the event of engine rotor non containment, separate elevator trim systems provide sufficient pitch control for elevator control redundancy.

Operation

By moving the control column aft (approximately 4 inches maximum deflection), the elevators rotate up, causing the nose of the aircraft to pitch up. By moving the control column forward (approximately 3 inches maximum deflection), the opposite motion occurs.

A single pitch servo is mechanically connected to the elevator cables. When the autopilot is engaged, the pitch servo provides autopilot input to the elevator system in response to the AFCS commands.

Normally, the autopilot can be disengaged by:

- Pressing the AP or YD button on the AFCS controller
- Pressing the AP TRIM DISC switch on either control yoke
- Commanding electric pitch trim

The pitch servo can also be manually overridden by either pilot applying a force to the control yoke. For information on the AFCS (including autopilot), refer to Chapter 16—"Avionics."

CONTROL LOCK SYSTEMS

Control locks, when engaged, restrain the primary flight controls. The control lock system prevents damage to the control surfaces and systems from wind gusts striking the aircraft while it is on the ground. There are two parts to the control lock system: aileron/elevator control lock and rudder lock.

Aileron/Elevator Control Lock

To lock the aileron and elevator control surfaces, a removable flag-insert device fits through a hole in both the control yoke bushing at the control panel and the back of the pilot control yoke (Figure 15-3). A special U-shaped lock pin locks the yoke in a most-forward position, nose down with the wheel at ailerons-neutral. The U-shape of the pin ensures that no single pin device can engage the lock. The device, installed from the top, pins the control yoke to the instrument panel. The flag on the pin covers the pilot primary flight display (PFD) airspeed tape and horizontal situational indicator (HSI). The flag portion of the pin is keyed to the instrument panel receptacle so the control lock cannot be installed without obstructing the view of the pilot.

Figure 15-3. Aileron/Elevator Control Lock

The yoke position and the visual obstruction from the flag provide unmistakable warning of control lock engagement. To insert the lock:

- Rotate the yoke to the center position so the receptacle in the bushing and the receptacle on the control yoke are aligned.
- Move the yoke forward until both ends of the pin can be inserted into their respective receptacles.
- Insert the U-shaped pin of the flag device into the receptacles.
- Check the control wheel is locked in both pitch and roll.

When removing the lock:

- Grasp the U-shaped pin between the receptacles (with the right hand) and remove, raising it straight up until clear of both receptacles.
- Stow the control lock.
- Check the control yoke is free and clear for both roll and pitch.

Rudder Lock

The rudder control lock inserts a pin into the aft rudder pulley, preventing movement of the rudder. The rudder lock must be operated from outside the aircraft (Figure 15-4).

To lock the rudder, the pilot rotates a handle on an external lever on the left side of the tail

Figure 15-4. Rudder Lock System (Left Side of Tail Cone)

cone 60° counterclockwise (up), which inserts a pin into the aft rudder pulley to lock the rudder torque tube.

The lock disengages when the external lever is rotated to point aft (streamlined). The lock can also be disengaged from the cockpit by pulling the control yoke aft from the neutral position.

NOTE

With the rudder lock engaged, the nosewheel system allows up to 55° of free castering when the pilot steers with differential power and/or differential braking. However, taxiing or steering with rudder lock engaged is *not* recommended. To release the rudder lock from the cockpit, pull aft on the control yoke.

CAUTION

Disengage the rudder lock before towing. The rudder lock can be released and re-engaged externally.

SECONDARY FLIGHT CONTROLS

The secondary flight controls consist of the trim systems for the primary flight controls, and the lift and drag controls (flaps and speedbrakes).

TRIM SYSTEMS

Trim is provided by a tab on the inboard trailing edge of most primary flight controls (both elevators, the left aileron, and the rudder). Trim systems are electrical on all three axes, with additional mechanical trim also available for pitch. Rudder and aileron trim are electrically actuated by trim switches on the lower pedestal. The elevator is operated by a manual trim wheel on the left side of the pedestal next to throttles. In addition, the electric trim switches on either pilot control wheel can control the elevator trim.

Aileron (Roll) Trim

The single aileron trim tab is on the trailing edge of the left aileron only. The AILERON TRIM control knob (Figure 15-5) controls the

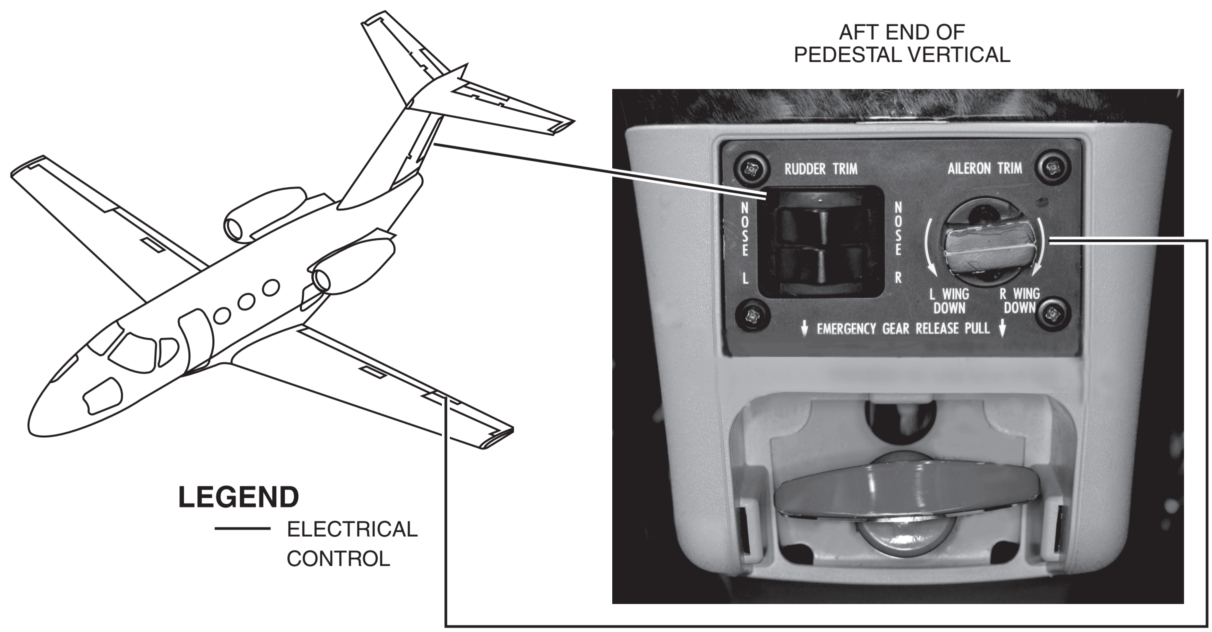

Figure 15-5. Aileron and Rudder Trim

aileron trim tab through an electrical trim actuator in the leading edge of the aileron. The electric actuator uses two independent control rods to move the aileron trim tab.

The aileron trim control knob is on the aft face of the center pedestal. To operate the knob, depress it before rotating it. Rotating the trim knob left (counterclockwise) causes the aircraft to roll left and trims the left wing down.

Near the bottom of the engine indication and crew alerting system (EICAS) display, a white horizontal analog scale and cyan pointer indicate position of aileron trim (Figure 15-6). If cockpit displays are set to reversionary mode, the trim display does not appear.

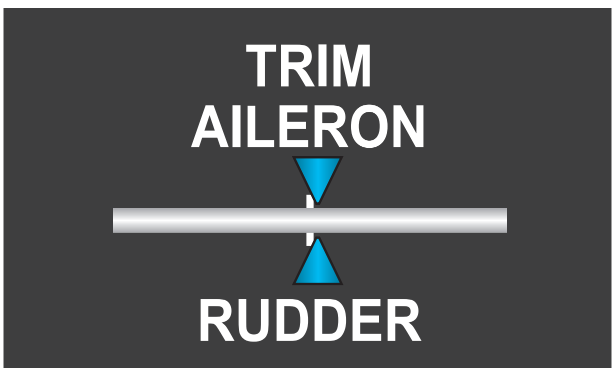

Figure 15-6. Trim Display

The aileron trim circuit breaker is on the left CB panel in the FLIGHT CONTROLS grouping.

Rudder (Yaw) Trim

The cockpit rudder trim tab is on the center of the trailing edge of the rudder. It is driven by an electrical trim actuator in the leading edge of the rudder, controlled by the RUDDER TRIM switch. The RUDDER TRIM switches (centering dual sliding rocker switches) are on the lower pedestal (see Figure 15-5).

Pushing the RUDDER TRIM switches to the left, toward the NOSE–L position, causes the aircraft to yaw toward the left. Pushing it right, toward NOSE–R, causes opposite movement.

Near the bottom of the EICAS display, a white horizontal analog scale and cyan pointer indicate position of rudder trim (Figure 15-6). If displays are set to reversionary mode, the trim display does not appear.

The yaw trim circuit breaker is on the left CB panel in the FLIGHT CONTROLS grouping.

Elevator (Pitch) Trim

The elevator trim tabs are at the trailing edges of both elevator surfaces. Both tabs travel synchronously. Each trim tab is connected to a mechanical actuator by two control rods. The trim tabs are controlled mechanically through cables by a mechanical trim control wheel on the left side of the pedestal beside the throttle controls (Figure 15-7), or electrically by split switches on the outboard grip of the control yokes.

The mechanical elevator trim system is a single cable loop system that routes from the command wheel in the cockpit to the tail cone, then through the vertical tail to mechanical actuators in each of the horizontal tail. The mechanical actuators move linkages, which move the trim tabs.

Additional cables connect the autopilot elevator trim servo to the system. When the control yoke switches are used or the autopilot is active, the autopilot servo electrically commands the entire mechanical system through its cable linkage.

The elevator pitch trim servo is powered from the left avionics bus through the AFCS circuit breaker on the FLIGHT CONTROL pilot CB panel. It operates only if the AVN PWR switch is set to the up position. The AVN PWR switch is on the AVIONICS switch panel, below the pilot PFD.

Manual Trim

By rotating the trim wheel forward toward the nose-down position, the trim tabs rotate upward, causing the elevator system to pitch the nose of the aircraft down. By rotating the trim wheel aft, the opposite is true.

Elevator trim position is indicated by a mechanical pointer, which rides in a slot of the LED-backlit panel of the throttle quadrant, connected to the elevator trim cable loop.

Electric Trim

Electric elevator trim is controlled by a split-element centering thumb switch on the outboard side of each control yoke (see Figure 15-7). When the pilot moves both elements of the rocker switch, the electric elevator trim actuator moves the cables to trim the aircraft in the direction selected. Selecting forward trims nose-down. The electric trim can be overridden by the mechanical trim. Additionally, pilot pitch trim inputs override the copilot trim inputs. As the trim switch is moved to the UP or DOWN

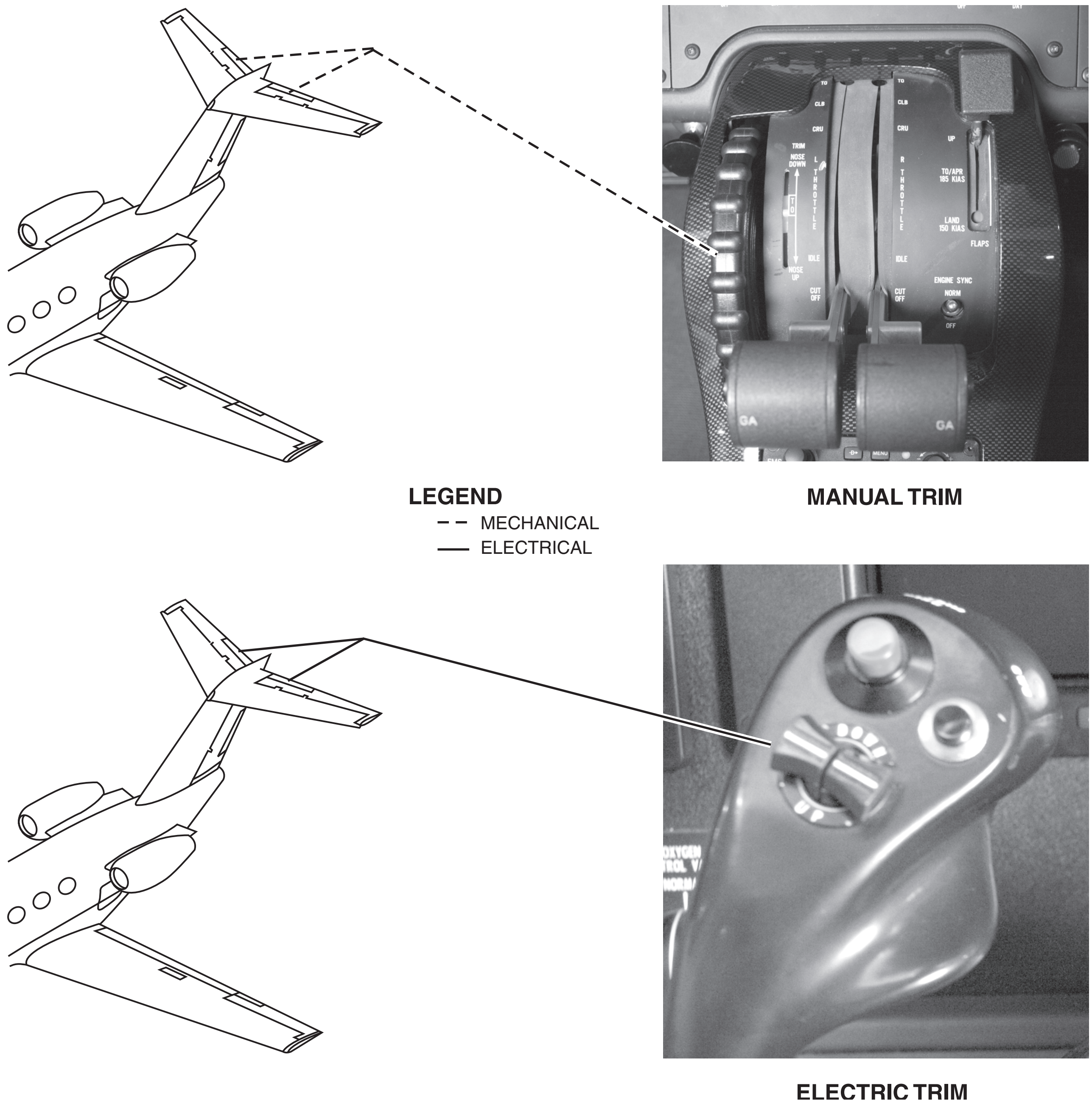

Figure 15-7. Elevator Trim System

position, the elevator tabs are repositioned as indicated by the elevator trim indicator.

Prior to flight, the electric pitch trim system can be checked for proper operation by moving both elements of the switch in both directions, noting whether trim occurs in the appropriate directions. Check for system malfunction by attempting to trim with one element of the switch. If trimming occurs, the system is malfunctioning and must be restored to normal operation prior to flight.

NOTE

If a pilot holds only one element of the trim switch in either the UP or DOWN position for more than 3 seconds, the red PTRM message appears on the upper left of the PFD.

Interrupt runaway or malfunctioning trim by depressing the red AP/TRIM DISC switch on the control yoke (see Figure 15-5) and pulling the AFCS circuit breaker in the FLIGHT CONTROLS section of the left CB panel.

NOTE

The autopilot will not engage if electric trim is not operating properly.

FLAPS

Flaps on the wings provide control of lift and drag. On the Citation Mustang, flaps increase both lift and drag.

Components

The flap system consists of electrical and mechanical components. The flap panels are on the inboard trailing edge of each wing, one on either side of the aircraft (Figure 15-8). They are hinged for operation in three positions: UP (retracted), TO/APR (takeoff/approach), and LAND (landing).

Each flap panel is directly connected to a mechanical actuator on the rear wing spar (Figure 15-9). The two actuators are driven through flexible drive shafts connected to a common electric motor (electrically powered, electronically controlled power drive unit). The power drive unit (PDU) is behind the rear wing spar at the aircraft centerline.

A mechanical interconnect system links the two flap panels together at their inboard ends via pushrods, pulleys, and cables (Figure 15-9). This system ensures that even with linkage failure, flap position remains synchronized, preventing asymmetrical flap positions.

Controls and Indications

A flap handle is in the cockpit, to the right of the throttle levers on the control pedestal (see Figure 15-8).

The flap handle can be moved aft from the UP detent and forward from the LAND detent. The flap handle can be set in any of the three detent positions:

- UP—On retraction, should not be selected until TO/APR flap position is achieved
- TO/APR
- LAND—On extension, may not be selected until TO/APR flap position is achieved

Three switches under the flap handle supply command signals for the control and monitoring circuits. The flap handle has a three-position mechanical detent, which requires that the handle be pushed down before it can be moved forward or aft to a new position.

Flap panel movement is directly controlled by a flap controller circuit that controls the flap power drive unit (PDU). The flap controller evaluates command signals from the flap handle and position signals from the left interconnect pulley to determine the appropriate operation of the flap PDU to drive the flap movement.

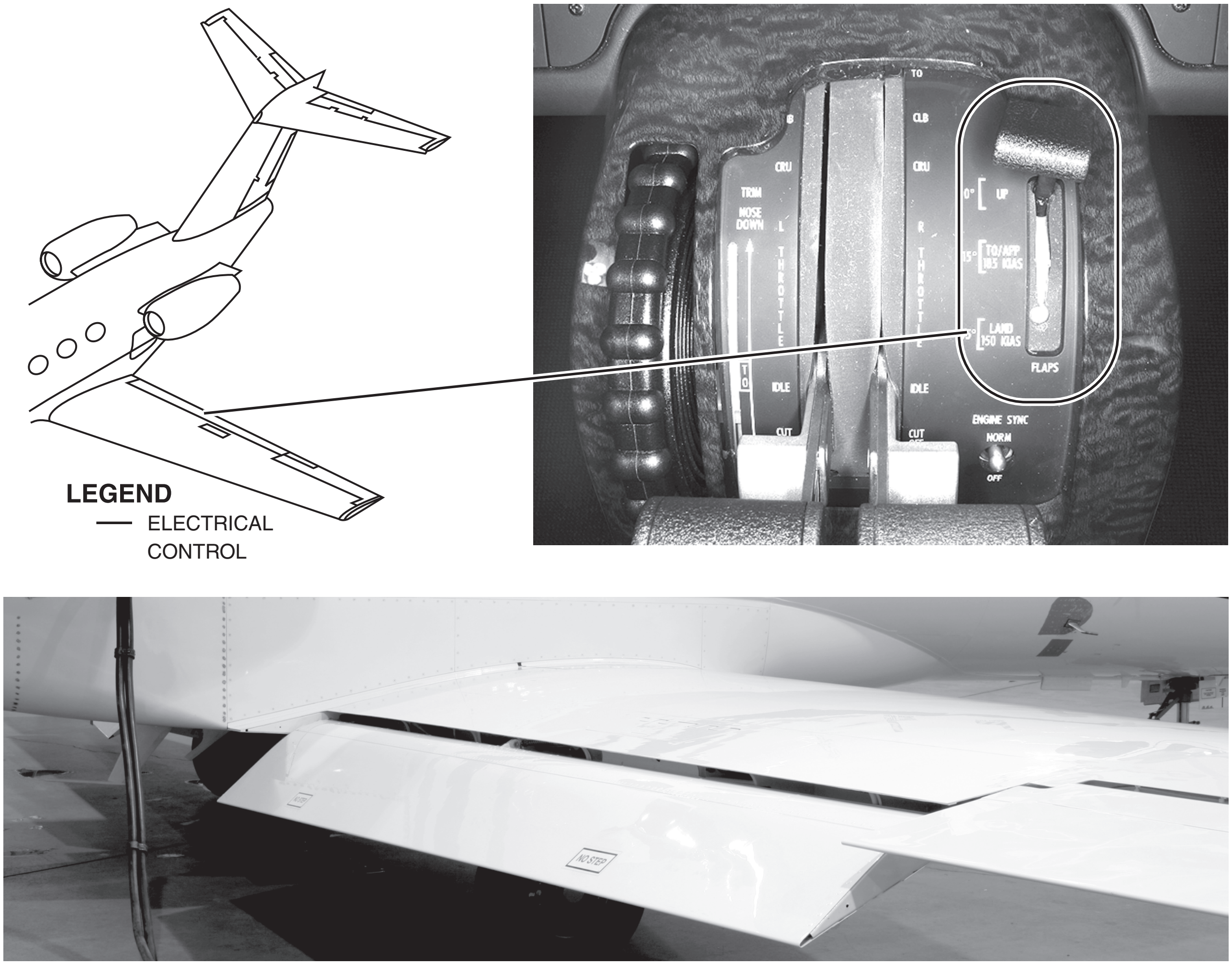

Figure 15-8. Flaps—LAND Position

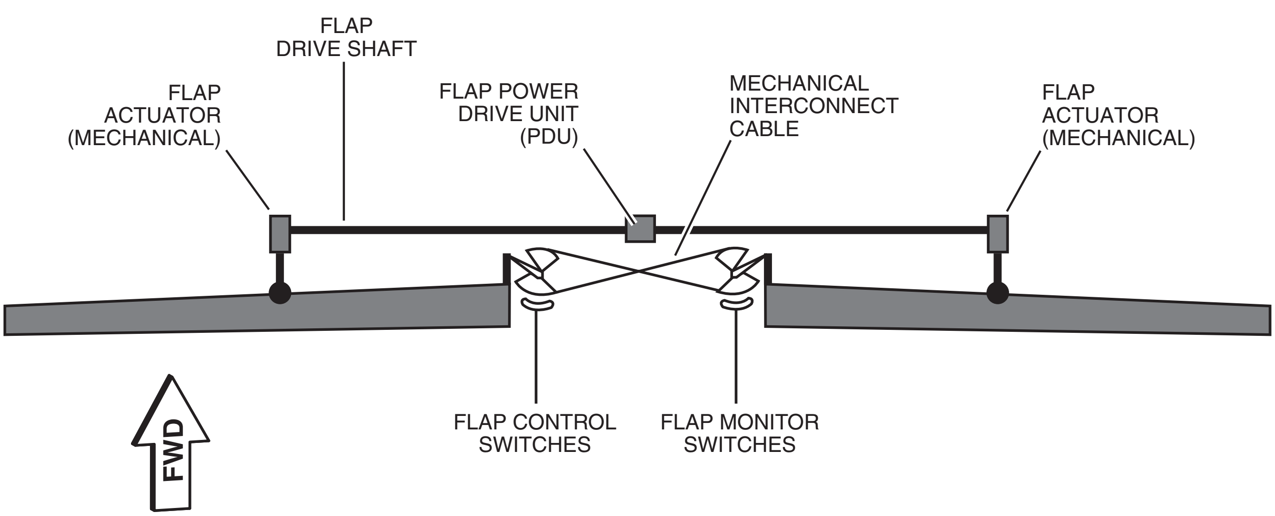

Figure 15-9. Flap System Schematic

When the pilot moves the flap handle from one position to another, the flap controller senses the disagreement between the flap handle position and the flap panel position, and energizes the PDU to move the flap panels until the signals are brought back into agreement. If the flap controller detects a fault, it immediately stops the PDU and goes into idle mode and the amber FLAPS FAIL message appears.

Flap panel position is monitored by a flap monitor circuit and is graphically depicted in the cockpit on the EICAS display, usually on the multifunction display (MFD) (Figure 15-10). To generate the analog flap position indication, the flap monitor evaluates:

- Command signals from the flap handle
- Position signals from the right interconnect pulley
- A monopole signal from the PDU

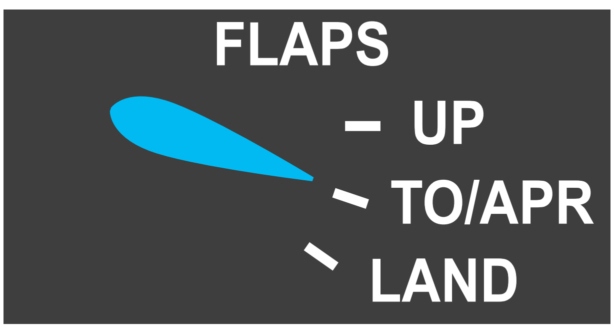

Figure 15-10. Flaps Position Display

If the flap monitor loses all flap-position inputs (i.e., TO/APR and LAND positions), it replaces the EICAS flap position display with a red "X."

In reversionary mode, only text appears on the EICAS to indicate flap position (Figure 15-11). Three positions are identified:

- UP (fully retracted)
- TO/APR (takeoff/approach)
- LAND (landing)

Figure 15-11. Flaps Position Display—Reversionary Mode

In emergency power mode, flap information is not shown on the EICAS, because the flap monitor circuit is not powered.

The flap system is DC-powered three ways:

- The *flap drive motor* is powered from the left feed bus No. 2, through a current limiter in the aft J-box, to the flap system printed circuit board (PCB).
- The *flap control* is powered from the left feed bus No. 2, through the FLAP CONTROL circuit breaker in the aft J-box.
- The *flap monitoring system* is powered from the left feed bus No. 1, through the FLAPS circuit breaker in the FLIGHT CONTROL section of the left (pilot) CB panel.

Operation

Preflight

During preflight, visually check that the flap position indication and the flap handle agree on position.

Rotary Test

Select the FLAPS position with the rotary TEST knob (Figure 15-12). The flap position display on the MFD is replaced with a red X and the amber STALL WARN FAIL and amber FLAPS FAIL messages appear for 3 seconds, then extinguish.

Normal Operation

To reposition the flaps, push in on the flap handle and select the desired position. Allow the flap panels to stabilize in the new position. Confirm that flap indication and handle position agree before selecting the next position. Takeoff/approach flaps are limited to airspeed at or below 185 KIAS. Landing flaps are limited to airspeeds at or below 150 KIAS.

Figure 15-12. Rotary TEST Knob

SPEEDBRAKES

Speedbrakes on the wings provide control of lift and drag. On the Citation Mustang, flaps increase both lift and drag, while speedbrakes increase drag and slightly reduce lift (acting as wing lift spoilers).

Components

The speedbrakes are on the upper and lower surface of the wing forward of the flaps, pivoting on hinge lines at (and parallel to) the aft spar (see Figure 15-1). The speedbrake system consists of an upper panel and a lower panel on each wing, driven by push rods connected to an electromechanical actuator (one on each wing) (Figure 15-13). The speedbrakes can be set at two different positions: stowed and extended. The panels are commanded to either extend or retract; there are no intermediate positions.

Controls and Indications

The speedbrakes are controlled by a three-position, momentary thumb switch on the outboard side of each throttle lever knob in the cockpit (Figure 15-14). The pilot uses the switch to select the desired speedbrake position (RET or EXT).

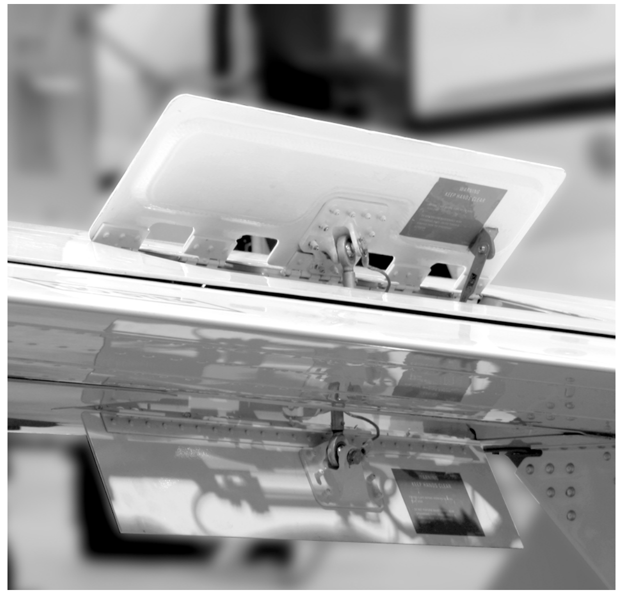

Figure 15-13. Speedbrakes (Extended)

Speedbrake position indication is provided by the white SPD BRK EXTEND message when the speedbrakes are not in the stowed position.

Operation

Move the momentary switch on the throttle control lever knob aft to EXT (extend) and forward to RET (retract). The speedbrakes extend when the speedbrake switch is pushed to EXT *and* the throttle levers are set for less than approximately 85% N_2 engine power.

When a direction is commanded, the actuator moves to that position and remains there until commanded (extend or retract) to the opposite direction. The pilot does not need to hold the speedbrake switch forward or aft during the entire cycle; only a momentary push or pull is required to initiate a sequence.

NOTE

A commanded extension can immediately be reversed by the pilot and the speedbrakes will stow. However, when a retraction is commanded, the speedbrakes cannot be reversed (opened) until fully stowed (closed).

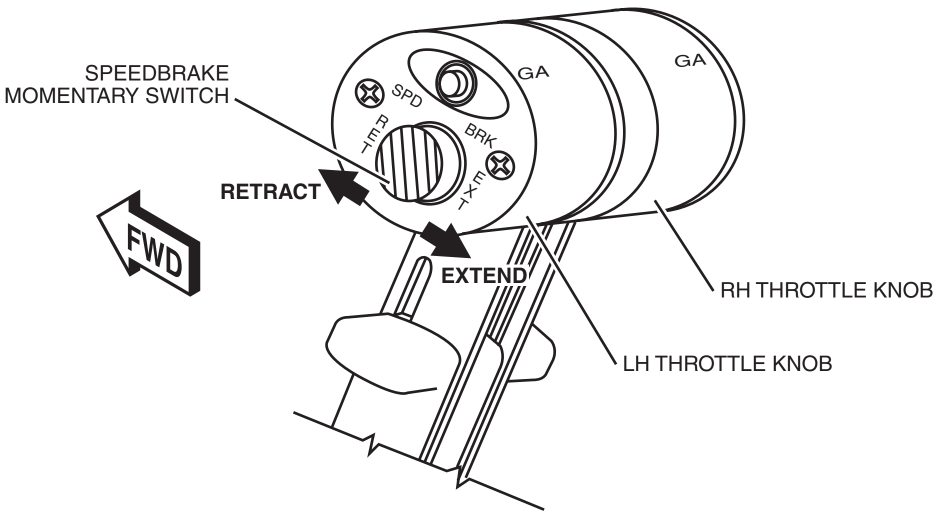

Figure 15-14. Throttle Knob Speedbrake Switch (Left Throttle)

The speedbrakes control-and-monitoring circuit monitors speedbrake positions and commands retraction when either throttle is set for greater than approximately 85% N_2.

The speedbrake system is DC-powered three ways:

- The *left speedbrake actuator and the speedbrakes control-and-monitoring circuit* are powered from the left electrical bus No. 1, through the L SPEED BRAKE circuit breaker in the FLIGHT CONTROL section of the left (pilot) CB panel.
- The *right speedbrake actuator* is powered from the right electrical bus No. 1, through the R SPEED BRAKE circuit breaker in the FLIGHT CONTROL section of the left (pilot) CB panel.
- The *speedbrake position sensors (proximity switches)* are powered from the left feed bus No. 2, through the SPD BRK SW circuit breaker in the aft J-box.

In the event of DC power failure, the speedbrakes remain in their current position.

Emergency/Abnormal

For specific information on emergency/abnormal procedures, refer to the appropriate FAA-approved abbreviated checklists or the *Airplane Flight Manual* (*AFM*).