PART 1

Chapter 5 — POWERED FLYING CONTROLS AND TRIMMERS

Contents

Description

1 Flying controls

(*a*) *In power*

The ailerons and elevator are power-operated by hydraulic oil under pressure from the aircraft hydraulic system. A hydrobooster consisting of a servo valve and jack body and a piston is fitted close to each control surface. Each control column is connected direct to the servo valve operating spindle so that depending on the direction of movement of either control column, the valve opens to admit pressure oil to one side of the jack piston and at the same time the other side is opened to return. The piston rod is anchored to the aircraft structure. The jack body is directly connected to one end of the control surface. When hydraulic pressure is fed from the servo valve to one side of

the jack piston, the jack body moves relative to the piston and deflects the control surface. When control column movement ceases the servo valve closes causing a hydraulic lock which prohibits further movement of the jack body and control surface.

(*b*) *In Manual*

Manual operation of the controls may be selected deliberately by a switch in the cockpit provided that electrical power is available, or will happen automatically if hydraulic pressure falls below 200 PSI. As soon as pressure falls below that figure a bypass valve in the jack opens and allows the residual fluid in the jack to be pumped from one side of the jack piston to the other. When operating in Manual the jack bodies move freely with the control surfaces, but the bypass facility prevents the higher stick forces which would otherwise exist.

(*c*) When Power is selected on, the bypass valve closes automatically as hydraulic pressure rises above 400 PSI. The controls are then in Power; the appropriate magnetic indicator shows black when pressure rises above 600 PSI. If hydraulic failure occurs or Power is selected off, the indicators show white as pressure falls below 600 PSI and the bypass valve opens automatically below 200 PSI. The controls are then in Manual.

2 Hydraulic power reserve

Accumulators are fitted in the powered control circuits to provide a reserve of power if the main hydraulic supply fails. This reserve may be sufficient for $1\frac{1}{2}$ to $2\frac{1}{2}$ complete cycles of aileron and elevator operation before the controls revert automatically to Manual but, even if no control movement is made, accumulator pressure is not maintained for a long period due to seepage through the hydraulic components. With some types of hydraulic failure immediate reversion to Manual results.

3 Tailplane and elevator

(*a*) An electrically-operated variable incidence tailplane is provided. It is hinged at the rear end, while a projection on the leading edge is connected to an electrically-operated actuator in the dorsal fin below the tailplane. After trimming to the required tailplane angle to give zero stick force for a given flight condition, the elevator is trailing with no air load imposed on it.

(*b*) The tailplane actuator is operated by one of two electric motors, the main and standby. The standby motor, which is fitted to meet the case of failure of the main motor or its electrical supply, operates at about one-third the rate of the main motor.

(*c*) The air loads on the elevator are resisted entirely by hydraulic jack effort, no load being felt on the control column. To provide control feel, a spring is fitted in the control circuit between the control column and the variable incidence tailplane. The spring gives an artificial feel to the elevator control circuit by imposing a force proportional to stick deflection but not airspeed (ie air loads).

4 Tailplane and elevator interconnection

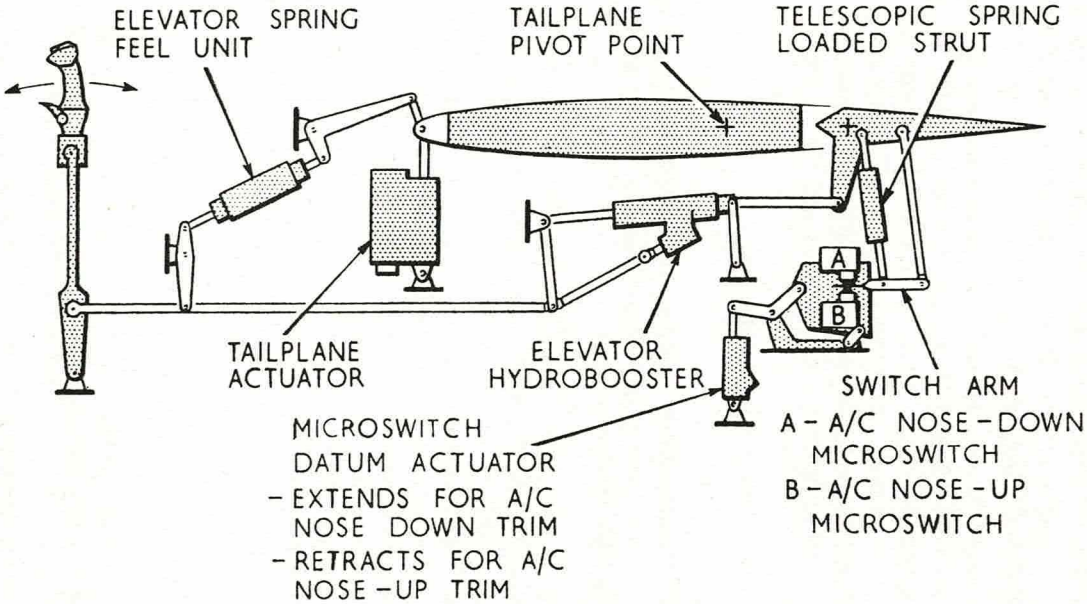
(*a*) *General*

An electrical interconnection enables the variable-incidence tailplane to follow up elevator movements automatically, giving greater manoeuvrability at high Mach numbers.

(*b*) *Function*

(i) A lift-gated TAILPLANE — ON/OFF switch on the centre panel controls the operation of the tailplane and elevator interconnection. The interconnection, in the form of a follow-up linkage attached to the elevator, provides a pre-determined tailplane and elevator movement for a given control column deflection. It functions irrespective of whether the elevator is in Power or Manual, when the interconnection is selected on and a DC supply is connected. The linkage carries a switch arm which moves between two microswitches in circuit with the tailplane actuator. Movement of the elevator relative to the tailplane causes the switch arm to operate one of the microswitches. The tailplane actuator then moves the tailplane to follow the elevator. When the tailplane reaches the appropriate setting for the control column deflection, the switch arm is back to its neutral position between the microswitches; the tailplane stops moving, leaving the elevator deflected relative to the new position of the tailplane.

(ii) To prevent continual hunting of the tailplane actuator, the elevator has a small range of movement over which the microswitches are not selected. Thus if the elevator is deflected and then returned to its original position the trim indication does not return fully to its previous setting.



TAILPLANE CONTROL

(iii) A spring-loaded telescopic strut is incorporated in the linkage so that full and unrestricted stick movement is always obtainable. The strut telescopes when either the elevator is moved faster than the rate at which the tailplane actuator can follow up or when the tailplane has reached the end of its travel.

(iv) Use of the main trimmer control overrides the operation of the follow-up tail.

(*c*) *Trimming*

Trimming is carried out by means of the variable-incidence tailplane actuator main motor switch, or by a standby motor switch should the main motor or its switch fail to function. In addition to altering the tailplane incidence, operation of the main switch also resets the datum position of the two microswitches. During trimming the elevator is kept in line with the tailplane by the centring action of the spring feel strut, the switch arm thus following the resetting of the microswitches datum position. The datum setting is not altered when the standby switch is operated.

5 Aileron gear change

(*a*) Provision is made for altering the aileron gear ratio so that, for the same stick movement, aileron travel in Manual is approximately two-thirds of that obtained in Power.

(*b*) A hydraulic jack is fitted in the aileron control linkage and, when extended by aileron hydraulic pressure, alters the effective arm of the aileron control linkage. When there is no hydraulic pressure the jack retracts under spring pressure.

Controls and Indicators

6 Aileron and elevator power — controls and indicators

(*a*) (i) Two Power ON/OFF selector switches on the port instrument panel, control electrically the hydraulic cocks, one for the aileron circuit and the other for the elevator circuit. When the engine is running and a switch is selected on, hydraulic pressure is fed to that circuit.

(ii) Two additional switches are on the starboard shelf so that the instructor may select Power off at any time. Power engagement by the pupil's switches is only possible if the instructor's switches are on.

(*b*) (i) Two magnetic indicators, one for the aileron circuit and one for the elevator are beside the selector switches on the port instrument panel; they show black when the controls are in Power and white when the controls are in Manual or when electrical power to the indicator is not available. A similar pair of magnetic indicators, above the starboard artificial horizon, is provided for the instructor's use.

(ii) An audio warning over the pilot's headset warns the pilot if hydraulic system pressure falls to 600 PSI. Further warning is given by a red hydraulic failure warning light and the reading of the hydraulic pressure gauge.

(*c*) A white datum spot is painted on the instrument panel at each station and is used during spin recovery. Alignment of the top of the control column with the spot corresponds to the aileron neutral position.

7 Tailplane — controls and indicator

(*a*) The tailplane main motor is controlled by a thumb switch on the top of the control column. The instructor's switch overrides the pupil's switch. A circuit breaker under a flap on the starboard shelf may be used to cut out the main trim circuit.

(*b*) The standby motor is controlled by a switch under a cover on the port shelf. The cover must be raised *fully* to ensure that the circuit breaker, protecting the main motor circuit, is tripped before the switch is operated.

(*c*) The setting of the tailplane is shown on an indicator on the port instrument panel.

8 Tailplane and elevator interconnection — selector and indicator

(*a*) Tailplane and elevator interconnection is selected by a TAILPLANE—ON/OFF switch on the centre panel. The tailplane indicator shows when the tailplane is functioning as a flying control, ie the indicator moves when the control column is deflected as well as when the trim switch is actuated.

(*b*) The circuit is so arranged that when the cover of the standby trim switch is raised, both the main actuator and the interconnection are isolated.

9 Aileron feel and trim

(*a*) The air loads are resisted entirely by the hydraulic jack effort and no load is fed back to the control column. To provide control feel, a spring is fitted in the control circuit and gives an artificial stick force which is proportional to aileron deflection but not to airspeed. A handwheel on the left-hand side of the pupil's control column provides spring feel adjustment and may be used to trim the aircraft when in Power. A white line is inscribed on the handwheel. When the trimmer is neutral the line points forward and the trimmer engages in a spring-loaded detent. Movement from this position is through 300° either to the left or to the right thereby adjusting the zero force position of the stick. This trimmer should not be used in Manual.

(*b*) A trim tab is fitted on the port aileron. It is only intended for use in Manual and a guard is placed round each combined rudder/aileron trim control to prevent the inadvertent use of aileron trim when in Power. A trim indicator is forward of each control. The pupil's trim control is inoperative when the guard on the instructor's control is swung clear of the control. The instructor's control provides aileron trim only. The guards on the controls may be left off for take-off and landing in case of Manual reversion.

Normal use of the Powered Controls

10 Pre-flight checks

(*a*) *Ailerons and elevator*

(i) After starting, select the power control switches to ON. Check that the magnetic indicators go black.

(ii) Immediately before take-off, check the controls over full range at not less than 4500 RPM and ensure the magnetic indicators remain black.

(*b*) *Tailplane interconnection and tailplane trim*

(i) With the stick free and tailplane angle at zero, select the tailplane interconnection on. Move the stick fore and aft over the full range. During this check, trim in the reverse direction to stick movement and check that the trim operation overrides the follow-up tail. Note that this action repositions the datum actuator and, when the stick is released, the tailplane takes up a new position.

(ii) Retrim to zero on the main trimmer to reset the datum actuator. Whilst moving the stick, raise the cover of the standby trim to check the cut-out. Check the operation of the standby trim, leaving the tailplane more than 1° away from zero. Lower the cover of the standby trim fully and check that the tailplane reverts to within ±1° of the zero position with the stick free. Switch the tailplane interconnection off.

(iii) Operate the main trimmers, checking that the instructor's control overrides that of the pupil, and leave at the take-off position.

11 Checks after landing

(*a*) To assist in servicing the hydroboosters after landing in Power, Manual should be selected prior to stopping the engine, so that the supply lines to the boosters are closed. This enables the handpump circuit to be used by the ground crew. If the controls are in Power when pressure is dissipated, the supply lines to the boosters are open and the handpump rendered ineffective because it cannot develop enough flow and pressure to shut the bypass valves which offer a path to return. For the same reason sufficient pressure cannot be built-up for the electro-hydraulic selector valves to move if selected to Power OFF. Additionally it is not possible to operate the canopy since accumulator pressure is not maintained.

(*b*) When Mod 895 is embodied, provision is made for Manual selection for servicing purposes and the foregoing is no longer essential.

Malfunctioning of the Powered Controls

12 Hydrobooster failures

(*a*) *Bypass valve fails to open when Power is selected off*

(i) The aileron and elevator loads in Manual are slightly increased compared to normal Manual due to the elimination of the bypass facility. The increased loads are acceptable however.

(ii) Reselecting Power on if this is possible, eliminates the fault but it will probably recur if Power off is again selected.

(*b*) *Aileron bypass valve fails to shut when Power is selected on*

(i) This gives a condition of one aileron in Power and one in Manual.

(ii) It is relatively easy to detect on the ground as the control column judders when moved laterally and operating loads are somewhere between normal Power and bypass Manual.

(iii) In flight there is a wing-low tendency, caused by the upfloat of the Manual aileron, which increases with increased airspeed. The stick force to maintain lateral level does not exceed 20 lb in level flight.

(iv) Increase of G increases the cut-of-trim condition.

(v) The wing-low tendency is reduced when the flaps are lowered.

(vi) Recommended action is to select Power off.

(*c*) *Servo valve operating spindle breaks when controls are in Power*

(i) Further movement of the jack body and control surface is prohibited by closure of the servo valve.

(ii) The control column will remain in a deflected position.

(iii) Selecting Power off enables the jack body to move freely and normal Manual control will be available.

13 Tailplane malfunctioning

(*a*) If the follow-up tail malfunctions, raise the standby trim switch cover immediately and use that trim. Then select the tailplane interconnection off and lower the standby trim switch cover. Check the normal trimming action. If the malfunction is still present, reselect the standby trim and return to base.

(*b*) If the tailplane trim actuator runs away, trip the tailplane main actuator circuit breaker by raising the cover of the standby trim switch fully or operate the instructor's tailplane cut-out switch. Control can then be regained by use of the standby trim switch.