PART 1

CHAPTER 5 — POWERED FLYING CONTROLS AND TRIMMERS

(Completely revised by AL7)

Contents

DESCRIPTION

1 Flying Controls

(a) The ailerons and elevators are normally hydraulically-operated from the aircraft hydraulic system. Both controls are fully-powered and stick forces are provided by spring-feel systems. To improve longitudinal control, an interconnection is provided between the elevators and the tailplane. A manual reversion capability is provided. Power or Manual can be selected as required; the controls automatically revert to Manual in the event of a hydraulic failure.

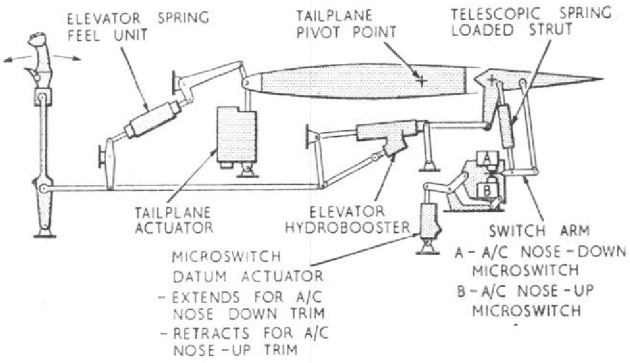
(b) In Power. A hydrobooster, consisting of a servo

valve and jack body and a piston, is fitted close to each control surface. The control column is connected to the servo valve operating spindle; depending on the direction of movement of the 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 and the jack body is directly connected to one end of the control surface. When hydraulic pressure is directed by 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 prevents further movement of the jack body and control surface. Indication of hydraulic power being available to the hydro-boosters is given by the aileron and elevator magnetic indicators showing black.

(c) In Manual. If Manual is selected or the hydraulic pressure falls below 200 PSI, a bypass valve in the jack opens to allow the fluid in the jack to be transferred from one side of the piston to the other. This allows the jack body to be moved freely about the piston by control column movements to operate the control surface. Feedback forces from the control surface are transmitted back to the control column resulting in high stick forces when manoeuvring. If Manual is selected or a hydraulic failure occurs, the aileron and elevator magnetic indicators show white when the hydraulic pressure falls below 600 PSI. If hydraulic pressure is available and Power is reselected, the bypass valve closes as the pressure rises above 400 PSI; the magnetic indicators show black as the pressure rises above 600 PSI.

2 Hydraulic Accumulators

In the event of a hydraulic failure, the hydraulic accumulators in the powered control circuits should, when fully charged, provide for $1\frac{1}{2}$ to $2\frac{1}{2}$ full reversals of each control before the controls revert to Manual. However, even if no control movements are made, the accumulator pressure is not maintained because of normal hydraulic component seepage; when the accumulators are exhausted, the controls automatically revert to Manual. Some types of hydraulic failure result in immediate reversion to Manual.



1—5 Fig 1 Tailplane Control Schematic

3 Tailplane

(a) A variable-incidence tailplane is fitted. The tailplane is hinged at the rear and the incidence is varied by an electrically-operated actuator connected to the leading edge of the tailplane. When the tailplane is trimmed to give zero stick force, the elevator is trailing with no air loads imposed on it.

(b) The tailplane actuator is driven by one of two electric motors, the main or the standby motor. The standby motor, which operates at about one-third of the rate of the main motor, is provided for use in the event of a failure in the main motor or its electrical supply.

4 Tailplane and Elevator Interconnection

(a) An electrical interconnection between the elevator and the tailplane is provided to adjust the tailplane incidence automatically when the elevator is moved. With the interconnection in use, longitudinal control at high mach numbers is improved. A schematic of the system is shown at Fig 1.

(b) The interconnection can be selected as required by the lock-toggle TAILPLANE — ON/OFF switch on the

centre instrument panel. 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. When selected, it functions irrespective of whether the elevator is in Power or Manual provided that DC power is available. 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.

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

(d) 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.

(e) Trimming. Trimming is effected by operation of the tailplane actuator main motor switch or by the 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. The main trimmer control overrides the operation of the tailplane interconnection.

5 Aileron Gear Change

(a) To reduce the aileron stick forces in Manual, the

aileron gear ratio is automatically changed when Manual is selected or if hydraulic pressure fails; for the same stick movement, aileron movement in Manual is about two-thirds of that obtained in Power.

(b) The gear change is effected by a hydraulic jack which acts as a lever in the aileron control linkage. When hydraulic pressure is available and Power is selected, the jack extends to effectively lengthen the lever to give normal operation. If hydraulic pressure fails, or if Manual is selected, the jack retracts under spring pressure to effectively shorten the lever giving reduced aileron movement for a given stick movement and thus reducing the aileron stick forces.

CONTROLS AND INDICATORS

6 Aileron and Elevator Power

(a) The electrically-operated hydraulic valves for the aileron and elevator power controls are controlled by two POWER ON/POWER OFF switches (AILERON and ELEVATOR) on the left of the port instrument panel.

(b) Two POWER CONTROL override switches (AILERON and ELEVATOR) are on the starboard shelf. The switches must be set to AILERON and ELEVATOR respectively before the power controls can be engaged using the main power control switches referred to in sub-para *(a)* above. The aileron and elevator power controls can be selected off at any time by selecting the appropriate switch to OVERRIDE TO OFF ONLY.

(c) When Manual (POWER OFF or OVERRIDE TO OFF ONLY) is selected, the aileron and elevator magnetic indicators adjacent to the associated power control switches (with repeaters on the starboard instrument panel) show white. If automatic reversion to Manual caused by hydraulic failure occurs, in addition to the above indications, an audio warning is given on the intercom and the red hydraulic failure warning light comes on.

(d) A white datum spot on each of the port and starboard instrument panels indicates the ailerons central

position. The datum is used as an aid to ensuring that the ailerons are central during spin recovery.

7 Tailplane Trim and Interconnection

(a) The tailplane main motor is controlled by a spring-loaded 3-position thumb switch on the top of each control column. The switch on the starboard control column has overriding authority. A circuit breaker under a cover on the starboard shelf can be used to cut out the main trim circuit.

(b) The tailplane standby trim motor is controlled by a spring-loaded 3-position TAILPLANE CONTROL switch under a cover on the port shelf. Raising the cover trips a circuit breaker to cut out the main trim circuit; the cover must be raised fully to ensure that the circuit breaker is tripped before operating the switch.

(c) The tailplane incidence is shown in degrees NOSE UP and NOSE DOWN on the TRIM indicator on the port instrument panel.

(d) The tailplane interconnection is selected by the TAILPLANE—ON/OFF switch on the centre instrument panel. When the interconnection is in use, movement of the tailplane as a result of control column movement is shown on the trim indicator.

(e) When the cover of the standby trim switch is raised, the tailplane interconnection is cut out in addition to the main trim motor.

8 Aileron Spring Feel and Trim

(a) The aileron spring feel unit on the port control column can be adjusted to trim the aircraft laterally when in Power. The trim is adjusted by a knob at the top of the spring feel unit; the knob can be rotated through 300° either side of the neutral position which is indicated by a detent and a white line on the knob pointing forwards. The trim should not be used in Manual.

(b) An electrically-actuated tab on the port aileron is used to adjust the lateral trim in Manual. The tab actuator is controlled by the combined aileron and rudder TRIMMING control on the port shelf and the aileron-only

TRIMMING control on the starboard shelf. Each trim control is spring-loaded to the centre position and is moved laterally to operate the aileron tab actuator; releasing the control to the centre position stops the actuator. Each trim control is provided with a hinged locking device to prevent inadvertent operation of the aileron trim when in Power. The lock does not prevent use of the rudder trimming function of the port control. When the starboard trim control lock is removed, the port aileron trim control is inoperative. The trim controls should normally be locked when in Power but, to permit rapid trimming in case of reversion to Manual, they can be left unlocked during take-off and landing. The positions of the aileron and rudder trim tabs are shown on a combined indicator just forward of each trim control; normally, both trims should be set to the neutral position.

NORMAL USE

9 Pre-Flight Checks

(a) After starting the engine, select both power control switches to POWER ON and check that the magnetic indicators show black.

(b) With the stick free and the tailplane set at 0°, switch on the tailplane interconnection. Move the stick fore and aft over the full range and check that the tailplane follows the stick movement. During this check, operate the tailplane trim in the reverse direction to the stick movement and check that the trim operation overrides the tailplane interconnection; note that the tailplane takes up a new position when the stick is released.

(c) Retrim to 0° and, whilst moving the stick, raise the standby trim switch cover and check the interconnection cut-out. Check the operation of the standby trim and leave the tailplane more than 1° from zero. Lower the cover of the standby trim switch fully and check that the tailplane reverts to within $\pm 1°$ of the zero position with the stick free. Switch off the tailplane interconnection.

(d) Operate the main tailplane trimmers and check that

the starboard switch overrides the port switch; set the trim to the take-off position.

(e) Check the operation of the aileron spring feel and set to neutral.

(f) Operate the aileron and rudder trim controls and check that the port aileron trim control is inoperative when the starboard control is unlocked; set both trims to neutral.

MALFUNCTIONING

10 Hydrobooster Malfunctions

(a) Bypass Valve Fails to Open. If a hydrobooster bypass valve fails to open when Manual is selected, the stick forces are slightly increased in the associated control but the forces are acceptable. The controls should operate normally if Power is reselected.

(b) Bypass Valve Fails to Close. If a hydrobooster bypass valve fails to close when Power is selected, the affected hydrobooster remains in Manual. In the case of the ailerons, this results in one aileron being in Power and the other remaining in Manual. On the ground, this can be recognised by the stick juddering when moved laterally with stick forces between normal Manual and normal Power. In the air, the affected aileron upfloats (increasing with speed and g) giving a maximum out-of-trim force of about 20 lb in level flight; the force is reduced when the flaps are lowered. It may be possible to clear the fault by cycling the appropriate power control switch; if not, select and remain in Manual.

(c) Servo Valve Spindle Breakage. If a servo valve operating spindle breaks when the control is in Power, the affected servo valve remains closed and the associated control cannot be operated. Selecting Manual gives normal Manual control.

11 Tailplane and Trim Malfunctions

(a) If the tailplane interconnection or trim malfunctions, raise the standby trim switch cover fully and use the standby trim. Switch off the tailplane interconnection,

lower the standby trim cover and check the main trim. If the malfunction is still present, raise the cover again and continue using the standby trim.

(b) If the tailplane runs away, raise the standby trim switch cover fully and retrim using the standby trim. If the microswitch fails to operate when the cover is raised, the main trim motor can be isolated by tripping the circuit breaker on the starboard shelf. Continue using the standby trim.

(c) If the aileron trim malfunctions in Manual, unlock the starboard trim control and use that control to retrim. If lateral trim cannot be regained, reselect and remain in Power. If Power cannot be reselected, reduce speed to below 200 knots and use the rudder trim to counteract any lateral imbalance.

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