Chapter 4 — FLYING CONTROLS

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DESCRIPTION

Introduction

1. Control of this aircraft about the longitudinal and lateral axes is by means of two groups of four elevons hinged into the wing trailing edge, one group each side. A conventional rudder control surface is fitted for control about the vertical axis. All surfaces are operated by means of electro-hydraulic power units.

2. To guard against complete loss of elevon control in the case of a single power unit failure, each elevon section is operated by its own power unit. Should a single power unit fail, the remaining sections are unaffected and approximately one-eight only of the effective control surface is lost. Duplicated power units are installed at the base of the rudder, each of which is powerful enough to operate the surface, one unit will normally be controlling the rudder whilst the other is idling, and in the event of failure of the main unit, the auxiliary unit comes into operation automatically.

3. Dual interconnected control columns and rudder pedals are provided in the pilots' cockpit. Tubular push-pull rods are used throughout from the cockpit to the power units, the circuits governing aileron and elevator sense control uniting at a mixing unit at the rear spar, from where a single control run, into each wing, operates all the elevon power units.

4. The pilots' control 'feel' is simulated by three artificial feel units, one for each control axis, situated in the bomb bay. Stick and pedal forces can be trimmed by the pilot via linear actuators adjacent to the feel units.

5. The stability of the aircraft is augmented under certain conditions by pitch damping and auto-mach trimming facilities on the wing surfaces and by yaw damping on the rudder. A complete automatic pilot system is also provided.

5A. An automatic landing system is installed in the aircraft, formed by the combination and integration of leader cable, F.M. radio altimeter Mk.7, auto-throttle, and the Automatic pilot Mk.10B. Full details of the system is given in Sect.7, Chap.9 of this Volume.

COCKPIT CONTROLS AND INDICATORS

General

6. A brief reference only is made to the various switches and indicators, comprehensive details of their operation and functions are given in Sect.6, Chap.10 of this Volume.

Powered flying control units

7. A panel attached to the port console (fig.1) houses at its rear end three push-button type switches for starting the inboard and outboard elevon and rudder P.F.C. units. Along the lower or inboard portion of this panel are ten spring-return push-switches with internal filaments, one switch for each power unit, by means of which any of the ten P.F.C. units can be switched off independently. Should a fault occur in a unit causing the hydraulic pressure to fail, the filament in the switch associated with that particular unit will be energised and the switch will display an amber light and, at the same time, the central warning system lights, one at each side, at the top of the cockpit centre instrument panel, will also be energised, both lights showing amber. When the faulty channel is isolated by depressing its push switch, a magnetic indicator, adjacent to the port side amber warning light, will be energised to display white and the two main warning lights will be extinguished. The magnetic indicator will continue to display white as a reminder to the pilots that a fault exists, and the push-switch will remain illuminated to identify the faulty channel. An attempt to restart a failed motor may be made by pressing the appropriate group start push-switch.

Artificial feel control

8. Should it be necessary to reduce the load on the flying controls, the artificial feel mechanism of the elevon feel units can be reduced to the low speed condition by pressing either of the two push-switches fitted one on each pilots' control handle. A separate artificial feel relief switch for the rudder unit is fitted on the fuel contents gauge panel forward of the throttle levers. The artificial feel system can be reset to normal, from the relieved condition, by operating the appropriate power unit group START switches at the rear end of the panel on the port console.

9. In the case of a feel unit failure, the central warning lamp on the pilots' centre panel will illuminate and also the relevant one of three push-pull switches on the port console P.F.C. panel. Operation of the illuminated push-pull switch on the console will extinguish the central warning light. The push-pull switch will remain illuminated to indicate the failed channel. A magnetic indicator on the centre panel is also energised and shows white when a feel unit failure occurs, this indicator remaining white as a reminder to the pilots that feel relief is in operation.

9A. When the aircraft is under the control of the automatic landing system, the artificial feel forces are automatically biased in all three axes, at various stages in the automatic landing sequence.

KEY TO FIG.1

FLYING CONTROLS AND INDICATORS

1. Air brakes emergency switch.
   NORMAL - up
   EMERGENCY - down - energises standby motor to complete retraction if main motor fails.
2. Emergency trim control - used in natural sense. Centre button must be depressed whilst operating.
3. Autopilot control panel.
4. Instinctive autopilot cut-out - press to disengage.
5. Trim control switch - elevons - four-way switch used in natural sense.
6. Artificial feel relief switch, aileron and elevator sense (guarded).
   Press to operate.
7. Autopilot controller.
8. Air brakes switches.
   IN - air brakes closed.
   MED. DRAG - air brakes partly extended.
   HIGH DRAG - air brakes fully extended.
9. Rudder trim control switch.
10. Rudder artificial feel relief switch-press to operate.
11. Rudder pedals adjuster.
12. FEEL RELIEF lock switch.
    Forward - NORMAL.
    Rearward - LOCK.
13. Pilot's control handle.
14. Side slip indicator.
15. Autopilot trim indicator.
16. Autoland phase and altitude indicator.
17. I.L.S. warning light.
18. MAIN WARNING indicators - illuminate amber when failure occurs in the flying controls. Extinguished when faulty circuit is switched off.
19. P.F.C. indicator - black when control units are running. White when any control unit is stopped.
20. ARTIFICIAL FEEL indicator - black when circuits are energised. White when circuit is isolated.
21. AUTO-STABILIZER indicator - black when circuits are energised. White when circuit is isolated.
22. AIR BRAKES indicator - black when air brakes are fully in. White when air brakes are out.
23. ALTernator FAILure indicator - amber warning light when single alternator failure occurs. Flashing amber light should more than one alternator fail. Extinguished when R.A.T. is lowered.
24. BOMB DOORS and FIN POSITION indicator.
25. CANOPY UNLOCKED indicator. White when canopy is unlocked. Black when canopy is closed and locked.
26. ENTRANCE DOOR UNLOCKED indicator - white when entrance door is unlocked. Black when entrance door is closed and locked.
27. PITOT HEATER indicator - white when pitot heater is off. Black when pitot heater is ON.
28. CONTROL SURFACE INDICATOR.
29. Artificial FEEL system failure indicator/push-pull switches.
    A - aileron sense
    R - rudder
    E - elevator sense
    Illuminate amber when failure of system occurs. Press to cancel main warning.
30. STARBOARD ELEVONS P.F.C. failure indicator/push - switches - ill - uminate amber when P.F.C. failure occurs. Press to isolate failed P.F.C.
31. RUDDER P.F.C. failure indicator/ push-switches. Inboard switch, main P.F.C. - outboard switch auxiliary P.F.C. Illuminate amber when P.F.C. failure occurs. Press to stop failed P.F.C. When main is stopped auxiliary will start.
32. PORT ELEVONS P.F.C. failure indicator/push-switches - illuminate amber when P.F.C. failure occurs. Press to isolate failed P.F.C.
33. P.F.C. group START push-switches.
    A - outboard elevons and artificial feel.
    R - rudder and artificial feel.
    E - inboard elevons and artificial feel.
34. YAW DAMPERS control switch.
    No.1 -switch aft - No.1 system engaged.
    No.2 -switch forward - No.2 system engaged.
35. COMPARATOR RESET push-switch. Depress to reset.
36. PITCH DAMPERS failure indicator/ push-pull switches.
    Illuminate amber to indicate failure.
    Depress to disengage.
37. AUTO TRIM RESET indicator/push switches.
    Illuminate blue when auto.mach-trim is in.
    Depress both switches to retract servos.
38. AUTO TRIM start failure indicator/ push-pull switch.
    Illuminate amber to indicate failure.
    Depress switch to disengage.
39. Rudder pedals

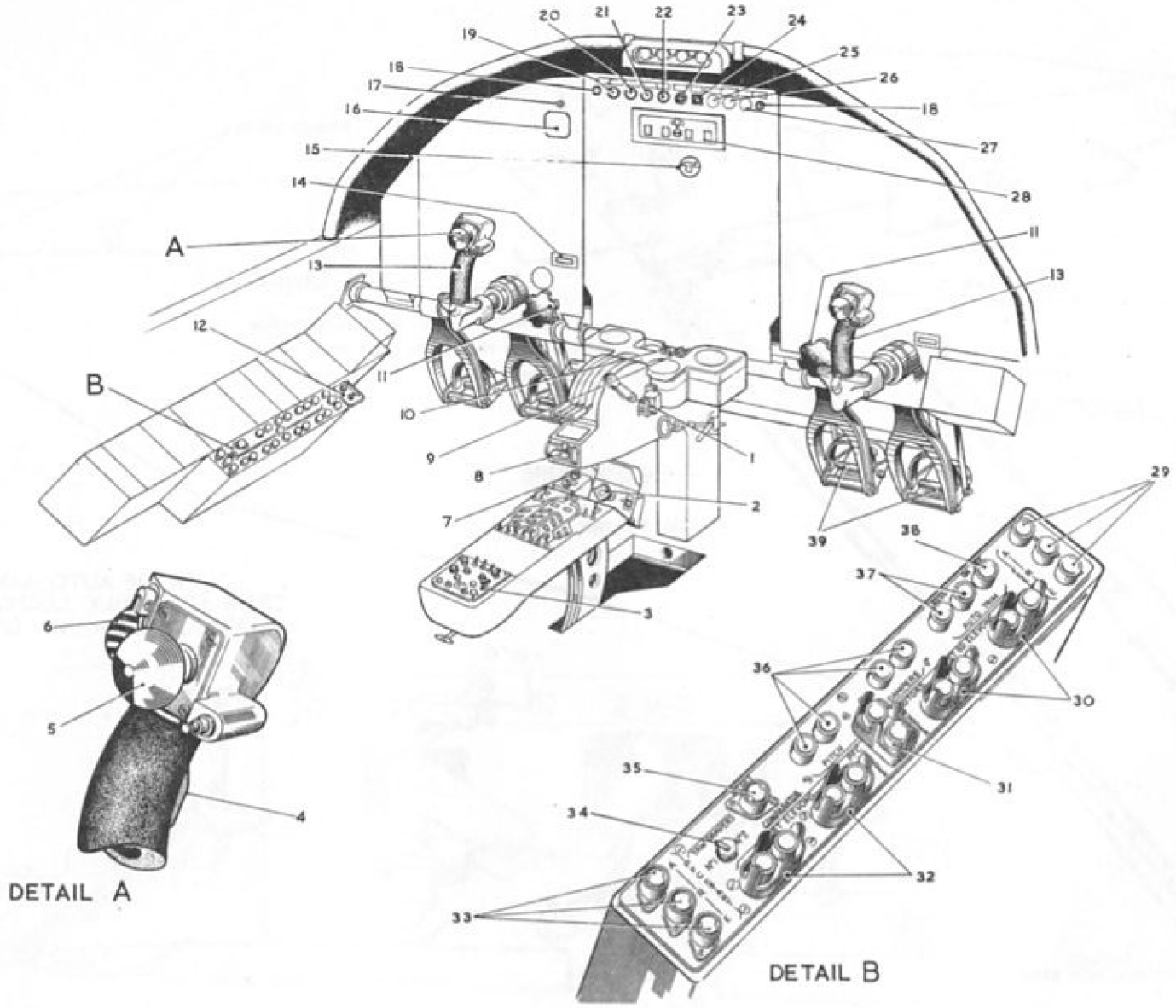


Fig. 1 Flying controls and indicators

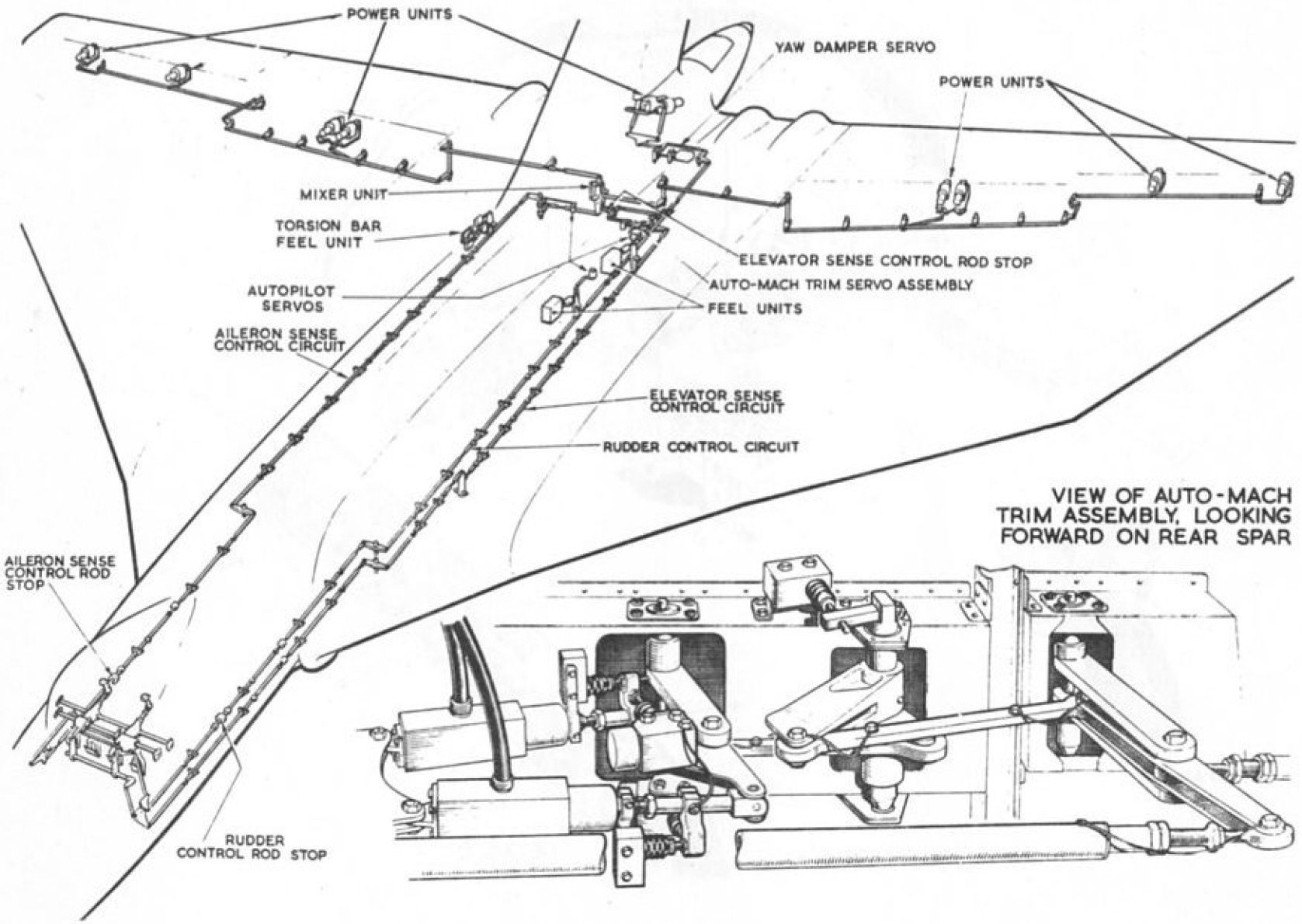


Fig. 2. Flying control system

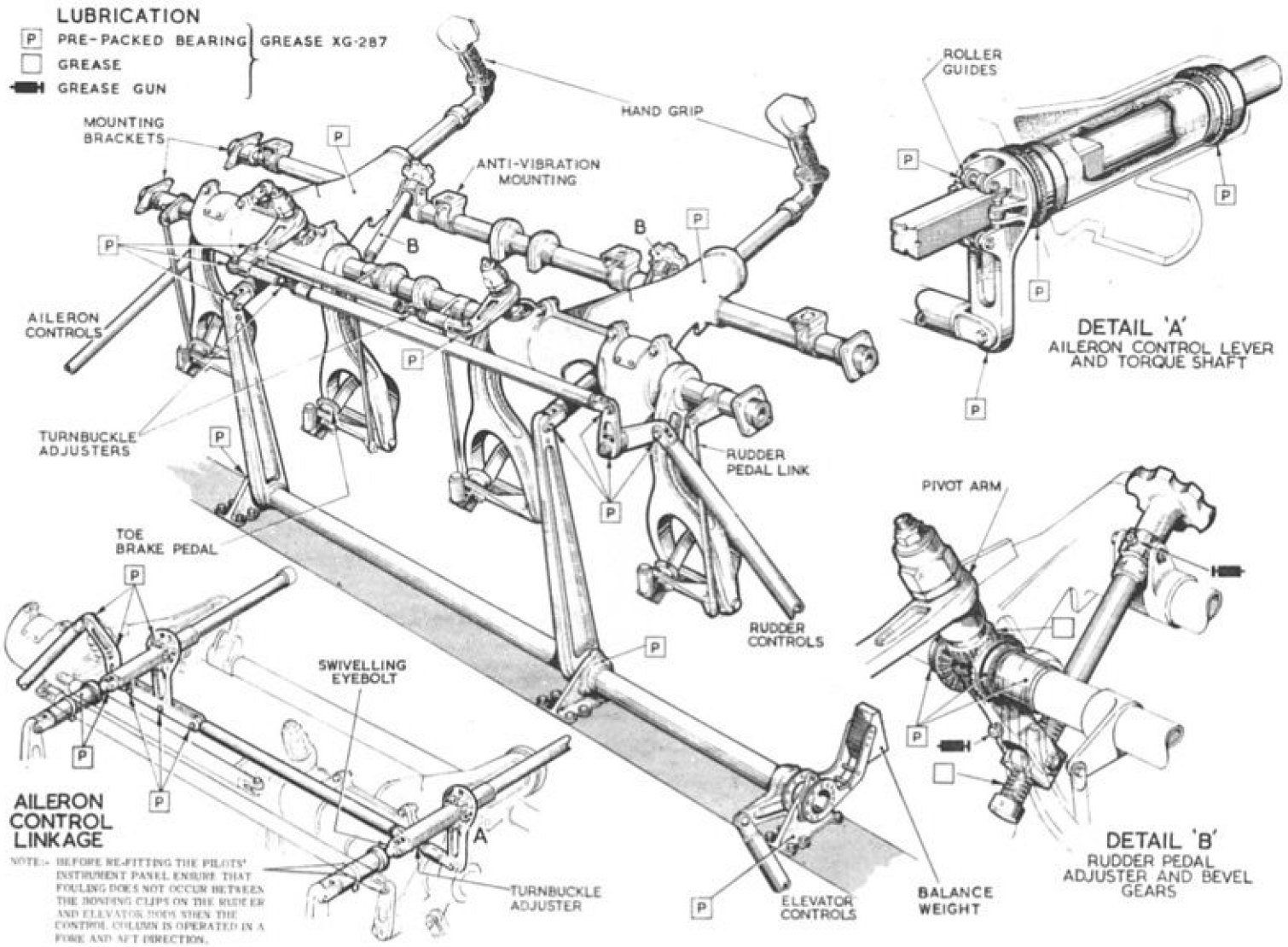


Fig. 3 Control Mechanism in Cockpit

◄ Control linkage corrected ►

Trim controls

10. For normal trim control in aileron and elevator sense, a two-axis switch is provided on each pilot's control handle and for the rudder a switch is located on the fuel contents gauge panel forward of the throttle levers. For emergency trim control, when required, a covered switch is provided at the forward end of the retractable console, a push button fitted in the centre of the switch must be operated whilst the switch is used. The emergency switch is used in a natural sense, i.e., forward or rearward for longitudinal trim, sideways for lateral trim and is rotated to adjust directional trim.

Automatic systems

11. Control switches for the auto-mach. trim, yaw damping and pitch damping systems are located on the upper half of the flying control panel on the port console. Push-pull switches with built-in indicating lamps are provided for pitch damper and auto-mach trim systems and a centre OFF change-over switch for the yaw dampers. In the case of a failure of any pitch damper or auto-trim channel, the central warning lamps will illuminate, also the lamp in the relevant push-pull switch will illuminate to indicate the failed channel and at the same time a dolls-eye indicator on the pilots' centre panel will turn white. The central warning lamps, will be extinguished with the failed channel switched off, but the dolls-eye indicator remains white to indicate a failure and the push-pull switch will remain illuminated to identify the failed channel. Pitch dampers and mach-trim are controlled through four height switches, in series with the two static vent lines, which complete the circuit to the servo at an altitude of 20,000 feet. A push-pull start switch/indicator on the port console shows amber for extension of mach trim and next to it are the mach trim reset push-button switches, which energise the mach trim servo units directly in case of failure to return to zero. No indication of failure in the yaw damper system is provided. Details of these systems are given in Sect.6, Chap.10 of this Volume.

◀ 11A. Control switches and control units for the automatic landing system are shown on fig.1 and are described in Sect.7, Chap.9 of this Volume. ▶

Control columns

12. Twin columns, each with a single hand-grip for pilot operation, provide dual control in the cockpit. Fore-and-aft travel of the column is translated into elevator sense control movement through a common torque shaft mounted at floor level forward of the main instrument panel. This shaft carries two levers connecting it to the control column by swivel jointed links which permit hand-grip rotation for aileron control. Each push-pull column is integral with a control unit which incorporates the rudder pedals and associated mechanism, the whole being contained in T-shaped light-alloy casing. Two such units are provided, one for the port and one for the starboard control position. In both instances the cross-head portion of the T forms the rotational axis for the pendulum-type rudder pedals, the stem portion pointing aft and housing the hand-grip push-pull column inside the aileron lever assembly.

ELEVON CONTROLS

General

13. Control of the aircraft in the aileron and elevator sense is carried out by the manipulation of one set of control surfaces, i.e., eight elevons. When elevator sense is selected on the control column eight elevons move up, or down, together. Should aileron sense control be selected, then four elevons on one side of the aircraft will move up whilst the four on the opposite side will move down. It follows therefore that a 'mix' selection by the pilot, i.e., for a climbing turn manoeuvre, will result in all elevons moving to provide the dual sense control. The degree of elevator sense control selected will be applied to all elevons and, at the same time, due to the differential action of the mixer unit, the selected degree of aileron sense control will also be introduced. The amount of aileron sense control selected will be added to the up movement of the four elevons on the inside of the selected turn and cancelled, or taken off the elevons on the outside of the turn.

14. Two independent control runs, from the control column to the rear spar, are provided for operation of the elevons, one for aileron sense and one for elevator sense movement of the control surfaces. These control runs unite at a mixing unit at the rear spar, from which point a single run extends into each wing to the power control units.

Aileron sense control

15. Aileron sense movement of the control surfaces is effected by part rotation of the pilot's hand-grip, which has a total range of movement of 83 deg. 30 min. As the hand-grip is rotated, simultaneous movement of the aileron lever occurs, driven by the square section of the hand-grip push-pull rod which is supported within the bearing tube of the 'aileron' lever assembly, with its forked square section protruding through the guide rollers on the base of the aileron lever. Port and starboard assemblies are identical and move in unison, an adjustable control rod with connecting links joining the two pedulum aileron levers. At the starboard side the link extends outboard to a bell-crank forging, and from this point a vertical push-pull rod transmits movement to the fuselage control run through a bell-crank lever below the pilots' floor. Extending aft along the

starboard side, the control run is stepped outboard by a counterlever at former 72F, then continued through the bomb bay to the mixing unit at the rear spar.

Elevator sense control

16. Elevator sense movement of the control surfaces is effected by push-pull action of the control column hand-grips, which have a fore-and-aft movement of 9·12 in. The push-pull rods, on which the hand-grips are mounted, slide inside the aileron lever bearing tubes, their forked ends being connected by swivel links to upright levers on a floor level torque shaft forward of the instrument panel. A vertical push-pull rod, at the port end of the torque shaft, transmits control movement to the fuselage control run via a lever assembly below the floor. The run is stepped outboard at former 72F by a counterlever and then continues through the bay into the front end of the bomb bay. At this point a change in relative heights occurs at a pillar type lever, which rocks about a fixed point on its base. The lever links the rods by its upper fork, the forward rod uppermost and the rear one immediately below, this arrangement reduces the linear travel of the rod. The control run continues aft through the mechanism of the auto-mach trim system to the mixing unit at the rear spar.

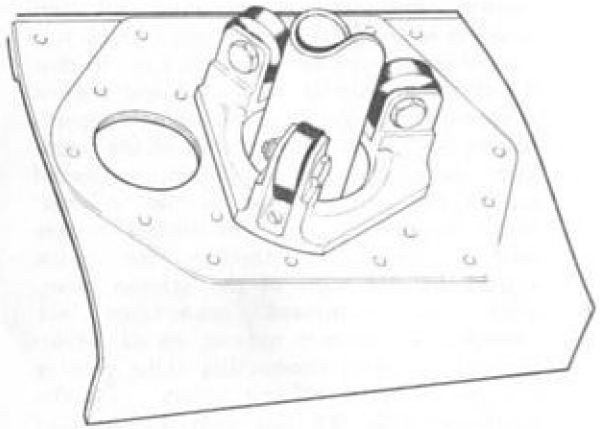


Fig.4. Typical three-roller bearing

Mixing unit (fig.10)

17. The fuselage control runs for aileron and elevator sense control unite at the mixing unit, which combines the pilots' stick movements in these senses into a single control run by use of a differential lever system. The levers of the unit are arranged so that movement of the pilots' controls in the elevator sense moves all the wing control surfaces in the same direction, and in aileron sense moves port and starboard surfaces in opposition. From the mixing unit single control runs extend outboard into each wing to operate the power units actuating the control surfaces.

RUDDER CONTROLS

General

18. The rudder pedals rotate about an axis within the cross-head of the control unit T-shaped casing. Two centre-jointed, non-rotating cross-tubes secure the units in the fuselage, one through the cross-head and the other through a cast lobe in the underside of the stem. The rudder pedal mechanism, embodying a reversing bevel gear assembly, is carried on the cross-head tube, each unit comprising the following components.

(1) Two side bevel gears with riveted torque sleeve extensions, mounted on ball races throughout.

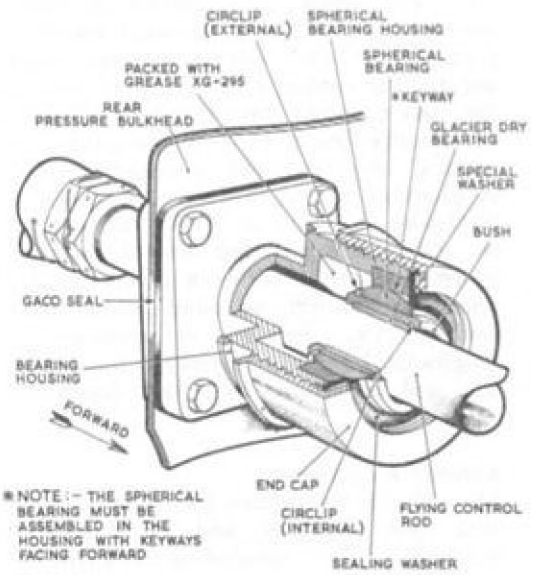


Fig.5. Control rod pressure seal bearing

(2) Left and right pedals attached to the respective gear extensions.

(3) A single bevel pinion in mesh with the slide gears, also carrying a forward facing lever arm for movement transmission.

(4) A pivot shaft, which mounts the single pinion between the side gears.

This latter item rocks about a plain bush fixed to the mounting tube, and is arrested by a screw adjuster shaft which engages its lower forked lever by a trunnion unit. Each adjuster shaft is extended and fitted with a knurled hand-wheel within easy reach of the pilot. Clockwise turning of the hand-wheel will move the rudder pedals closer to the pilot, the full range of the operating screw giving approximately 11 in. of adjustment.

19. All other movements are synchronised by a link between the forward facing levers, movement by either pilot being transferred to the other controls via a push-pull tube and bell-crank assembly. From this point a vertical push-pull rod transmits movement, via a bell-crank lever below the pilots' floor, to longitudinal push-pull rods. These continue down the side of the fuselage rear section, from where they pass inboard, through the servo unit assembly of the yaw-damping system, to a three armed lever in the centre of the fuselage. Equal arms of the lever extend to port and starboard to connect to the relative power units by fore-and-aft telescopic rods.

CONTROL STOPS

Elevon (aileron sense) and rudder (fig.6)

20. Two adjustable stops are fitted on one of the control rods in each control system. In the case of the aileron and rudder system, each pair of collars is positioned one each side of a U-shaped stop bracket bolted to the aircraft structure, the stop for both systems being fitted to the forward face of former 288F in the crew's nacelle. Movement of the aileron and rudder control runs is limited by these stops.

Elevon (elevator sense)(fig.7)

21. In the case of the elevator sense controls, the collars are fitted in the roof aft of rear spar, one on each side of the port front fin post assembly. 10 s.w.g. light-alloy plates fitted to each side member of the fin post assembly act as limiting stops.

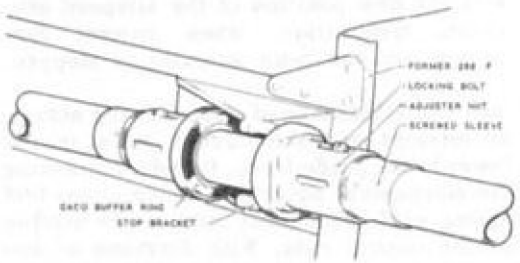


Fig.6. Control rod stops-aileron sense and rudder

POWER UNITS

General

22. Ten power control units are incorporated in the flying control system, eight of these being mounted in the wing and two in the rear fuselage. All the units are basically of the same construction except that the rudder units, being interconnected have various additional valves. There are three variations of the basic unit used, those for the inner elevons being manufactured in the left hand form, whilst for the rudder a dual unit is used comprising a main and an auxiliary unit interconnected by a flexible pipe. The outer elevon power control units are not handed. When mounted in the aircraft each unit is supported by its hydraulic jack which is attached to the aircraft structure by means of its non-moving parts. The moving part, i.e., the ram, is attached to the control surface so that the control unit has a small angular displacement imparted to it when it actuates the surface. The control rods connecting with the input lever on each power unit are telescopic, and are spring-loaded to a value which allows collapse or extension in the event of a power unit failure.

23. Each power control unit is self-contained, and consists essentially of an electric motor, a hydraulic jack, and a differential lever assembly, the basic principle of operation being similar for all units. Movement imparted by the respective cockpit control through the appropriate control run is transmitted to the input lever of the differential lever assembly on the power unit. The mechanism of the unit then operates to supply fluid to one side or the other of the hydraulic jack, which by movement of the jack piston operates the control surface. When the control surface reaches a position relative to the cockpit control demand, the fluid is automatically cut off and the surface ceases to move, remaining in this position until a further input movement registers on the power unit.

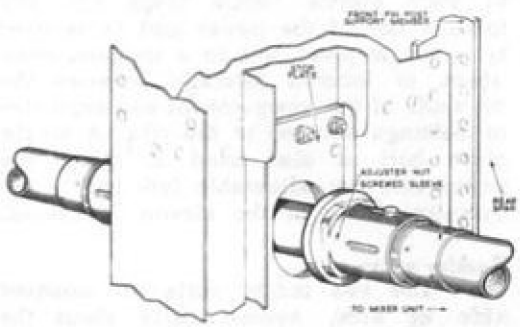


Fig.7. Control rod stops - elevator sense

Inboard elevon units

24. Each inboard elevon power unit is housed in a separate compartment built into the main plane trailing edge. An attachment lug on the forward end of the main casting is secured by a single pivot bolt to a trunnion beam. This beam is located between the inner and outer walls of the compartment and supported in bearings secured to the walls. A further pivot bolt secures the adjustable fork-end of the power unit ram to the operating lever on the elevon concerned. Inboard elevon power units are interconnected by a single rod which passes through a cut-out in the dividing rib-web.

Outboard elevon units

25. Due to the trailing edge section toward the wing tip being restricted in depth, the outboard elevon power units are only partially housed in the main plane, the unaccommodated portion below the main plane being enclosed in a streamlined light-alloy fairing which is removable for servicing purposes. Each power unit is housed in a separate compartment formed by two wing ribs adjacent

to each elevon centre hinge rib. The forward end of the power unit is secured by a single pivot bolt to a trunnion beam which is located laterally between the rib walls of the compartment and supported in bearings secured to the ribs. A single pivot bolt is also used to attach the power unit ram adjustable fork end to the operating lever of the elevon concerned.

Rudder units

26. The two rudder units are mounted side by side, symmetrically about the fuselage centre line, in the rear fuselage section aft of the electrical power compartment. Each unit is attached by two pivot bolts; one bolt locates the attachment lug at the rear of the main casting, with a support beam secured to the forward face of former 487.5A, and the second bolt locates the power unit ram adjustable fork end with one arm of a horizontal rocket lever secured to the base of the rudder post. The rudder is under control of one unit at a time, change-over occurs automatically should the main unit fail. When change-over is initiated by the control switches on the port console, the change-over time from main to auxiliary unit can vary up to a 15 seconds maximum. Average time is however 8 seconds with the rudder static.

ARTIFICIAL FEEL UNITS

General

27. With power units being used to operate the control surfaces, there is no feed back of control surface loads to the pilot. The control surface resistance felt at the control column and rudder bar is therefore provided entirely by artificial means from three feel simulator units, one for each control axis. Each unit is mounted in the bomb bay, and is attached through a trim actuator and a reaction lever to its respective control push-pull rods. Each unit can be locked in any predetermined position by manual selection of a switch at the forward end of the powered control panel on the port console. This locking facility is used to prevent the possibility of actuator runaway to a low speed value when the aircraft is flying at high speed and low altitude. Full electrical details of the units and control circuits are given in Sect.6, Chap.10 of this Volume.

Rudder and elevator sense units (fig.8)

28. These units are designed to provide increase of loading on the pilots' controls proportionate to control surface angular movement and indicated air speed. The two units are similar, each comprising the following components:-

(1) A boxed spring unit, at the top of the feel box.

(2) An input shaft, mounted on guide rollers and protruding through each end of the casing. This also incorporates a control system centring spring, pre-loaded to overcome circuit friction.

(3) A main linear actuator for variable fulcrum operation, connected to one of two levers on the torque shaft mounted across the box.

(4) A follow-up transmitter, cam-driven from the fulcrum point. An assister spring, attached to the transmitter arm, prevents possible sticking of the transmitter in low temperature conditions.

(5) A feel relief linear actuator in the bottom of the housing, connected to a swinging lever which also anchors the main actuator.

(6) A vertical link connecting the boxed spring unit and the lower input shaft. This engages, by a slotted guide track, a roller on the longer torque shaft lever which forms the fulcrum point for feel reaction.

(7) An electrical unit mounted externally on the feel box. This contains a transmitter potentiometer sensitive to airspeed, and relays suitably wired for fulcrum actuator operation.

For a more detailed description of the electrical components incorporated in the feel units reference should be made to Sect.6, Chap.10 of this Volume.

29. Movement of the pilots' controls in either direction is transmitted to the input shaft of the feel unit, the 'feel' or resistance to movement of the control being supplied through the vertical link, by the internal spring in the upper boxed spring unit. As airspeed changes, the fulcrum roller on the torque lever moves in the vertical slotted guide track, its position being regulated by the main function actuator which is controlled by the external airspeed-sensitive transmitter in conjunction with the internal follow-up transmitter. With change of airspeed the external transmitter moves out of synchronisation with the internal transmitter and a current passes through the main actuator, extension or retraction of which operates the short torque lever to rotate the feel unit cross shaft, thereby causing movement of the longer torque lever and with it the fulcrum roller and cam plate. The moving cam plate causes the arm of the follow-up transmitter to rotate, this movement continuing until the follow-up transmitter is synchronised with the new position of the airspeed sensitive transmitter, when current flow ceases and the main actuator is stopped.

30. With increase of airspeed, the actuator retracts and the fulcrum roller moves lower in the guide track, thereby increasing the mechanical advantage of the upper feel spring with consequent increase in loading in the control rods. With decrease of airspeed the actuator extends and the roller rises in the guide track, giving a progressively lower loading in the control rods.

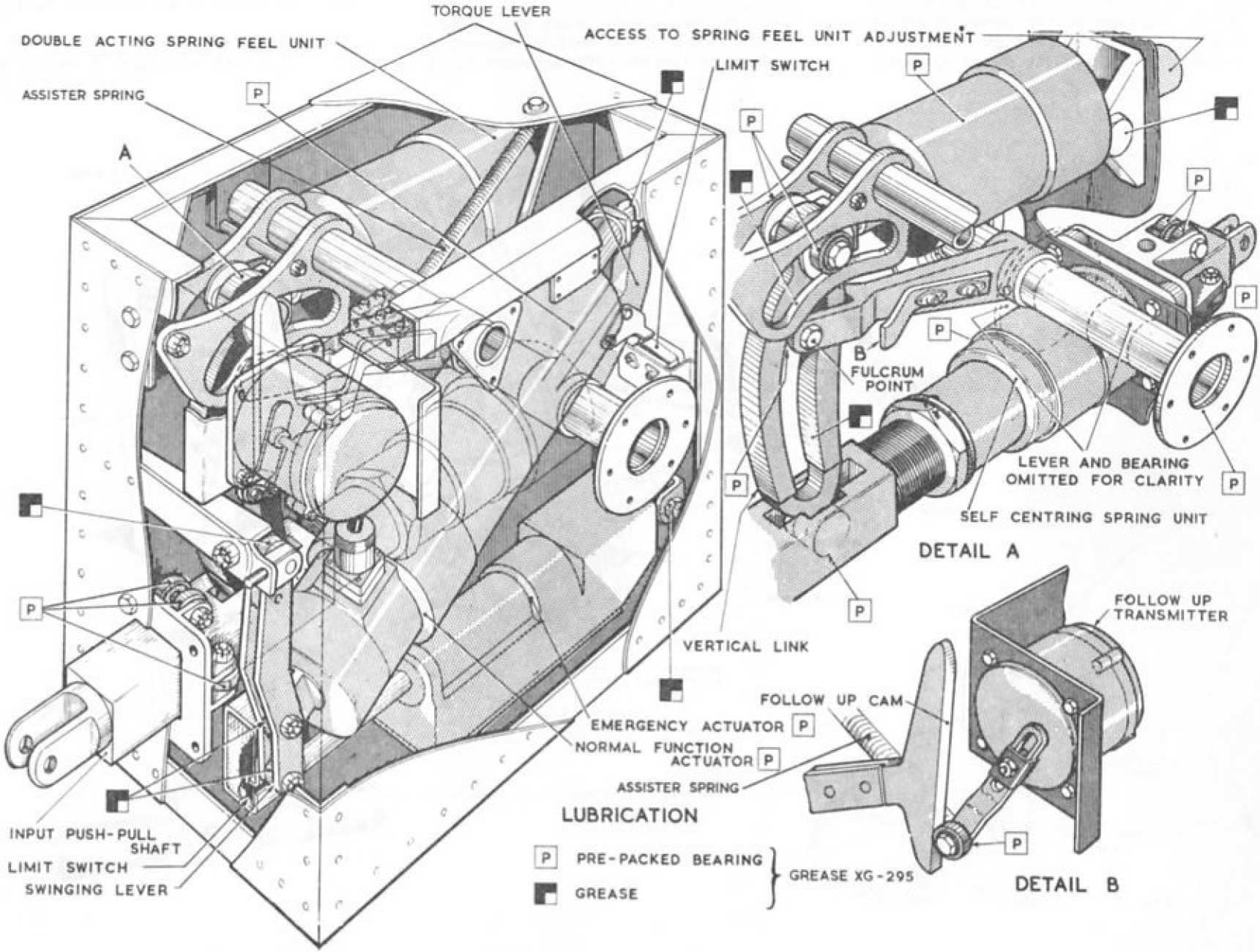


Fig. 8. Artificial feel unit elevator sense and rudder

[◄ Mod. 1883 ►]

RESTRICTED

30A. On aircraft with the autoland system fitted, selection of the autopilot rudder channel, in flight, retracts the rudder feel actuator to increase the forces opposing the autopilot by 30 to 45%. On commencement of the attitude phase of an automatic landing normal feel is required to perform the kick-off-drift manoeuvre during the flare phase of an automatic handing.

Aileron sense unit (fig.9)

31. This unit comprises a torsion bar

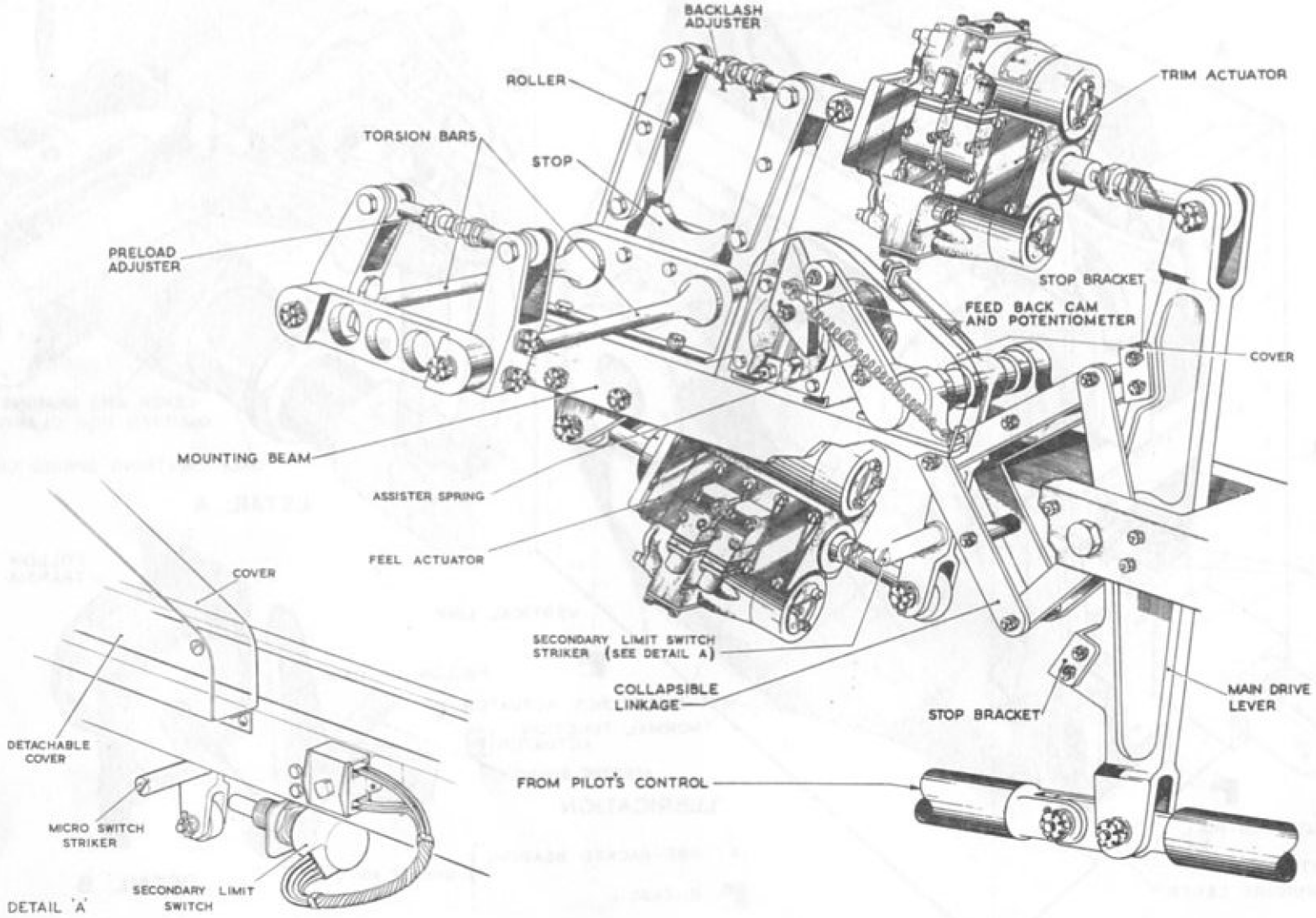


Fig.9. Artificial feel unit - aileron sense
(◀ Mod. 1806 and 2106 ▶)

RESTRICTED

spring unit of fixed rate and positive self-centre value coupled into the aileron sense control circuit, on the starboard side of the bomb bay, through a trim actuator and a main drive lever. The unit is designed to provide simple spring feel, when the controls are used in the aileron sense, giving 24 lb. stick force for full control surface deflection, the available surface angular movement being decreased with increasing airspeed above 150 knots indicated air speed.

32. Movement of the pilots' controls in either direction is transmitted via the vertical main drive lever and trim actuator to the torsion bar assembly at the forward end of the unit. The 'feel' or resistance to movement is supplied by the resistance of the twin torsion bars to the torque load applied to them when the controls are operated. The 'twist' is applied at one of the torsion bars, and is transmitted through that bar and a link assembly to the second torsion bar, one end of which is prevented from twisting by a stop. When the stick force applying the twisting moment is removed, the bars return to their normal condition, thus centring the controls.

33. The available movement of the elevons, when used in the aileron sense, is governed by the gap between the stops on the feel unit main drive lever and a collapsible linkage attached to the lever. The linkage is operated by a dual-motored electrical actuator mounted on the forward lower side of the feel unit mounting beam.

34. For air speeds up to 150 knots the gap between the collapsible linkage and the drive lever stops is at a maximum permitting full control surface travel in the aileron sense of 12.5 deg. for inboard and 15.625 for outboard elevons. As airspeed increases above 150 knots the gap is progressively decreased, thus restricting available surface travel until at 365 knots the position of minimum available travel is reached, i.e., ± 5 deg. for inboard and ± 6.25 deg. for outboard elevons. With decreasing air speed the gap widens, permitting increased surface movement until normal full travel is regained at 150 knots. When an aileron selection is made, with auto-pilot engaged, the aileron sense movement is limited to ± 5 deg. This range limitation is extended to ± 6 deg. when autoland I.L.S. 'Track' is selected. When the autoland attitude phase is started all restrictions are removed to allow full aileron range of 12.5 deg. Stop range adjustment is carried out electrically and is fully described in Sect.7, Chap.6 of this Volume.

◀ 34A. A Honeywell Type 1EN-N14 micro switch (Ref.No.5CW/6865) is secured by a bracket to the feel unit mounting beam. Operated by a striker on the feel unit lever this switch acts as a second limit switch in the extend field of the feel actuator should the internal limit switch fail. Operation of the switch also energises the warning indicator circuits. ▶

Artificial feel relief

35. In the event of a feel unit failure in the high speed condition, the load or 'feel' on the pilots' controls can be reduced to a minimum by use of the appropriate relief switch in the cockpit to operate a feel ◀ relief actuator in each unit. The feel relief actuators can also be locked in any predetermined position by operation of a switch at the forward end of the powered control unit control panel on the port console. This locking facility prevents the possibility of actuator runaway to a low speed value when the aircraft is flying at high speed at low altitude. ▶

36. In the elevator and rudder units, selection of feel relief causes the relief actuators in the selected unit to retract carrying the swinging lever toward the centre of the unit. Initial movement of the swinging lever releases a Burgess Type V3 micro switch (Ref.No.5CW/4615) to break the electrical supply to the trim actuator, thus preventing any further operation by it during the relief operation. The micro switch, operated when the relief actuator is in its extended (feel engaged) position, connects a power supply to the feel control and warning systems. Movement of the swinging lever is transmitted through the feel actuator to operate the feel actuator torque lever and thereby rotate the cross-shaft. Rotation of the cross-shaft moves the fulcrum point to the minimum feel position at the top of the slotted guide track. When the relief actuator reaches its retracted (feel relief) position, a striker bracket on the feel actuator torque lever operates a Burgess Type V3 micro switch mounted on the feel unit end plate. This micro switch acts as a secondary limit switch to the relief actuator internal switch and terminates the electrical supply to the relief actuator.

37. Feel relief selection in the aileron sense control brings into action a standby motor in the aileron feel unit stop actuator, which opens the gap between the collapsible linkage and the lever stops to permit full aileron sense movement.

38. The relative control unit START switch at the aft end of the port console panel should be operated to reset feel to normal from the relieved condition. Should this be unsuccessful, the main warning lamp can be extinguished by pressing the relevant feel unit push-pull switch, leaving the dolls eye indicator white, as a reminder to the pilot to observe the required limitation on speed, and the push-pull switch illuminated to indicate the failed channel.

TRIM ACTUATOR

39. Trim is effected by extension or retraction of electrical linear actuators, positioned between the feel units and the flying control runs in the bomb bay, their function being to increase or decrease the effective length of the push-pull tubes between the feel unit and the pilots' con-

trols. In all cases a single actuator unit comprises two motors driving a common ram through a differential gear box, one motor serving as a stand-by in the event of failure of the normal motor.

AUTOMATIC PILOT

40. An electrical automatic pilot system is installed in this aircraft. The positions of various units associated with the system are shown in the illustrations in this chapter. For descriptive and servicing information on the automatic pilot system reference must be made to Sect.7, Chap.6 of this Volume. The autopilot exerts a limited control over the flying control feel circuits, full details are given in Sect.7, Chap.9 of this Volume.

AUTO-STABILISATION

General

41. The stability of the aircraft is augmented by the provision of pitch damping and auto-mach trimming facilities on the wing control surfaces, and by yaw damping on the rudder. The pilots' control switches and indicators are shown in fig.1, and descriptive and operating details are given in Sect.6, Chap.10 of this Volume. Reference must also be made to A.P.14693.

Yaw damper system

42. This system has two completely separate channels operating one at a time at the discretion of the pilot. The master control is a centre-off changeover switch on the flying controls panel on the port console. The equipment for this system is located part in the pressure cabin and part at the forward end of the bomb bay, with the exception of the duplicated servo unit which forms an extensible link operating through a differential lever linkage into the rudder control circuit behind the power compartment rear bulkhead.

Pitch damper system

43. This system comprises four inde-

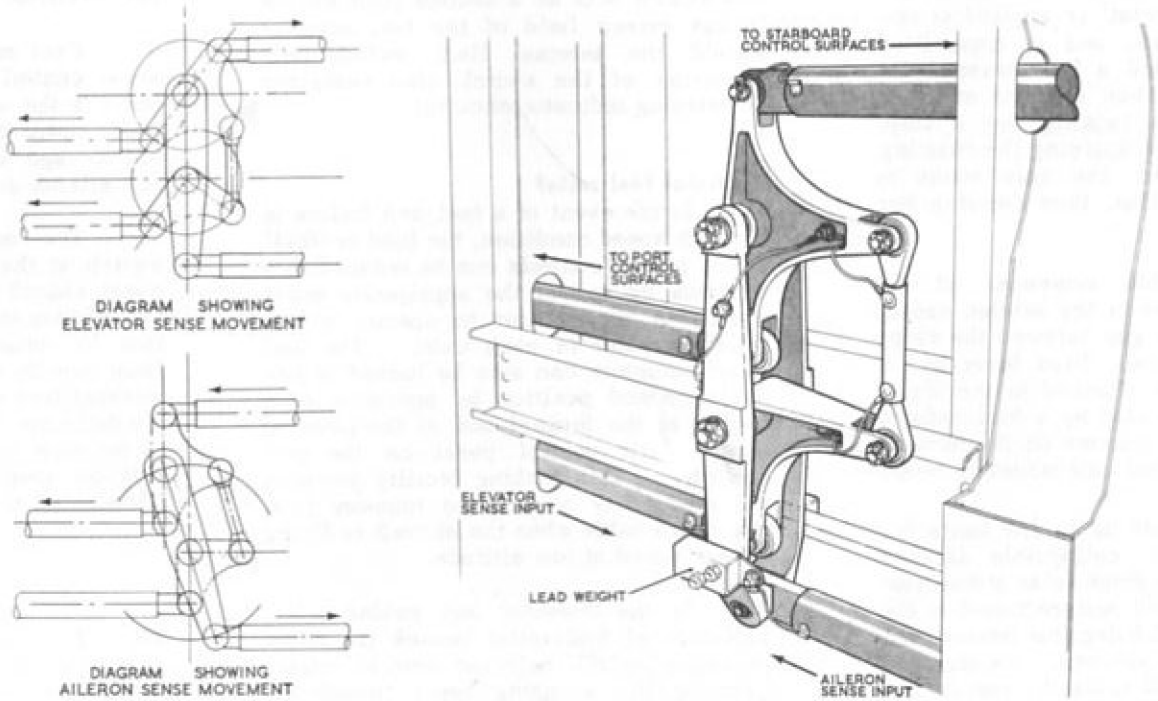


Fig. 10. Mixing unit

pendent channels operating simultaneously with the four servo motors mounted, so as to form the mechanical feedback links of the power units on the two inner pairs of elevons. The push-pull button control switches, located in the panel on the port console, are normally left in the ON position, the system being switched on automatically by height switches at 20 000 feet.

Auto-mach trim system

44. The auto-mach trim system is provided in the aircraft to combat static instability which becomes apparent at high mach numbers. The nose down tendency of the aircraft at mach numbers above 0.82 is corrected by progressive application of the elevons in the elevator sense, to a maximum of 12 deg up on the inboard elevons. This correcting movement is achieved by the auto-mach trim system, no pilot action being necessary. The system has two completely independent channels the servos of each channel being coupled together through a differential beam linkage and introduced into the elevator sense control run just to port of the mixer unit. Control switches, arranged at the forward end of the flying control panel on the port console, consist of a master switch, controlling the power supplies to both channels, and two individual channel switches. The master switch, which is the most forward of the three switches, contains a lamp which will illuminate to indicate either a misalignment of the two channels or that the system is switched off. The individual channel switches will both emit a blue light when the system is 'in' and operating correctly. These two switches, when pressed together, will bring the servo assembly to its fully retracted position. The system is energised automatically at 20 000 feet by height switches. Should any extension of either servo occur below this altitude, the main warning lights on the centre instrument panel will illuminate. Full descriptive and operating details are contained in Sect.7, Chap.6 of this publication.

AIR BRAKES

General

45. The air-brakes are of the electrically operated slat type, two sets of which are fitted, one port one starboard, mounted in the centre section above and below the engine air intake. Each set consists of two slats above the centre section and one below, no outer slats being fitted on the lower surface. A description of the air-brakes structure is given in Sect.3, Chap.1 of this Book, and electrical controls and circuit operation are described in Sect.6, Chap.10 of this publication.

46. Controls for air-brake operation consist of twin switches on the throttle console, each switch controlling one of the paired motors mounted centrally in the centre section. These motors operate the air-brake mechanism in the engine bays on each side of the centre section, via a gear box and extended drive shafts. To ensure simultaneous motor action both switches are mechanically linked, the air brakes moving in accordance with the three positions of the switches which are marked IN-MED.DRAG - HIGH DRAG. An emergency switch labelled NORMAL - EMERGENCY is also provided, the use of which is explained in Sect.6, Chap.10 of this publication. A magnetic indicator on the pilots' centre panel shows black when the brakes are fully in.

Air brake microswitches

47. Twelve microswitches, Microseal Type CDN.1241Z Mk.1A, positioned in pairs, are utilised in the control of the air brakes, three pairs are positioned on the port side and three pairs on the starboard. The microswitches are operated by cam strips which are riveted to the inboard legs of the top inboard air brakes.

47A. With the air brake selector switches at the IN position all the air brake legs are retracted and the air brake flaps faired into the wing forming part of the wing contour. When MED. DRAG is selected air brake leg extension occurs, above and below the main plane surface, until motor rotation is stopped by the operation of microswitch F, the air brake flaps having reached an angle of 35 ± 3 degrees. When HIGH DRAG is selected the motor circuit is restored and the air brake legs extend further until stopped by the operation of microswitches G and H, the air brake flaps having increased their angle to 55 ± 3 degrees. If the alighting gear is lowered with the air brakes in the high drag position the air brakes automatically extend until stopped by the operation of microswitches C and D (port) and L and M (stbd) the air brake flaps having reached 77 ± 3 degrees. If the alighting gear is retracted, with the air brakes in the fully extended position, air brake retraction can only be achieved by selection on the air brake selector switches. To obtain the HIGH DRAG 55 degree position when the aircraft is on the ground, selection must be made on the air brake test switch in the nose undercarriage bay.

47B. When the selector switches are operated from HIGH DRAG to MED. DRAG. the brake legs retract into the main plane until motor rotation is stopped by the operation of micro-switch E, with the air brake flaps at an angle of 55 ± 3 degrees. On selection from MED. DRAG to IN the motor circuit is restored and the air brake legs retract into the main plane until motor rotation is stopped by the operation of microswitches A, B, J and K, the operation of these microswitches also energises the indicator on the pilot's centre panel. On an emergency IN selection it is permissible to allow up to 0.25 in extension from the skin line, this tolerance is allowed as the emergency actuator has less overrun than the normal actuator. Full information on the electrical system is given in Sect.6, Chap.10 of this publication.

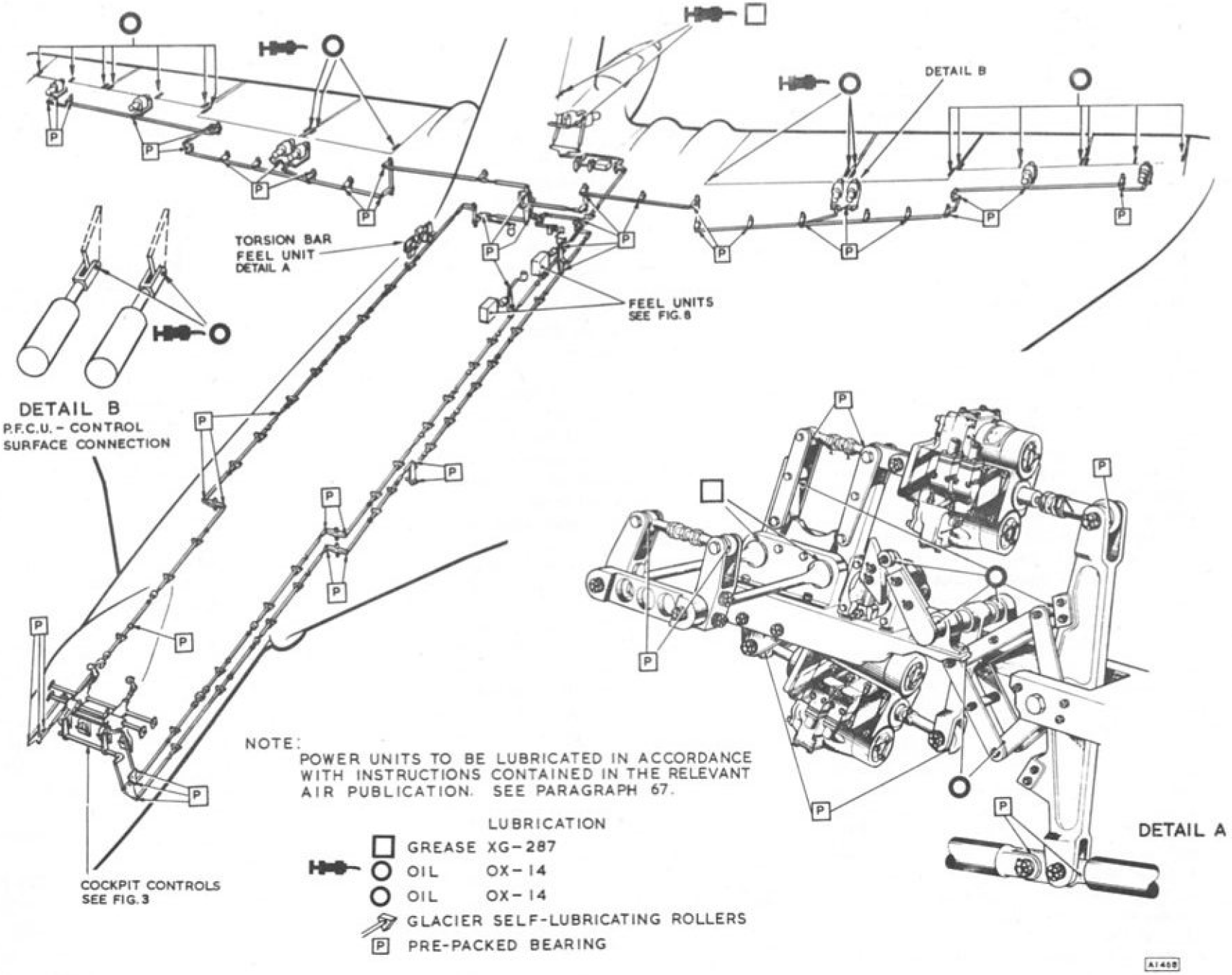


Fig. 11 Flying controls lubrication

SERVICING

CONTROLS RIGGING

General

48. Control surface movement and related system settings are illustrated in the controls rigging diagrams in this chapter. Surface movements are checked with the power units in operation; it is important that the systems are set to movements given, as incorrect adjustment causing excess travel in any direction may result in damage to the control surfaces and adjacent mounting structure. For the purpose of control surface rigging, the following neutral setting gauges are provided:-

Control surface	Gauge Ref. No.	Position
Inboard inner elevon	26DC/95178	Rib 18
Inboard outer elevon	26DC/95179	Rib 19
Outboard inner elevon	26DC/95180	Outboard end rib
Outboard outer elevon	26DC/95181	Inboard end rib
Rudder continuity	26DC/95033	Fin rib 11 and rudder rib 18.
Fin verticality	26DC/95034	Centre and bottom rudder hinges on fin.

49. Rigging instructions for the controls are given in fig.21 to fig.26. Detailed instructions are given for each system, and whether these are applied in whole or in part it is essential that in all cases where repairs, replacements or adjustments have been effected in a system, that the system is finally checked to ensure that full and free travel and correct sense movement are obtained.

Control circuit friction

50. Static friction loads, present in each control run, are measured with a spring balance at the first pilot's controls, before the power units and feel units are connected. When checking stick movement in the aileron sense it is important that measurements are made at right angles to the handgrip - port and starboard - and 4·5 in. from the centre of the fore-and-aft tube. When checking the loads, the controls must be moved through their full range of travel in both directions and an average reading taken. The friction in each circuit should not exceed the following values:-

Aileron sense control	-	2 lb. port and starboard
Elevator sense control	-	4 lb. fore and aft.
Rudder control	-	8 lb. port and starboard (with brake pipes connected).

FEEL UNITS

51. Prior to installation in the aircraft each feel unit is accurately adjusted, by the manufacturer, to give the degree of feel required for its particular control and the feel unit sealed, no further adjustment is considered necessary. Lubrication of the units in accordance with the instructions in A.P.101B-1902-4 is the only servicing permissible during normal use. In the event of defects occurring which would call for resetting of the feel units or individual component renewal, it is necessary to remove the complete unit, which will require a full range and calibration check after rectification of faults.

52. To ensure that the system is operating within the limits laid down in this chapter, a routine calibration is carried out with the units in-situ, at the periods specified in A.P.101B-1902-4. For this check the following equipment is required.

Pitot test set
Spring balance
Inclinometer
Electrical supply for power unit operation.

With the elevon power units running, airspeed is simulated through the test set connected into the pitot side of the relevant feel unit airspeed transmitter. Care should be taken not to overshoot the calibration speed but to achieve the required pressure with a rising indicator. The cockpit control is then pulled by the spring balance until a prescribed force is attained; the elevon angle, in the aileron or elevator sense whichever circuit is being calibrated, produced at this condition is a measure of the feel unit effect at the applied airspeed. Before applying forces with the spring balance, the control column should be deflected in an opposite direction to that in which it is intended to make the check. The control should then be allowed to return to the self-centring position by slowly releasing the force exerted upon it. When applying stick force, the loading spring should not be allowed to overshoot and fall back to the nominal load as this would introduce serious errors due to friction. It is essential, throughout the calibration, that the application of control to any given angle or force, whether increasing or decreasing, should be steady and progressive. The check should be made at recommended airspeeds for each control system and the values obtained should agree with those given in Table 1 and fig.16, 17, 19 and 20 (elevator sense and rudder), and

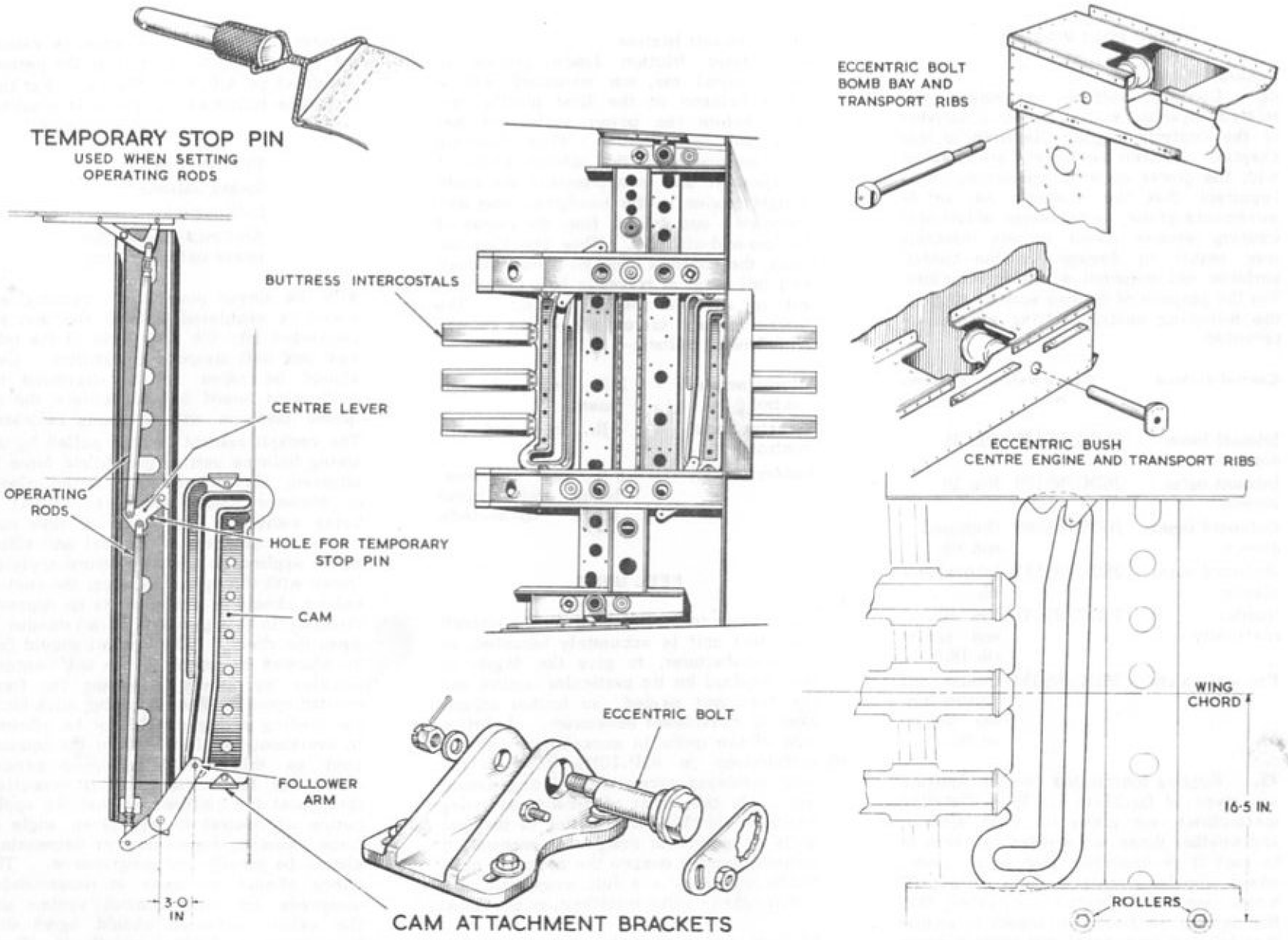


Fig. 12 Air brake settings

Tables 2 and 3 and fig.18 (aileron sense).

NOTE...
With all P.C.U's running it is possible to induce aileron sense movement when calibrating in the elevator sense and this may result in restricted movement of the control surface in the sense in which it is being calibrated. To ensure that only the required sense is applied, both port and starboard surface movement must be measured and these measurements must be similar.

Micro switches

52A. The micro switches fitted in the elevator sense and rudder feel units are adjusted for correct operation by the manufacturer, no further adjustment is considered necessary. The secondary limit switch, mounted on the aileron sense feel unit beam, is set as follows:-

(1) Operate the feel actuator to its fully extended position.

(2) Adjust the micro switch until the plunger just touches the striker pin and that a further 0·018 to 0·020 in. extension will operate the switch.

(3) Verify the setting by connecting a battery test lamp across terminals D-E on T.B.1325 and inserting a 24 s.w.g. plate between the micro switch plunger and the striker pin. The test lamp must light when the plate is inserted and extinguish when the plate is removed.

52B. The ground test procedure and calibration checks of the artificial feel units in conjunction with the autopilot are given in Book 3, Sect.7, Chap.9 of this Volume.

CALIBRATION CHECKS

53. Prior to commencing these checks the control circuits must have been cleared for geometry, control surface range checks, normal and emergency trim ranges and the circuit limit stops set. The circuit friction should be checked as described in para.50. The checks should be carried out on the No.3 and No.6 elevons.

54. The object of the calibration is to determine the following:-

Elevons (elevator sense) and rudder

The break-out force and friction of the complete control circuit, together with the force/deflection characteristics (see graphs).

The change of force rate with airspeed.

To ensure that the surface self-centres, within 0·8 deg. elevator sense and 0·75 deg. rudder, when the applied force is released slowly.

Elevons (aileron sense)

The aileron sense range/stop law throughout the speed range.

The break-out force and friction of the complete control circuit, together with the force/deflection characteristics.

To ensure that the control column self-centres within 1 degree when the control force is released slowly.

STANDARDS

55. The following standards determine the acceptability of the system.

Elevons (aileron sense)

Break-out force - see para.63.

Available aileron sense range Vs Airspeed - Design Law ± 10% (see graph).

Aileron sense force rate - full deflection at 20 ± 4 lb. force increasing.

NOTE...
With reduction due to friction with force decreasing (see graph).

Elevons (elevator sense)

Break-out force - minimum 6 lb., maximum 11 lb.

NOTE...
Checking of the break-out force must be carried out in the low speed condition i.e., below 200 knots.

Rudder

Break-out force - 18 ± 6 lb.

PRELIMINARY CHECKS - ELEVONS (ELEVATOR SENSE) AND RUDDER

56. The cut-in and cut-out speeds (see Table 1) are the air speeds at which the actuator in the feel unit starts and ceases to move, throughout the air speed range. Cut-in and cut-out speeds are measured as follows:-

(1) Disconnect the aircraft pitot piping

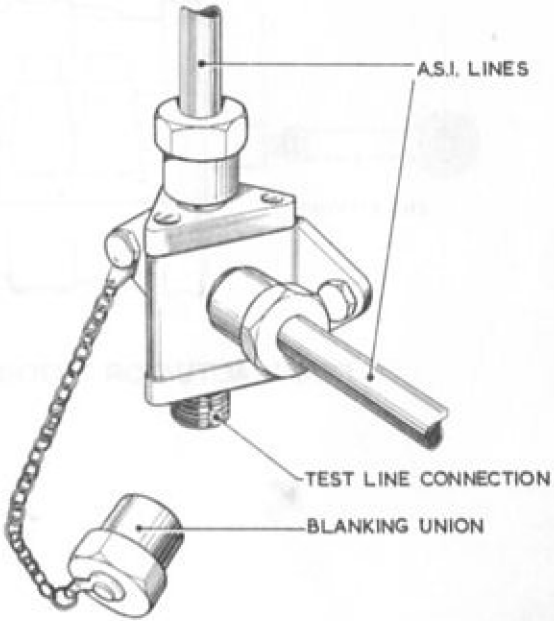
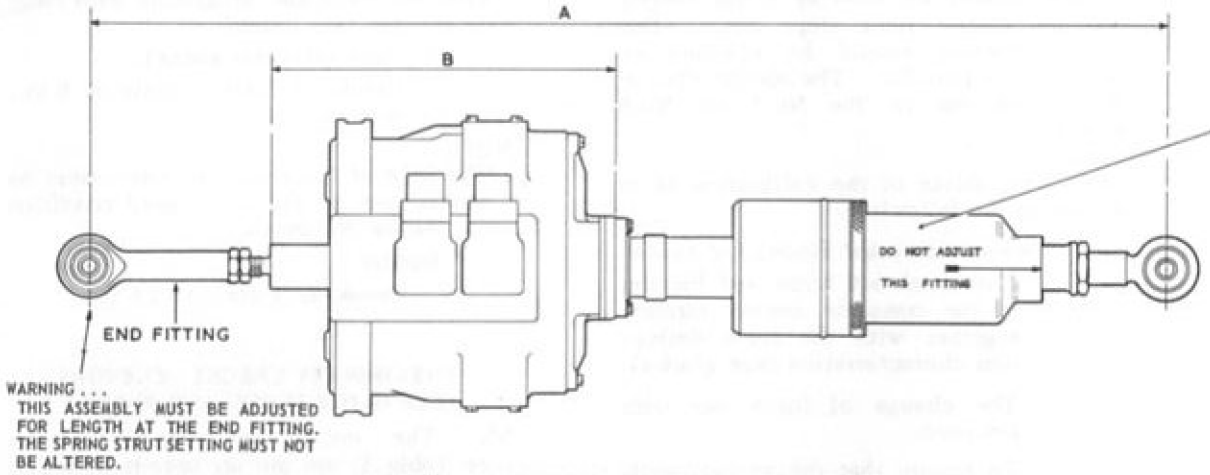
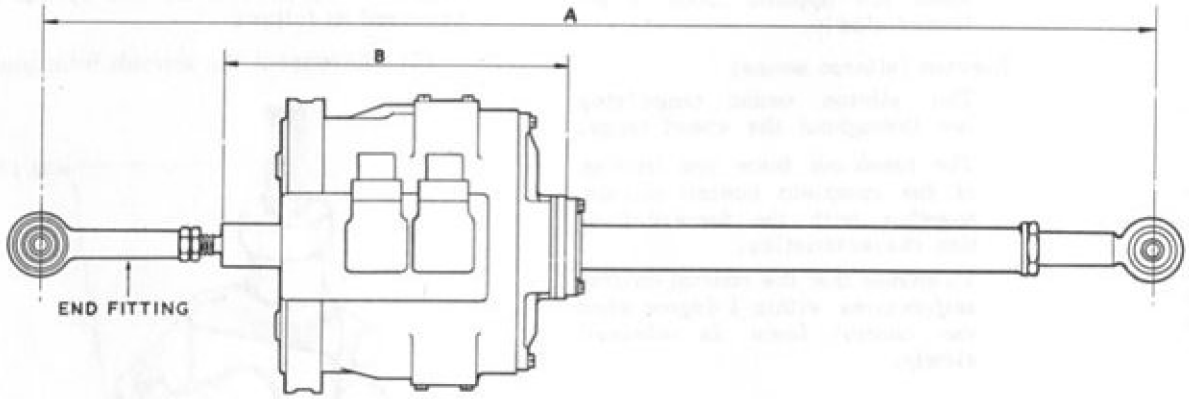


Fig.13. A.S.I. system ground test point.



ROTAX ACTUATOR A.1709 – ELEVATOR

ACTUATORS TO BE SET TO DIMENSIONS GIVEN FOR INSTALLATION IN AIRCRAFT. THE ELEVATOR SENSE TRIM ACTUATOR ASSEMBLY MUST BE ADJUSTED FOR LENGTH AT THE END FITTING AND NOT AT THE SPRING STRUT.
DIMENSIONS GIVEN ARE SUBJECT TO SLIGHT VARIATIONS ACCORDING TO INSTALLATION REQUIREMENTS.



ROTAX ACTUATOR A.1708 – RUDDER

ACTUATOR	CONTROL	DIM. A	DIM. B	MOVEMENT	TOTAL
A.1709	ELEVATOR	19·67 IN.	6·165 IN.	+0·96–0·54 IN.	1·5 IN.
A.1708	RUDDER	20·175 IN.	6·375 IN.	±0·5 IN.	1·0 IN.

Fig.14. Trim actuator settings
[◄ *Warning and notice added* ►]

RESTRICTED

from the feel unit airspeed transmitter.

(2) Connect the rubber piping from the portable A.S.I. transmitter to the airspeed transmitter.

(3) Check that the 28-volt and 200-volt supply are ON. Start appropriate P.F.C.'s to engage feel.

NOTE . . .
Switch off P.F.C.'s when 'feel' is engaged.

(4) Apply pitot pressure to the airspeed transmitter.

(5) Control the rate of increase in airspeed to 2 knots per second when approaching the cut-in speed figure.

(6) Check the cut-in of the feel unit actuator and read the I.A.S. on the portable airspeed transmitter immediately this occurs.

NOTE . . .
At the moment of cut-in the movement of the actuator can be heard.

(7) Reduce the airspeed by 50 knots and repeat items (5) and (6).

(8) Increase the airspeed to within 50 knots of the cut-out speed (speed increasing) and increase air speed at 2 knots per second until the cut-out figure is reached.

NOTE . . .
The I.A.S. should be noted at each movement of the actuator just before the cut-out speed. When no further movements are heard the last recorded reading is the cut-out speed.

(9) Reduce the airspeed by 50 knots and repeat item (8).

(10) Increase airspeed to 30 knots above the cut-out speed and reduce speed at 2 knots per second until the cut-in (speed decreasing) is obtained.

(11) Increase airspeed by 30 knots and repeat item (10).

(12) Reduce the airspeed to 50 knots above the cut-in speed, item (6), and reduce airspeed at 2 knots per second until the cut-out figure (speed reducing) is obtained, see item (8).

(13) Increase airspeed by 50 knots and repeat item (12).

Airspeed must not exceed 500 knots I.A.S.

AILERON STOP CALIBRATION

57. Calibration of the aileron stops is carried out as follows:-

(1) Connect the pitot test set to the pitot side of the aileron feel unit airspeed transmitter.

(2) Switch all elevon power units ON and check feel is engaged.

(3) Trim all elevons to wing chord i.e., in line with the combined hinge rib. Measure the angle of the control surface at the No.3 elevon for subsequent use as a datum. From this datum trim the elevons to 6 deg. up, again measured on the No.3 and No.6 elevons.

(4) Check that the first and second pilot's controls are central i.e., that both sticks are vertical.

(5) Simulate an I.A.S. reading of 100 knots on the pitot test set.

(6) Move the aileron control carefully throughout its range and check for any irregularity in stick forces or any roughness.

(7) Apply full aileron, to port and starboard in turn, and measure the aileron sense movement on the No.3 elevon.

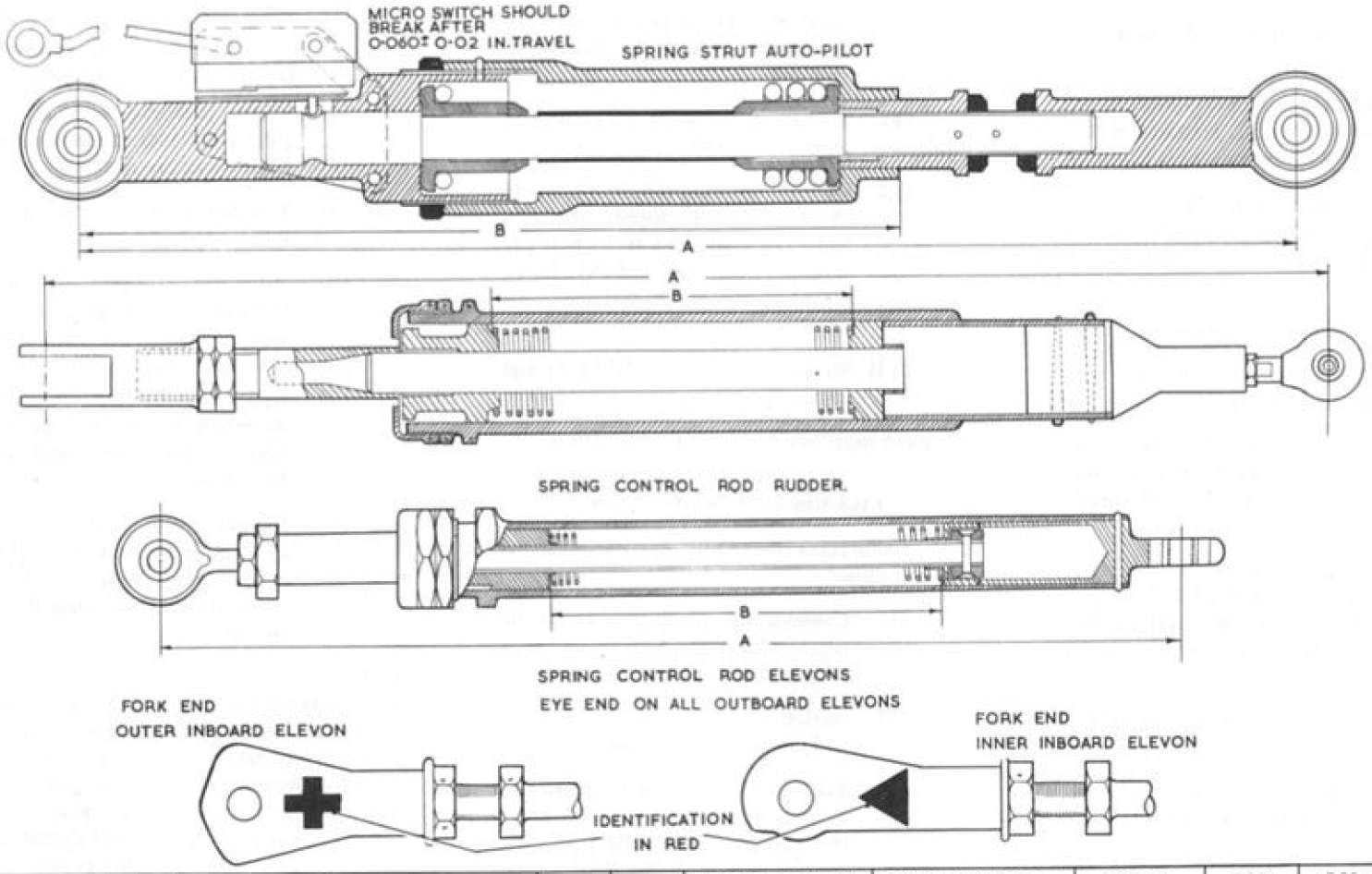
(8) Increase I.A.S. to the speeds listed in TABLE 2 and measure the No.3 elevon angle with full port and starboard aileron applied at each speed.

NOTE . . .
At approximately 145 - 160 knots the stops will begin to restrict the elevons in the aileron sense. If the target speed is exceeded at any setting, before continuing, the speed must be reduced to 20 knots below for speed increasing and 20 knots above for speeds decreasing. No load should be applied at the control column during alterations to airspeed.

TABLE 1

CUT-IN AND CUT-OUT SPEEDS

	Elevons (elevator sense)		Rudder	
A.S.I.	Speed Increasing	Speed Decreasing	Speed Increasing	Speed Decreasing
Cut-in	80-100 knots	440-465 knots	125-145 knots	420-460 knots
Cut-out	450-470 knots	50-90 knots	430-470 knots	140-110 knots



REF. No.	PART No.	LOCATION	A	B	TORQUE LOAD ON CAP LOCK-NUTS	TORQUE LOAD ON ROD END LOCK-NUTS	SPRING PRELOAD	ROD EXT'N.	ROD COMP'N.
26 DC/	14/R4167	P.F.C. UNIT OUTBOARD ELEVONS	18·2"	7·0"	200 LB.IN.	80 LB. IN.	11 $\frac{+1}{-3/4}$ LB.	2·7"	2·7"
26 DC/	21/R4166	P.F.C. UNIT INNER INBOARD ELEVONS	22·9"	9·5"	200 LB.IN.	80 LB. IN.	12 $\frac{+1}{-3/4}$ LB.	3·8"	3·8"
26 DC/	22/R4166	P.F.C. UNIT OUTER INBOARD ELEVONS	24·8"	9·5"	200 LB.IN.	80 LB. IN.	12 $\frac{+1}{-3/4}$ LB.	3·8"	3·8"
26 DC/	15/R4439	P.F.C. UNIT RUDDER	30·85"	10·25"	300 LB.IN.	250 LB.IN.	19 $\frac{+1}{-3/4}$ LB.	4·125"	4·125"
	1/R4734	SPRING STRUT AUTO-PILOT	13·56	9·2"	———	———	78 $\pm$ 2 LB.	0·01"	0·01"

Fig. 15. Spring control rods and strut

Mod. 2311

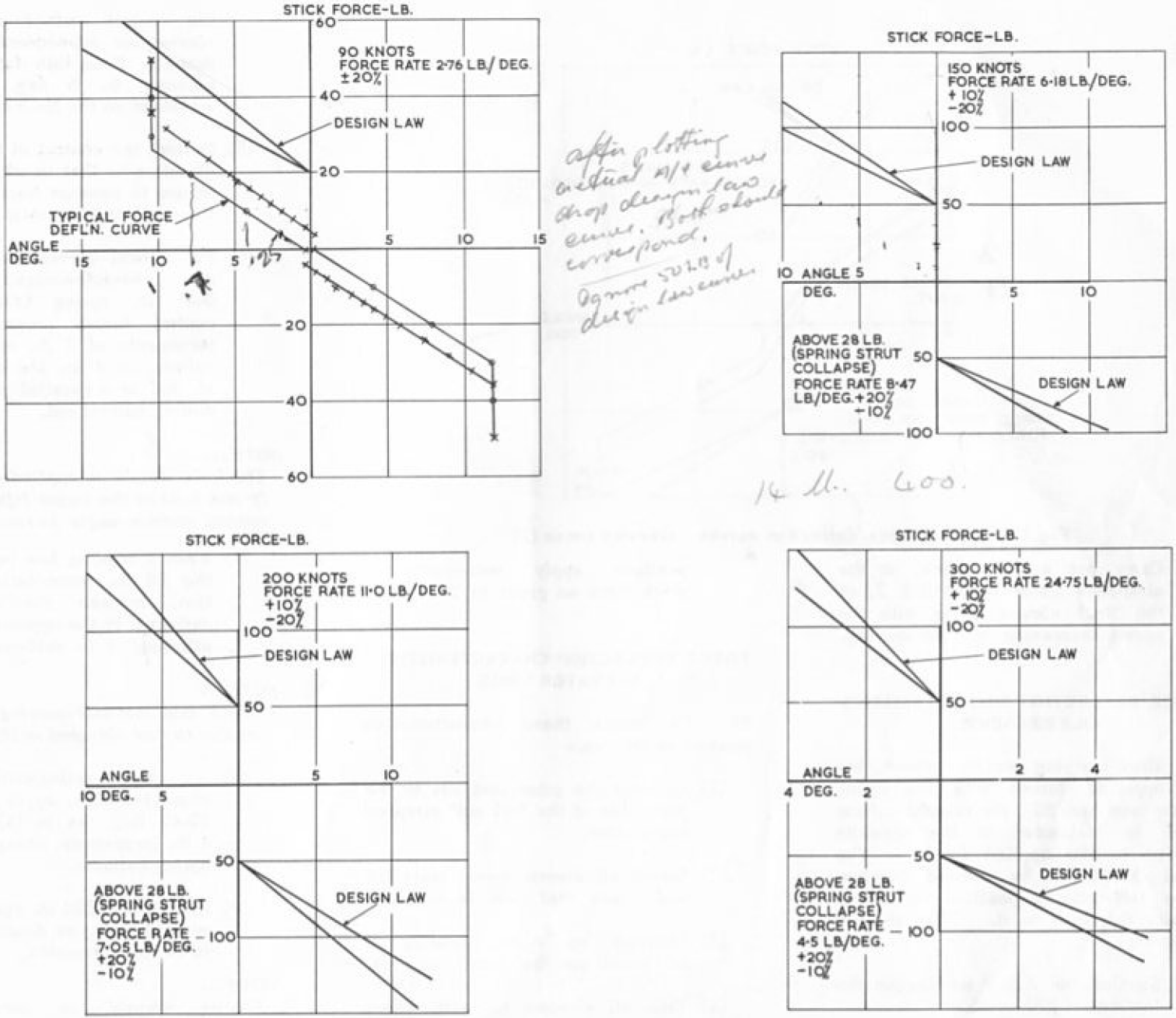


Fig.16 Typical force/deflection curves - elevator sense (1)

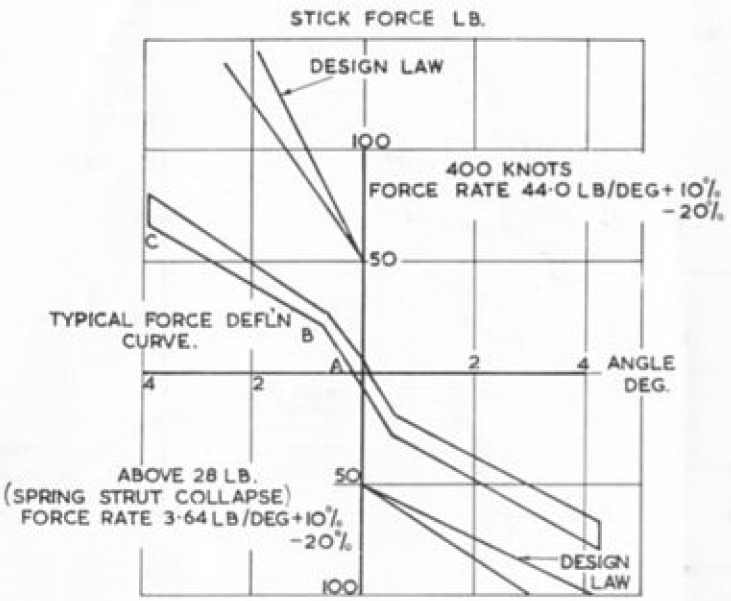


Fig.17 Typical force/deflection curves - elevator sense (2)

(9) Carry out a full check, at the airspeeds listed in TABLE 2, of the No.3 elevon angle with the speed increasing and decreasing.

FORCE/DEFLECTION CHARACTERISTICS AILERON SENSE

58. When carrying out this check, before applying forces with the spring balance (see para.52), the control column should be deflected in the opposite direction to the applied force. The control should then be allowed to return to the self-centring position by slowly releasing the force on it. Then proceed as follows:-

(1) Simulate an A.S.I. reading on the test set of 100 knots.

(2) Starting from the self-centring position apply increments of stick force as given in TABLE 3.

FORCE/DEFLECTION CHARACTERISTICS ELEVATOR SENSE

59. To check these characteristics proceed as follows:-

(1) Connect the pitot test set to the pitot side of the feel unit airspeed transmitter.

(2) Select all elevon power units ON and check that feel is engaged.

(3) Simulate an A.S.I. reading of 90 knots on the pitot test set.

(4) Trim all elevons to wing chord i.e., in line with the combined hinge rib. Measure the angle of the control surface at the No.3 elevon for subsequent use as a datum. From this datum trim the elevons to 6 deg. up, again measured on the No.3 elevon.

(5) Deflect the control in the opposite direction to that in which it is intended to measure forces and allow it to self-centre slowly.

(6) For normal elevator sense break-out characteristics, using a 0-25 lb. spring balance, apply control forces progressively, in increments of 2 lb. to the pilot's column, at 4 in. above the centre of, and in a parallel plane to, the sliding control rod.

NOTE...
The force should be applied progressively and held at the target figure until the control surface angle is recorded.

(7) When a reading has been taken at the 20 lb. force/deflection position, release the control and deflect it in the opposite direction, allowing it to self-centre slowly.

NOTE...
Check that the self-centring position is similar to that obtained in (5).

(8) To check spring-strut break-out characteristics, apply forces from 20-40 lb., as in (6) and (7) in 4 lb. increments, using a 0-100 lb. spring balance.

(9) Using the 0-100 lb. spring balance apply forces, as described in (6), in 10 lb. increments.

NOTE...
Forces should be increased progressively to the maximum (fig.16) and then decreased progressively to zero.

(10) Repeat items (6) to (9) in the opposite direction.

NOTE...
On returning to zero force after carrying out checks in one direction the control should not be moved from the self-centring position until deflected in the opposite direction up to the first 20 lb. When releasing, the force should be removed gently to avoid over self-centring.

(11) With the control force at zero repeat items (5) to (10) at airspeeds of 150, 200, 300 and 400 knots I.A.S.

RUDDER FORCE/DEFLECTION CHARACTERISTICS

60. The principles of this calibration are similar to those for the elevators with the exception of the method of checking rudder trailing-edge deflection. This is taken as a linear measurement using a steel tape. Proceed as follows:-

(1) Connect the pitot test set to the pitot side of the rudder feel unit airspeed transmitter.

(2) Loop a strap round each of the first pilot's rudder pedals.

(3) Select rudder power units ON.

(4) Simulate an A.S.I, reading of 135 knots.

(5) Move the rudder throughout its range to check for any irregularities or roughness in the system.

(6) Set the rudder to neutral on the trimmer.

(7) Deflect the rudder in the opposite direction to that in which it is intended to make the measurements and allow it to self-centre slowly.

(8) Record the rudder measurement for zero force.

(9) Hook a 0-25 lb. spring balance into the strap round one pedal taking care not to disturb its position, and progressively pull forces in increments of 2 lb. and record the trailing edge deflection at each increment.

NOTE...
Keep the direction of pull parallel to the line which the pilot's leg would make from the seat to the rudder pedal.

(10) When reaching 24 lb. release the force and deflect the rudder in the opposite direction and allow it to self-centre slowly.

(11) Remove the 0-25 lb. spring balance and fit the 0-100 lb. balance, taking care not to disturb the pedal position.

(12) Apply forces in increments of 10 lb. until 100 lb. has been reached and at each 10 lb. increment record the rudder trailing-edge deflection.

(13) Reduce force in 20 lb. decrements and record the trailing-edge deflection at each 20 lb. decrement.

(14) When zero force is reached remove the balance, taking care not to disturb the pedal.

(15) Fit the 0-25 lb. balance to the strap on the opposite pedal and repeat items (9) to (14).

(16) Repeat items (9) to (15) at airspeed settings of 200, 300 and 400 knots.

PREPARATION OF RESULTS

61. The following points are given to assist in the preparation and interpretation of the results obtained from all checks.

(1) Convert all inclinometer readings to angles relative to the nominal neutral.

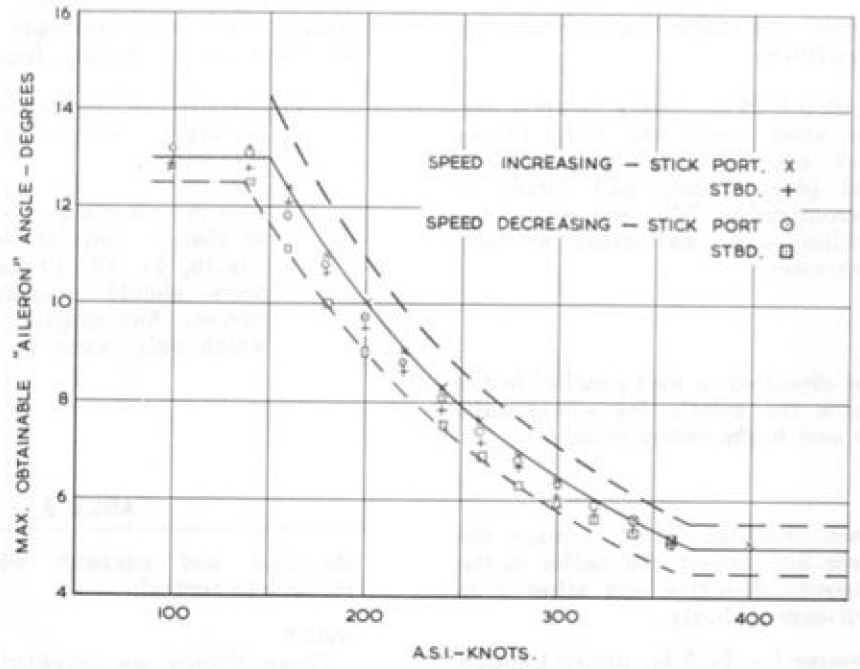
(2) Plot the results in a similar manner to that of their respective graphs (fig.16, 17, 18, 19 and 20). The plots should produce continuous curves. Any irregular discrepancies which only occur at one airspeed

TABLE 2

Maximum and minimum elevon angles relative to neutral.

NOTE...
These figures are provided in graphical form in fig.18. (See para.58).

A.S.I. KNOTS	ELEVON ANGLE TOLERANCE AT STOPS	
	MAX.	MIN.
100	-	12°30'
140	-	12°18'
160	13°13'	11°06'
180	12°12'	10°06'
200	11°00'	9°00'
220	9°57'	8°12'
240	9°05'	7°27'
260	8°21'	6°50'
280	7°42'	6°15'
300	7°06'	5°45'
320	6°36'	5°20'
340	6°6'	4°54'
360	5°42'	4°36'
400	5°30'	4°30'



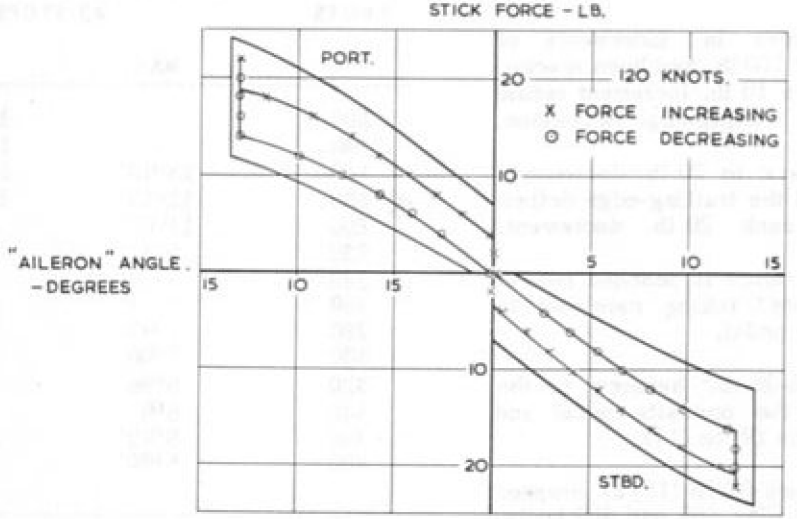


Fig. 18 Typical aileron sense calibration

technique. A further check should be carried out to see if the fault is repeated prior to breaking down the circuitry.

(3) The graphs will indicate:-

(a) The break-out force.

(b) The friction of the combined box and circuit.

(c) The variation of force/deflection characteristics with airspeed.

(4) The converging lines represent the upper and lower limits of the design law at each airspeed. To check whether the elevons (elevator sense) and rudder force/deflection characteristics fall within this law at any airspeed the mean slope through the calibration point should be transposed through the point of convergence of the design law limits and should lie between these limits.

NOTE...

To reduce the high level of stick forces encountered at high Mach. numbers a spring strut is introduced into the elevator sense control circuit. This strut collapses at a stick force of 29 ± 2 lb. and results in an increased surface movement at the ratio of 1 deg. gain per 20 lb. increment of force. Referring to the force/deflection curve for elevator sense, fig.16 and 17, line AB is at a force rate prior to collapse of the spring strut and line BC after collapse.

Feel relief check

62. At 400 knots I.A.S., select artificial feel relief, by depressing the feel relief button for the relevant system, and check that the corresponding feel indicator is de-energised. In the relieved con-

dition, check that the full control angle is obtainable with stick forces not exceeding the following maximum values:-

Aileron sense	...	18 ± 6 lb.
Elevator sense	...	40 lb.
Rudder		80 lb.

After the check, re-engage the feel system by operating the appropriate power unit START switch, checking that the feel indicator is energised and that the high speed feel condition returns. No stick force should be applied for 10 seconds after selecting the reset circuit. Aileron and elevator sense relief should also be tested using the second pilot's relief button.

Break-out force

63. The break-out force at the pilot's control is equal to the control circuit static friction plus an artificial feel box pre-load which is just sufficient to provide self-centring. The break-out for each control from any position within the full trimmer range, and for any airspeed setting on the artificial feel box, must not be greater than the following:-

Aileron sense	...	7 lb. port or starboard
Elevator sense	...	6 lb. (min) - 11 lb. (max) fore or aft
Rudder		18 ± 6 lb. port or starboard

Controls self-centring

64. It is recommended that, on completion of the calibration, the controls are checked for self-centring within the limits given in para.54. If the limits are not obtained carry out a control circuit friction check (para.50), with power units connected and running and with power units disconnected. Friction loads should be similar, in either case, but if high loads are encountered the affected circuit must be checked to find and eliminate the fault. If these checks are satisfactory the fault lies in the relevant feel unit, which must be removed for a rig check.

TABLE 3

Aileron sense force/deflection characteristics

NOTE...

These figures are provided in graphical form in fig.18.

STICK TO PORT OR STARBOARD

Stick force	Maximum Elevon angle		Minimum Elevon angle	
lb.	deg.	min.	deg.	min.
0	0	0	- 1	0
4	0	12	- 0	48
6	2	0	- 0	12
8	3	0	- 0	36
10	4	3	1	48
12	6	0	3	0
14	7	18	4	3
16	9	0	5	48
18	11	18	7	18
20	13	3	9	0
22	13	3	11	0
20	13	3	12	3
18	13	3	12	3
16	13	3	12	3
14	13	3	10	0
12	13	3	8	18
10	10	4	6	3
8	8	3	4	48
6	6	3	3	24
4	4	3	2	18
0	1	0	0	0

TRIM SYSTEM

Actuators

65. Servicing instructions for the Rotax linear actuators will be found in A.P.4343, Vol.1. After servicing, the trim actuators will require resetting to the nominal installation centres before assembly into the aircraft. For information on the lengths required for the respective systems see fig.14.

Trim system checks

66. Checks on both normal and emergency trim systems are done at the times specified in Vol.4 of this publication. The following procedure is given for guidance when carrying out these checks:-

(1) Start the power control units.

(2) Check the sense and range of all normal trim circuits; the trim angles for aileron and elevator sense should be checked on each pilot's control separately.

Aileron sense

Outboard elevons

Up - 8 deg. 6 min. $^{+30}_{-15}$ min.

Down - 8 deg. 6 min. $^{+30}_{-15}$ min

Inboard elevons

Up - 6 deg. 30 min. $^{+30}_{-15}$ min.

Down - 6 deg. 30 min. $^{+30}_{-15}$ min.

Elevator sense

Outboard elevons

Up - 15 deg. 0 min. $^{+\ 1\ \text{deg.}}_{-\ 0}$ 30 min.

Down - 7 deg. 30 min. $\pm$ 30 min.

Inboard elevons

Up - 12 deg. 0 min. $^{+\ 1\ \text{deg.}}_{-\ 0}$ 30 min.

Down - 6 deg. 0 min. $\pm$ 30 min.

Rudder

Port	15·5 ± 1 in.
Starboard	15·5 ± 1 in.
(Normal to hinge line)	

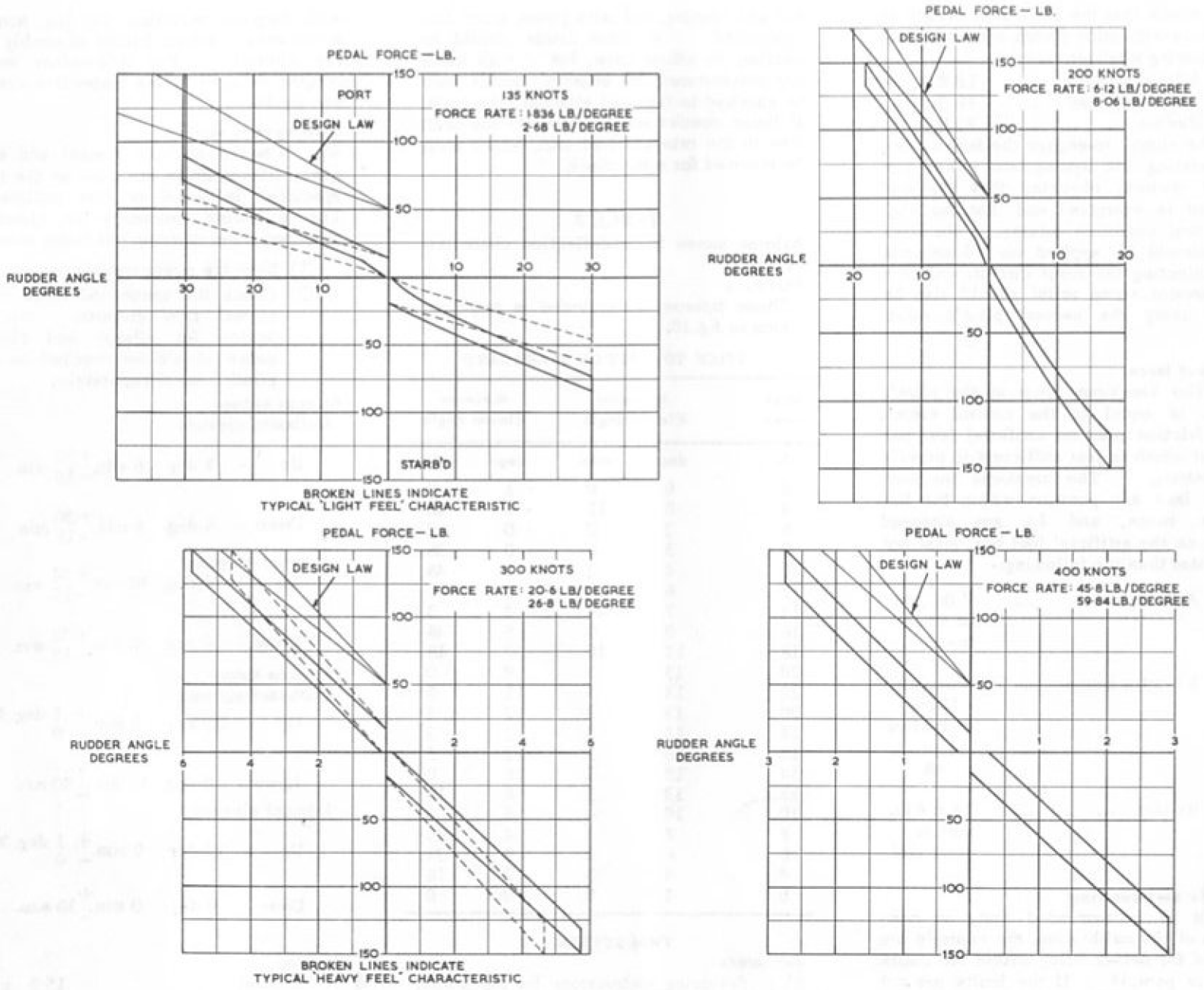
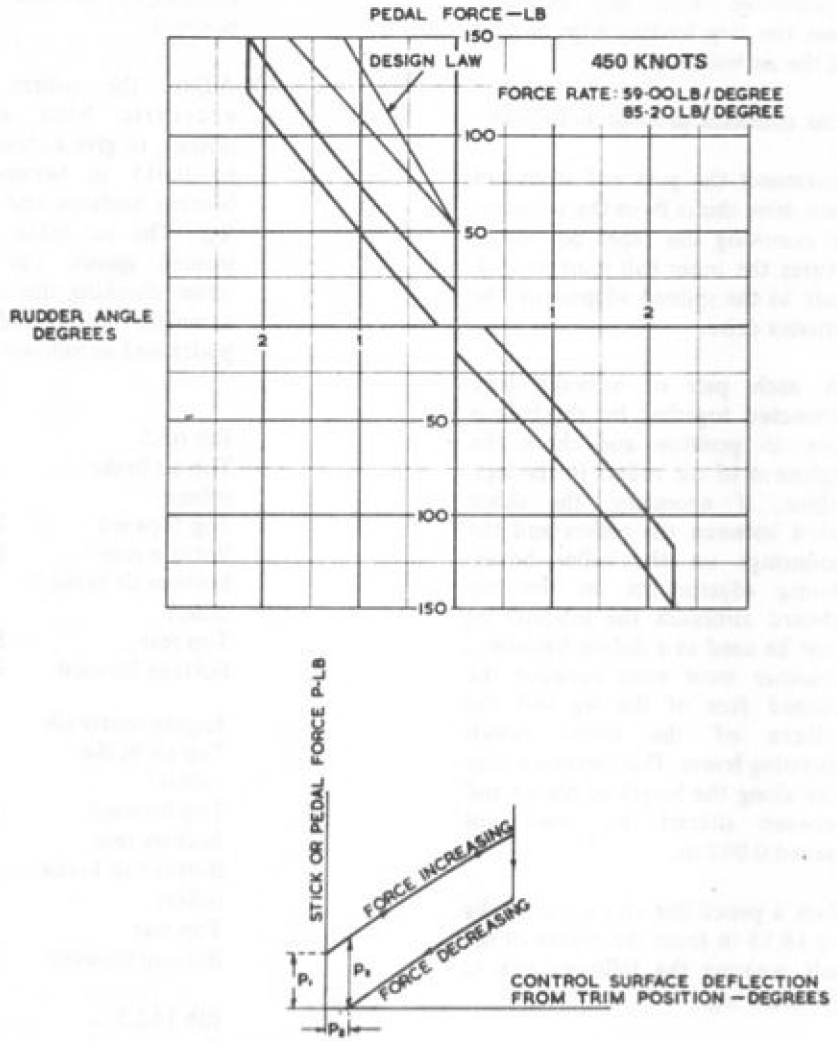


Fig. 19 Typical force/deflection curve - rudder (1)



DEFINITIONS USED IN ANALYSIS

P_1 BREAK—OUT FORCE

P_2 LACK OF SELF CENTRING

P_3 THE FRICTION CAN BE DEFINED AS HALF THE VERTICAL DISTANCE BETWEEN THE GRADIENTS MEASURED AT THE SELF-CENTRING POSITION

Fig. 20 Typical force/deflection curve - rudder (2)

(3) Operate the trim button on both control columns simultaneously in the same direction. The circuit should operate.

(4) Split the mushroom switch on the pilots' columns, and ensure that NO trim can be obtained by manipulating either of the two switches contained within the mushroom switch.

(5) Check the emergency trim system by operation of the 3-axis emergency trim switch on the centre console. Press the button in the centre of the switch and keep pressed while operating. Check sense and range for all three circuits; the measurements should be the same as when using normal trim control.

(6) Operate the emergency trim control without the centre button depressed; the system should not operate.

POWER CONTROL UNITS

67. Servicing of the P.F.C. units is in accordance with the instructions given in A.P.101B-1902-5 and the information contained in the appropriate Air Publication provided for each particular unit. Hinged panels and removable fairings are provided which permit certain servicing operations to be carried out with the P.F.C. unit in situ. Access to the forward bleed point on No.2 and 7 elevon power units will be considerably improved if the spring control rod is removed.

NOTE . . .
It is essential that the wire-locking of the spring control rod remains undisturbed during removal and subsequent installation, otherwise complete readjustment of the controls to that particular unit will be required.

SPRING CONTROL RODS AND STRUTS

68. Spring control rods and struts are subject to periodical checks and inspections in accordance with A.P.101B-1902-5. Fig.15 shows cut-away views of spring control rods and struts and contains particulars regarding spring settings, installations and length.

AIR BRAKES SETTING

69. Normal servicing of the air brakes consists of following the instructions in A.P.101B-1902-5. When any renewals or repairs to the air brakes and/or mechanism have been effected, resetting the air brakes will be necessary.

◀ *NOTE . . .*
After fitment of a new chain, or undertaking any work which may have affected chain tension, all chains should be checked for correct tension (para.71, op.8). The air brakes should then be electrically operated from 'in' to 'out' and 'out' to 'in' a minimum of six times and the chains finally re-checked for correct tension. ▶

70. During air brake setting it is imperative that the back-lash is kept to a minimum and that air brake flap/air brake leg relationship is correct. To keep the back-lash to a minimum the clearances laid down in para.71 op.(6) must be maintained as near to the minimum limit as possible. Correct flap/leg relationship on initial movement outward is essential as an excessive flap angle, combined with any excessive back-lash, causes the flap leading edge to foul on the front of the air brake well.

71. To set the airbrakes proceed as follows:-

(1) Disconnect the port and starboard main drive shafts from the actuator, by removing the taper pin which secures the inner ball joint of each shaft to the splined adapter on the actuator drive.

(2) Fit each pair of airbrake legs, connected together by the torque tube, in position and check the alignment of the rollers to the legs. Adjust, if necessary, the shims fitted between the rollers and the mountings on the roller boxes. During adjustments on the top inboard airbrakes the inboard leg must be used as a datum because a clearance must exist between the inboard face of the leg and the rollers of the micro switch operating levers. This clearance may vary along the length of the leg and between aircraft, but must not exceed 0.062 in.

(3) Mark a pencil line on each air brake leg 18.15 in from the centre of the bolt securing the follower arm to the brake leg.

(4) Mark the main plane chord line on rib 63.5, the engine centre rib and rib 162.5 (fig.12).

(5) Position the air brake legs with the marks made in op.(3) coinciding with the main plane chord line. Connect the operating chains to the air brake legs and tension the chains sufficiently to retain the legs in position.

(6) Adjust the rollers, fitted with eccentric bolts and eccentric bushes, to give a clearance of 0.002 to 0.015 in between the roller bearing surfaces and the air brake legs. The air brake legs must be pushed against the fixed rollers when checking this clearance. The eccentric bolts and bushes are positioned as follows:-

Rib 63.5	
Top air brake rollers	
Top forward	Eccentric bolt
Bottom rear	Eccentric bolt
Bottom air brake rollers	
Top rear	Eccentric bolt
Bottom forward	Eccentric bolt
Engine centre rib	
Top air brake rollers	
Top forward	Eccentric bush
Bottom rear	Eccentric bush
Bottom air brake rollers	
Top rear	Eccentric bush
Bottom forward	Eccentric bush
Rib 162.5	
Top forward	Eccentric bush
Bottom rear	Eccentric bolt

When the clearances are set, torque load the roller bolts and nuts as follows:-

7/8 in B.S.F.	27-33 lb ft
7/16 in B.S.F.	18-22 lb ft

(a) Lock the eccentric bushes to the roller boxes by the locking screws. If the locking screw holes in the bushes do not line up with the holes in the roller boxes it is permissible to drill an additional hole in the roller box. This additional hole must be pitched at a position of 10 degrees minimum from the existing hole centre.

(b) Lock the eccentric bolts with the locking plates, which are secured to the roller boxes with pop rivets.

(c) Lock the nuts to the roller bolts with split pins, except the roller bolt at the bottom rear of the bottom air brake at rib 63.5 and the two top roller bolts at rib 162.5. These three bolts engage in threaded blocks secured to the roller boxes and must be wire - locked after torque loading.

(7) Extend the air brakes, manually, and check the air brake leg to flap connecting levers for freedom of movement. This is to ensure that there will be no differential loading on the flap operating rods which would cause twisting in the flaps. Fit the air brake flaps, locking the securing bolts with 22 s.w.g. locking wire. Ref.No.30A/9437135.

NOTE . . .
Do not fit the springs to the bottom air brake flaps at this point in the sequence.

(8) Fully extend the air brake legs, manually, and apply a horizontal load of 3.5 lb at the mid position of each chain and adjust on the chain connectors to obtain a chain deflection of 0.3 ± 0.05 in. The mid position of the chain is defined as the position midway between the centre of the chain sprocket and the attachment point of the chain to the air brake leg. On completion of adjustments tighten the chain adjuster lock nuts.

(9) Manually retract the air brake legs to the position given in op.(5).

(10) Fit a stop pin Ref.No.26DC/95114 in each leg of one air brake. With the centre lever of the flap operating rod mechanism in each leg against the stop pin, adjust simultaneously on the inboard and outboard rod connected to the flap operating lever, to bring the flap parallel to the main plane skin line. If it is found that the flap is not flush with the main plane skin line, adjustment must be carried out on the operating chains to retract the ▶ air brake legs. Chain tension, as detailed in operation (8), must be checked if adjustments on the chains are carried out. ◀

(11) Adjust on the rod connecting the centre lever to the follower arm, in each air brake leg, to obtain a measurement of 3 in between the centres of the follower arm pivot and the follower arm roller, measured at right angles to the air brake leg (fig.12). Remove the stop pins.

(12) Repeat op.(10) and (11) to each air brake in turn, removing the stop pins when adjustment is satisfactory.

(13) Disconnect the cams from the buttresses and check the alignment of the follower arms to the cams, in the air brakes retracted and extended positions. Adjust, if necessary, on the shims fitted between the cams and the cam attachment brackets.

(14) Manually extend the air brakes to their fullest extent and temporarily fit the follower arm rollers engaging with the cam track. Check that an air brake flap angle of 80 degrees is reached and that there is a clearance beyond this reading. Adjustment, to obtain this figure, must be carried out on the eccentric bolts which secure the cams to the attachment brackets bolted to the roller boxes. Move the top air brake cams down to increase the angle and up to decrease the angle, the bottom air brake cams must move up to increase the angle and down to

decrease the angle. If insufficient movement is provided by the eccentric bolts further movement can be obtained by adjustment on the packing pieces between the cam attachment brackets and the roller boxes. Remove the follower arm rollers.

(15) Manually retract the air brakes to the 'in' position and check the air brake flaps to main plane skin line, adjust, if necessary, as laid down in op.(10).

(16) Repeat op.(10) and (14) until full air brake travel is achieved. Fit the locking plates to the eccentric bolts.

NOTE . . .
During movement of the air brakes from 'in' to 'out' and vice versa when carrying out op.(10) and (14) the follower arm rollers must be removed.

(17) Retract the air brakes to the fully 'in' position and insert a stop pin in each leg of one of the top air brakes. Fit the follower arm rollers and check that a clearance, not exceeding 0.015 in, exists between the rollers and the cam track when the roller is held against one side of the track. Check also that the rollers are free to rotate in the cam track, adjustment, if required, is by loosening the four bolts securing the cam bottom attachment bracket to the roller box and moving the attachment bracket fore or aft as required. During the adjustment the stop pins must be free to rotate. On completion of adjustment, tighten the bracket attachment bolts and remove the stop pins.

NOTE . . .
On the top air brakes the slots in the cam bottom attachment brackets may be elongated to a maximum of 0.45 in.

(18) Repeat op.(17) on each of the top air brakes.

(19) Manually extend the air brake legs 10 in and check the top air brake angle which must be 17 $\pm^{2}_{0}$ degrees. Adjustment, if required, must be carried out by moving the cam top attachment brackets fore or aft as required. Tighten the attachment bracket securing bolts and check that the follower arm rollers rotate in the cam tracks.

(20) Retract the air brakes to the fully 'in' position and check the top air brake follower arm rollers for freedom of movement in the cam track. Adjust, if necessary, as in op.(17). Repeat op.(17) and (19) until the setting is satisfactory.

(21) Attach suitable pointer to bomb arch 44.592F to indicate on the sleeves at the inboard ends of the port and starboard main drive shafts.

(22) Manually extend the air brakes 21 turns of the main drive shaft less 5/32 in measured round the circumference of the drive shaft as indicated by the pointers fitted in op.(21).

(23) Check the top air brakes flap angles, which must be 55 ± 3 degrees.

(24) Fit the rollers to the follower arms of the bottom air brakes and check the bottom air brake flap angle which must be 55 ± 3 degrees. Adjustment, if required, is made by moving the cam bottom attachment brackets fore or aft as required. Check that the rollers rotate in the cam track and tighten the attachment bracket securing bolts.

(25) Fit the springs to the bottom air brake flaps and retract the air brakes to the fully 'in' position.

(26) Loosen the bottom air brake cam top attachment bracket securing bolts and move the bracket fore or aft, as required, to bring the bottom air brake flaps to the main plane skin line. On completion of adjustment tighten the securing bolts.

NOTE . . .
On the bottom air brakes the slots in the cam top attachment brackets may be elongated to a maximum of 0.45 in.

(27) Extend the air brake legs 10 in and check the bottom air brake flap angle which must be 14 $\pm^{2}_{0}$ degrees.

Adjustment, if required, must be by loosening the four bolts securing the cam bottom attachment brackets to the roller boxes and moving the attachment brackets fore or aft as required. On completion of adjustment tighten the attachment bracket securing bolts.

(28) Retract the air brakes and check the bottom air brake flaps in relation to the main plane skin line. Adjust, if necessary, as laid down in op.(26).

(29) Repeat op.(26) and (27) until the setting is satisfactory.

(30) Carry out a full range check, to the measurements given in the table in para.72.

(31) Connect the buttresses to the cams using shims, if required, between the buttresses and the attachment brackets on the cams.

(32) Wire-lock the adjusters on the operating chains and the adjusters on the flap operating linkage rods, using 22 s.w.g. locking wire Ref.No. 30A/9437135.

(33) Connect the port and starboard main drive shafts to the actuators. Remove the pointers fitted in op.(21).

(34) Retract the air brakes to the fully in position and using an inclinometer measure the angle of one air brake flap.

(35) Extend the air brakes to one of the predetermined positions and remove the follower arm rollers from the air brake measured in op.(34).

(36) Fit the stop blocks to the air brake flap, securing them in position with the two attachment bolts.

(37) Position the air brake flap to the angle obtained in op.(34). If necessary, file the stop blocks until the blocks just contact the air brake legs with the flap at the correct angle.

(38) Lock the stop block securing bolts to the adjacent flap-to-operating mechanism attachment bolts using 22 s.w.g. locking wire Ref.No.30A/9437135.

(39) Replace the follower arm rollers.

(40) Repeat op.(34) to (39) on each air brake flap.

(41) Set the air brake microswitches to the instructions in para.73 and 74.

▶ *NOTE . . .*
On completion repeat operation (8) to check chain tensioning. ◀

72. The following table gives the relative figures for pillar extension and flap angle rotation:-

FLAP SETTINGS

Pillar extension inches	Angle of rotation Upper air brakes deg	min	Lower air brakes deg	min
1	2	12	3	0
2	4	6	6	0
3	6	0	9	12
4	8	0	12	0
5	9	42	13	0
6	11	12	13	12
7	12	48	13	18
8	14	18	13	36
9	15	36	13	48
10	17	6	14	0
25.5	35	0	35	0*
27.5	55	0	55	0*
30	80	0	80	0*

The permissible tolerance on the above angles is plus 2 deg. minus 0 deg. except where indicated with an asterisk, in which case the tolerance is plus or minus 3 deg.

▶ *NOTE . . .*
Refer to para 74(11) and 74(16) for final procedures relating to the flap angle setting in the approach high drag position. ◀

MICROSWITCH SETTING

73. After the air brakes have been set mechanically (para.71) the microswitches must be adjusted to stop the air brakes at the selected position. An air brake test set Ref.No. 26DC/95215 and an inclinometer are required for the setting operations. Prior to carrying out checks and adjustments, the angle of the air brake flaps in the fully 'in' position must be measured and noted. The flap reading of the

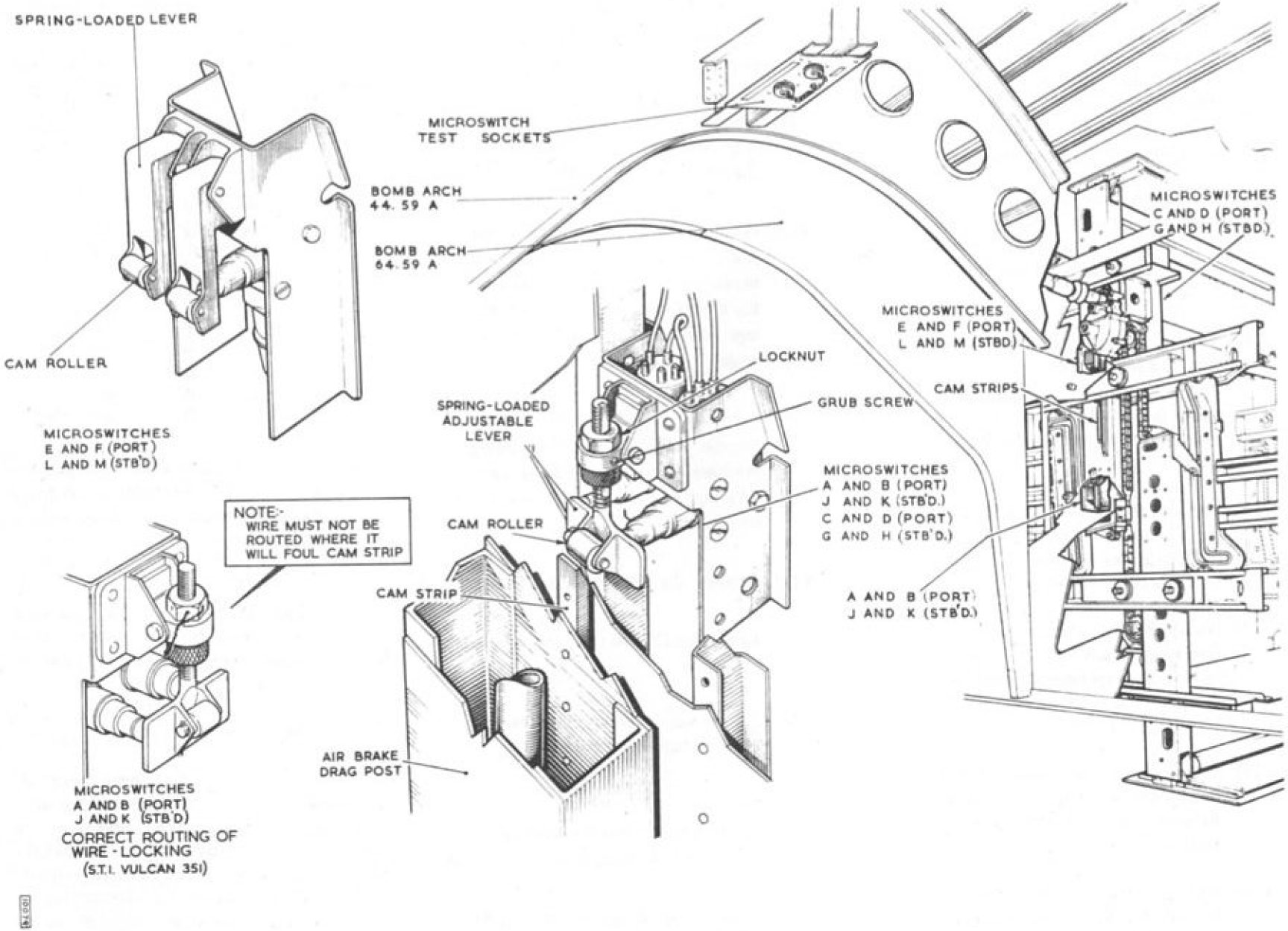


Fig. 20A Air brakes microswitches

top air brakes must be added to the readings obtained during the setting operations, the reading of the bottom air brake flaps must be subtracted from the readings obtained during the setting operations. Check the clearance between the air brake leg and the rollers of the microswitch operating arms, which must be 0.062 in maximum, adjustments if necessary must be made as given in para.71 op.(2).

74. To set the microswitches proceed as follows:-

(1) Extend, electrically, the air brakes to the MED. DRAG position and disconnect the electrical plugs from both motors on the air brake actuators.

(2) Connect the air brake test set into the normal circuit at fuse 551 in panel 4P.

(3) Unscrew the 4 B.A. grub screw securing the adjustable operating lever to the pivot block at microswitches A and B and adjust the operating lever to its highest operational limit.

(4) Connect the electrical plug to the starboard motor of the air brake actuator and using the air brake test set inch the air brakes to all the operational positions to check operation of microswitches. Return the air brakes to the MED. DRAG position.

(5) Disconnect the air brake test set and replace fuse 551. With the air brakes emergency switch at NORMAL, select IN on the air brakes selector switch. Measure and note the distance that the air brake flaps project from the main plane skin line. Return the air brakes to the MED. DRAG position.

(6) Connect the air brake test set into the emergency circuit at fuse 640 in panel 3P.

(7) Disconnect the electrical plug from the starboard motor of the air brake actuator and connect the plug to the port motor. With the air brake emergency switch at EMERGENCY, using the air brake test set make a check as in op.(4).

(8) Disconnect the air brake test set and replace fuse 640. With the air brakes emergency switch at EMERGENCY, select IN on the air brakes selector switch. Measure and note the distance that the air brake flaps project from the main plane skin line. Return the air brakes to MED. DRAG.

(9) Compare the measurements obtained in op.(5) and (8). The measurements obtained on the normal motor must be the smaller, indicating that the normal motor has the greater overtravel. If it is found that the emergency motor has the greater overtravel proceed as follows:-

(a) Remove the actuator from the aircraft (Sect.3, Chap.1, para.87).

(b) Remove the eight nuts securing each combined motor and brake unit to the actuator and interchange the combined motors, brake units and gear trains as complete units. Ensure that new tab washers are used when fitting the nuts.

(10) Select NORMAL on the air brake emergency switch and IN on the air brake selector switch and by adjustment on microswitches A and B bring the air brake flaps flush with the main plane skin line.

(11) Operate the air brakes outward and inward and adjust on the microswitches to obtain the required flap angles, i.e., HIGH DRAG 55 ± 3 degrees, microswitches G and H; for the APPROACH HIGH DRAG 77 ± 3 degrees, microswitches C and D. Adjustment to the microswitches is made by unscrewing the 4 B.A. grub screw which secures the microswitch operating lever to the pivot block and adjusting on the nuts on the operating lever.

NOTE . . .
Microswitches L and M must be backed off during the adjustment for range setting.

Microswitches E and F which control the air brakes at MED. DRAG on inward and outward movement, respectively, are fitted in the correct position on initial assembly and no provision for adjustment is fitted.

The HIGH DRAG 55 degree position is obtained by selection on the test switch in the nose undercarriage bay.

(12) Operate the air brakes to the MED. DRAG position and disconnect the electrical plugs from both actuator motors.

(13) Remove the taper pins which secure the port and starboard main drive shaft inboard ball joints to the splined adapters fitted on the actuator splined drives.

(14) Attach suitable pointers to bomb arch 44.592F to indicate on the sleeves at the inboard ends of the port and starboard main drive shafts.

(15) Connect a test box to the air brake test points at bomb arch 44.592F. This test box must incorporate indicator lamps for microswitches A and B, J and K, C and D and L and M.

▶ (16) It is important that microswitches L and M do not operate before microswitches C and D on outward travel of the air-brakes. This condition is checked by manually moving the air-brakes outwards whilst observing microswitch operation on the test lamp box.

NOTE . . .
Microswitches L and M are fixed and variations in their operating parameters can only be achieved by repositioning the switch mounting brackets as detailed in operation (21) and illustrated on fig.20B. ◀

(17) Manually operate the port brakes inward until microswitches A and B are just operated, as indicated on the test box lamps. Manually operate the starboard air brakes inward and adjust microswitches J and K to operate simultaneously with or up to 1/8 in of air brake leg travel after operation of microswitches A and B on inward travel.

NOTE . . .
The 1/8 in leg travel can be measured by utilizing the pointers fitted in op.(14). One inch of travel measured round the circumference of the sleeve on the air brake main drive shaft gives 1/8 in of air brake leg travel.

(18) On completion of microswitch adjustment lock the nuts on the microswitch operating levers using 22 s.w.g. locking wire (Ref.No. 30A/9437135). Lock the operating levers to the pivot blocks using the 4 B.A. grub screws. Ensure that the grub screws locate in the slots of the operating levers, this is facilitated by ensuring that the ends of the grub screws are filed flat. Lock the grub screws with two centre-punch marks.

(19) Manually operate the air brakes to the MED. DRAG position and replace the taper pins which secure the main drive shaft inboard ball joints to the adapters on the actuator drives.

(20) Disconnect the test box and fit the covers to the test points. Remove the pointers fitted in op.(14).

▶ (21) If L and M microswitch brackets require moving refer to fig.20B and proceed as follows:-

(a) Remove bracket, securing bolts and clamp bolts from between the channel stiffeners.

(b) Elongate the securing bolt holes in each of the channel members approximately 0.10 in each way to provide clean slots.

(c) Refit mounting bracket and adjust to the required new position using the clamp bolts.

(d) When the setting is satisfactory rivet the 14 s.w.g. aluminium alloy cover plates into the channels as shown.

(e) Drill bolt holes morse 11 (0.191 in D) from the bracket side of the stiffeners in line with the elongated slots for the securing bolts.

NOTE . . .
Because of the limited access within the mounting bracket a 90 degree angled windy drill is considered suitable for the drilling operation.

(f) Remove swarf, deburr holes and fit securing bolts, nuts and washers. ◀

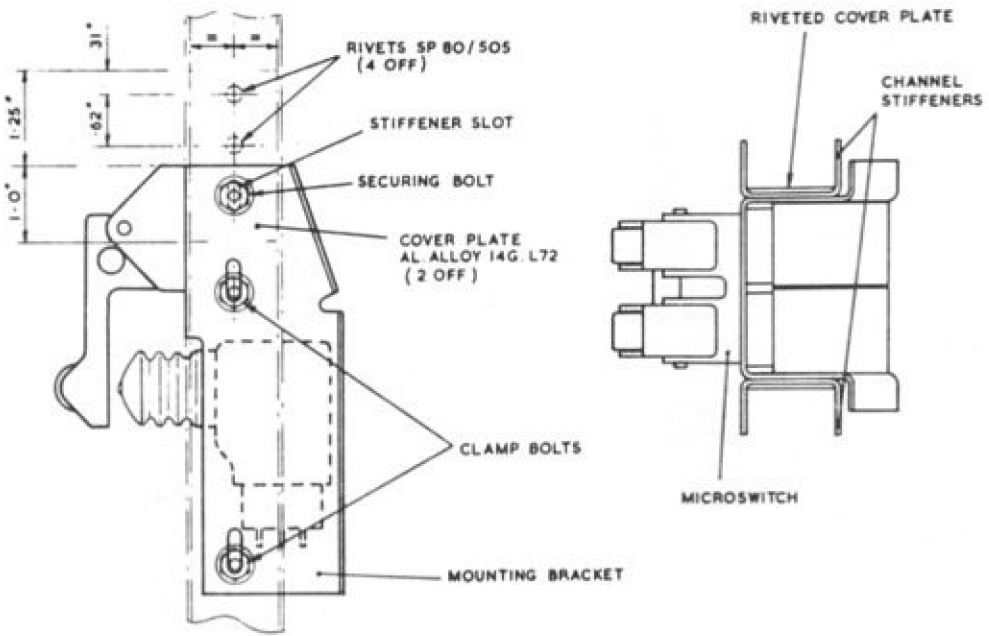


Fig. 20B Repositioning of L and M microswitch brackets 10975

RIGGING PROCEDURE

Elevons (fig.21, 22 and 23)

75. The procedure for rigging the elevon controls is as follows:-

(1) Disconnect the elevator sense trim actuator rod from the lever connecting it to the elevon control unit. (port side).

(2) Disconnect the auto-mach trim servo assembly at the stop rod connection to the mixing unit.

(3) Disconnect the telescopic spring rods from the input levers of the power control units.

(4) Set and secure the pilots' control handles to vertical and 4.89 in back from the front butting position (point C of detail B, fig.21).

(5) Working from front to rear in the fuselage, set all levers in the con-

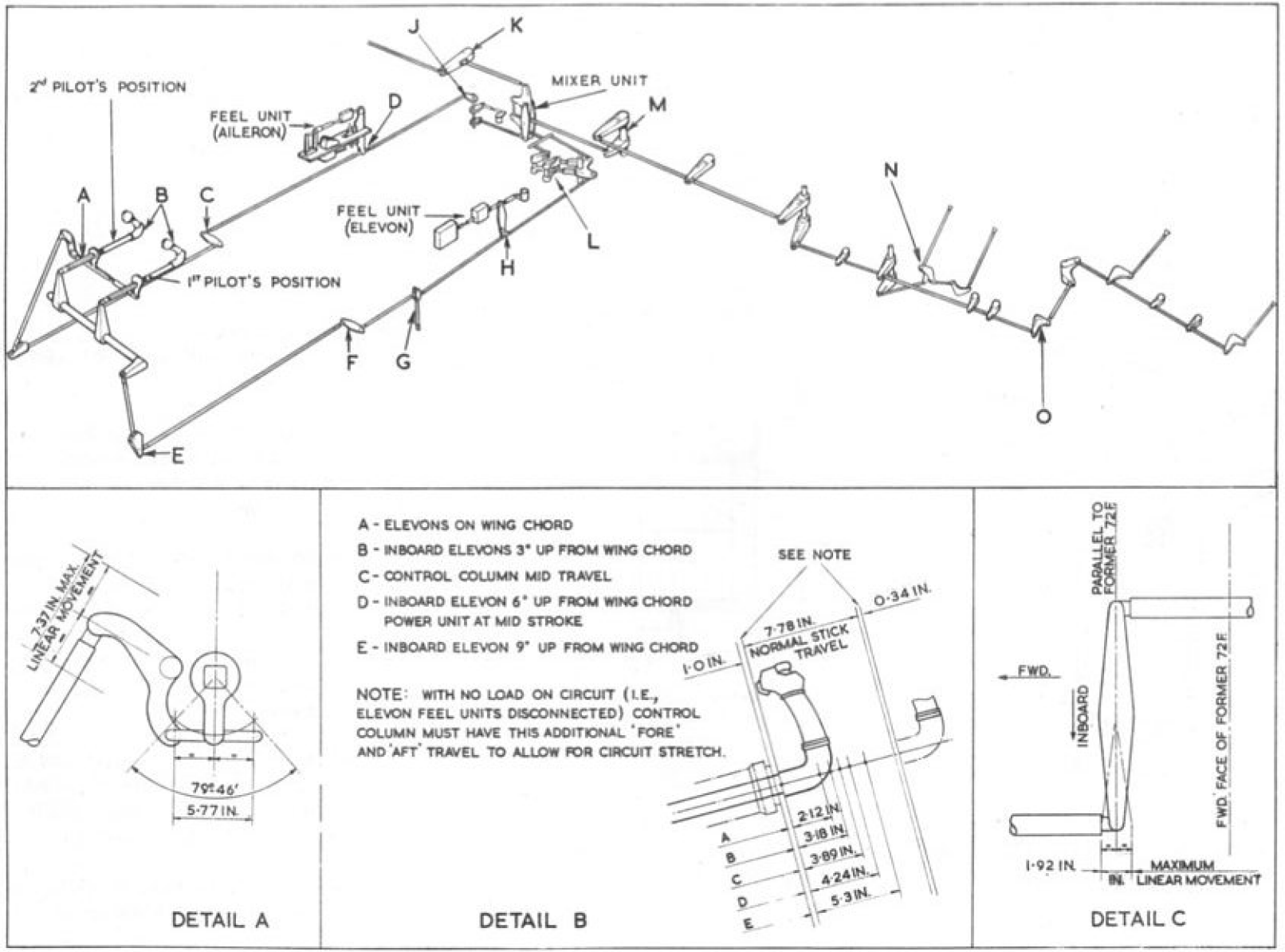


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Fig. 21 Elevon controls rigging (1)

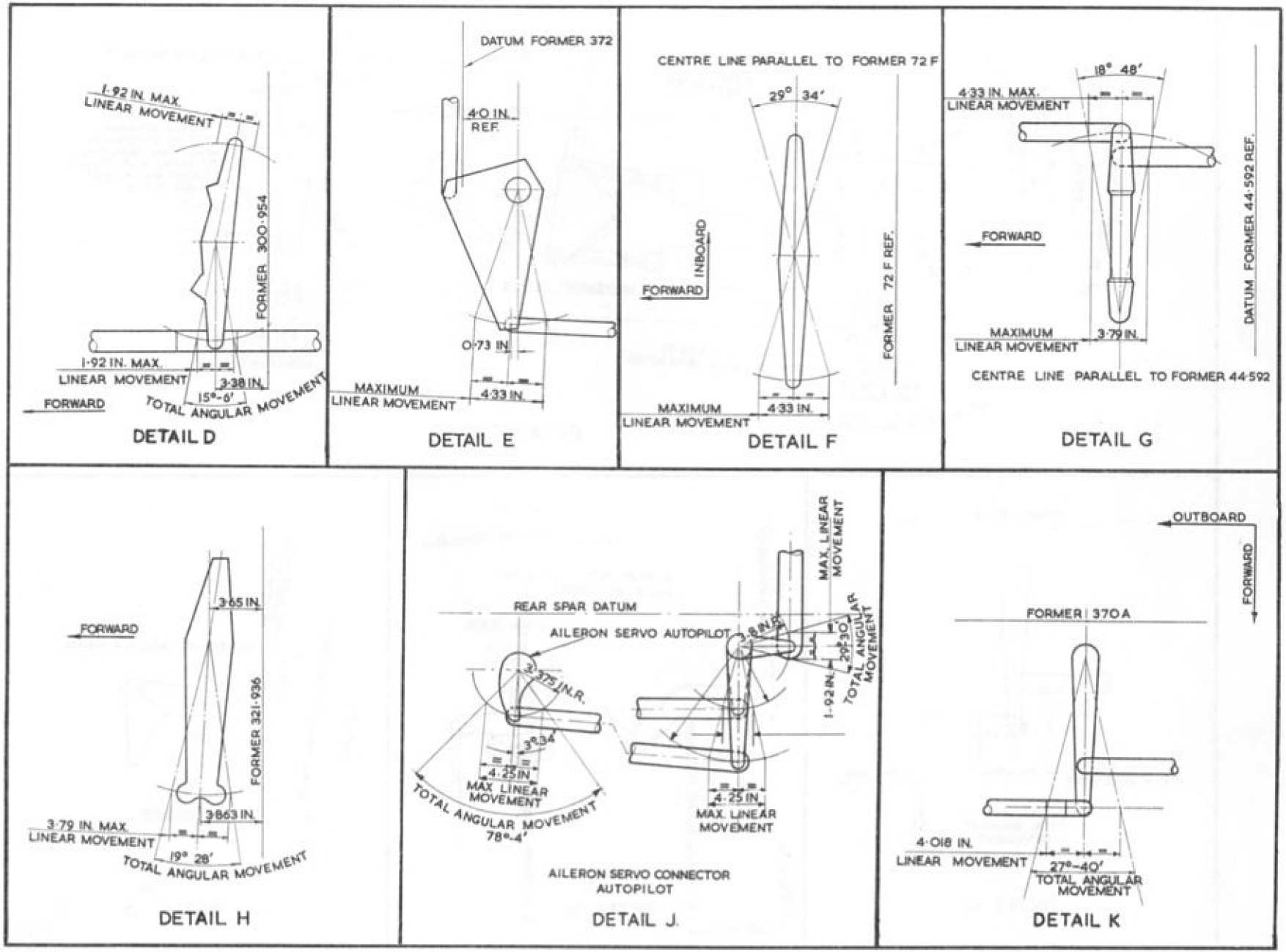

Fig. 22 Elevon controls rigging (2)
(*New detail 'J' added*)

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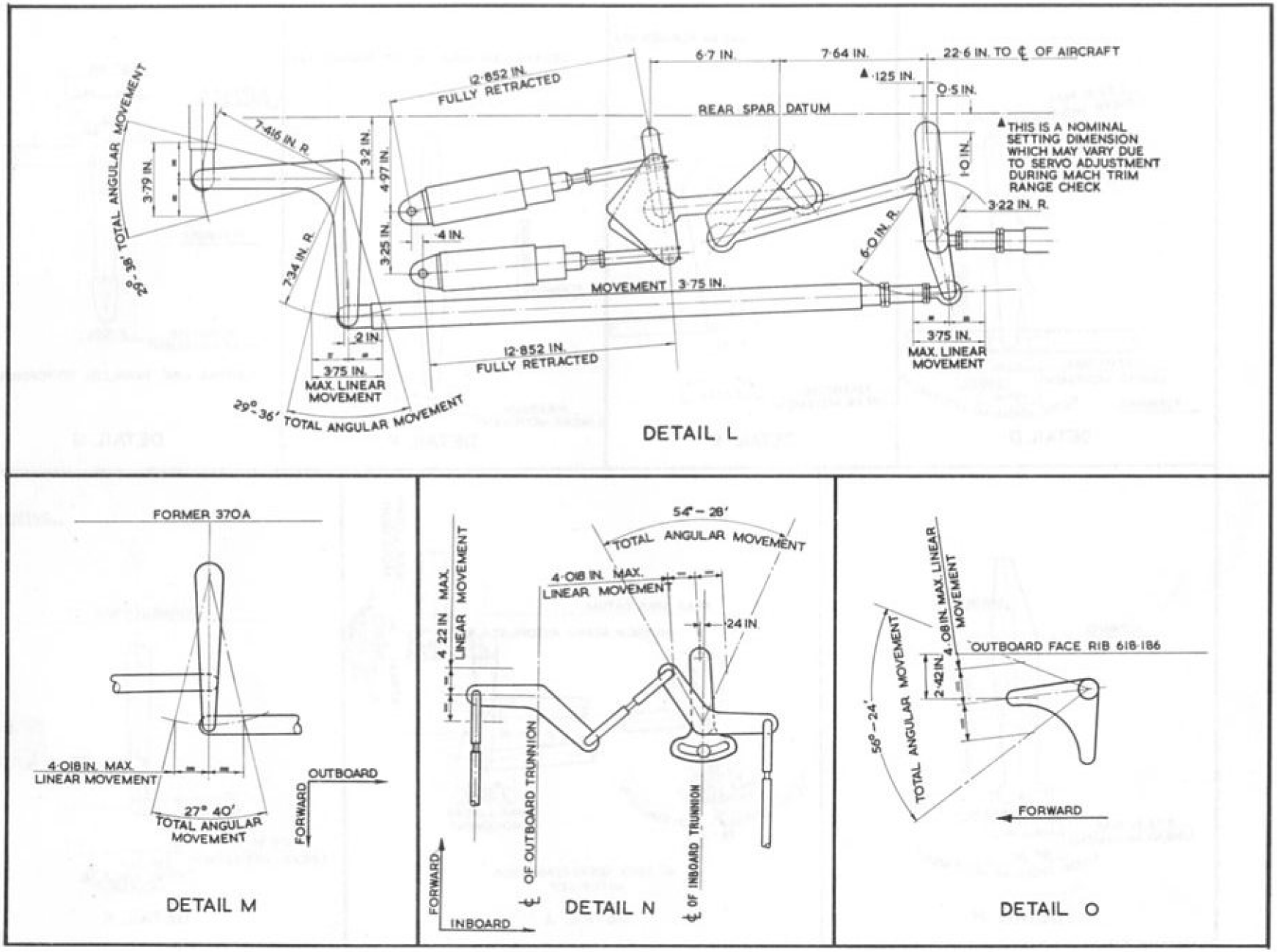

Fig. 23. Elevon controls rigging (3)

[◄ Detail re-arranged ►]

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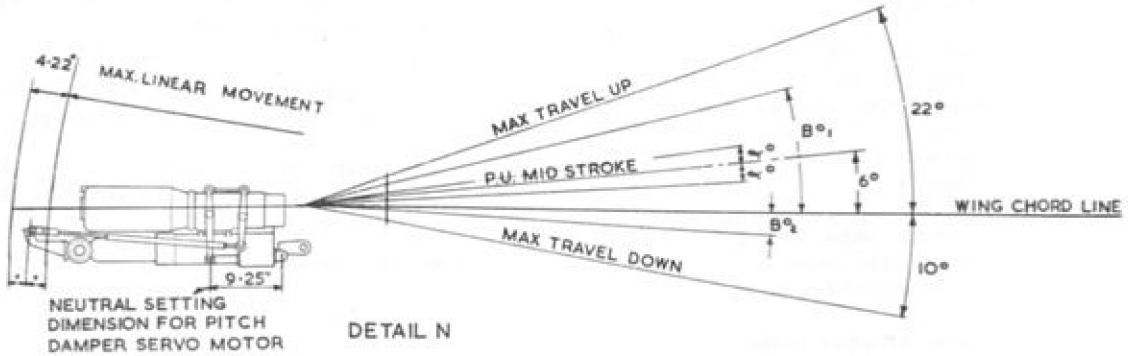
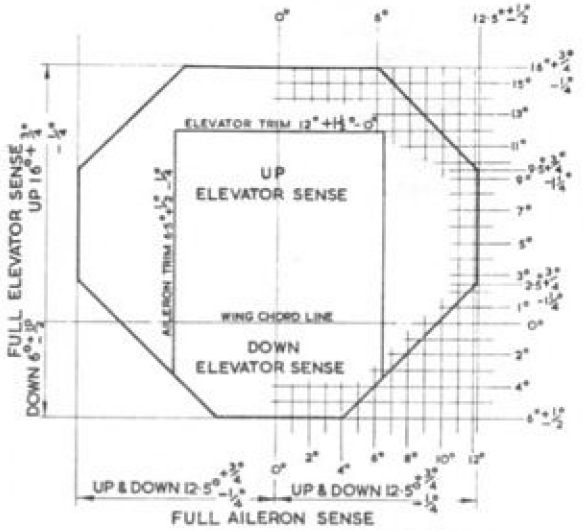


DETAIL N

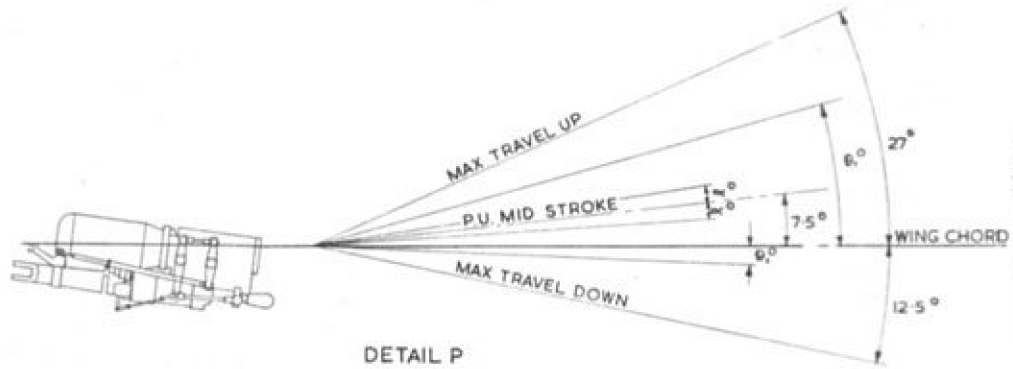
CONTROL SURFACE MOVEMENTS		
AILERON	±12·5°	FROM ELEVATOR ANGLE SEE DIAGRAM
ELEVATOR	16° UP 6° DOWN	FROM WING CHORD LINE

TRIM RANGES	FROM WING CHORD LINE	FROM POWER UNIT MID STROKE POS.
CONTROL		
AILERON α°	6·5° SEE DIAGRAM	
ELEVATOR UP β_1°	12°	6°
ELEVATOR DOWN β_2°	6°	12°

INBOARD ELEVON SETTING



INBOARD ELEVON MOVEMENT

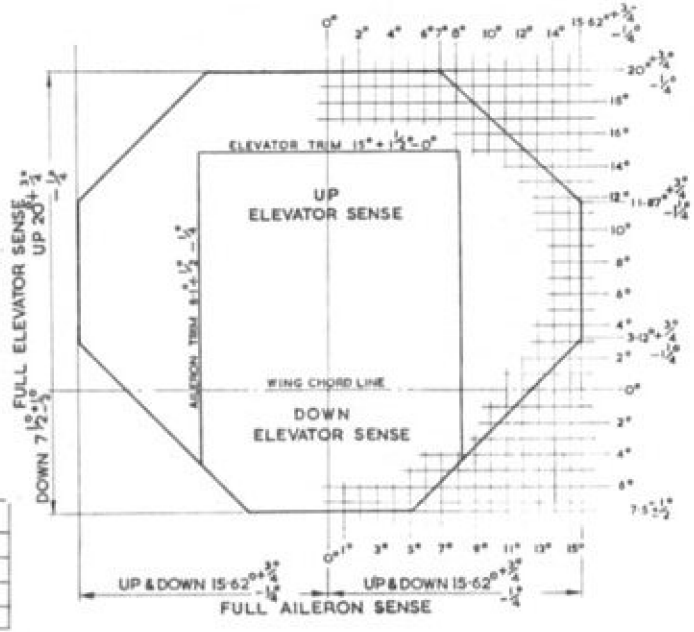


DETAIL P

CONTROL SURFACE MOVEMENTS		
AILERON	±15·62°	FROM ELEVATOR ANGLE SEE DIAGRAM
ELEVATOR	20° UP 7·5° DOWN	FROM WING CHORD LINE

TRIM RANGES	FROM WING CHORD LINE	FROM POWER UNIT MID STROKE POS.
CONTROL		
AILERON α°	8·1°	TRIM OVER TOTAL ELEVATOR RANGE
ELEVATOR 'UP' θ_1°	15°	7·5°
ELEVATOR DOWN θ_2°	7·5°	15°

OUTBOARD ELEVON SETTING



OUTBOARD ELEVON MOVEMENT

Fig. 24 Controls movement diagram

trol run forward of the rear spar to the mid-travel position (details C.D.E.F.G. and H., fig.21 and 22). Adjustment, if required, is carried out on the control rod forward of each lever.

(6) Reset and secure the pilots' control handles vertical and 5.24 in back from the front butting position (point D on detail B, fig.21).

(7) Set the mixing unit levers vertical. Adjust, if necessary, the control rod connecting the starboard side fuselage control run to the unit.

(8) Ensure that the auto-mach trim servos are fully retracted and that the assembly is set in accordance with detail K, fig.23. Connect the stop rod to the mixing unit.

(9) Working outwards from the mixing unit, set all levers aft of the rear spar in the mid-stroke position (detail J of fig.22 and details L, M and N of fig.23).

(10) Ensure 'kidney' stops (detail M fig.21) are central.

(11) Check the control run for freedom of movement to the 'kidney' stops by disconnecting the rods to the port and starboard controls at the mixer unit and apply movement to each side independently. Re-connect rods to mixer unit.

(12) Open the hydraulic lock valve on each power unit to permit movement of the control surfaces by hand.

NOTE . . .
Opening of the hydraulic lock valve must be limited to NOT MORE THAN TWO COMPLETE TURNS of the valve.

(13) Move each control surface, upwards and downwards, to the limit of power unit jack movement, in each direction, and ensure no fouls exist between any control surface and the mainplane and that no damage is caused to sealing shrouds.

(14) Set each control surface to the chordal position, using the appropriate setting gauge at the positions marked on the top surface of the main plane (Sect.2, Chap.4).

(15) Measure angle of each surface, using inclinometer. Record measurement for use as datum.

(16) From datum established in (15) set elevons as follows:-

No.1,2,7 and 8	7½ deg UP
No.3,4,5 and 6	6 deg UP

(17) Close hydraulic lock valve and lock with wire.

(18) Press the neutral setting plunger on the power unit and move the unit input lever until the plunger registers with the indentation in the carrier assembly.

(19) Adjust the spring control rods and connect them in position.

◀(20) Check that the aileron sense trim actuator is in the approximate mid-travel position (between electrical stops) and adjust eye end until connection can be made to circuit lever.

(21) Reset and secure pilots' control handles vertical and 4.18 in from front butting stop (point B on detail B, fig.21). Set elevator sense trim actuator to approximately mid-position (between electrical stops) and adjust eye end until connection can be made to circuit lever. ▶

(22) Release the pilots' control handles, ensure that control surfaces are free from obstruction and switch on elevon power units.

(23) Adjust spring rod fork ends to bring surfaces to mid-stroke position (sub-para.16).

NOTE . . .
Discrepancies may occur due to slight inaccuracies in neutral plunger setting.

(24) Carry out a complete range check of the elevons as detailed in para.77.

Rudder (fig.25 and 26)

76. The procedure for rigging rudder controls is as follows:-

(1) Disconnect the spring control rods at the input levers of the power units.

(2) Disconnect the trim actuators and the nose-wheel steering from the control run.

(3) Set the rudder pedal adjusters in mid-position.

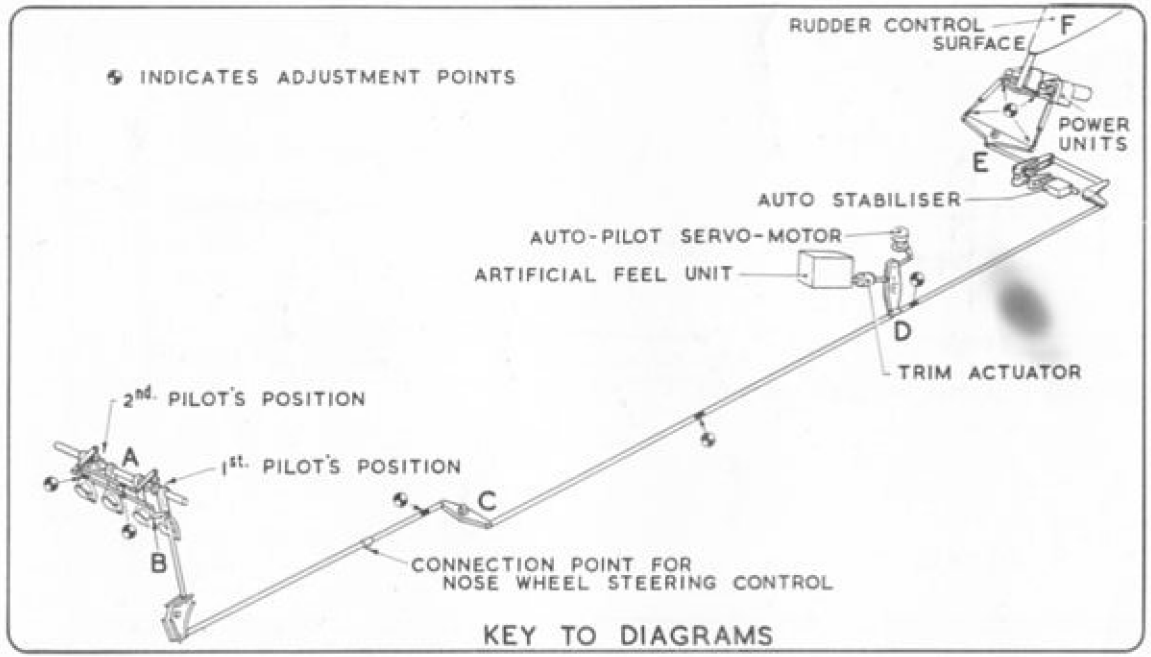
(4) Set the rudder pedals in line, using setting bar Part No.Z8352.

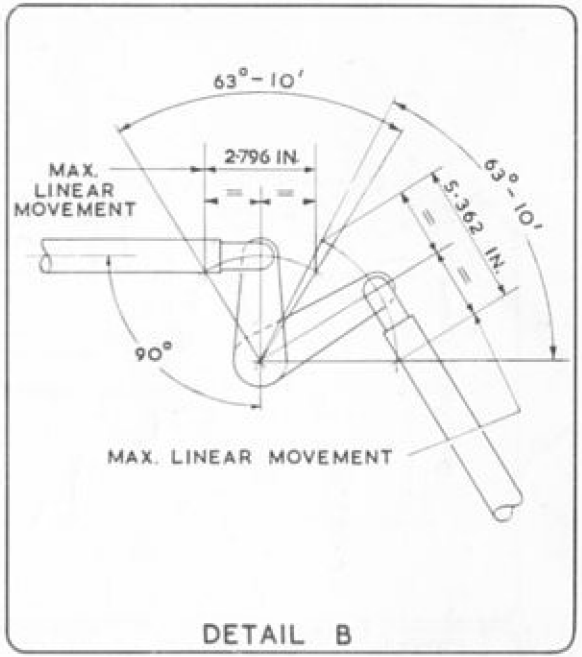
(5) Set the connecting rods and levers on the control unit in the cockpit as shown in details A and B, fig.25, adjusting as necessary.

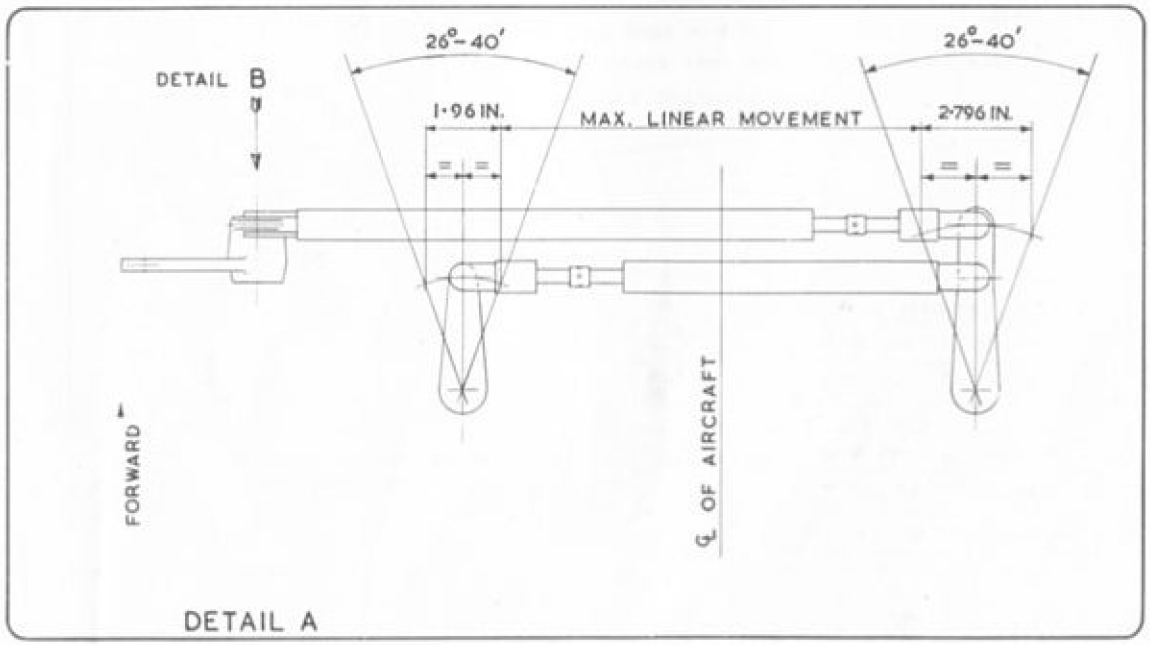
(6) Check the centrally-pivoted lever at former 75F. Adjust, if necessary, on the control rod running forward from this point so that the lever is in mid-travel position as shown in fig.25, detail C.

(7) Check the vertical lever at the feel unit position. Adjust, if necessary, the forward control rod so that the lever is at mid-travel (detail D, fig.26).

(8) Check the bellcrank lever at the rear of the fuselage control run.







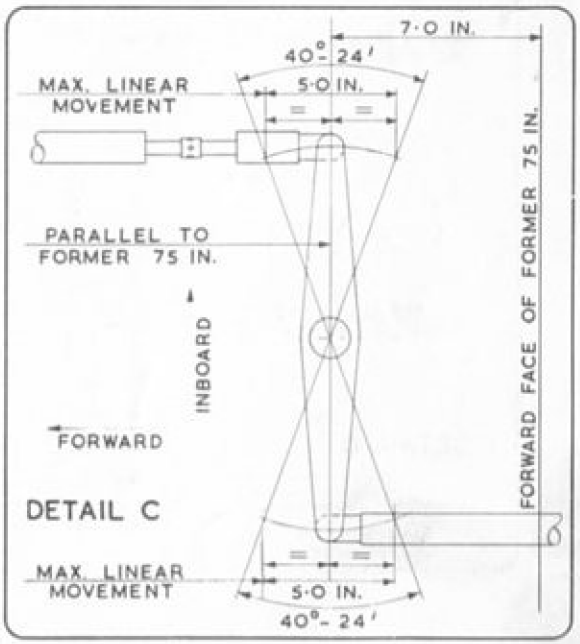
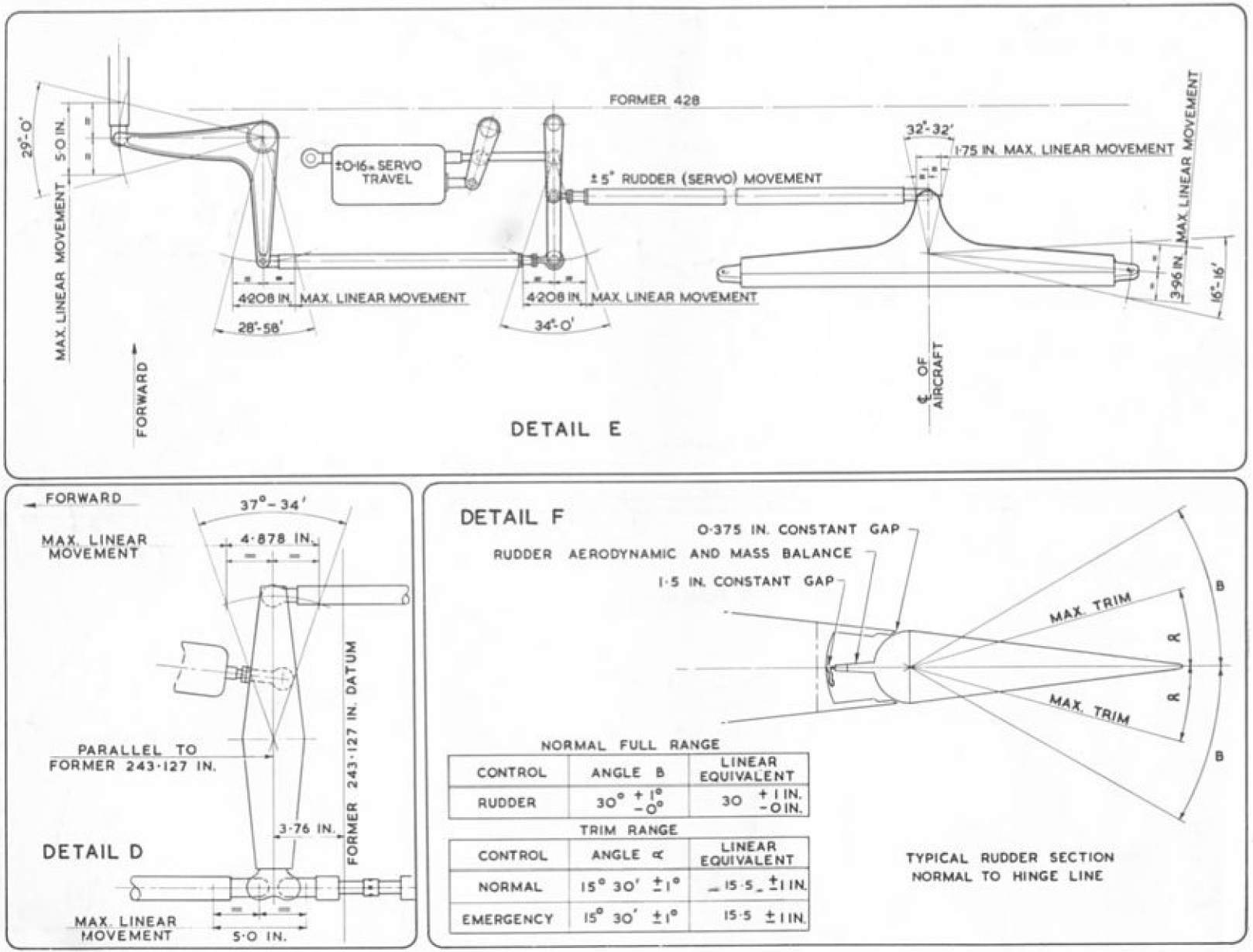


Fig.25. Rudder controls rigging (1)



NORMAL FULL RANGE

CONTROL	ANGLE B	LINEAR EQUIVALENT
RUDDER	30° +1° −0°	30 +1 IN. −0 IN.

TRIM RANGE

CONTROL	ANGLE ∝	LINEAR EQUIVALENT
NORMAL	15° 30' ±1°	15·5 ±1 IN.
EMERGENCY	15° 30' ±1°	15·5 ±1 IN.

Fig. 26. Rudder controls rigging (2).

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Adjust, if necessary, the forward control rod so that the lever is at mid-travel (detail E, fig.26).

(9) Check the transverse lever in the centre of the aircraft. Adjust, if necessary, the rod between this lever and the auto-stabiliser unit so that the transverse lever is in the mid-travel position (detail E, fig.26). Before carrying out items 10 to 21, ensure that yaw damper system is centralized, as failure to do so will result in incorrect measurements on the range of movement check.

NOTE...
At this point it may be convenient to check the static friction load (para.50).

(10) Open the by-pass valve on the auxiliary power unit. Move the rudder control surface to starboard, by hand, to the limit of the power unit jack movement, taking care damage is not caused to the shrouds or sealing fabric. Measure the amount of control surface movement; it should be not less than $30 \pm \frac{1}{0}$ in. from neutral, measuring to the base of the trailing edge centre line.

(11) In the same manner, check that rudder movement to the port side is also $30 \, ^{+1}_{-0}$ in.

(12) If the angles to port and starboard of neutral do not agree with the above, adjust on the power unit ram fork-end. When adjustment is complete lock the adjusters.

(13) Move the control surface to the neutral position. In turn, on each power unit, press the neutral setting plunger and gently move the unit input lever until the plunger registers with the identation in the unit carrier assembly.

(14) Adjust the spring control rods to fit and connect them in position.

(15) Close the by-pass valve (auxiliary power unit) taking care not to overtighten. See instruction in A.P.4603E, Vol.1, Sect.4, Chap.2.

(16) Release the pilots rudder pedals and with a ground electrical supply connected, engage each rudder power unit in turn and check the rudder for full and free travel at all positions of the rudder pedal adjusters. Full travel is from $30 \, ^{+1}_{-0}$ in. port to $30 \, ^{+1}_{-0}$ in. starboard of neutral.

NOTE...
Should a 'kick' be evident during the change from main to auxiliary units check that the input levers of both power units are adjusted in accordance with the instructions contained in A.P.4603E, Vol.1, Sect.1, Chap.2.

(17) Check that the rollers of the triple roller bearings are working freely.

(18) Check that when the rudder is moved $30 \, ^{+1}_{-0}$ in. to port the rear stop sleeve on the control rod contacts the limit stop at former 288F. Adjust the sleeve if necessary.

(19) Set the trim actuator (fig.14) and connect between the feel unit and the lever in the control run. Connect the nose-wheel steering.

(20) Check that all adjustment and connection points are safe and correctly locked.

(21) Finally, check the fluid level in the power unit and replenish if necessary.

RANGE CHECKS

77. Elevon control surface range checks are carried out with the aid of an inclinometer and a straightedge. With the control column set to position A of detail B, fig.21, and the elevons at the chordal position, establish a datum reading on the elevons by placing a straightedge and inclinometer on the top surface of each elevon and, using a soft wax pencil to prevent damage to the surface skinning marking around the base of the straightedge. All subsequent checks are to be taken from this position on each control surface and inclinometer readings will be relative to the datum established. For identification purposes the elevon surfaces are numbered 1 to 8, from port to starboard.

78. With a ground electrical supply connected to the aircraft, ensure the control surfaces are free from obstruction, the P.F.C. electrical system is clear and start the power units. Establish the control surface datum (para.77) and carry out range checks as detailed in the following paragraphs.

Elevator sense

79. The elevator trimmer is used in these checks to reduce operating loads and assist the operation.

(1) Trim the elevons fully down (elevator sense) and check control surface positions. These should be:-

No.1,2,7 & 8 ...	7 deg. 30 min. ± 30 min.
No.3,4,5 & 6 ...	6 deg. 0 min. ± 30 min.

(2) Check elevator circuit stops at the fin post. Stop should be touching. Full down elevator trim must coincide with full down elevator sense range and adjustment, if required, is as follows:-

(a) If range is short and stop is touching - open out the stop.

(b) If range is short and stop is not touching - adjust trimmer eye-end.

(c) If range is overrun - adjust both stop and trimmer eye-end.

(3) Check the control column position. This should be central and 1.05 to 1.15 in. back from the front stop.

(4) Trim elevons fully up (elevator sense) and check control surface positions. These should be:-

No.1. 2. 7 & 8 elevons

+1 deg. 30 min.
15 deg. 0 min. –0

No.3. 4. 5 & 6 elevons

+1 deg. 30 min.
12 deg. 0 min. –0

NOTE...

When checking trim ranges the control column should always be assisted into its trimmed position i.e., artificial feel unit neutral. If this is not done, then any self-centring deficiency of the control circuit (due to friction) emerges as a trim range deficiency.

(5) From full trim select 'full up' elevator on the control column. The elevon surface angles should be:-

No.1. 2. 7 & 8 elevons

+45
20 deg. 0 min. –15 min.

No.3. 4. 5 & 6 elevons

+45
16 deg. 0 min. –15 min.

(6) Check circuit stop at fin post. Stop should be touching.

NOTE...

Full elevator sense range can only be obtained when the elevons are between ± 4 deg. down and ± 6 deg. up (aileron sense - inboard elevons).

Aileron sense

80. To check the elevon range in aileron sense, proceed as follows:-

(1) Set the elevons to the chordal position and establish datum reading on inclinometer.

(2) Trim the elevons (aileron sense) to the following position:-

No.1,2,7 & 8 ... 7 deg. 30 min. UP
No.3,4,5 & 6 ... 6 deg. 0 min. UP

Check the control column position. This should be at point D, detail B, fig.21.

(3) Operate the control column (aileron sense) for full movement of the elevons, first to port then to starboard, these should be:-

No.1.2.7 & 8 elevons

+45
Up - 15 deg. 37 min. –15 min.

+45
Down - 15 deg. 37 min. –15 min.

No.3.4.5 & 6 elevons

+45
Up - 12 deg. 30 min. –15 min.

+45 min.
Down - 12 deg. 30 min. –15 min.

(4) Centralise the control column.

(5) Using the trim control, check elevons for aileron sense trim. This should be:-

No.1.2.7 & 8 elevons

+30
Up - 8 deg. 6 min. –15 min.

+30
Down - 8 deg. 6 min. –15 min.

No.3.4.5 & 6 elevons

+30
Up - 6 deg. 30 min. –15 min.

+30
Down - 6 deg. 30 min. –15 min.

NOTE...

Full aileron sense range can only be obtained with the inboard elevon at some position between 2.5 deg. and 9.5 deg. up from the wing chord. A tolerance of + 0.75 deg. or – 1.25 deg. is permissible on these dimensions. For this check, the power unit mid-stroke position, i.e., inboard elevons 6 deg. and outboard elevons 7.5 deg. up from wing chord, has been used as the datum from which aileron sense range is measured.

Elevons

81. When checking elevon ranges (in the mixed condition) it should be borne in mind that full elevon range is less than full elevator plus full aileron. It can be seen, from the movement diagram that when full elevator is applied, full aileron cannot be obtained and vice-versa. To check the elevons in the mixed condition i.e., when both aileron and elevator sense are required, proceed as follows:-

(1) Trim the elevons to full down (elevator sense).

(2) Apply full available column movement to starboard (aileron sense). Undue force should not be used, and the operator should hold the control column as soon as the kidney stop is felt.

NOTE...

Care should be exercised at this point to ensure that the control column does not move aft due to sideways

force, since this will leave the port elevons down but bring the starboard elevons up.

(3) Position of elevons should be as follows:-

No.1 and 2	12 deg. 30 min. ± 30 min. DOWN
No.3 and 4	10 deg. 0 min. ± 30 min. DOWN
No.5 and 6	2 deg. 0 min. ± 30 min. DOWN
No.7 and 8	2 deg. 30 min. ± 30 min. DOWN

(4) Apply full available control column movement to port. The positions given in (3) should be reversed port to starboard.

(5) Centralise the control column.

(6) Trim elevons full up (elevator sense).

(7) Pull the control column the remainder of the distance to the circuit up-stop and apply full available aileron movement to port.

(8) Position of the elevons should be as follows:-

No.1 and 2	27 deg. 0 min. ± 30 min. UP
No.3 and 4	22 deg. 0 min. ± 30 min. UP
No. 5 and 6	10 deg. 0 min. ± 30 min. UP
No.7 and 8	13 deg. 0 min. ± 30 min. UP

(9) Apply full available column movement to starboard. The positions given in (8) should be reversed port to starboard.

(10) Centralise the control column.

(11) To check the auto-mach-trim system, trim the elevons to wing chord and establish a datum on No.3 elevon.

(12) Run out the auto-mach-trim servos to full extension. Check, that No.3 elevon is 12 deg. ± 12 min. up.

NOTE...
Should it be necessary to adjust the mach trim range, 1½ turns out on the adjusters of both servos will increase the range by 1 deg.

(13) Retract the auto-mach trim servo.

(14) Trim the elevons to 3½ deg. up, on the inboard elevons, from wing chord, and check that the control surface indicator shows all surfaces on lubber line.

(15) Switch off the P.F.C's.

MASS BALANCING OF CONTROL SURFACES

General

82. To prevent flutter and vibration and subsequent damage, each flying control surface is balanced, to within specified limits, by a series of weights incorporated in or attached to its structure forward of the hinge line. It is, therefore, important that this mass balance is correct at all times. The following paragraph, with reference to fig.27, gives the methods of checking and adjusting the control surfaces, when necessary, i.e., after repair, application of finishing, etc., which may have affected the balance. Reference must also be made to A.P.101B-1900-6A which contains information on weight/repair allowances relative to mass balance adjustment. To avoid confusion, elevons will be referred to by numbers, 1 to 8 from port to starboard.

Elevons

83. Each elevon must be pivoted on and be allowed to move with minimum friction about the two end hinge points in the horizontal plane and checked separately in the following manner:-

(1) No.1 and 8 elevons
  (a) With the chord line 10 deg. tail down, the elevon must be either statically balanced or nose heavy when supporting a check weight of 4½ lb. at 32 in. aft of the hinge line.
  (b) With the chord line 10 deg. tail down, the elevon must be either statically balanced or tail heavy when supporting a check weight of 12 lb. 5 oz. at 32 in. aft of the hinge line.

(2) No.2 and 7 elevons
  (a) With the chord line 10 deg. tail down, the elevon must be either statically balanced or tail heavy when supporting a check weight of 9 lb. at 32 in. aft of the hinge line.

84. Correct balance can be achieved by the addition or removal of slotted circular trim weights (Ref. No. 26DC/17474), which are contained within the three mass balance arms. These weights are retained in housings by countersunk - head bolts, distance tubes, nuts, washers and split pins. Trim weights must be distributed evenly between the three arms, and the length of the distance tubes must be adjusted accordingly to take up the full length of the bolts.

85. When Mod.891 is embodied, nine balance weights are deleted from No.3 and 6 elevons and twelve balance weights from No.4 and 5 elevons. Aircraft with both pre and post Mod.891 elevons may be met in service, therefore mass balancing procedures for both types of elevon are given:-

(1) No.3 and 6 elevons (pre Mod.891)

(a) With the chord line 3 deg. tail up and a check weight of 2½ lb at 65 in aft of the hinge line. The elevon must be either statically balanced or tail heavy.

(b) With the chord line 3 deg tail up and a check weight of 7 lb at 20 in forward of the hinge line, the evelon must be either statically balanced or nose heavy.

(2) No.3 and 6 elevons (post Mod.891)

(a) With the chord line 3 deg tail up and no check weight the elevon must be tail heavy. This ensures a CG aft of the hinge line.

(b) With the chord line 3 deg tail up and a vertical spring balance attached 72 in aft of the hinge line, the load on the spring balance to retain the elevon in this position must not exceed 16 lb.

▶86. In both bases, additional mild steel balancing strips can be attached to the upper surface of the elevon beak when extra weight is required forward of the hinge line. The inboard strip (Part No. 17/F8050) measures 23-68 in x 16 swg and weighs 0.427 lb. The outboard strip (Part No. 106/F9724) measures 25.26 in x 1 in x 16 swg and weighs 0.45 lb. The strips may be cut to the length required and are affixed by removing the upper ferrules on the elevon beak as required, adding the balancing strip, and replacing new ferrules (Ref.No.28/H7849), which have a longer reach. Tie rods (Ref.No.28R/7135393 must be replaced if necessary. When balance is correct the tie rods must be riveted over.◀

87. Inner elevons No.4 and 5, are checked in a similar manner and are again covered in the pre and post Mod.891 state.

(1) No.4 and 5 elevons (pre Mod.891)

(a) With the chord line 3 deg tail up and a check weight of 2 lb at 83 in aft of the hinge line, the elevon must be either statically balanced or tail heavy.

(b) With the chord line 3 deg tail up and a vertical spring balance attached at 80 in aft of the hinge line, the load on the spring balance to retain the elevon in this position, must not exceed 14 lb.

88. In both cases, balancing is carried out in a manner similar to that for No 3 and 6 elevons, using mild steel balancing strip (Part No.19/F8049) outboard and 20/F8049 inboard) which both measure 24.47 in x 1 in x 16 swg and weighs 0.44 lb. If necessary the weight of the lead mass balance may be reduced by removing the ferrules and the rods securing the nose section and drilling ½ in dia holes in the exposed rear face of the lead mass balance weight. The holes must be interspaced between the distance tubes and may be drilled to a depth of 1½ in (detail A, fig.27).

Rudder

89. The rudder must be pivoted on and be allowed to move with minimum friction about the two end hinge points in the horizontal plane. Mod.1028 provides additional stiffening angles to strengthen the rudder skin attachment ribs and Mod.891 deletes four balance weights from the rudder nose, therefore, balancing procedures for both types of rudder are given.

(1) Rudder (pre Mod.1028 and 891)

(a) With the chord line horizontal and no check weight, the rudder must be either statically balanced or tail heavy.

(b) With the chord line horizontal and a check weight of 19½ lb at 10 in forward of the hinge line, the rudder must be either statically balanced or nose heavy.

(2) Rudder (post Mod.1028 and/or 891)

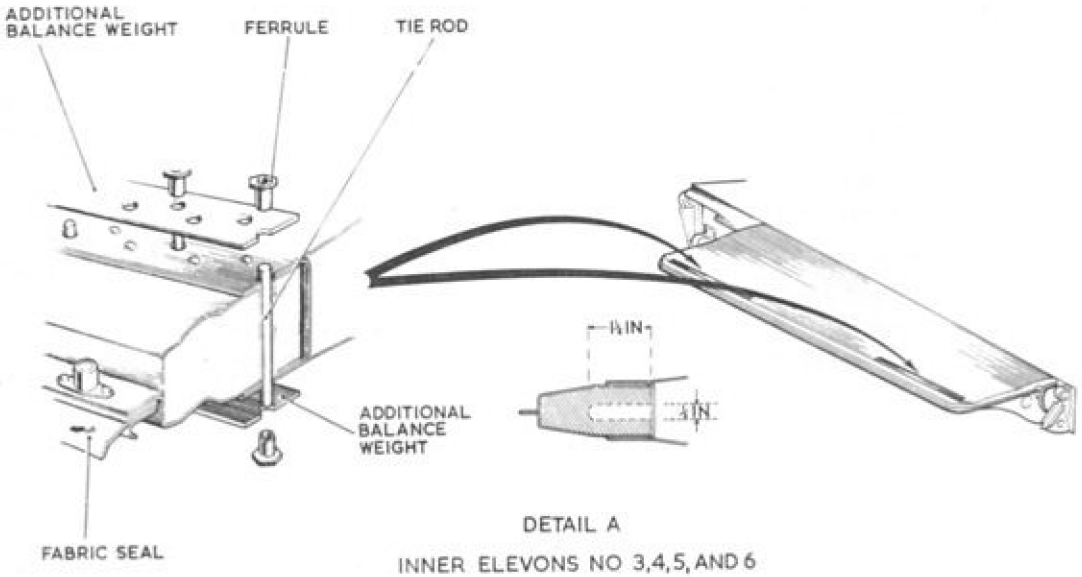
(a) With the chord line horizontal and no check weight the rudder must be tail heavy.

(b) With the chord line horizontal and a vertical spring balance attached at 44 in aft of the hinge line, the load on the spring balance must not exceed 17 lb.

To achieve the balance conditions required on rudders (post Mod.1028 and/or 891), it is permissible to add bottom mass balance weights (Part No.84/H2588 and 85/H2588) to port and starboard or a single weight to port. When any weights are added, balance checks (2) (a) and (b) must be repeated.

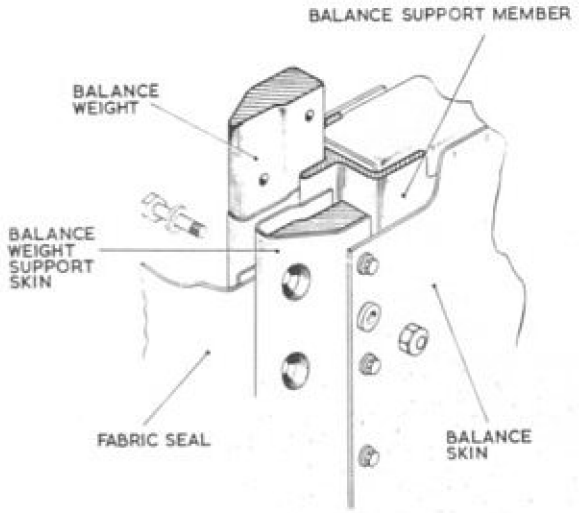
CONTROL ROD BEARING

▶90. Control rod bearings must be checked periodically in accordance with instructions contained in AP 101B-1902-5A to ensure that the rollers of each bearing are free moving with no excessive clearance. Wear on the rods at any of the three roller positions is acceptable up to a maximum depth◀

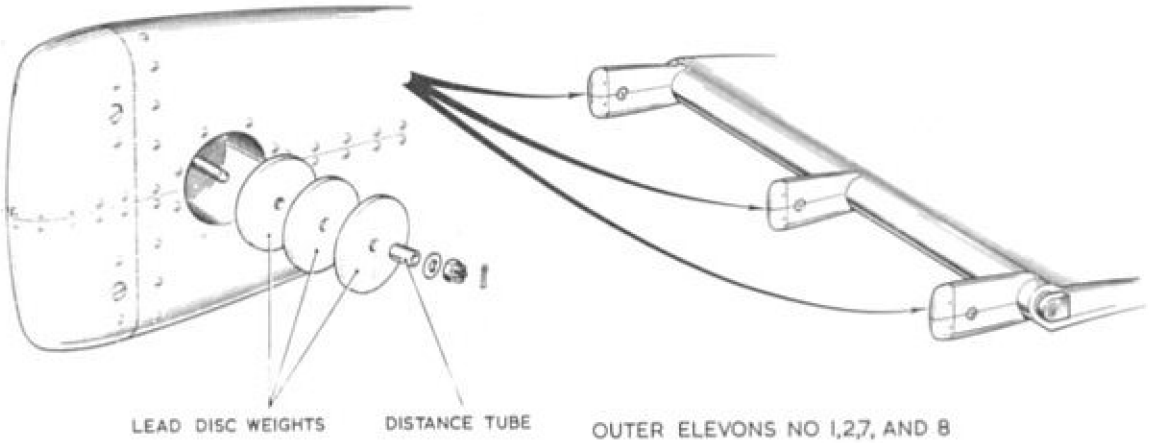


DETAIL A

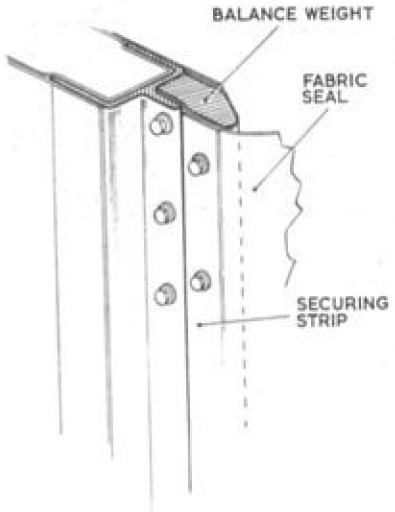
INNER ELEVONS NO 3,4,5, AND 6



RUDDER BALANCE – DOUBLE WEIGHT



OUTER ELEVONS NO 1,2,7, AND 8



RUDDER BALANCE – SINGLE WEIGHT
(BOTTOM WEIGHT ONLY)

A1483

Fig.27. Balancing of control surfaces

▶ of 0.015 in. On attaining maximum permissable wear at any one roller position the rod must be rotated through 180 deg to give new bearing surfaces, ensuring that basic clearances are within limits and that all rollers are free to rotate. After rotating a control rod the maximum permissable wear limit is 0.010 in. If a rod cannot be rotated it must be renewed (para 97). When fitting new rods the clearance between each roller and the control rod, with control rod central, must be 0.010 in minimum to 0.030 in maximum. Static friction test (para 50) must be carried out after fitting a new control rod or rotating a worn control rod. Score marks on rods can be polished out and providing an Ardrox check is clear the following tolerances must be observed. The width of the polished out area must not be greater than 25 per cent of the rod circumference and the depth limit is 0.015 in.

NOTE . . .
If a bearing assembly is removed or renewed, care must be taken to ensure that any packer used is refitted in its correct position. This ensures that the bearing assembly is at right angles to the control rod. ◀

REMOVAL AND ASSEMBLY

POWER UNITS

91. Recommended procedures for removal of the powered flying control units are given in fig.28, 29 and 30 together with their relative keys. Installation is a reversal of the removal procedure, each unit being adjusted to the control system in accordance with the information provided in the appropriate rigging instructions (para.75). When fitting the telescopic input rod (item 7, fig.28 and associated key) ensure the rear connecting bolt is fitted with the head adjacent to the pitch damper.

ARTIFICIAL FEEL UNITS

92. When an artificial feel unit is to be replaced, the following instructions should be adhered to:-

(1) Trim the flying control surfaces so that the inboard elevons are 5 deg up from wing chord. A control column setting for this condition is provided in the rigging illustration - fig.21, detail B, point C.

(2) Remove the defective artificial feel unit.

(3) Fit serviceable unit.

(4) If the trimmer cannot be connected without moving other controls, adjust the screwed end of the trim jack to the nearest half turn and connect.

KEY TO FIG.28

(INBOARD ELEVON POWER UNIT REMOVAL)

1. Ensure that the electrical power supply is off.

2. Remove the power unit access door.

3. Remove the small access panel from the elevon in the region of the power unit.

4. Disconnect the electrical connections.

5. Disconnect and remove the power unit coupling rod which passes through the web of the centre hinge rib.

6. Disconnect the input rod from the inboard P.F.C.

7. Disconnect and remove the telescopic input rod.

8. Secure the control surface concerned so that when released from the power unit it will not rise due to the weight of the mass balance.

9. Remove the coupling from the power unit ram adjustable fork-end and the elevon operating lever. Support the unit during this operation.

10. If difficulty is experienced in removing the bolt, it is probably due to captive pressure in the power unit operating jack. This pressure may be relieved by unscrewing the by-pass valve, not more than two turns, and manipulating the control surface.

WARNING . . .
Care must be exercised to ensure that the expansion chamber assembly, on No.3 and 6 units, do not foul on the P.F.C. unit fulcrum brackets.

11. Lower the unit and allow to hang from the main trunnion beam attachment, ensuring in the case of No.4 and No.5 power units that the input rod eye-end is clear of the input lever fork-end.

12. Support the unit and remove the attachment bolt at the mounting trunnion, then lower the unit on to a suitable trolley.

13. Fit a jury strut Ref.No.26DC/95200.

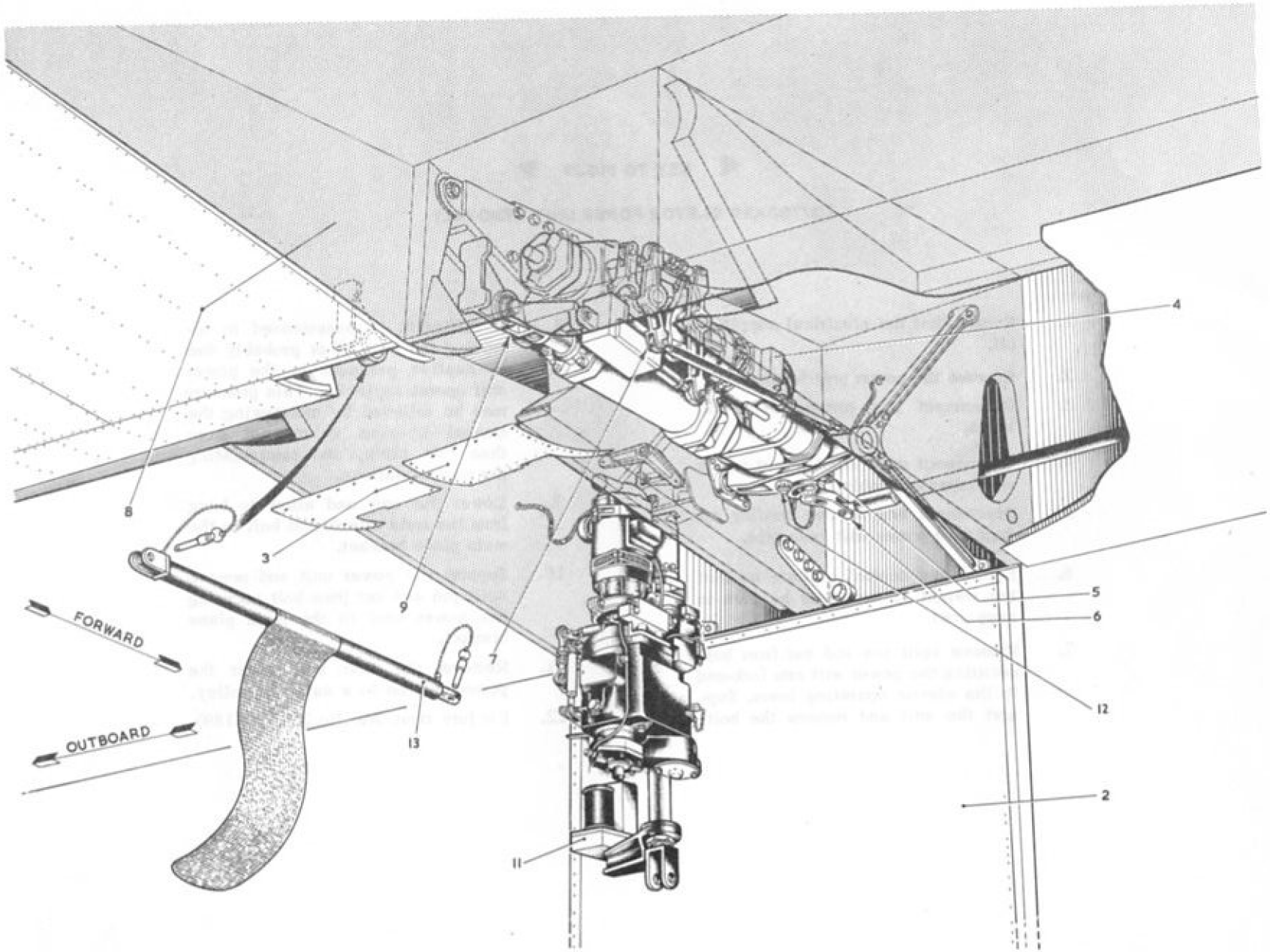


Fig.28. Inboard elevon power unit removal
(cooling ducts deleted)

◀ KEY TO FIG.29 ▶

(OUTBOARD ELEVON POWER UNIT REMOVAL)

1. Ensure that the electrical supply is off.
2. Remove the power unit fairing.
3. Disconnect and remove electrical leads.
4. Disconnect main input rod at power unit lever assembly.
5. Disconnect and remove cooling air duct from power unit generator.
6. Secure the control surface so that the weight of the mass balance is supported.
7. Remove split pin and nut from bolt securing the power unit ram fork-end to the elevon operating lever. Support the unit and remove the bolt.
8. If difficulty is experienced in removing the bolt, it is probably due to captive pressure in the power unit operating jack. This pressure may be relieved by unscrewing the manual by-pass valve, not more than two turns, and manipulating the control surface.
9. Lower the unit and allow to hang from the main attachment bolt in the main plane bracket.
10. Support the power unit and remove split pin and nut from bolt securing the power unit to the main plane bracket.
11. Remove the bolt and lower the power unit on to a suitable trolley.
12. Fit jury strut (Ref.No.26DC/95189).

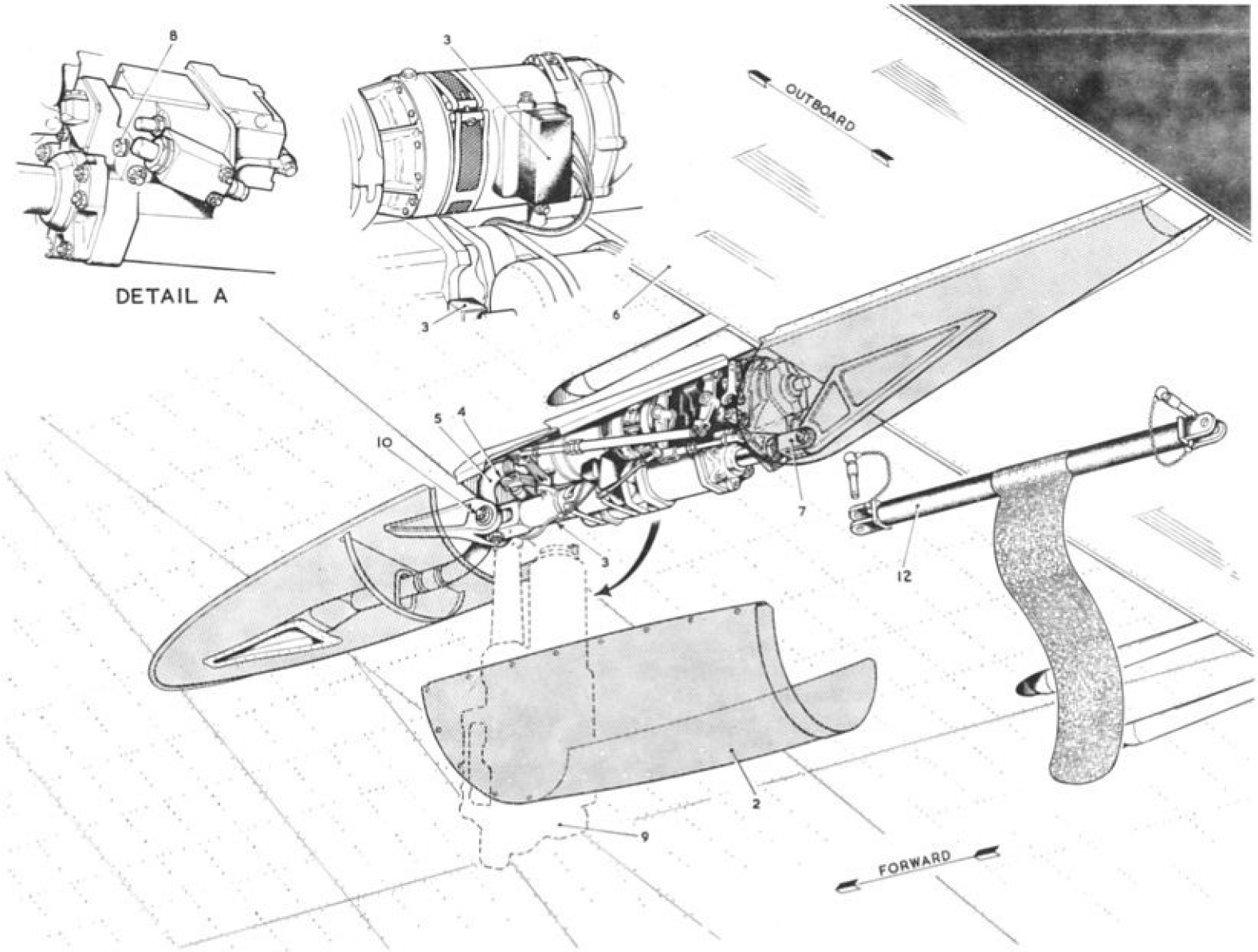


Fig. 29 Outboard elevon power unit removal

KEY TO FIG.30

(RUDDER POWER UNIT REMOVAL)

1. Ensure that the electrical power supply is off.

◀ 2. Disconnect and remove radio receiver Type 17170 and power unit Type 17203.

3. Remove the four 2 B.A. stiffnuts and washers from the bolts securing the power units drip tray to its side attachment brackets, withdraw the bolts and remove the tray. Remove the two 4 B.A. stiffnuts and washers from each side attachment bracket, withdraw the bolts and remove the brackets. ▶

4. Disconnect the electrical leads from the power units.

5. Disconnect the drain pipe from the starboard control unit cooling air duct.

6. Disconnect and remove the cooling air inlet ducts from the two way branch on the port side of the unit support beam, and from the Rotax motors.

7. Disconnect and remove the cooling air exhaust ducts and manifolds from the Rotax motors and the exhaust outlet on the fuselage outer skin.

8. Remove the Rotax motors from the main and auxiliary units.

9. Remove the guard assembly (Mod.1102), then disconnect and remove the telescopic input rods.

10. Disconnect and remove the flexible interconnecting pipe from each unit. Blank off banjo union connections.

11. Remove the split pin and nut from the bolt securing the power unit to the rudder operating lever. Support the unit and withdraw the bolt, then lower the unit and allow to rest on the support beam stop bracket. ◀ ▶

12. Remove the split pin and nut from the bolt securing the unit to the support beam. Support the unit and withdraw the bolt.

13. Lower the released unit through the access door on to a suitable trolley.

14. Fit jury strut Ref. No. 26DC/95039.

◀ 15. Repeat operations 11, 12, 13 and 14 to remove the remaining unit. ▶

16. Fitting of the power control units is a reversal of the removal procedure.

NOTE . . .

◀ *(1) When fitting the guard, removed in operation (9), ensure a minimum clearance of ¼ in. is obtained between the guard and each telescopic input rod.* ▶

(2) Prior to fitting the Rotax motor, turn the generator drive briskly by hand to check freedom of movement and to ensure that oil is passing through the 1/64 in. dia. hole in the end of the distributor stalk.

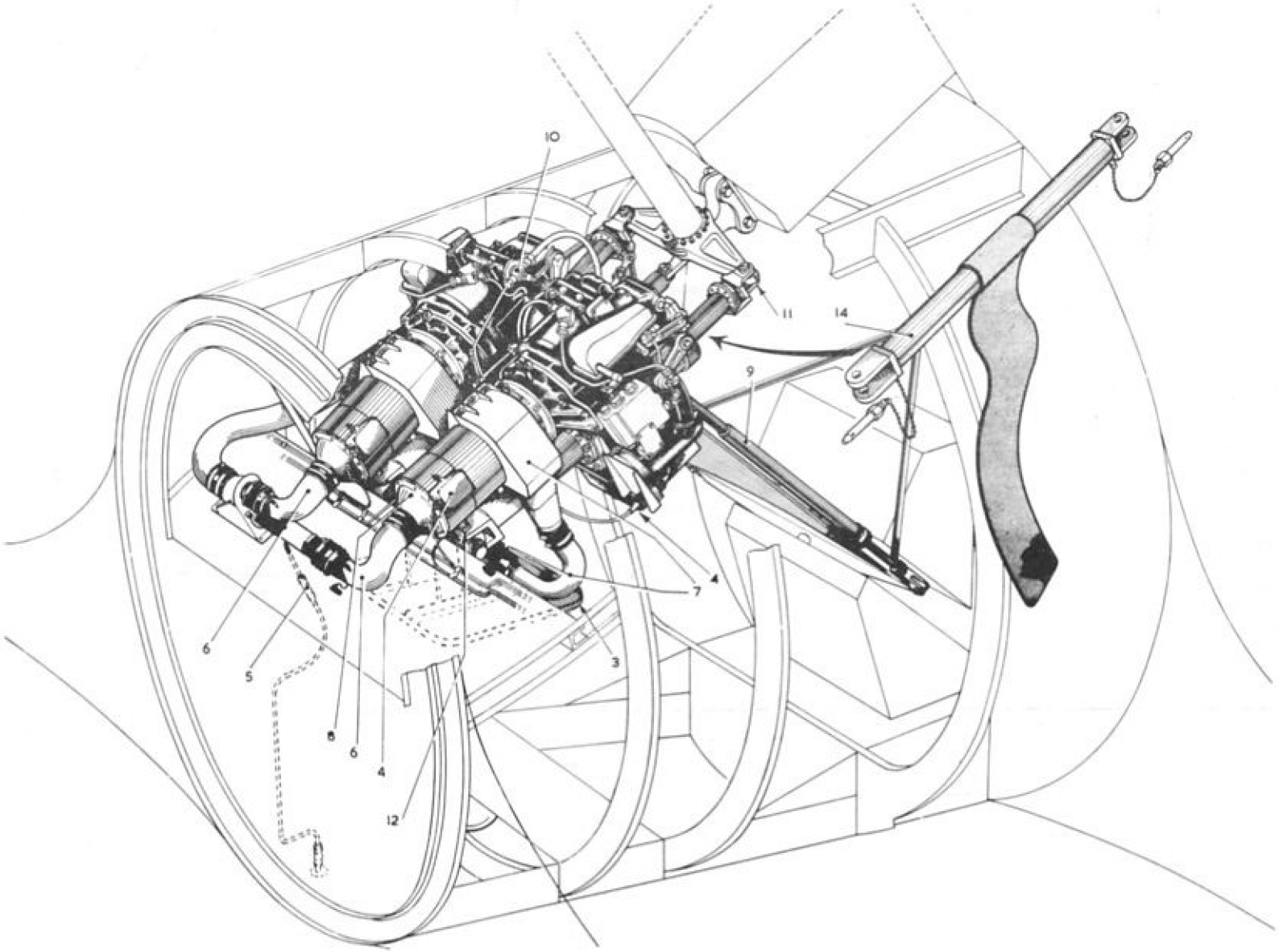


Fig. 30 Rudder power unit removal

‹Mod. 2304›

(5) Check that any out-of-neutral on the relevant control surface does not exceed the tolerance allowed on the trim range.

(6) Check the trim range.

SPRING CONTROL RODS

93. Little difficulty is anticipated when removing or installing spring control rods, care must be exercised however, when any adjustment of the rod end is carried out, to ensure that the lock-nuts are not over-tightened. Torque loading in excess of the recommended limits will cause serious damage to the rod or tube ends. For particulars regarding torque-loading functioning limits, etc., refer to fig.15.

NOTE . . .
When connecting a spring control rod to the input lever of No.2 or 7 power units, use connecting bolt Pt. No.A59/8E (Ref.No.28D/1215687) reduced in length from 1.3in to 1.1in. Any other bolt will foul the fairing during operation of the power unit. When reducing the length of the bolt, be sure to leave sufficient material between the split pin hole and the end of the bolt.

CONTROL ROD PRESSURE SEAL BEARINGS

94. When the control rod pressure seal has been disturbed for any reason, care must be taken during assembly to ensure that the cavity is packed with grease XG-295 and that the end cap is tightened only sufficient to nip the seal. The complete assembly must be wire locked to prevent movement of the end cap in either direction.

AIR BRAKE LEG/FLAP ASSEMBLY

Removal

95. The removal sequence given is for one air brake assembly, it may be applied in full or in part to any of the air brakes. Refer to fig.31 and proceed:-

(1) Check in accordance with the warning adjacent to the air brake selector switch that it is safe to operate the air brakes then, if safe, extend the air brakes to the APPROACH HIGH DRAG, 80 deg. position.

(2) Isolate the electrical system by removing the 28 volt fuses 640 and 551 from panels 3P and 4P respectively and the 200 volt fuses 81 and 152 from panels 18P and 19P respectively.

(3) Remove the two bolts (Ref.No. 26DC/10864) securing the air brake flap to the flap operating lever in each leg. Remove the flap.

(4) Remove the split pins, nuts and washers from the four bolts securing each end of the bracing tube to the air brake legs. Remove the bolts and the bracing tube. Note the type and location of each bolt as it is removed, there are two bolts Ref.No.28D/1011238, one bolt Ref.No.28D/1013178 and one bolt Ref.No.28D/1011240 at each end. These bolts must be correctly located during subsequent assembly.

(5) Remove the bolts, (Ref.No.28D/9133012) securing the air brake assembly access panel and remove the panel.

(6) Remove the split pin, nut and washer from the bolt, (Ref.No. 26DC/9608), securing the cam follower arm to the flap operating linkage rod in each leg. Remove the bolt.

(7) Remove the locking plate, (Ref.No. 26DC/9611), and the bolt, (Ref.No. 26DC/11189), securing the cam follower arm to the air brake leg. Tie the cam follower arm to the cam clear of the air brake leg.

NOTE...
Only the operating chains now support the air brake legs.

(8) Remove the locking wire from the chain adjusters and the adjuster block on the air brake leg. Release both locknuts on each chain adjuster.

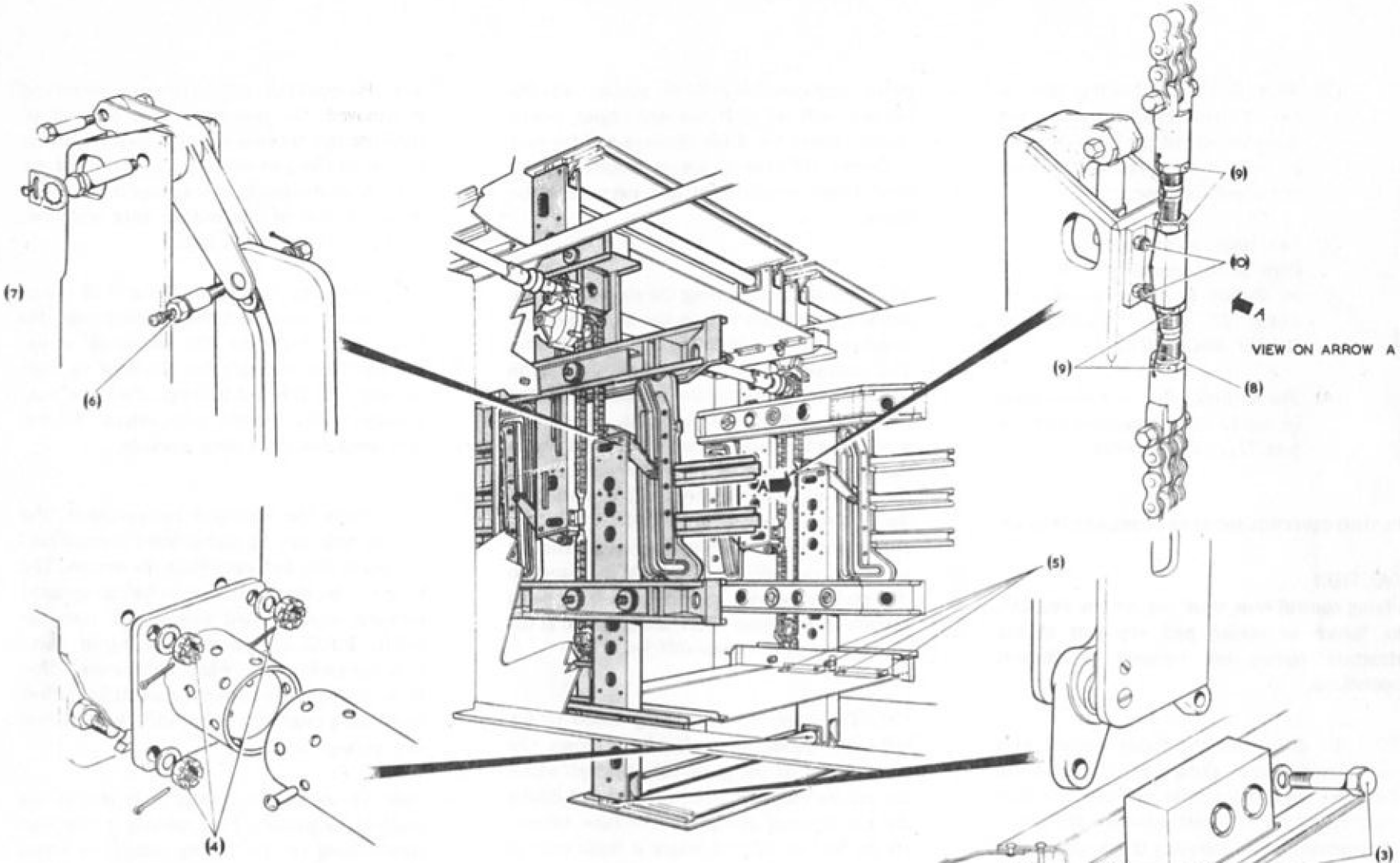
(9) Support the air brake leg and release the chain adjusters from the adjuster block.

(10) Remove the split pins, nuts and washers from the four bolts (Ref. No.26DC/9088) securing the adjuster block to the air brake leg. The air brake leg can now be withdrawn from the roller box.

Assembly

96. Installation is a reversal of the removal sequence and must include the setting procedures given in para.69 to 74 of this chapter. During assembly the following must be noted.

(1) When fitting the adjuster blocks to the air brake legs the right-hand threaded hole must be at the top on a bottom air brake leg and the bottom on a top air brake leg.



NOTE...

THE FIGURES IN BRACKETS REFER TO THE SUB-PARAGRAPHS OF PARAGRAPH 95.

Fig. 31 Air brake leg / flap removal

(2) When fitting the bracing tube to the air brake legs ensure that the threaded end of the bolts clear the air brake roller boxes. Cut the ends of the bolts, if necessary.

(3) The bolts, securing the air brake flaps to the operating lever, must be locked to the adjacent bolts using 22 s.w.g. locking wire Ref.No. 30A/9437135.

(4) The air brake flap stop block must be set to the instructions given in para.71, op.(34) to (40).

FLYING CONTROL RODS IN FUSELAGE (FIG.32)

CAUTION . . .
Flying control rods must not, on any account, be forced or sprung past any part of the structure during rod removal or fitment operations.

97. To disconnect the flying control rods, one from the other, along the full length of the fuselage, remove the split pin and nut from each connector bolt and withdraw the bolt – this operation also releasing the bonding leads.

98. The connector bolts of the elevator, rudder and aileron control rods forward of former 75F are accessible from the nose wheel compartment. At former 75F the connector bolts are accessible on removing a riveted panel, approximately 9 in square, on the inboard wall of each inboard engine intake tunnel (detail A). Rods disconnected forward of former 75F may be passed directly into the nose wheel compartment and away from the aircraft.

99. The bolts connecting the elevator, rudder and aileron control rods in the bomb bay side structure are accessible from the bomb bay. The rearmost connector bolts of the aileron and elevator controls are accessible in the electrical power compartment. The bolt connecting the rudder rearmost control rod to the servo bell-crank is accessible on removing the rivets securing the forward 2 ft portion of the closing panel Pt.No. 26/D10702 on the port lower side of the trailing edge structure and then carefully peeling back the panel to the position shown in detail E. The panel extends from former 428A, along the rib at the 63.5 in datum, to former 487.5A.

100. The operation of gaining access to the bell-crank connector bolt also exposes the forward end of the guide tube through which the rudder rearmost control rod is fed during the rod removal operation. The tube extends aft to former 487.5A where it leads into an angular compartment enclosed by two panels each measuring 10.25 in x 5.25 in and riveted one to the upper surface of the trailing edge and one to the lower surface. Removal of these panels allows the rod to be withdrawn from the trailing edge (detail C).

101. Provided the rudder rearmost control rod is removed, the tube may then be used to facilitate the removal of other rods from that section of the port side fuselage aft of former 75F. A similar guide tube arrangement, in the starboard side of the trailing edge structure, caters for starboard side rods.

102. When the rods aft of former 75F are to be removed, start with the rearmost ones and feed them back to the electrical power compartment, ensuring that the bonding leads do not foul the rod bearings. To allow easy passage of the forward rods, release the feel unit levers and move them upwards.

103. From the electrical compartment, the shorter rods may be manipulated forward into the bomb bay and away from the aircraft. The longer rods, those too long to be manipulated forward, are directed further aft into the rudder P.F.C. compartment and from there into the guide tubes. When withdrawing a rod from the trailing end of the guide tube, deflect the trailing edge section just sufficient to allow easy passage of the rod.

104. To install the control rods reverse the removal sequence. For riveting procedures appertaining to the closing panel, the access panel in the engine intake tunnels and the trailing edge panels refer to A.P.101B-1900-6A, Part 1, Chap.1, para.112 and 113. For details of rear fuselage skinning refer to Part 1, App.1, Chap.2, fig.A217 of that A.P.

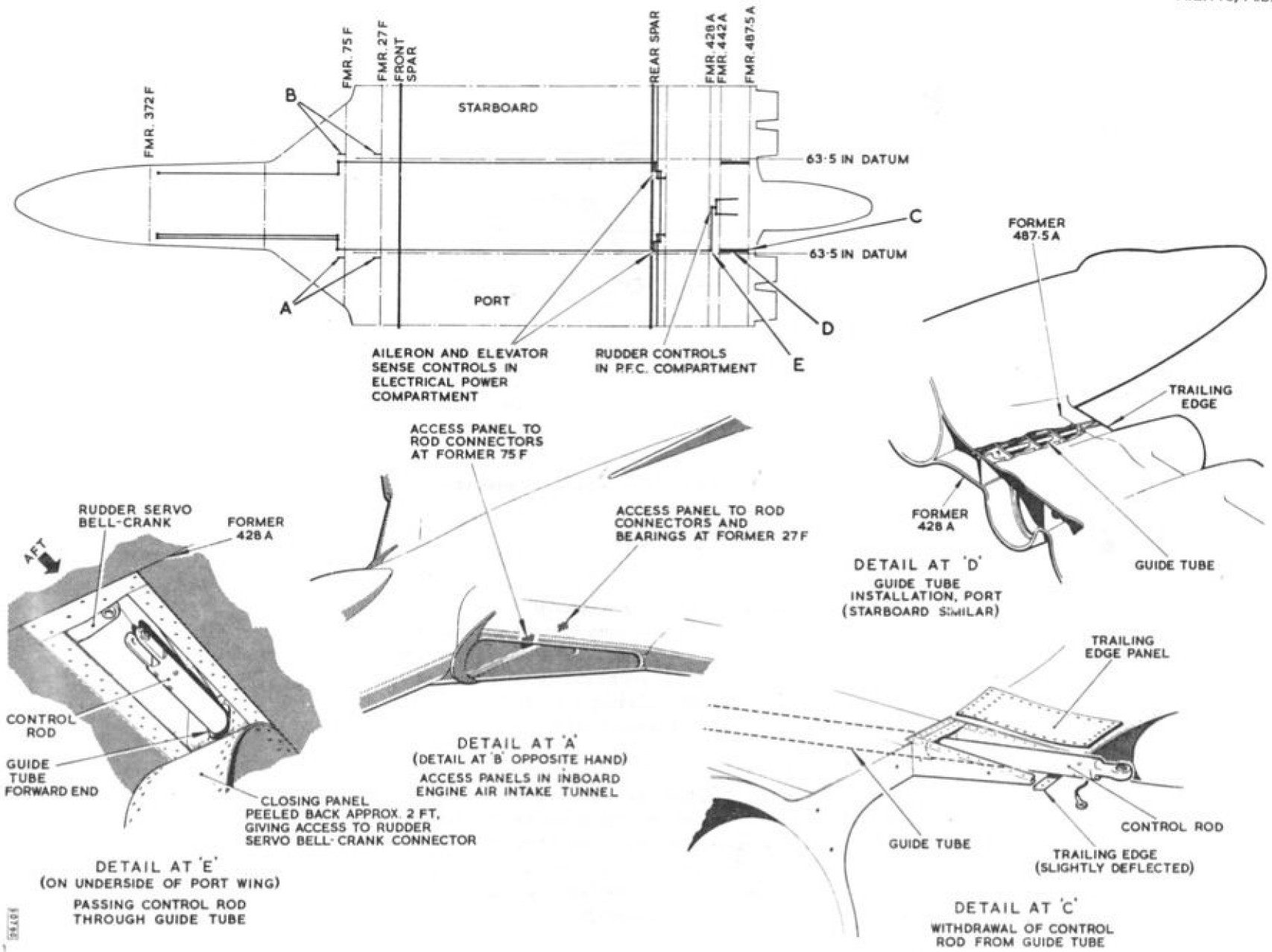


Fig. 32 Flying control rods – removal

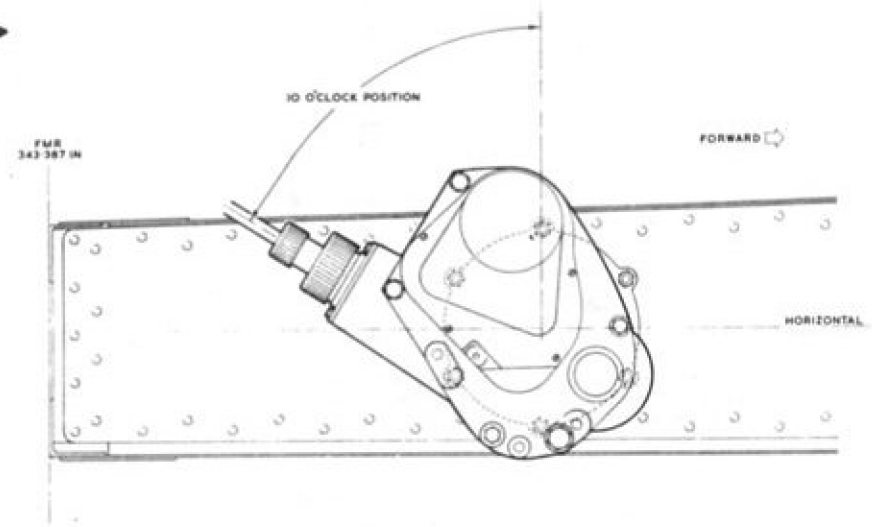


Fig.33 Elevon autopilot servomotor

Autopilot servomotor mountings

105. Special instructions for the removal and installation of these units are unnecessary providing the electrical disconnections and reconnections have been made and the following CAUTION relevant to the elevon servomotor mounting is observed.

CAUTION . . .

When installing the elevon servomotor mounting, ensure correct orientation of the servomotor. The servomotor electrical connection must be at the 10 o'clock position to prevent fouling of the connector on the port bomb bay doors hinge mechanism during operating procedures.

Appendix 1

FORCE/DEFLECTION PLOTTER TEST SET

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. This appendix deals with the calibration of the flying control systems using the force/deflection plotter test set, as an alternative to the spring balance and inclinometer method, detailed in Chapter 4. Using the test set, the controls and rudder pedal forces are plotted in graphical form relative to control surface movement throughout the airspeed range. By comparing the resultant graphs with master traces, the following control system characteristics can be determined:-

Break-out and self centring
Force/deflection characteristics
Aileron stop range of movement

FORCE/DEFLECTION PLOTTER TEST SET

2. The test set comprises a box of equipment 26DC/95403 and a box of carriers and linkages 26DC/95401. The equipment consists of a monitor unit, recorder unit, three control force transmitters, five electrical connecting cables and a set of master traces. Three carrier assemblies and linkage mechanisms are provided to connect the recorder unit to the respective control surfaces. For checking the elevons in both the elevator and aileron sense, the connection is made to one elevon, the outer inboard only, and the aileron carrier and linkage mechanism are therefore not required for Mk.2 aircraft.

3. The equipment is arranged in the aircraft as in fig.1. The aircraft controls are functioned through the force transmitters, and control surface movement is transmitted to a magazine within the re-

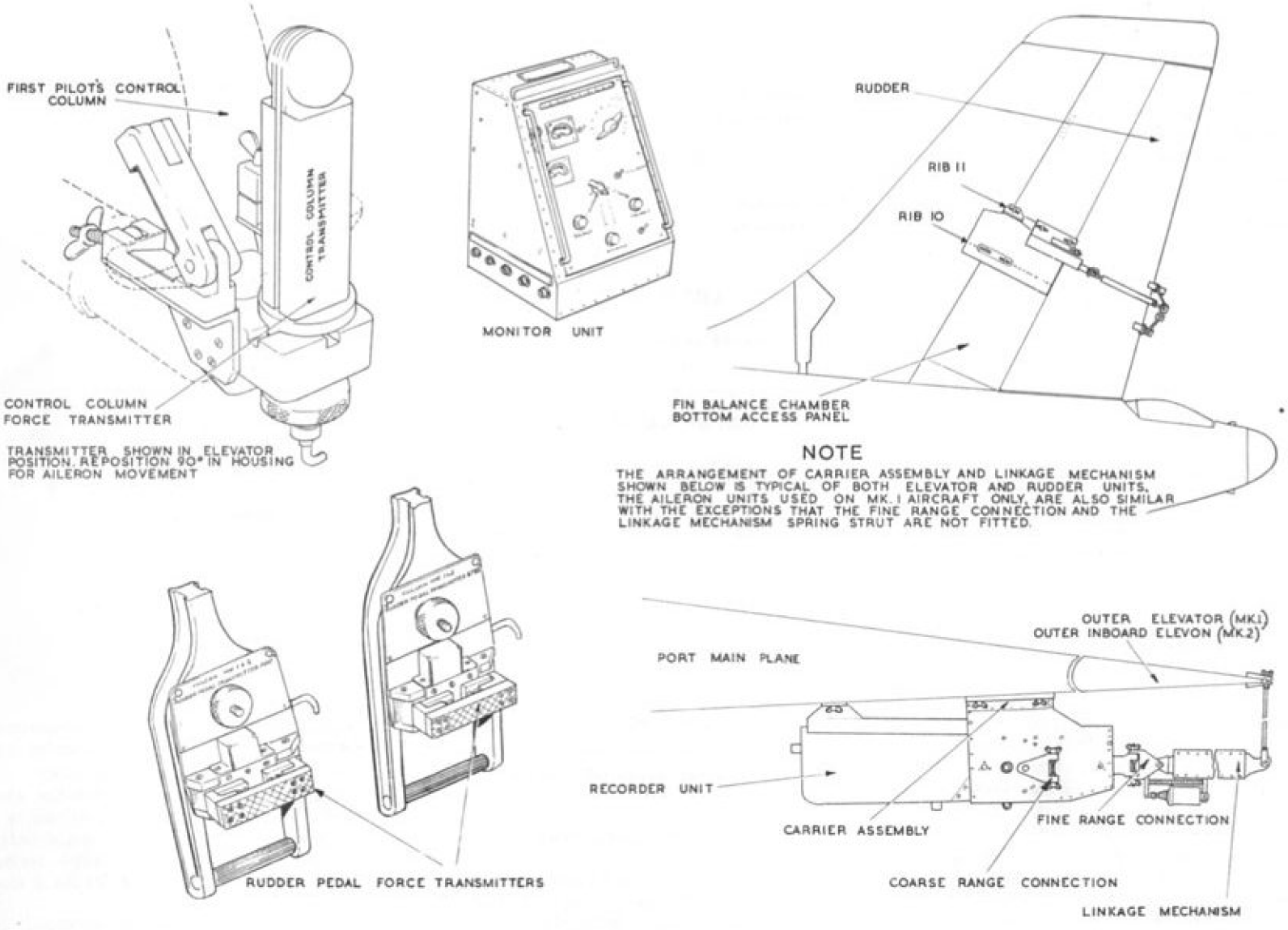


Fig.1. Arrangement of test equipment

corder unit by the linkage mechanism which is clamped to the control surface trailing edge. The graph is made on sensitised recording paper contained in the magazine. The paper moves in conjunction with the control surface and is exposed to a light beam reflected by a galvanometer which deflects in proprotion to the force applied to the transmitter. To check calibration of the aileron stops and also provide a means of identifying the individual graphs, a second galvanometer is arranged to deflect, in small steps across the paper, by operation of the airspeed selector switch. Similar galvanometers in the monitor unit operate in parallel to provide the force and airspeed light spots which are displayed on the monitor scale to give visual indication of system functioning.

4. The controls and indicators for functioning the test set are mounted on the front panel of the monitor unit as in fig.3. The magazine rewind control is mounted on the side of the recorder unit and has direction and position markings. By turning the control one revolution, the recording paper will be advanced the amount required for each individual graph. A full description of the test set will be found in A.P.1275T, Vol.1, Sect.7, Chap.24.

INSTALLATION OF TEST EQUIPMENT

5. Prior to installation in the aircraft, the test equipment must be checked for satisfactory functioning and sufficient recording paper must be available for the calibration. This check-out of equipment will normally have been made prior to issue from the Instrument servicing bay, in accordance with the procedure contained in A.P.1275T, Vol.1, Sect.7 Chap.24.

Control force transmitters

6. The control column and rudder pedal force transmitters, mounted on the respective controls at the first pilot's station, as shown in fig.1, are to be secured in position using the clamps provided. The port and starboard pedal transmitters are not interchangeable. The control column transmitter is used for elevon operation in both the elevator and aileron sense. For elevator movement the strain gauge blade must be located in a transverse position in the transmitter, and in the fore-and-aft position for aileron movement.

Monitor unit

7. The monitor unit should be positioned in the 2nd pilot's seat within convenient reach of the cabin operator.

Carrier assemblies and linkage mechanisms

8. The elevator carrier assembly is mounted to the port wing undersurface at the elevator power unit access door position. The rudder carrier assembly is mounted on the port side of the fin at the balance chamber bottom access panel. To mount the carrier assemblies, remove the five securing screws from the respective access doors at the positions shown in fig.2, and secure each assembly using the bolts provided.

9. To couple the carrier assemblies to their respective control surfaces:-

(1) Set the control surface in the neutral position.

(2) Support the link mechanism in approximate alignment with the carrier assembly gearbox and clamp the peg fittings to the control surface trailing edge.

(3) Move the gearbox driving lever against the spring action to the mid-position, and engage the link mechanism fork end in the gearbox FINE range connecting lever. Tighten the wing nuts to secure the connection.

NOTE . . .
The FINE range lever extends through the rear end of the gearbox. The alternative COARSE range connecting lever is mounted on the side of the gearbox.

Recorder unit

10. To fit the recorder unit in the carrier assemblies:-

(1) Remove the knurled locating pin from the carrier gearbox.

(2) Slacken off the knurled nut on the recorder transmission arm connecting pin and set the transmission arm in the mid-position.

(3) Slide the recorder unit into the carrier mounting rails from the rear end, and move into position so that the gearbox driven lever engages the transmission arm connecting pin, and the locating pin can be refitted to enter the transmission arm shaft.

(4) Tighten the locating pin and the connecting pin knurled nut.

Electrical connections

11. Connect the five electrical cables supplied with the test set to the monitor unit in accordance with the cable idents. Make the connections to the control column and rudder pedal force transmitters. Run out the recorder unit cable through the cabin entrance door and connect to the recorder unit. Connect the supply cable to the aircraft 28 volt d.c. supply through the lamp housing under the navigator's table; it is important that the connection is made in the correct polarity.

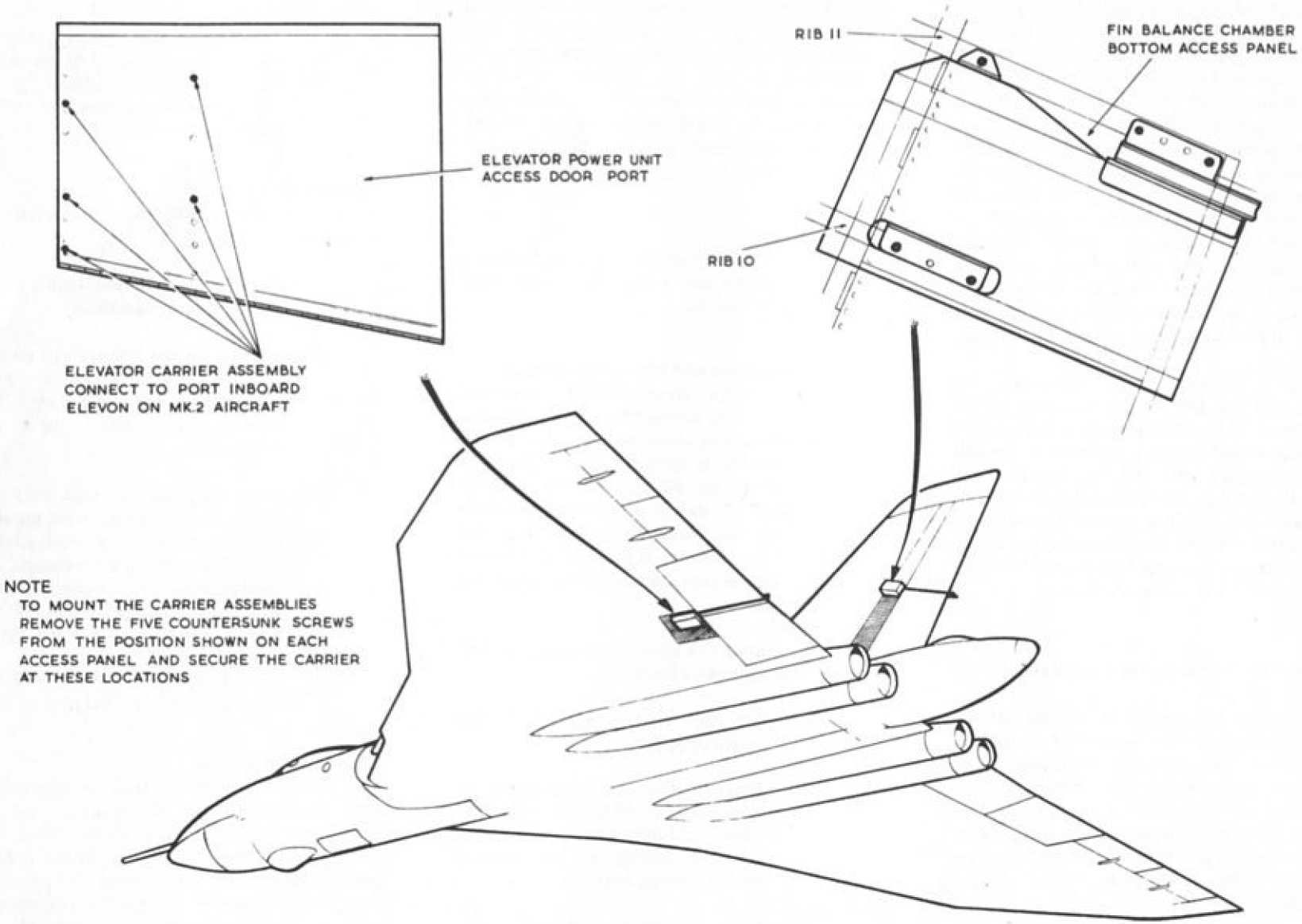


Fig. 2 Location of carrier assemblies

CALIBRATION

Calibration procedure

12. For this method of calibration three men are required. The test procedure is controlled by one operator stationed in the cabin who moves the aircraft controls and also makes the necessary selections on the monitor control panel. A second operator makes the required adjustments at the recorder unit, and a third applies varying airspeeds to the artificial feel units in the bomb compartment. A pitot test set is required to simulate airspeed at the feel unit, and electrical supplies of 28 volt d.c. and 200 volt a.c. must be available in the aircraft to operate the test equipment and to function the power units.

Precautions

13. During calibration the following points must be observed:-

(1) All connections must be made between the monitor unit and the test equipment before switching on the 28 volt supply - a warning to this effect is displayed on the monitor panel.

(2) Movement of the aircraft controls must be smooth and progressive. The applied forces must be such that the tracer light movement across the monitor scale never exceeds 2.5 inches either side of zero. This is particularly important when operating on the FINE range setting. At increased airspeed settings, full deflection of the tracer light cannot be obtained, and sufficient control movement will have been made when forces of approximately:-

25 lb. - Elevon - aileron sense

80 - 100 lb. - Elevon - elevator sense

120 - 150 lb. - Rudder

have been applied. The controls should be allowed to return to the self-centring position by slowly removing the applied force.

(3) Airspeed must always be applied to the elevator and rudder feel units in a rising direction, and to the aileron artificial feel unit in the direction of airspeed switch sequence.

(4) During calibration of elevons it is essential that the control surface is moved only in the sense in which it is being calibrated. Inadvertent sideway movement of the control column when calibrating in the elevator sense, (or fore-and-aft movement when calibrating in the aileron sense) will falsify results.

(5) All P.F.C. motors, appropriate to the system being operated, must be running during calibration. If a single motor in the system fails to run, the results will be effected.

(6) The record switch must only be set to RECORD for the minimum periods necessary to complete individual tests. At each selection to RECORD, ensure that the filament lamp in the recorder unit is illuminated by noting that the milliameter registers between 200-300mA.

Test system checks

14. With the test equipment installed and connected, check the test system as follows:-

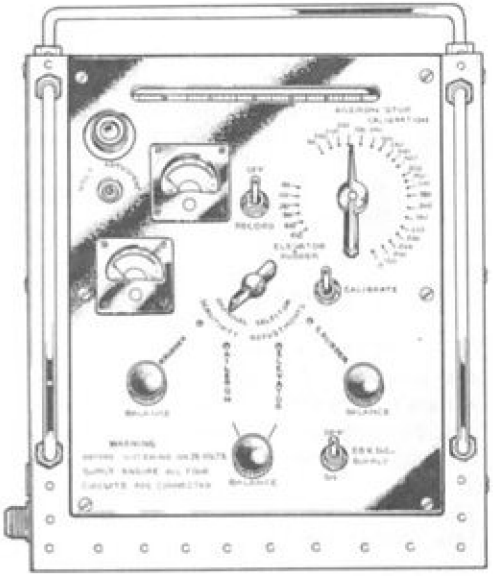


Fig.3. Monitor unit control panel

(1) Set the 28 volt supply switch to ON and check that the power ON warning lamp illuminates.

(2) Set the indicated voltage to 6 volts.

(3) Set the channel selector switch to P. RUDDER.

(4) Centralize the force trace light on the monitor scale using the appropriate balance control.

NOTE...
Two light spots will be apparent on the monitor scale. The airspeed trace light can be identified by operating the airspeed selector switch.

(5) Press the calibrate switch and check that the force trace light deflects 2.5 main divisions across the monitor scale. Adjust the appropriate sensitivity trimmer if necessary.

(6) Set the channel selector switch to AILERON, ELEVATOR and S. RUDDER in turn, and repeat operations (4) and (5) at each setting.

(7) Switch OFF the 28 volt supply at the monitor unit.

CALIBRATION CHECKS

15. Before commencing these checks the ranges of movement and friction of the aircraft control circuits, and the cut-in and cut-out speeds must have been proved satisfactory as described in Chapter 4.

16. The checks necessary for each control circuit are contained in the following paragraphs. The graphs which will result, are listed in sequence in Table 1, together with the master traces against which they are to be compared and the system characteristics which are to be determined.

Elevon controls - elevator sense

17. To check the elevon controls in the elevator sense:-

(1) Connect the pitot test set to the elevator artificial feel unit.

(2) Fit the recorder unit in the elevator carrier.

(3) Check that the linkage mechanism is connected to the gearbox FINE range setting.

(4) Set the control column force transmitter for elevator movement (see fig.1).

(5) Start the eight elevon P.F.C. motors. Ensure that the controls are in the neutral position.

(6) Switch on the 28 volt supply switch.

(7) Set the channel selector to the ELEVATOR position.

(8) Set the airspeed selector switch to 100 knots on the elevator/rudder scale.

(9) Apply 100 knots to the feel unit.

(10) Set the record switch to RECORD. Using the *pilot's control handle* move the control column forward, then allow to centralize. Switch OFF the record switch.

NOTE...

The purpose of operation (10) is to obtain a zero force reference on the plot, and only slight movement of the controls is necessary.

(11) Set the record switch to RECORD. Using the *force transmitter* move the control column forward then allow the controls to centralize. Move the control column aft then allow the controls to centralize. Switch OFF the record switch.

(12) Rotate the frame rewind control one turn.

(13) Set the airspeed selector to 150, 200, 300, 400 and 450 knots in turn on the elevator/rudder scale, and with an equivalent airspeed applied to the feel unit, repeat operations (10), (11) and (12) at each setting.

(14) Reduce airspeed at the feel unit to 100 knots.

(15) Set the airspeed selector switch to 100 knots on the elevator/rudder scale.

(16) Disconnect the link mechanism lever and reconnect to the gearbox COARSE range connection.

(17) Repeat operations (10), (11) and (12) at the 100, 150, 200 and 300 knots airspeed settings.

(18) Reduce airspeed at the feel unit and airspeed selector switch to ZERO.

(19) Stop the P.F.C. motors.

Elevon controls - aileron sense

18. To check the elevon controls in the aileron sense:-

(1) Connect the pitot test set to the aileron artificial feel unit.

(2) Fit the recorder unit to the elevator carrier and connect the extension cable loom.

(3) Connect the linkage mechanism to the gearbox FINE range setting.

(4) Set the control column force transmitter for aileron movement.

(5) Start the eight elevon P.F.C. motors. Ensure that the controls are in the neutral position.

(6) Switch on the 28 volt supply switch.

(7) Set the channel selector to the AILERON position.

(8) With zero airspeed at the feel unit, set the airspeed selector switch to zero on the aileron stop calibration scale.

(9) Set the record switch to RECORD. Using the *pilot's control handle* move the control column to port, then allow to centralize. Switch OFF the record switch.

NOTE...
The purpose of operation (9) is to obtain a zero force reference on the plot, and only slight movement of the controls is necessary.

(10) Set the record switch to RECORD. Using the *force transmitter* move the control column fully to port then allow the controls to centralize. Move the control column fully to starboard then allow the controls to centralize. Switch OFF the record switch.

(11) Rotate the frame rewind control one turn.

(12) Disconnect the link mechanism lever and reconnect to the gearbox COARSE range connection.

(13) With zero airspeed still selected, repeat operations (9) and (10).

(14) Rotate the frame rewind control one turn.

(15) Set the airspeed selector switch to 150 knots on the aileron stop calibration scale.

(16) Apply 150 knots airspeed to the feel unit.

(17) Set the record switch to RECORD. Using the *pilot's control handle* move the control column fully to port then allow the controls to centralize. Move the control column fully to starboard then allow the controls to centralize. Switch OFF the record switch. DO NOT MOVE THE FRAME REWIND CONTROL.

(18) Progressively move the airspeed selector switch to 200, 250, 300, 320, 340, 360, 380, 400, 420, 450, 420, 400, 380, 360, 340, 320, 300, 250, 200 and 150 knots on the aileron stop calibration scale, and with an equivalent airspeed applied to the feel unit, repeat operation (17) at each setting.

(19) Rotate the frame rewind control one turn.

(20) Reduce airspeed at the feel unit and the airspeed selector switch to zero.

(21) Switch OFF the 28 volt supply at the monitor unit.

(22) Stop the P.F.C. motors.

Rudder controls

19. To check the rudder controls:-

(1) Connect the pitot test set to the rudder artificial feel unit.

(2) Fit the recorder unit to the rudder carrier and connect the extension cable loom.

(3) Check that the link mechanism is connected to the gearbox FINE range setting.

(4) Start the rudder P.F.C. motors. Ensure controls are in the neutral position.

(5) Switch ON the 28 volt supply switch.

(6) Set the airspeed selector switch to 100 knots on the elevator/rudder scale. Apply 100 knots to the feel unit.

(7) Set the record switch to RECORD. Using the *pilot's rudder pedals* move the rudder bar, then allow to centralize. Switch OFF the record switch.

NOTE...
The purpose of operation (7) is to obtain a zero force reference on the plot, and only slight movement of the controls is necessary.

(8) Set channel selector switch to P. RUDDER. Set the record switch to RECORD. Using the *force transmitter* move the port rudder pedal forward then allow to centralize. Switch OFF the record switch. Set the channel selector to S. RUDDER. Set the record switch to RECORD. Using the *force transmitter* move the starboard rudder pedal forward then allow to centralize. Switch OFF the record switch.

(9) Rotate the frame rewind control one turn.

(10) Set the airspeed selector switch to 150, 200, 300, 400 and 450 knots in turn on the elevator/rudder scale, and with an equivalent airspeed applied to the feel unit, repeat operations (7), (8) and (9) at each setting.

(11) Reduce airspeed at the feel unit to 100 knots.

(12) Set the airspeed selector switch to 100 knots on the elevator/rudder scale.

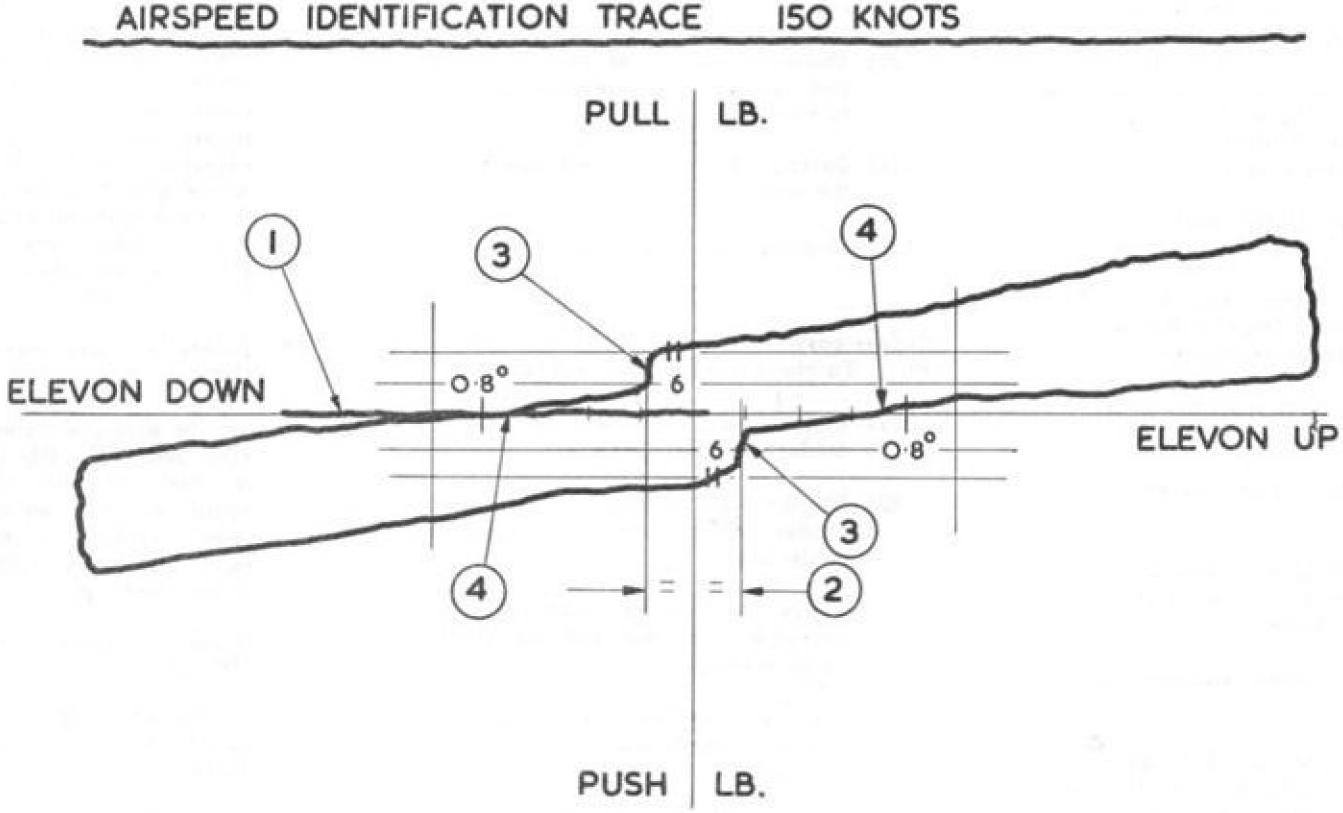
(13) Disconnect the link mechanism and reconnect to the gearbox COARSE range connection.

(14) Repeat operations (7), (8) and (9) at the 100, 150 and 200 knots airspeed settings.

(15) Reduce airspeed at the feel unit and airspeed selector switch to zero.

(16) Switch OFF the 28 volt supply at the monitor unit.

(E8) ELEVON (ELEVATOR SENSE) FINE RANGE BREAKOUT AND SELF-CENTRING



To check break-out and self-centring (all systems):

(1) Position Master trace on graph and set horizontal axis on zero force trace.

(2) Set vertical axis midway between break-out points.

(3) Break-out points must be within limits marked on Master trace.
i.e., For elevon (elevator sense) as shown, between 6 and 11 lb.

(4) The self-centring position is the point at which the graph cuts the horizontal axis, and must be within the limits marked on the Master trace.

i.e., For elevon (elevator sense) as shown, 0.8° or less from centre.

Fig.4. Break out and self-centring calibration

(17) Stop the P.F.C. motors.

Assessment of results

20. On completion of checks, remove the recorder unit by reversing the procedure detailed in para.10, and return to the instrument bay for film processing.

21. The graphs should be in the form of continuous curves of reasonably smooth contour. Elevator and rudder system graphs will include a zero force trace to provide a reference for aligning the master trace horizontal axis, and an airspeed identification trace. The position of the identification trace varies with the airspeed setting, and will appear near to the top edge of the frame at 450 knots and move progressively inwards with decreasing airspeeds.

22. To interpret the results, select the master trace appropriate to the graphs as listed in Table 1. With the trace in position on the graph check the respective circuit characteristics as follows:-

Break-out and self-centring

A typical graph and the method of determining break-out and self-centring is shown in fig.4.

Force/deflection characteristics

A typical graph and the method of determining the force/deflection characteristics is shown in fig.5 for rudder and elevator circuits, and in fig.6 for the aileron circuit.

Aileron stop calibration

A typical graph of aileron stop calibration is shown in fig.7.

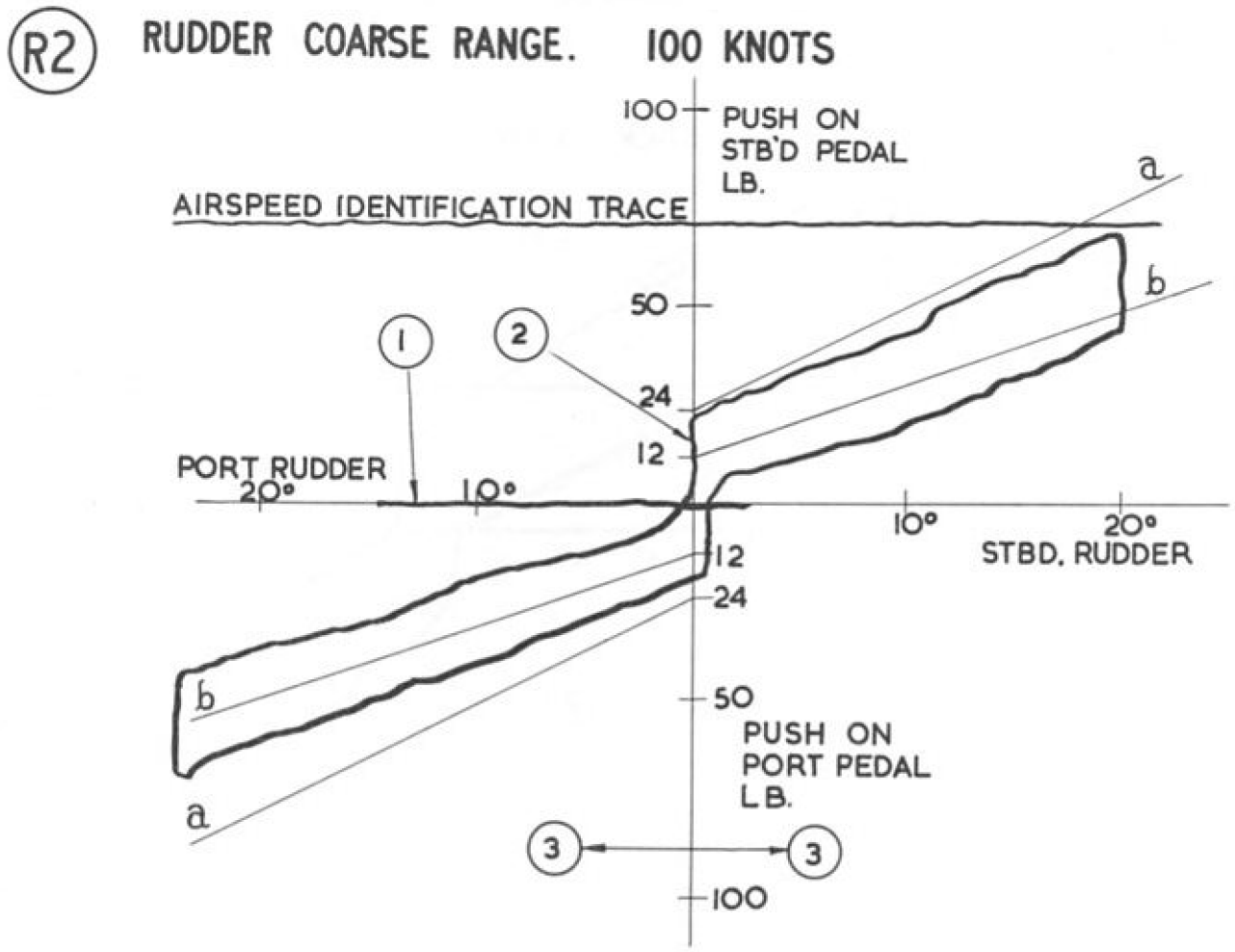
After test

23. Remove and stow the test equipment. Reconnect the artificial feel units to the aircraft pitot system and make independent checks on the system in accordance with current procedure.

TABLE 1

List of graphs and master traces

	Graph No.	Range	Airspeed	Master trace(s)	
Elevon - elevator sense	1	Fine	100	E8	(1) Check break-out and self-centring at 6 airspeeds, (Graphs 1 to 6) using single Master trace E8.
	2	Fine	150	E8	
	3	Fine	200	E8	
	4	Fine	300	E8	
	5	Fine	400	E8, E13	(2) Check force/deflection characteristics at 6 airspeeds (Graphs 5 to 10) using the individual Master traces specified.
	6	Fine	450	E8, E14	
	7	Coarse	100	E9	
	8	Coarse	150	E10	
	9	Coarse	200	E11	
	10	Coarse	300	E12	
Elevon - aileron sense	11	Fine	Zero	A4	(1) Check Graph 11 for break-out and self-centring using Master trace A4.
	12	Coarse	Zero	A5	(2) Check Graph 12 for force/deflection characteristics using Master trace A5.
	13	Coarse	150/450	A6	(3) Check Graph 13 for aileron stop calibration using Master trace A6.
Rudder	14	Fine	100	R1	(1) Check break-out and self-centring at 6 airspeeds, (Graphs 14 to 19) using single Master trace R1.
	15	Fine	150	R1	
	16	Fine	200	R1	
	17	Fine	300	R1, R5	
	18	Fine	400	R1, R6	
	19	Fine	450	R1, R7	(2) Check force/deflection characteristics at 6 airspeeds, (Graphs 17 to 22) using the individual Master traces specified.
	20	Coarse	100	R2	
	21	Coarse	150	R3	
	22	Coarse	200	R4	



To check rudder and elevator force/deflection characteristics:

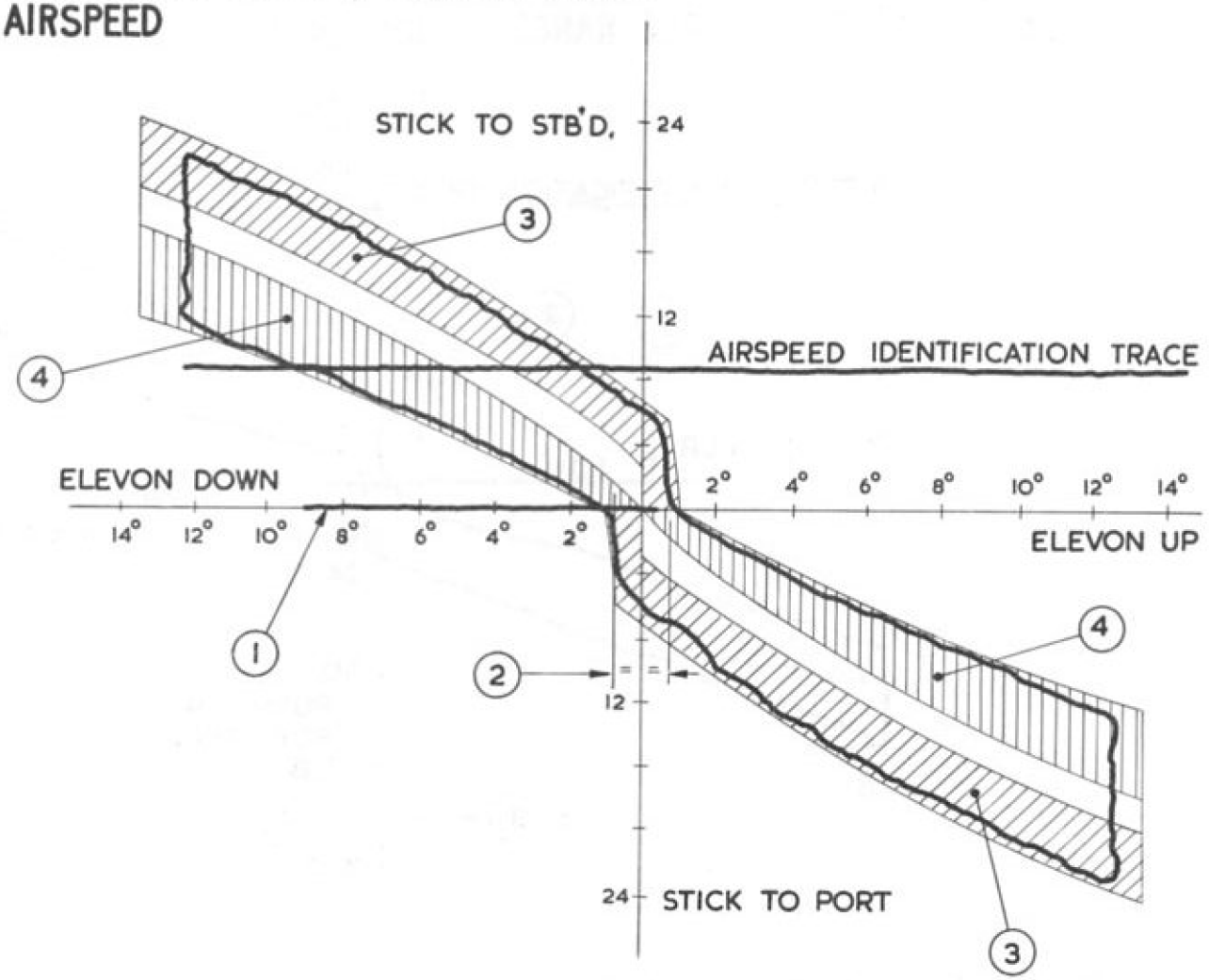
(1) Position Master trace on graph and set horizontal axis on zero force trace.

(2) Align the vertical axis with each break-out point in turn and check that the traces of increasing force lie between the limit lines *a* and *b*.

(3) Move the Master laterally and check that the traces of increasing force each have a slope that is not more than that of *a* or less than that of *b*.

Fig.5, Force/deflection calibration - rudder and elevon (elevator sense)

(A5) ELEVON (AILERON SENSE) COARSE RANGE ZERO AIRSPEED



To check aileron force/deflection characteristics:

(1) Position Master trace on graph and set horizontal axis on zero force trace.

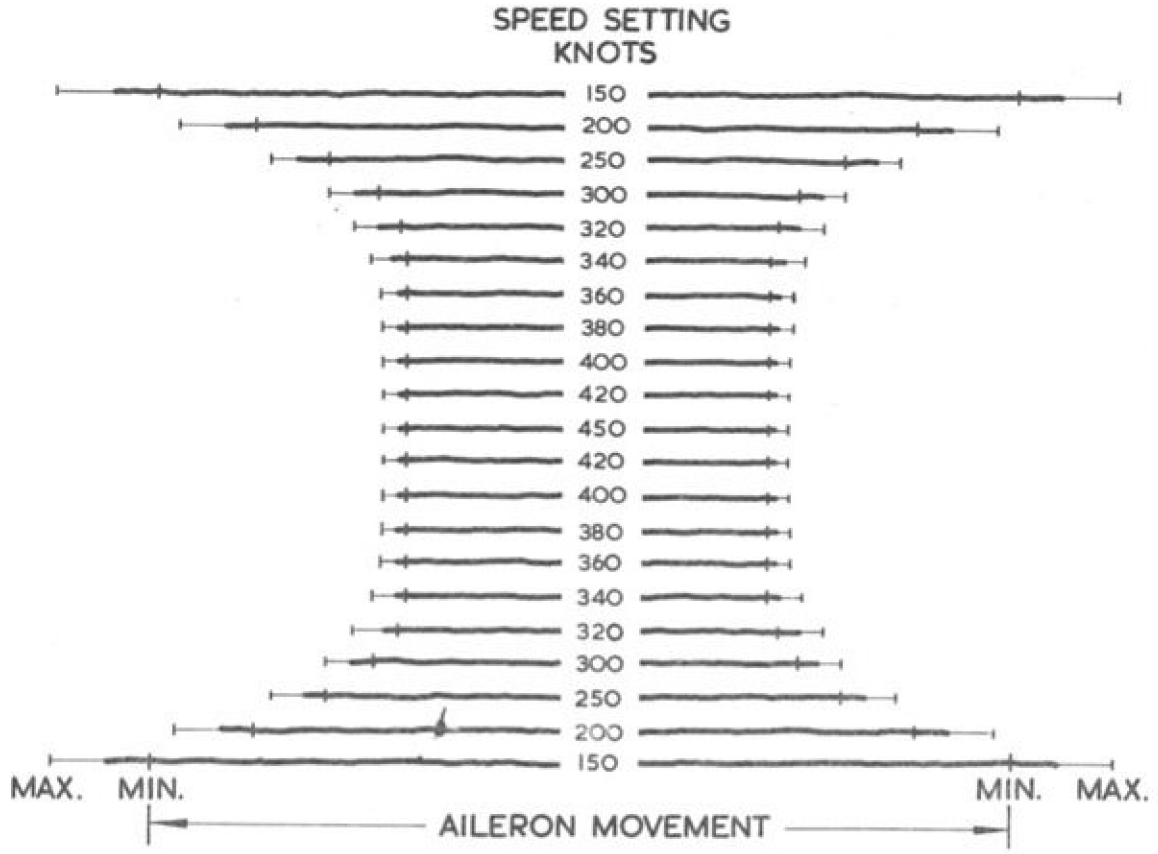
(2) Set vertical axis midway between the break-out points.

(3) Traces of increasing force must be within the areas marked thus ////

(4) Traces of decreasing force must be within the areas marked thus ||||

Fig.6. Force/deflection calibration - elevon (aileron sense)

(A6) ELEVON (AILERON SENSE) COARSE RANGE STOP CALIBRATION



To check aileron stop calibration:
Position the Master trace on the aileron movement traces. At each airspeed the movement trace must extend between the limits appropriate to that speed.

NOTE...
The vertical spacing of the traces may not be perfectly regular and it is permissible to move the Master up or down to allow for this.

Fig.7. Aileron stop calibration