Chapter 4

FLYING CONTROLS

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29. EMERGENCY TRIM CONTROL
    Used in natural sense. Centre button must be depressed whilst operating.

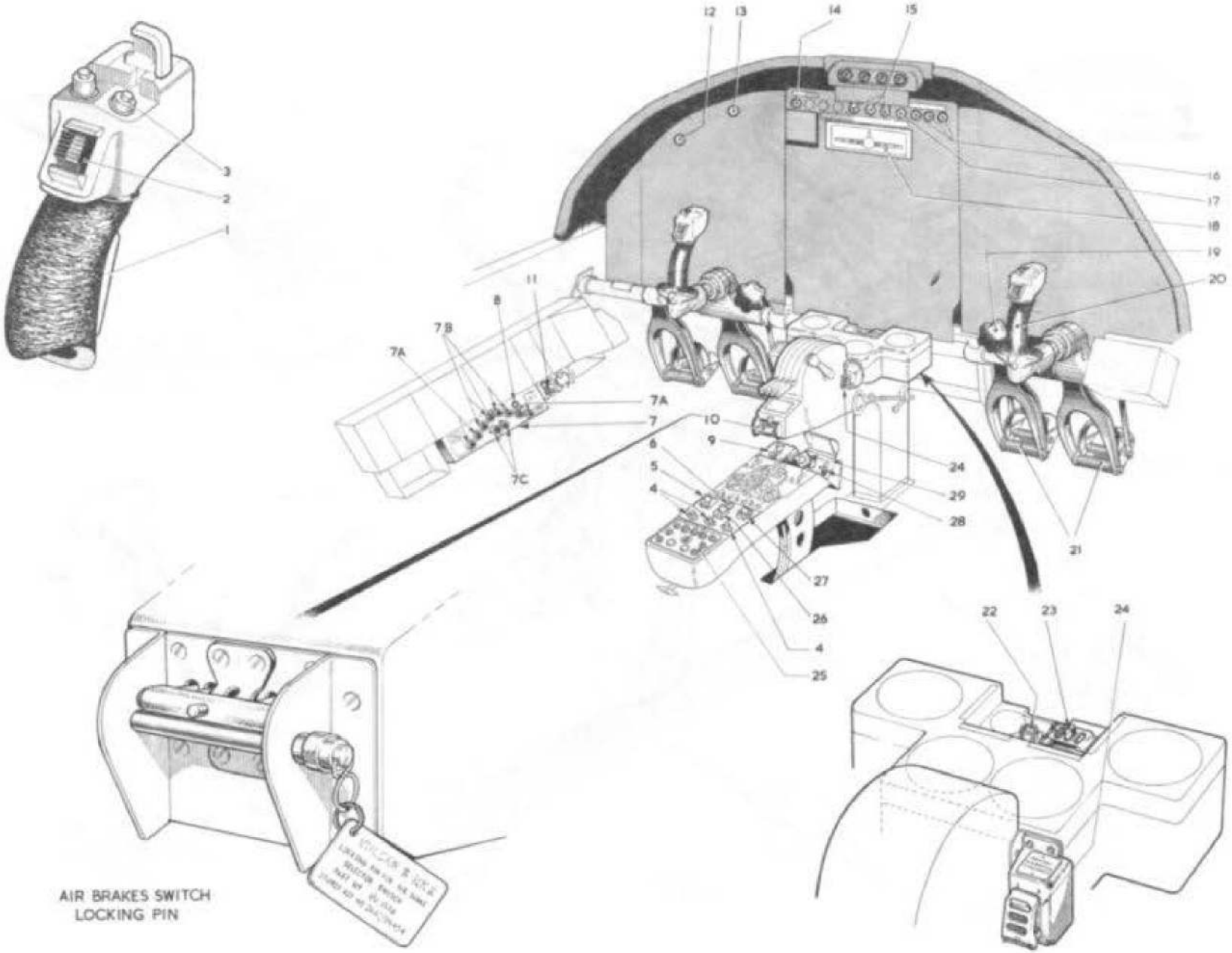


Fig. 1. Flying controls and indicators in cockpit
(◄ Mod. 1927 ►)

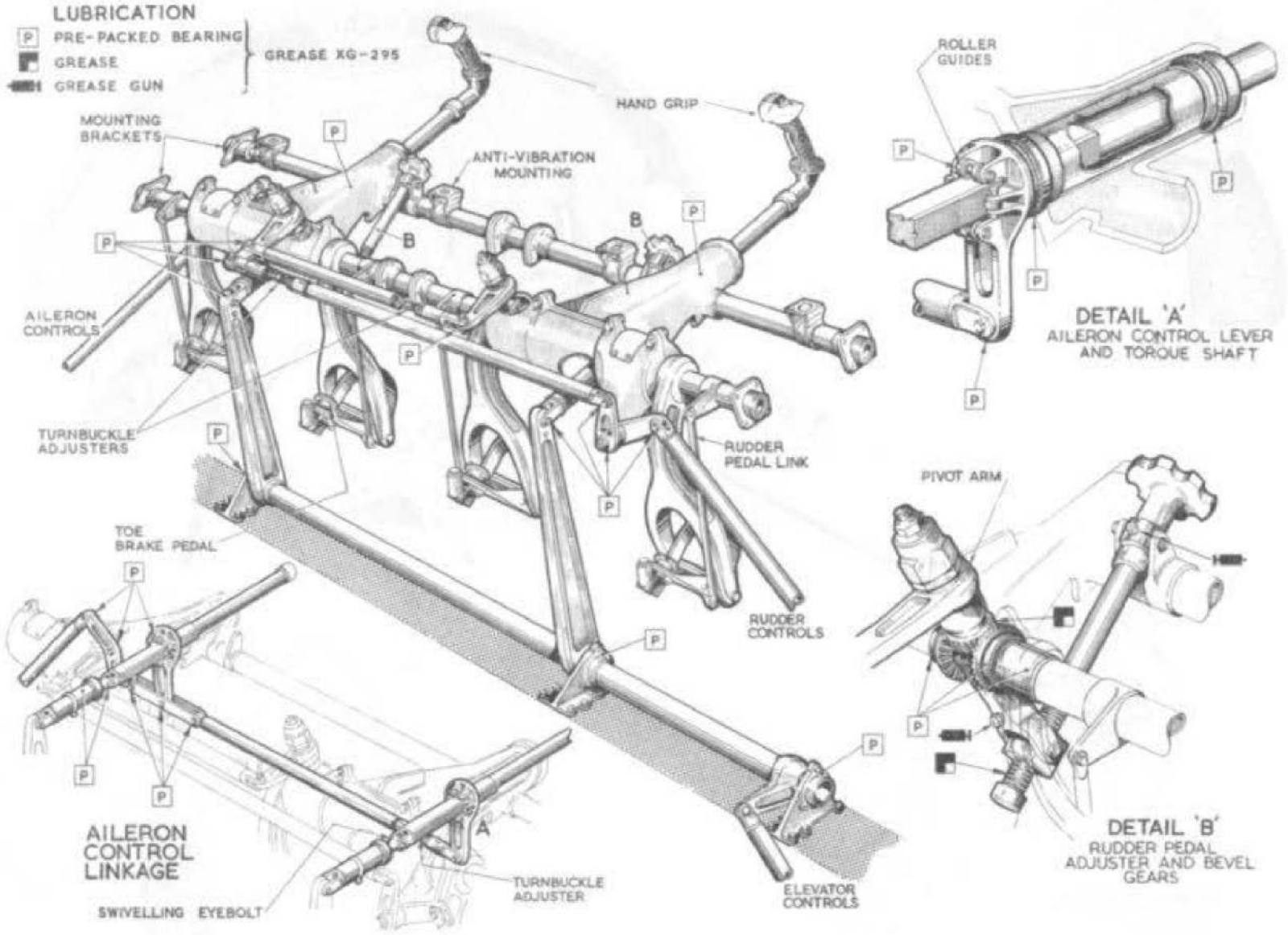


Fig. 2 Cockpit controls mechanism

DESCRIPTION

Introduction

1. Conventional aileron, elevator and rudder control surfaces are fitted to this aircraft, operated by electro-hydraulic power units. Since there is no tail plane, the elevators are hinged into the outer plane trailing edges inboard of the ailerons. Internally sealed balances at the leading edges of the control surfaces relieve the operating loads.

2. To guard against complete loss of aileron or elevator control, in the event of a power unit failure, the control surfaces are divided into half sections, each operated by its own power unit. Should one of a pair of units fail, the half section normally controlled by the failed unit will assume a trailing position, and the remaining unit continue to operate the other half section so that control of the aircraft is maintained. Safety in operation of the single rudder control surface is obtained by arranging its two power units in parallel so as to operate opposite ends of the rudder actuating arm, which is pivoted at its centre. Only one unit is necessary to operate the surface, the auxiliary unit coming into use automatically if the main unit should fail.

3. Dual interconnected control columns and rudder pedals are provided in the pilots' cockpit. Tubular push-pull rods supported in triple-roller bearings are used throughout the aircraft from the cockpit controls to the associated power units. To prevent loss of cabin pressure the rods pass through seals fitted to the cabin pressure bulkhead.

4. Artificial loading of the cockpit controls, as a function of aircraft speed, is introduced by spring-loaded feel units (para.22). Provision is made to trim the loads with the changes of aircraft trim.

COCKPIT CONTROLS AND INDICATORS

General

5. A brief description of the various switches and indicators is given in this chapter, comprehensive details of their operation and functions are given in Book 2, Sect.5, Chapter 1 of this publication.

Power units

6. A panel on the centre console (fig.1), located aft of the fuel control panel, houses three push-button type START switches for the aileron, elevator and rudder power units. On the port console a group of ten push-button STOP switches, one for each power unit, is provided so that units may be switched off independently. A magnetic indicator adjacent to the STOP switches, indicates when all power units are OFF. During operation, visual indication of the state of the power units is given by warning lamps, at the top of the centre instrument panel, which illuminate if their associated power unit is not functioning correctly.

Trim controls

7. For normal trim control of ailerons and elevators, a two-axis switch is provided on each pilot's control handle, and for the rudder a switch is located on the fuel contents gauges panel forward of the throttle levers. For emergency trim control, when required, a covered switch is provided at the forward end of the centre console, a push-button fitted in the centre of the switch must be operated before the switch can be used. The emergency switch is used in a natural sense, forward or rearward for longitudinal trim, sideways for lateral trim and rotated to adjust directional trim. A reset switch, adjacent to the emergency switch, is used to restore normal trim control, if required, after it has been cut out for any reason.

Artificial feel control

8. Should it be necessary to reduce the load on the flying controls, the artificial feel mechanism of the aileron and elevator feel units can be reduced to the low speed condition by pressing either of the two push switches, fitted one on each pilot's control handle. A separate artificial feel relief switch for the rudder unit is fitted on the fuel contents panel forward of the throttle levers. The artificial feel can be reset to normal from the relieved condition by operating the appropriate power unit START switch on the centre console. Magnetic indicators at the top right of the centre instrument panel show when the units are set to the reduced feel position.

Automatic systems

9. Control switches for the auto-mach trim, yaw damping and pitch damping systems are located on the centre console immediately forward of the power control unit START switches. A magnetic indicator on this panel shows black when the actuator in the auto-trim system is fully retracted and white when the actuator is not fully retracted, i.e., when the system is trimming.

Control columns

10. 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 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 columns by swivel-jointed links which permit handgrip 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 a 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 handgrip push-pull column inside the aileron lever assembly.

AILERON CONTROLS

11. Aileron movement is effected by part rotation of the control handgrip, which has a range of movement of 42 degrees 17 minutes each side of the vertical position. As the handgrip is rotated, simultaneous movement of the aileron lever occurs, driven by the square section of the handgrip 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 boss of aileron lever. Two of the guide rollers, the one on the bottom and the one on the port side, are adjustable. Port and starboard assemblies are identical and move in unison, an adjustable control rod with connecting links joining the two pendulum aileron levers. At the starboard side the links extend 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 fuselage run is stepped outboard by a counter lever at former 72F., then continued through the bomb compartment to terminate at the lower lever of a three levered torque tube assembly immediately aft of the rear spar. From the upper lever of this torque tube assembly, push-pull rods run outboard, port and starboard, to the power units actuating the control surfaces.

ELEVATOR CONTROLS

12. Elevator movement is effected by push-pull action of the control hand grips, which have a normal fore-and-aft range of 7·453 inches. 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 control run is stepped outboard at former 72F. by a counter lever and then continues through the fuel bay to the forward end of the bomb compartment. 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 aft rod immediately below. This arrangement reduces the linear travel of the rear rod, which continues aft, through the servomotor of the automach trimmer system, to engage the bottom arm of a three levered torque assembly aft of the rear spar. From the upper lever of this assembly, control rods run outboard to port via an intermediate lever to connect to the upper lever of a torque tube arrangement at the main plane spar joint, from the lower lever of which a control rod runs outboard to the power units actuating the elevators. The starboard control run moves in opposition to the port, driven by a second torque assembly, intercoupled with the first, aft of the rear spar. From this point the lay-out and components are identical with the port side.

RUDDER CONTROLS

13. 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 mount 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.

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

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

(4) A pivot shaft, which mounts the single pinion between the two 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 nut. Each adjuster shaft is extended and fitted with a knurled handwheel within easy reach of the pilot. Clockwise turning of the handwheel works both pedals towards the pilot, the full range of the operating screw giving approximately 11 in. of leg adjustment.

14. All other movements are synchronised by a link between the forward facing levers, movement by either pilot being taken from the starboard unit by a push-pull tube to a bell-crank assembly on the port unit. From this point a vertical push-pull rod transmits movement, via a bell-crank lever below the floor, to longitudinal push-pull rods. These continue down the port side of the fuselage rear section, from where they pass inboard through the servomotor 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 related power units by fore-and-aft telescopic rods.

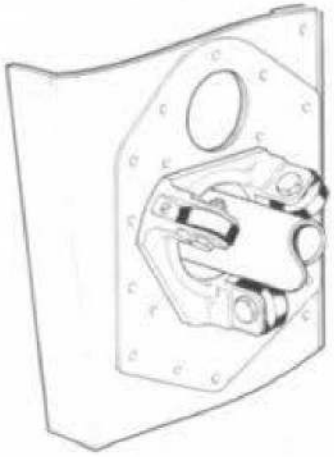


Fig.3. Typical three-roller bearing

CONTROL STOPS

15. Two fixed collars are fitted on one of the push-pull rods in each control system, each pair of collars being positioned on either side of a U-shaped stop bracket bolted to the aircraft structure. All the stops, which are similar, are fitted to the forward face of former 288F, in the crew's nacelle. In the aileron and rudder systems, movement of the control run in either direction is limited by these stops. In the elevator system, with the auto-trim servo actuator installed in the control run, limitation of movement is obtained by employing secondary stops at the inboard power unit trunnion levers as well as the control rod stops, so that the required range of control movement may be obtained whether the actuator is extended or retracted The methods for setting and checking control stops are given in the control rigging instructions in the servicing section of this chapter.

16. Each push-pull rod collar comprises a screwed sleeve and an adjuster nut with a slotted extension. Initially the sleeve is riveted to its related push-pull rod with the adjuster nut free. When the required movement is obtained, the sleeve and rod are drilled through one of the slots and the nut is locked by a split-pinned bolt; no further adjustment is normally required. The secondary stops at the inboard power unit trunnion levers in the aileron and elevator systems are not adjustable.

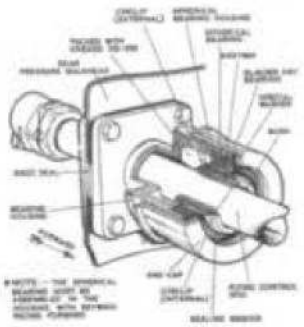


Fig.4. Control rod pressure seal bearing

POWER UNITS

General

17. Ten power control units are incorporated in the flying controls 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 inter-connected, have various additional valves. There are three variations of the basic unit used, those for the ailerons and elevators being manufactured in the left-hand and right-hand form, whilst for the rudder a dual unit is used comprising a main and auxiliary unit interconnected by a flexible pipe. When mounted in the aircraft, each unit is supported by its hydraulic ram which is attached to the aircraft structure by means of its non-moving parts. The moving part of 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.

18. Each power control unit is self-contained, and consists essentially of an electric motor, a hydraulic ram 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

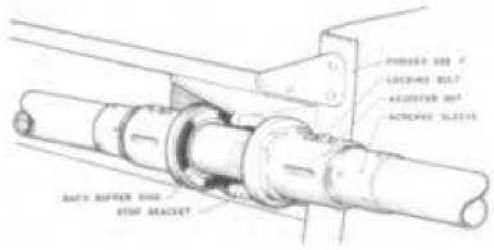


Fig.5. Control rod stops

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 ram which, by movement of the ram rod, operates the control surface. When the control surface obtains a position relative to the displacement of the cockpit control the fluid supply to the ram is automatically cut off and the surface ceases to move, remaining in this position until a further input movement is received by the power unit. Reference should be made to A.P.4603 series for complete descriptive and operating details of the power units.

Elevator units

19. Each elevator unit is housed in a separate compartment built into the wing 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 port and starboard walls of the compartment and it pivots in bearings secured to the walls. A further pivot bolt secures the hydraulic jack piston rod end to an operating lever on the elevator portion concerned. Incorporated on the unit tail piece is a damper valve assembly, this provides a

hydraulic lock which restricts movement of the associated control surface following failure of the unit in flight. The damper valve also acts as a control surface movement damper when the aircraft is parked.

Aileron units

20. The trailing edge section towards the outboard end of the wing is restricted in depth, consequently the aileron power control units are contained in the wing. Each unit is housed in a separate compartment formed by two wing ribs and the front and rear spars. The tail piece of the unit is secured by a single pivot bolt to a trunnion beam which is located, laterally across the compartment, in bearings secured to the two wing ribs. The hydraulic jack is connected by a further pivot bolt to the lower end of a swinging lever. This lever is secured to a shaft which is located, laterally across the compartment, in bearings secured to the two wing ribs. A push-pull rod connects the swinging lever to the operating lever on the aileron portion concerned. A damper valve, secured to the unit tail piece, restricts movement of the associated control surface following failure of the unit or when the unit is switched off. When the aircraft is parked with the control surface in neutral a high load on the control surface will cause the surface to move to the up position only. Should a failure occur in flight the damper valve allows the control surface to assume the no-load position from the down position. Should the failure occur with the surface in the up position, movement to the no-load position is dependent on the loads on the surface and the leak rate through the damper valve.

Rudder units

21. 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. The main unit is fitted on the starboard side and the auxiliary unit on the port side. Each unit is attached by two pivot bolts, one bolt locates the attachment lug, at the rear of the tailpiece, with a support beam secured to the forward face of former 487·5 A. The second bolt locates the jack piston rod end with one arm of a horizontal rocker lever secured to the base of the rudder post. Normally the control surface is operated by the main unit with the auxiliary unit idling. Should a failure of the main unit occur, operation of the control surface is taken over by the auxiliary unit. A damper valve, secured on the tail piece of the auxiliary unit, restricts movement of the control surface following failure of both units or when both units are switched off. The action of the damper valve, when both units fail or are switched off, prevents the ram of the auxiliary unit from moving inward, the ram can move to the fully out position dependent on the loads on the control surface.

ARTIFICIAL FEEL UNITS

General

22. With the introduction of power control units to operate the control surfaces, the aerodynamic forces with which a pilot is familiar on manually-controlled aircraft are no longer apparent. The control column and rudder bar forces are therefore supplied synthetically. Three feel simulator units are provided, all similar in operation, but each adapted to give the degree of feel required for its particular control.

23. 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. The feel units are positioned as follows:-

Starboard side of the bomb compartment:-
Aileron unit, between formers 279·092A and 300·954A.

Port side of the bomb compartment:-
Elevator unit, between formers 279·092A and 300·954A.
Rudder unit, between formers 201·367A and 255·227A.

24. All feel units incorporate similar components housed inside a light-alloy box-type housing attached to the airframe structure. A single unit consists of:-

(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, and in the case of the ailerons to provide simple feel up to normal full movement.

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

(4) A follow-up transmitter, cam-driven from the fulcrum point.

(5) An emergency linear actuator in the bottom of the housing, connected to a swinging lever which also anchors the fulcrum actuator.

(6) A vertical link connecting the box spring unit and the lower input shaft. This engages, by a slotted guide track, a roller on the lower 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. Full electrical details are given in Sect.5, Chap.1 of this Volume.

The feel actuator can be locked in any predetermined position by manual selection of a switch located forward 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.

Operation of aileron feel unit

25. This unit is designed to provide simple spring feel giving approximately 11 ± 2 lb. stick force for full aileron movement up to 312 knots indicated air speed. Above this speed the aileron range available in normal conditions is progressively cut down to 5·36 to 7·24 degrees at 412 knots indicated air speed.

26. Movement of the pilot's 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 by the pre-loaded spring fitted on the shaft. This movement of the input shaft causes angular movement of the vertical link which, pivoting about the fulcrum roller, moves the shaft of the boxed spring unit in the top of the feel unit casing. This shaft has unresisted movement in either direction of 0·525 inches, which corresponds with the normal full range of the aileron controls; it then comes against sliding stops inside the spring unit which offer considerable resistance to further movement, being heavily loaded by a spring located between them.

27. As airspeed changes above 312 knots, the fulcrum roller on the torque lever moves in the vertical slotted guide track, its position being regulated by the normal function actuator which is controlled by the external airspeed-sensitive transmitter in conjunction with the internal follow-up transmitter. With increase of airspeed, the external transmitter moves out of synchronisation with the internal transmitter and a current flow passes through the normal actuator, which retracts and causes the short torque lever to which it is attached to rotate the feel unit cross shaft, thereby causing downward 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 normal actuator is stopped.

28. As the fulcrum roller moves lower in the slotted guide track, the amount the input shaft moves to take up the free movement in the boxed spring unit is reduced. The input shaft being operated through the main control run, it follows that the normal movement of the pilot's control is reduced and also the aileron range, until at the lowest position of the roller the available aileron movement up or down is 6·2 degrees. With decreasing airspeed the actuator extends and the roller rises in the guide track, permitting increased aileron movement.

29. Should aileron movement greater than normal be required in an emergency, it can be obtained by considerably increasing the stick force to move the stops in the upper boxed spring unit against their heavily loaded springs.

Operation of elevator and rudder units

30. These units are designed to provide increase of loading of the pilot's controls proportionate to control surface angular movement and indicated air speed.

31. The two units are identical, each, housing components similar to those in the aileron unit. In the case of the elevator and rudder units, however, the lower spring unit on the input shaft is purely a control system self-centring spring, pre-loaded to overcome circuit friction. The upper boxed spring unit differs from the one in the aileron feel unit in that no unrestricted movement of its shaft is given, resistance by the internal spring being immediate and increasing progressively with increased movement of the shaft and being felt, through the vertical link and the feel unit input shaft, as an increasing resistance to movement of the pilot's controls.

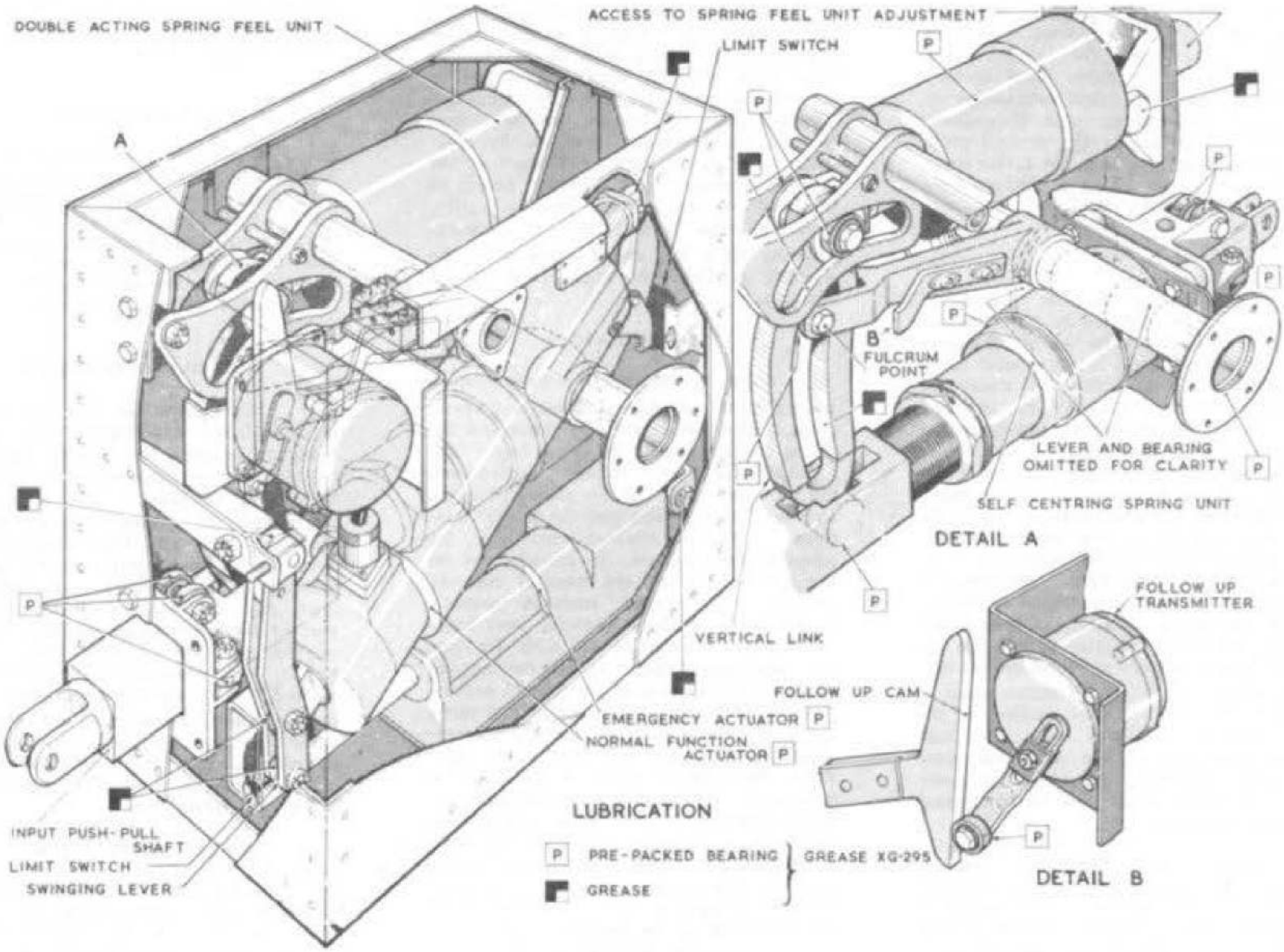


Fig.6. Feel simulator

RESTRICTED

32. As airspeed changes, the fulcrum roller moves in the slotted guide track its position being regulated in the same manner as in the aileron unit. With an increase of airspeed, 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 decreasing airspeed the roller rises in the guide track, giving a progressively lower loading in the control rods.

Artificial feel relief

33. The load, or feel on the pilots' controls can be reduced to the minimum at any time, in flight, by use of the appropriate relief switches in the pilots' cockpit (para.8). This action will cause the emergency linear actuator in the selected unit, or units, to retract, carrying the swinging anchor point of the normal functioning actuator towards the centre of the casing. Initial movement of the swinging lever releases a micro switch to break the electrical circuit of the main actuator, thus preventing any further operation by it, during the relief selection. Movement of the swinging lever, due to the retraction of the emergency actuator, is transmitted through the main actuator to operate the torque levers and therefore rotate the unit cross shaft, causing the fulcrum roller to move to the minimum feel position at the top of the slotted guide track. A limit switch mounted on the unit end plate terminates electrical supply to the emergency actuator when the minimum feel position is reached.

34. Normal feel conditions can be regained by operating the relative powered control unit start switch. This operation completes an electrical circuit to the relief actuator which then extends until stopped by its own internal limit switch. This extension moves the swinging lever back to the wall of the unit casing, causing the fulcrum roller to move down the guide track. The final movement of the swinging lever depresses a micro switch to complete the electrical circuit to the main actuator, which then moves the fulcrum roller until the airspeed and follow-up transmitter are again synchronised. The feel relief actuators can be locked in any pre-determined position by operation of a switch located forward 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.

TRIM ACTUATORS

35. 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. The actuators function to increase or decrease the effective length of the push-pull tubes between the feel unit and the pilots' controls. The position of zero force, for ailerons and rudders, is usually set on the ground to set the cockpit controls central with control surfaces neutral. In the case of the elevators, zero force position for take-off is set with the control surfaces 3 deg. above the rigging neutral, in this position the control surface position indicator on the instrument panel registers the elevators and the centralised ailerons as one continuous line. When the trim actuator is extended or shortened, the pilots' controls take up a new position of zero force, and in consequence a hydraulic selection is made in the related power control unit to reposition the control surface to correct for the change in trim. Operation of the actuators is by natural sense movement of selector switches in the pilots' cockpit (para.7). In each case the actuator is a single unit containing two electric motors, one motor only being used for normal trim actuation and the second serving as an emergency standby in the event of failure of the first motor. Complete electrical details are given in Sect.5, Chap.1 of this volume.

AUTOMATIC PILOT

36. An electric automatic pilot system is installed which includes three separate units coupled into the major control systems. For the positions of the units see the relevant rigging diagram, for the position of cockpit controls refer to fig.1. Further information on the automatic pilot is included in Sect.5, Chap.2 of this Volume.

PITCH DAMPER SYSTEM

37. This system is basically a Mk.2 auto-stabiliser installation, its purpose being to improve the natural damping of any pitching oscillations of the aircraft at high mach numbers. The equipment is duplicated to operate separate elevator surfaces, and, with the exception of the servo-motors and control switch gear, is mounted in the forward port side of the bomb bay. The twin servo-motors form part of the mechanical feedback linkages of the outboard elevator power control units. A two-position control switch, marked ON - OFF, is located on the centre console immediately aft of the fuel control panel. For descriptive details of the pitch damper system reference must be made to Sect.5, Chap.2 of this Volume and in A.P.1469S, Vol.1.

YAW DAMPER SYSTEM

38. This system is basically an auto-stabiliser Mk.2 installation, its purpose being to improve the natural damping of any yawing oscillations of the aircraft. All equipment with the exception of the servo-motor is mounted in the pressure cabin, the servo-

motor forming a series link in the rudder control circuit in the rear fuselage. The pilot's control is an ON-OFF switch located on the centre console immediately aft of the fuel control panel. For full descriptive details of the yaw damper system, reference must be made to Book 2, Sect.5, Chap.2 of this Volume, and A.P.1469S, Vol.1

AUTO-MACH TRIMMING SYSTEM

39. When the aircraft is flown in excess of M = 0·85, changes in pressure distribution over the wing cause a rearward shift of the centre of pressure with increasing Mach No., resulting in static instability. The purpose of the Auto-Mach Trimmer is to prevent this instability by trimming the elevators without pilot action being required, and it is designed to operate at high Mach No. at altitudes above 20,000 ft. All equipment with the exception of the control switches and transmitting machmeter, is mounted in the bomb bay, the amplifier pack at the forward starboard side and the servomotor forming a link in the elevator control circuit at the port rear end. Pilot control is by an ON-OFF-RESET switch spring-loaded to OFF from the RESET position, and located on the centre console immediately aft of the fuel control panel. For descriptive details of this system reference must be made to Book 2, Sect.5, Chap.2 of this Volume and A.P.1469S, Vol.1.

AIR BRAKES

40. The air brakes are electrically actuated slat type, two sets of which are fitted, one port and one starboard, mounted in the centre section above and below the engine air intakes. 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 brake structure is given in Sect.3, Chap.1 of this book and electrical controls and circuit operation are described in Book 2, Sect.5, Chap.1 of this Volume.

41. Controls for the air brake operation consist of twin switches on the pilots' throttle box, each switch controlling one of the paired motors mounted centrally in the centre section. These motors, by a gearbox and extended drive shafts, operate the air brake mechanism in the engine bays on each side of the centre section. 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 Book 2, Sect.5, Chap.1 of this Volume. A magnetic indicator fitted at the top left-hand corner of the pilots' centre panel indicates brakes in full IN position only. During ground testing of the air brakes a check must be made that the access doors, in the forward ends of the bomb bay doors, are closed before the air brakes are selected out. A warning label to this effect is adjacent to the switch in the cockpit.

◀ **Air brake micro switches**

42. Ten micro switches, Dowmic Type C1831Y, Mk.1, positioned in pairs, are utilised in the control of the air brakes, three pairs are situated on the port side and two pairs on the starboard. The micro switches are operated by cam strips which are riveted to the inboard legs of the top inboard air brakes.

42A. 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 main plane, forming part of the main plane 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 micro switch F, the air brake flaps having reached an angle of 35 ± 3 deg. When HIGH DRAG is selected the motor circuit is restored and the air brake legs extend further until stopped by the operation of micro switches G and H, the air brake flaps having increased their angle to 55 ± 3 deg. 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 micro switches C and D, the air brake flaps having reached 80 ± 3 deg. If the alighting gear is retracted, with the air brakes fully extended, air brake retraction can only be achieved by selection on the air brake selector switches. To obtain the HIGH DRAG 55 deg. position when the aircraft is on the ground, selection must be made on the air brake test switch in the nose undercarriage bay.

42B. When the selector switches are operated from HIGH DRAG to MED. DRAG the air 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 35 ± 3 deg. On selection from MED. DRAG to IN the motor circuit is restored and the air brake legs fully retract into the main plane until motor rotation is stopped by the operation of micro switches A, B, J and K, the operation of these micro switches also energizes the indicator on the pilots' centre panel. On an emergency IN selection it is permissible to allow up to 0·25 in. extension from the skin line. Full operation of the electrical circuit is given in Book 2, Chap.1, Group 6 of this Volume. ▶

SERVICING

CONTROL RIGGING

43. Control surface movement and related systems setting are illustrated in the figures called up in the following paragraph. Surface movements are checked with the power units in operation.

It is important that the systems are set to the 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 setting gauges are provided:-

Control surface	Setting gauge (Ref.No.)	Position
Elevator, inner	26DC/95163	Rib 18
Elevator, outer	26DC/95164	Rib 19
Aileron, inner	26DC/95165	Rib 20
Aileron, outer	26DC/95166	Rib 21
Rudder continuity	26DC/95033	Fin rib 11 and rudder rib 18
Fin verticality	26DC/95034	Centre and bottom rudder hinges on fin.

44. Rigging instructions for the controls are given in fig.17 to 22 and in their associated keys. 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 repair, replacement or adjustment has been effected in a system, that system is finally checked to ensure that full and free travel and correct movement are obtained.

45. The dimensional setting of the control geometry and the rigging of the control surface movements is to be accomplished and recorded with fuel tanks empty. Any deviations from these figures with various fuel loads should be ignored provided the deviation does not exceed thirty minutes. When a component is to be removed, which may affect the original rigging figures, a dimensional check should be taken at the prevailing fuel load, and this figure obtained at the same conditions and fuel load when refitting the component.

Control circuit friction

46. Static friction loads, present in each control run, are measured with a spring balance at the first pilot's control with the feel units disconnected. In the case of the ailerons it is important that the measurements are made at right angles to the handgrip, and 4 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. The friction in each circuit must not exceed the following values:-

Aileron 1·5 to 3 lb. port and starboard
Elevator 3 lb. fore and aft.
Rudder 7·5 lb. port and starboard (with brake pipes disconnected).

FEEL UNITS

47. Prior to installation in the aircraft each feel unit is accurately adjusted to give the degree of feel required for the particular control. No further adjustment is considered necessary, lubrication being the maximum servicing envisaged during normal use. In the event of defects occuring which would call for resetting of spring units or individual component renewal, it will be necessary to remove the complete unit which will require a full range check after rectification of the faults.

48. To assist in early detection of possible faults, a routine check may be carried out with the units in situ, the periods at which this should be done being specified in Vol.4 of this publication. For this check the following equipment is required:-

(1) A.S.I. calibration manometer

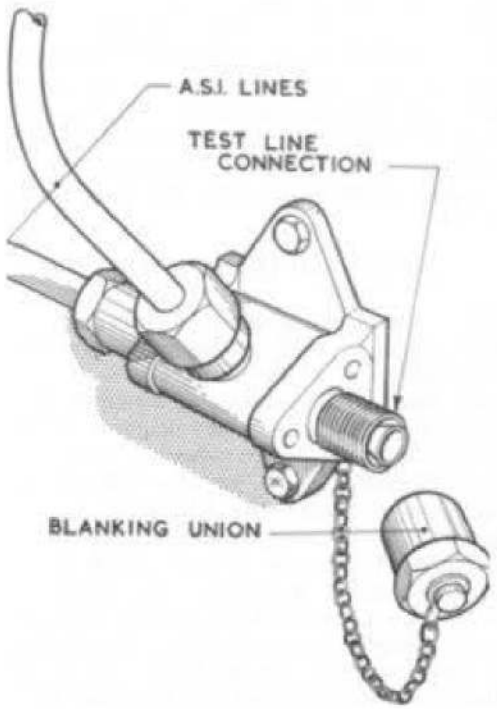


Fig.7. Feel unit test point

(2) Spring balance
(3) Inclinometer
(4) Power supply for power unit operation.

With the relevant power unit running, air speed is simulated through the A.S.I. calibration manometer connected to the special test point provided in the bomb bay (fig.7). Care must be taken not to overshoot the calibration speed, but to achieve the required pressure with a rising manometer. The cockpit control is then moved, pulled by the spring balance until a prescribed force is attained, the aileron angle 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 Tables 1, 2 and 3.

CALIBRATION CHECKS

49. 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.46. The checks should be carried out on the port outboard elevator or aileron.

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

Elevator and rudder

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

(2) The change of force rate with airspeed.

(3) To ensure that the surface self-centres within 0·5 deg. elevator 0·75 deg. rudder, when the applied force is released slowly.

Ailerons

(1) The aileron range/spring stop law, throughout the speed range.

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

(3) To ensure that the control column self-centres within 1 deg. when the control force is released slowly.

STANDARDS

51. The following standards determine the acceptability of the system:-

(1) Break-out force - see para. 60.

(2) Available aileron range Vs Airspeed - Design Law + 20% - 10% (see graph).

(3) Aileron force rate - full deflection at 11 ± 2 lb. force increasing.

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

Elevators

(1) 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

(1) Break-out force - minimum 10 lb. maximum 20 lb.

PRELIMINARY CHECKS - ELEVATOR AND RUDDER

52. 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 from the feel unit air speed transmitter.

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

(3) Check that the 28-volt and 115-volt supply are ON. Start appropriate P.F.C.'s to engage feel.

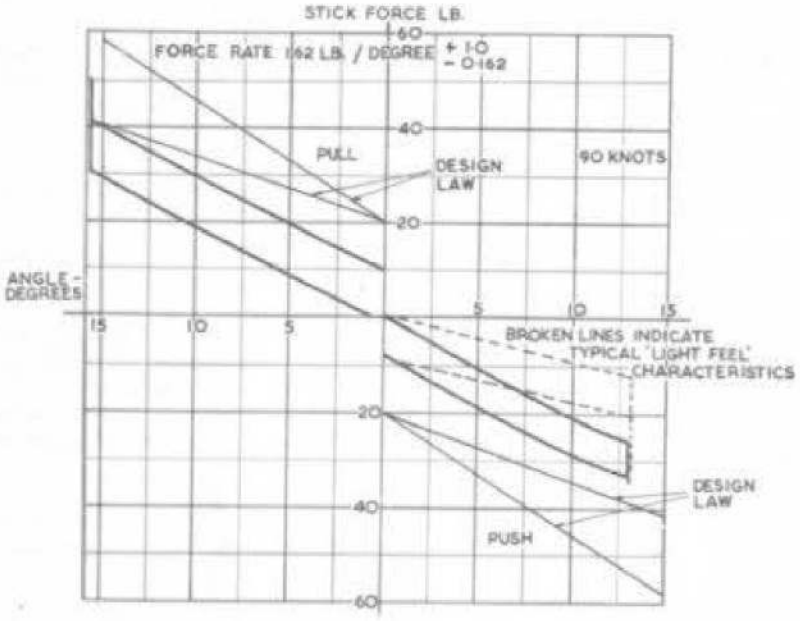
NOTE . . .
Switch off P.F.C.'s when 'Feel' is engaged.

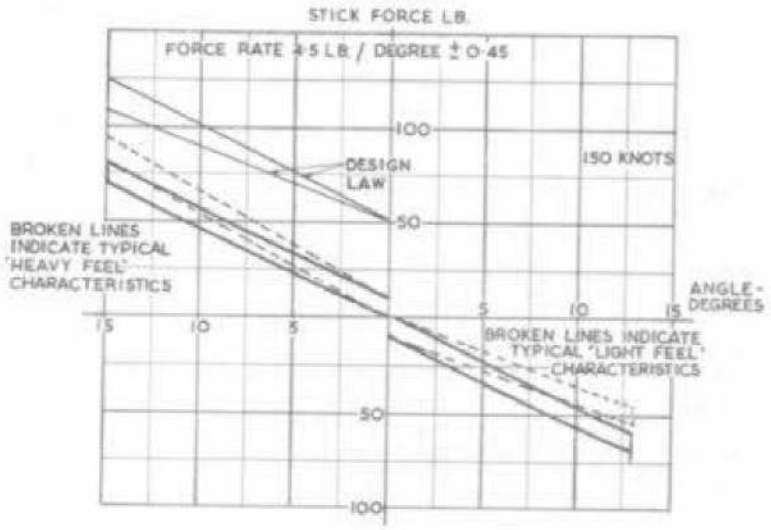
(4) Apply pitot pressure to the air speed transmitter.

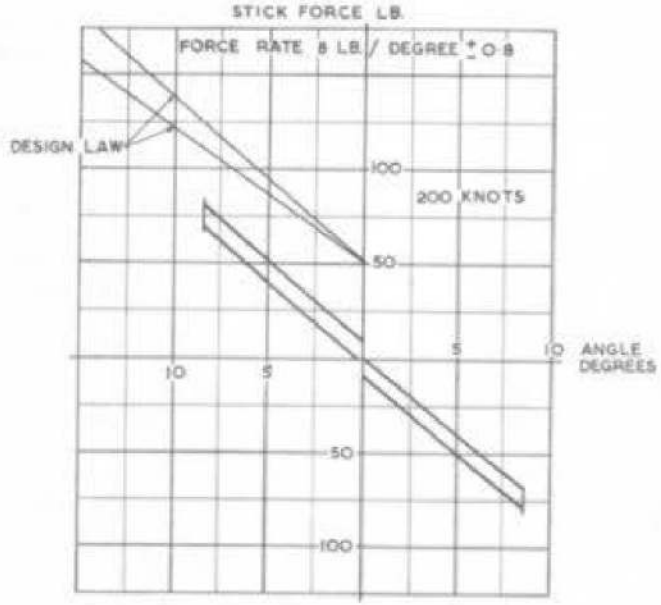
TABLE 1

Cut-in and Cut-out speeds

	Elevators		Rudder	
A.S.I.	Speed Increasing	Speed Decreasing	Speed Increasing	Speed Decreasing
Cut-in	70-90 knots	445-470 knots	125-145 knots	420-460 knots
Cut-out	450-470 knots	50-90 knots	430-470 knots	140-110 knots







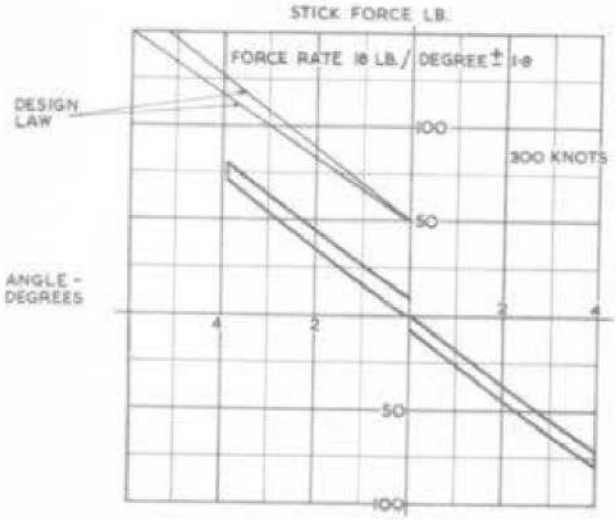


Fig.8 Typical force/deflection curve - elevator (1)

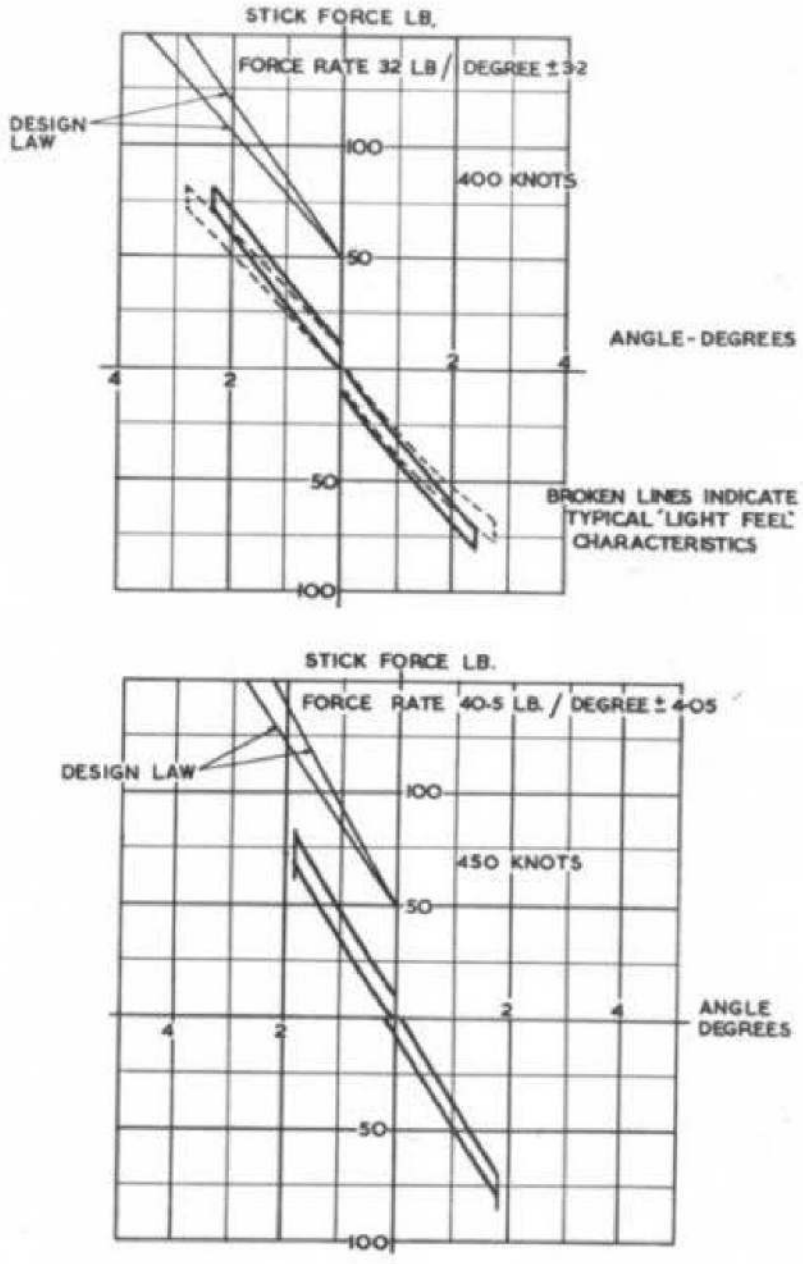


Fig.9. Typical force/deflection curve - elevator (2)

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

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

NOTE . . .

At the moment of cut-in the movement of the actuator can be heard and the pointer of the micro-ammeter on the feel unit will return to zero.

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

(8) Increase the air speed 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 air speed by 50 knots and repeat item (8).

(10) Increase air speed 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 air speed by 30 knots and repeat item (10).

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

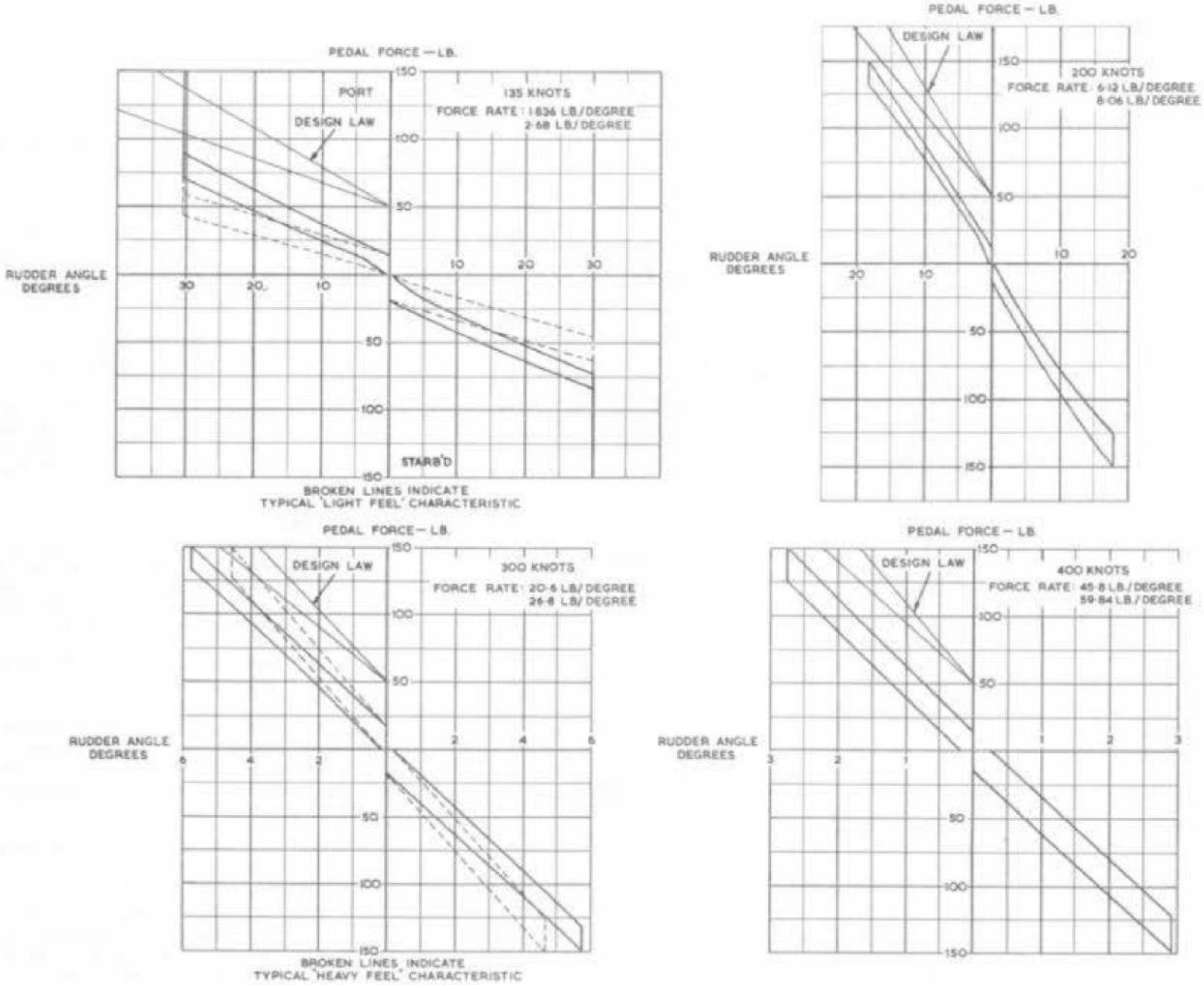
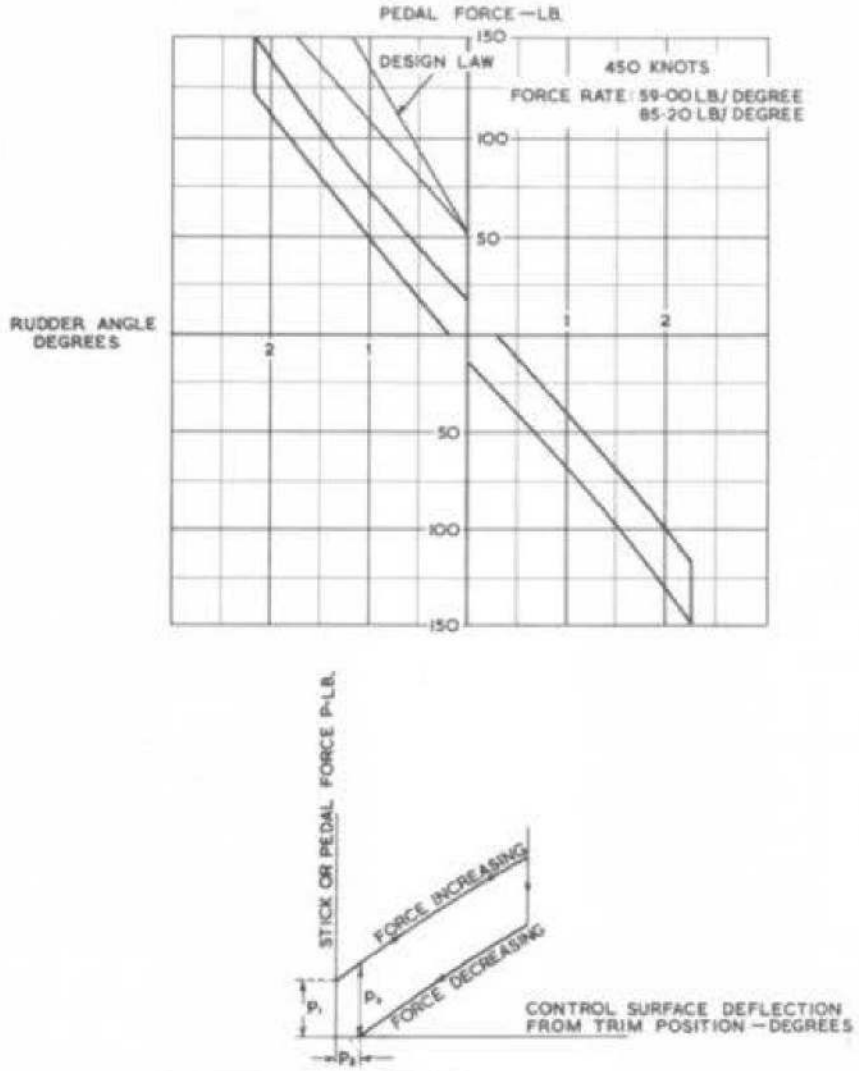


Fig.10 Typical force/deflection curve - rudder (1)



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.11. Typical force/deflection curve - rudder (2)

(13) Increase air speed by 50 knots and repeat item (12). Air speed must not exceed 500 knots A.S.I.

53. Carry out feel relief checks as described in para.59.

AILERON SPRING STOP CALIBRATION

54. Calibration of the aileron spring stops is carried out as follows:–

(1) Connect the A.S.I. calibrator to the pitot side of the aileron feel unit airspeed transmitter.

(2) Select aileron power units ON and check feel is engaged.

(3) Trim the aileron to neutral by setting the port and starboard ailerons to the same angle ± 0 deg. 6 min.

NOTES . . .

Measure the angle at the inboard end of the outboard ailerons for subsequent use as a datum.

No alteration of the trim setting should be made after setting of the neutral.

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

(5) Simulate an A.S.I. reading of 200 knots on the A.S.I. calibrator.

(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 angle at the inboard end of the port outboard aileron.

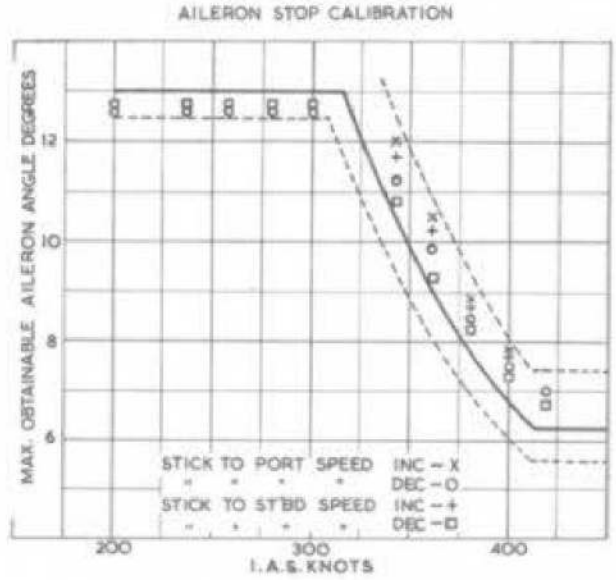


Fig.12. Typical aileron calibration

(8) Increase indicated air speed to the speeds listed in Table 2 and measure the port outboard aileron angle with full port and starboard aileron applied at each speed.

NOTE . . .

At approximately 312 to 320 knots the spring stops will commence to restrict the aileron range and care should be taken not to force the control through the spring stops. If the target speed is exceeded at any setting, before continuing, the speed must be reduced to 20 knots below for speeds increasing and 20 knots above for speeds decreasing. No load should be applied at the column during alterations in air speed.

(9) Carry out at a full check, at the air speeds listed in Table 2, of the port outboard aileron angle with the speed increasing and decreasing.

AILERON FORCE/DEFLECTION CHARACTERISTICS

55. When carrying out this check, before applying forces with the spring balance (see para.48), 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 calibrator of 200 knots.

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

ELEVATOR FORCE/DEFLECTION CHARACTERISTICS

56. To check these characteristics proceed as follows:-

TABLE 2

Maximum and minimum aileron angles relative to neutral

NOTE:- *These figures are provided in graphical form in Fig.12 (see para.58).*

A.S.I.	AILERON ANGLE TOLERANCE AT STOPS			
	MAXIMUM		MINIMUM	
knots	deg.	min.	deg.	min.
200	0	0	12	30
240	0	0	12	30
260	0	0	12	30
280	0	0	12	30
300	0	0	12	30
320	0	0	11	12
340	12	42	9	42
360	10	54	8	12
380	9	21	7	06
400	8	06	6	06
420	7	24	5	36
450	7	24	5	36

(1) Connect the A.S.I. calibrator to the feel unit test point.

(2) Select all elevator power units ON and check that fuel is engaged.

(3) Simulate an A.S.I. reading of 90 knots on the A.S.I. calibrator.

(4) Set the elevators to nominal neutral using the trim control and record the inclinometer reading obtained.

NOTE . . .
This is the datum from which all subsequent angles will be recorded.

(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) Using the 0-25 lb. spring balance, apply control forces progressively in increments of 2 lb. to the pilots' column at 4 in. above the centre of the sliding control rod and in a parallel plane.

NOTE . . .
The force should be applied progressively and held at the target figure until the elevator 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) Using the 0-100 lb. spring balance apply forces as described in (6) but using the 10 lb. increments applicable to this balance.

NOTE . . .
Forces should be increased progressively to the maximum (fig.8) and then decreased progressively to zero.

(9) Repeat items (6) to (8) 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 last increment of force, with force decreasing, the force should be removed gently to avoid over self-centring.

(10) With the control force at zero repeat items (5) to (9) at air speeds of 150, 200, 300 and 450 knots I.A.S.

RUDDER FORCE/DEFLECTION CHARACTERISTICS

57. The principles of the calibration are similar to those for the elevators with exception of the method of checking rudder trailing edge linear deflection measurements which are taken using a steel tape instead of an inclinometer. Proceed as follows:-

(1) Connect the A.S.I. calibrator to the feel unit test point.

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

(3) Select the 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.

TABLE 3

Aileron forces/deflection characteristics

NOTE:- These figures are provided in graphical form in Fig.12

STICK TO PORT					STICK TO STARBOARD				
AILERON STICK FORCE	MAXIMUM AILERON ANGLE		MINIMUM AILERON ANGLE		AILERON STICK FORCE	MAXIMUM AILERON ANGLE		MINIMUM AILERON ANGLE	
lb.	deg.	min.	deg.	min.	lb.	deg.	min.	deg.	min.
0	0	00	- 1	00	0	0	0	- 1	00
1	0	18	- 0	18	1	0	18	- 0	18
2	0	18	- 0	12	2	0	18	- 0	12
3	0	30	0	00	3	0	30	0	00
4	1	30	0	00	4	1	30	0	00
5	2	30	0	00	5	2	30	0	00
6	4	00	1	00	6	4	00	1	00
7	6	00	2	00	7	6	00	2	00
8	8	48	3	00	8	8	48	3	00
9	12	30	4	00	9	12	30	4	00
10	12	30	5	45	10	12	30	5	45
11	13	00	7	30	11	13	00	7	30
12	13	00	9	30	12	13	00	9	30
13	13	00	12	30	13	13	00	12	30
12	13	00	12	30	12	13	00	12	30
11	13	00	12	30	11	13	00	12	30
10	13	00	12	30	10	13	00	12	30
9	13	00	12	30	9	13	00	12	30
8	13	00	10	00	8	13	00	10	00
7	13	00	7	45	7	13	00	7	45
6	13	00	6	00	6	13	00	6	00
5	13	00	4	05	5	13	00	4	05
4	7	30	3	30	4	7	30	3	30
3	5	30	2	30	3	5	30	2	30
2	3	30	1	30	2	3	30	1	30
1	2	09	0	45	1	2	09	0	45
0	1	00	0	00	0	1	00	0	00

(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.

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 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 force/deflection.

(13) Reduce forces in 20 lb. decrements and record the force/deflection at each 20 lb. decrement.

(14) When reaching zero force 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 (14) at air-speed settings of 200, 300, 400 and 450 knots.

PREPARATION OF RESULTS

58. 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.8, 9, 10, 11 and 12). The plots should produce continuous curves. Any irregular discrepancies which only occur at one airspeed are due to faulty 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 elevators 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.

Feel relief check

59. At 415 knots indicated airspeed, 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 condition, check that the full control angle is obtainable with stick forces not exceeding the following maximum values:-

Aileron	11± 2 lb.
Elevator	40 lb.
Rudder	70 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 relief should also be tested using the second pilot's relief button.

Break-out force

60. 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 force 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	5 lb. port or starboard
Elevator ...	6 lb. (min.) - 11 lb. (max.) fore and aft
Rudder	10 lb. (min.) - 20 lb. (max.) port or starboard

Controls self-centring

61. The value of each centring spring is accounted for in the full figures obtained at the control column during the calibration check. While these would indicate complete failure of the centring spring, it is possible by the presence of additional friction in the controls to record misleading figures. It is therefore recommended that on completion of the calibration check, with the control column free and the power units in operation, the controls are checked for attainment of neutral position. If the neutral of any control is not reached it will be necessary to ascertain the cause by a process of elimination. With all feel units and power units disconnected, the static friction of each control run should be checked and compared with the values given in para.46; if the figures obtained are high, the affected control run must be checked, section by section, to find and eliminate the fault. If the figures are satisfactory, a further static friction check should be made with the power units connected and running; the values for this check should not be noticeably higher than the first, for any control run. Unsatisfactory figures will indicate that the trouble is in the power unit, which should be checked and serviced in accordance with A.P.4603 series.

62. If both the foregoing checks give satisfactory results, the indication would be that trouble lay in the relevant feel unit, in which case the unit would have to be removed for a rig check at a suitably equipped servicing depot.

TRIM SYSTEM

Actuators

63. Servicing instructions for the Rotax linear actuators will be issued 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 refer to fig.13.

Checks

64. 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 aileron and elevator trim angles should be checked on each pilot's control **separately.**

Aileron ... UP 5 deg. 12 min. ± 30 min.; DOWN 5 deg. 12 min. ± 30 min.

Elevator .. UP 9 deg. ± 30 min.; DOWN 9 deg. ± 30 min.;

Rudder Port 16.36 ± 1 in.; Stbd. 16.36 ± 1 in. (Normal to hinge line). Measured to base of trailing edge.

The aileron and elevator angles given above are measured from the rigging neutral, i.e. 3 deg. above the wing datum.

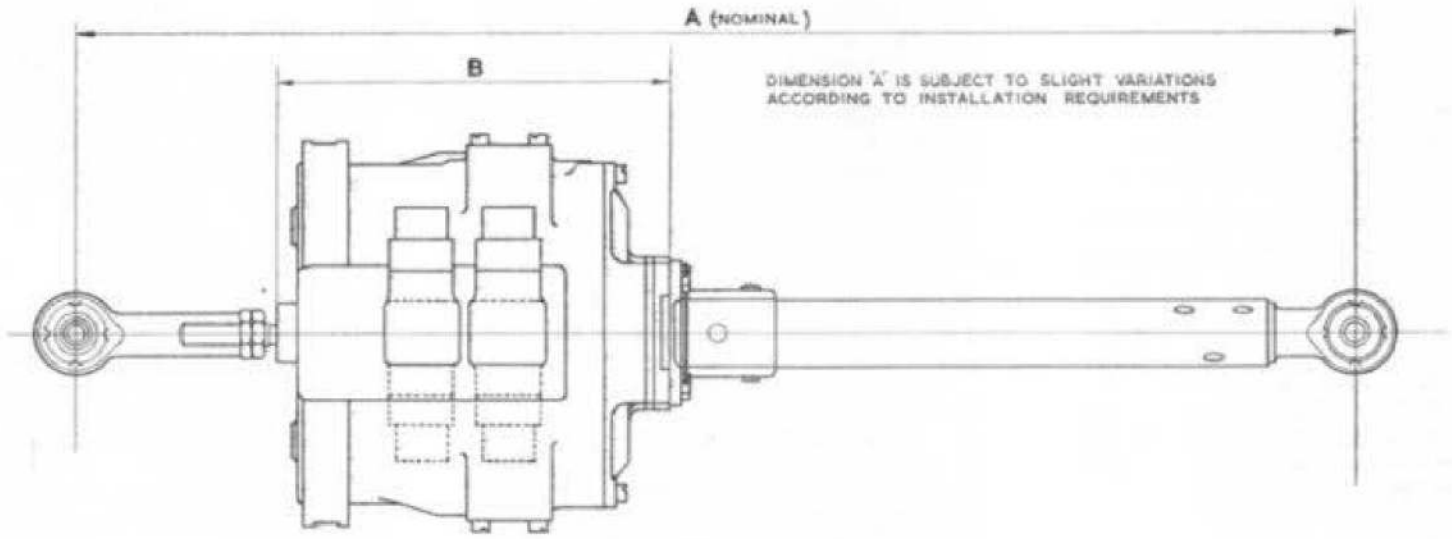
(3) Operate the trim buttons on both control columns simultaneously and in opposite senses, for both aileron and elevator circuits in turn. The circuit should become inoperative.

(4) Operate the RESET SWITCH, and then operate the trim buttons normally to ensure the circuits have returned to normal.

(5) Operate both pilot's trim buttons simultaneously in the same direction. The circuit should operate.

(6) 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:-

Aileron ... UP 5 deg. 12 min. ± 30 min.; DOWN 5 deg. 12 min. ± 30 min.



ACTUATOR	CONTROL	DIM. 'A'	DIM. 'B'
A.1706	AILERON	19·8 IN.	6·375 IN.
A.1702	ELEVATOR	19·84 IN.	6·3 IN.
A.1703	RUDDER	20·175 IN.	6·375 IN.

CONTROLS SET AT NEUTRAL i.e. WITH AILERONS AND ELEVATORS 3° UP

Fig.13 Setting trim actuators

Elevator ... UP 12 deg. ± 30 min.; DOWN 13 deg. (limited by power unit).

Rudder ... PORT 24·5 ± 1 in.; STBD. 24·5 ± 1 in. (normal to hinge line). Measured to base of trailing edge.

Aileron and elevator angles given above are measured from the rigging neutral position, i.e., 3 deg. above the wing datum.

(7) Operate the emergency switch without the centre button depressed, the system should not operate.

POWER CONTROL UNIT

65. Servicing of the power units is in accordance with the items detailed and the periods specified in Vol.4 of this publication. For details of the servicing procedures reference must be made to the A.P.4603 series. Instructions for the removal of the units from the aircraft are given in fig.23, 24 and 25 of this chapter.

AIR BRAKES

66. Normal servicing of the air brakes consists of following the instructions in Vol.4 of this publication. When any renewals or repairs to the air brakes and/or mechanism have been effected, resetting the air brakes will be necessary.

67. During air brake setting it is imperative that the back-lash is kept to a minimum and that the air brake flap/air brake leg relationship is correct. To keep the back-lash to a minimum the clearances laid down in para.68 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.

68. 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 air brake legs, connected together by the torque tube, in position and check the alignment of the rollers to the legs. Adjust, if necessary, on the shims fitted between the rollers and the mountings on the roller boxes. During adjustments on the top inboard air brakes the inboard leg must be used as a datum because a clearance of 0·06 in. must be maintained between the inboard face of the leg and the rollers of the micro switch operating levers.

(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 air brake leg.

(4) Mark the main plane chord line on rib 63·5, the engine centre rib and rib 162·5 (fig.15).

(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 on 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

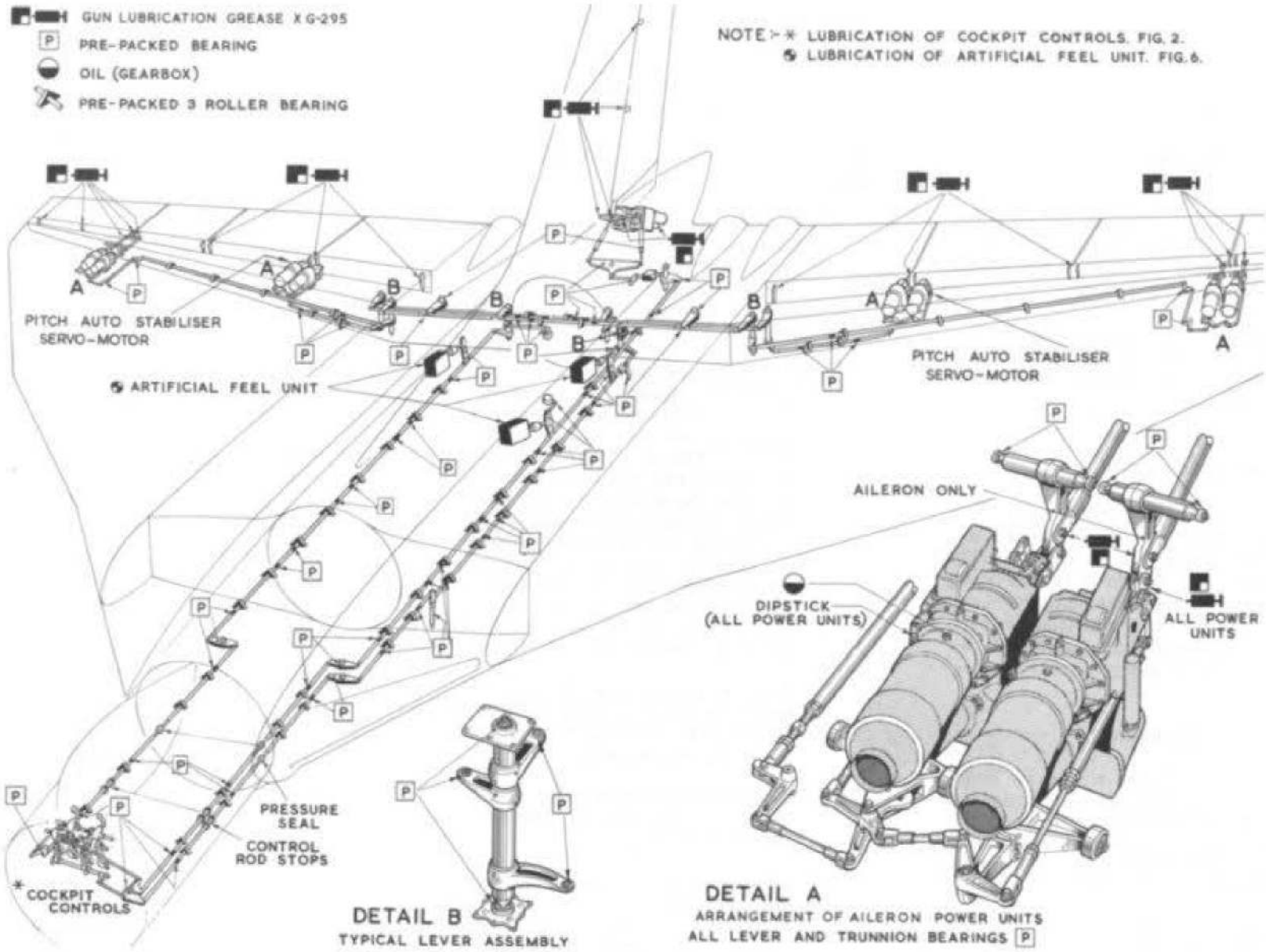


Fig. 14 Lubrication main flying controls

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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 maximum 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 by 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/3339).

(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 $\pm$ 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.

(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 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.15). 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 0·0015 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

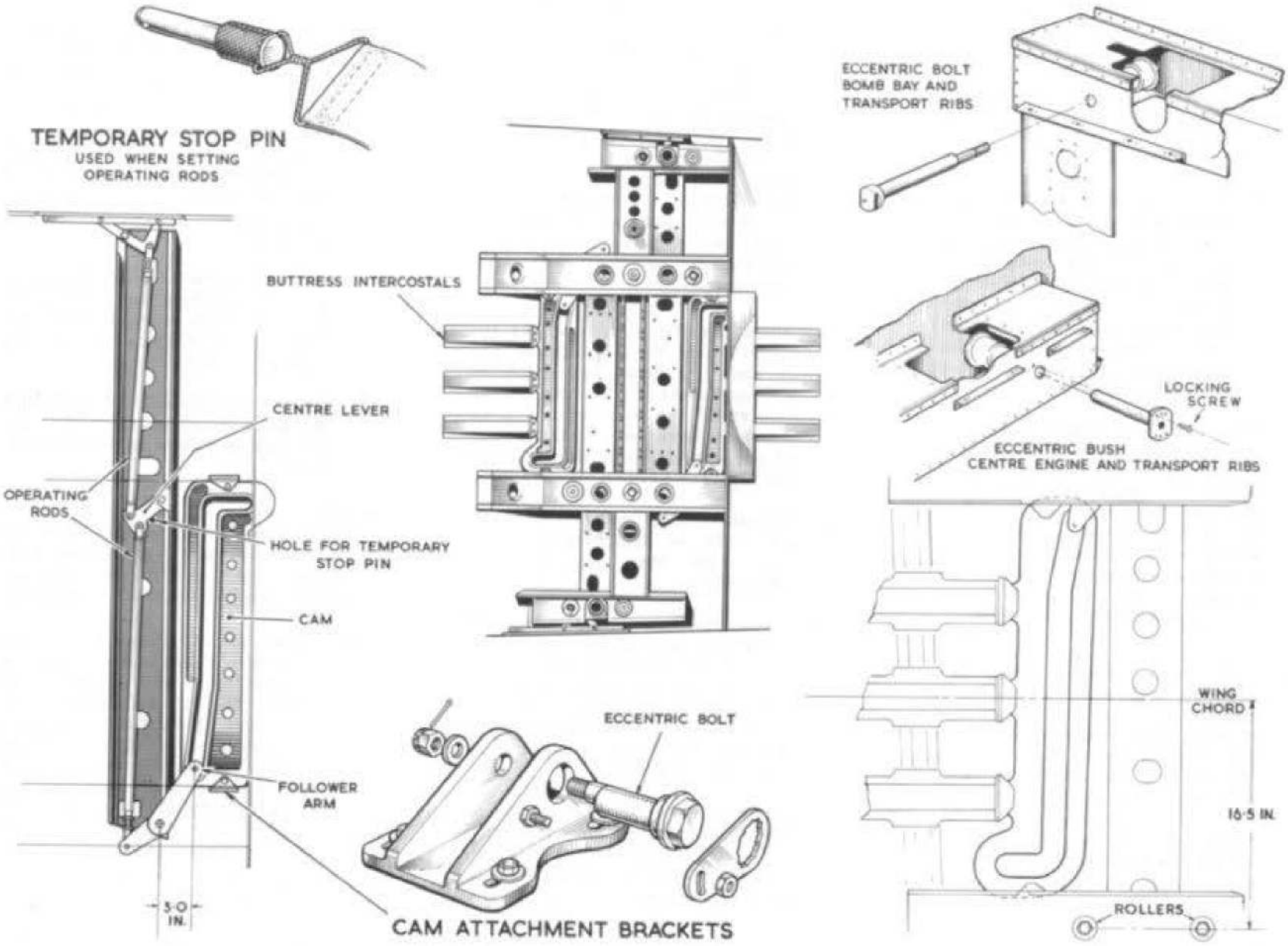

Fig. 15. Air brake settings

(*New setting instructions*)

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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) Insert a stop pin in each leg of one of the bottom air brakes. Fit the follower arm rollers and check that a clearance not exceeding 0·0015 in. exists between the rollers and the cam track when the roller is held against one side of the track. Check that the rollers are free to rotate in the cam track, adjustment, if required, is by loosening the four bolts securing the cam top 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.

(20) Repeat op.(19) on the remaining bottom air brake.

NOTE...
On the bottom air brakes the slots in the cam top attachment brackets can be elongated to a maximum of 0·45 in.

(21) Manually extend the air brake legs 10 in. and check the top air brake angle which must be 17^{+2}_{-0} deg. 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.

(22) With the air brake legs extended 10 in. check the bottom air brake angle which must be 14^{+2}_{-0} deg. Adjustment, if required, must be carried out by moving the cam bottom 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.

(23) Retract the air brakes to the fully 'in' position and check the follower arm rollers for freedom of movement in the cam track. Adjust, if necessary, as in op.(17), and (19).

(24) Repeat op.(17) to (23) until the setting is satisfactory.

(25) Attach suitable pointers to bomb arch 44·592 F to indicate on the sleeves at the inboard ends of the port and starboard main drive shafts.

(26) 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.(25).

(27) Check the air brake flap angles which must be 55 ± 3 deg.

(28) Carry out a full range check to the measurements given in the table in para.69.

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

(30) Wire lock the adjusters on the operating chains and the flap operating linkage rods, using 22 s.w.g. locking wire (Ref.No. 30A/3339).

(31) Connect the port and starboard main drive shafts to the actuator. Remove the pointers fitted in op.(25).

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

(33) Extend the air brakes to one of the predetermined settings and remove the follower arm rollers.

(34) Fit the stop blocks to the flap, securing them with the two attachment bolts.

(35) Position the air brake flap to the angle obtained in op.(32). If necessary, file the stop blocks until the blocks just contact the air brake legs with the flap at the correct angle.

(36) 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/3339).

(37) Replace the follower arm rollers.

(38) Repeat op. (32) to (37) on all the air brake flaps.

(39) Set the air brake micro switches to the instructions in para.70 and 70A.

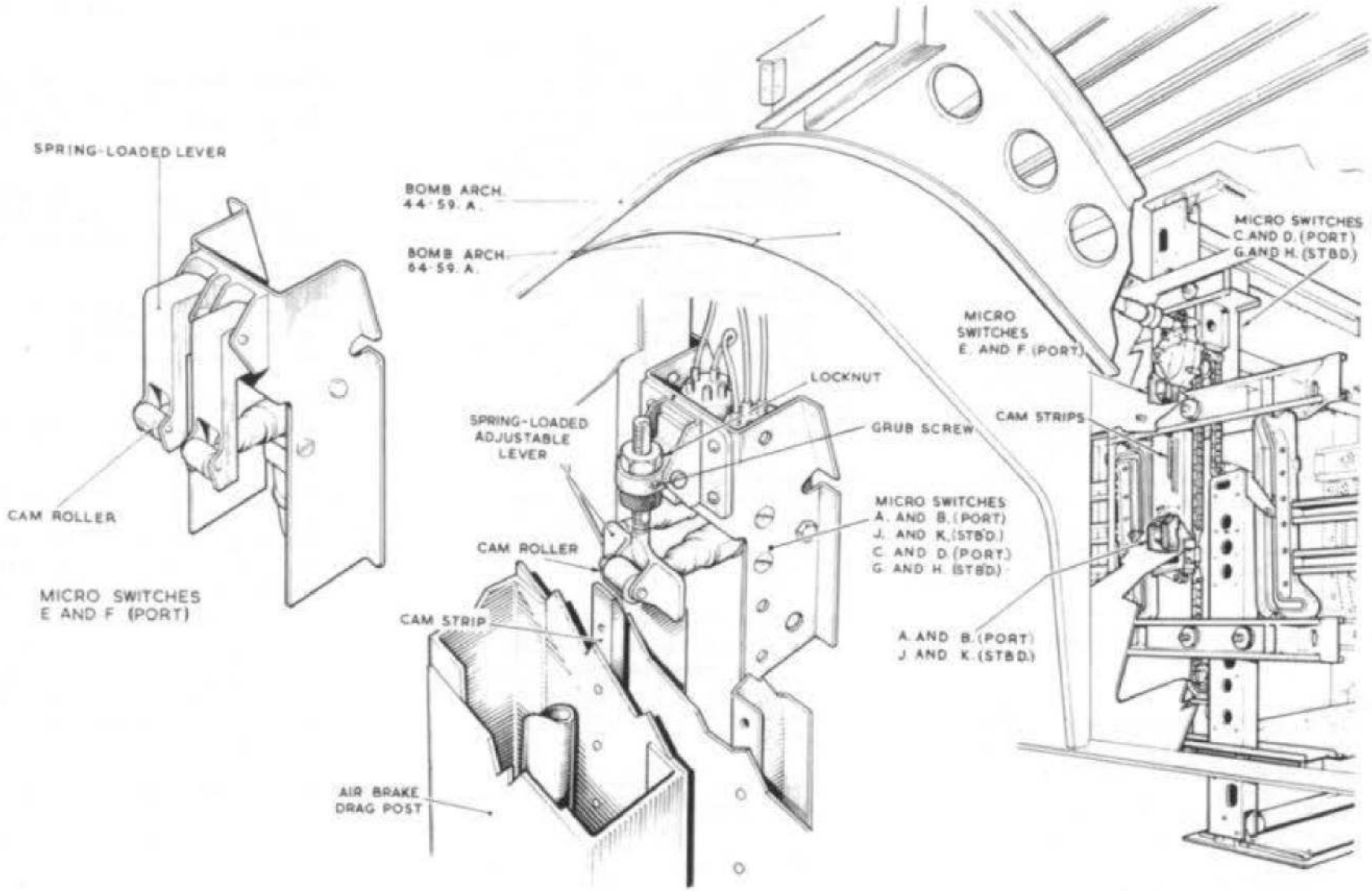

Fig.15A. Air brakes micro switches

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69. The following table gives the pillar travel relative to flap angle of 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
26·5	35	0	35	0*
27·5	55	0	55	0*
30·5	80	0	80	0*

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

When checking pillar extension relative to flap angle of rotation on the air brake motors, an inching device, (Ref.No. 26DC/95215), will be required and an external electrical supply used. If the inching device is not available the drive shafts must be disconnected from the actuator and the shaft manually operated.

NOTE...
The air brake motors may be used continuously for only three minutes after which a 45 min. cooling period is necessary.

WARNING...
Air brakes must not be operated by the electrical motors if the brakes on either side of the motor are disconnected, or, if any of the micro switches are isolated or disconnected.

MICRO SWITCH SETTING

70 After the air brakes have been set mechanically (para.68) the micro switches 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 in the setting operations. Prior to carrying out the checks and adjustments, the angle of the air brake flaps, in the fully in position, must be taken and noted. The reading obtained from the top air brake flaps must be added to the readings obtained during the setting operations to give the correct flap angle and the readings obtained from the bottom flaps must be subtracted from the readings obtained during the setting operations. A check must be made on the clearance between the air brake leg and the rollers of the micro switch operating arms, this clearance must be 0·06 in. and adjustments, if necessary, must be carried out as given in para.68 op.(2).

70A To set the micro switches 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 actuator.

(2) Connect the air brake test set into the normal circuit at fuse 97 in panel 3P.

(3) Unscrew the 4 B.A. grub screw securing the adjustable operating lever to the pivot block at micro switches A and B and J and K and adjust the operating levers to their 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 that micro switch operation is taking place. Return the air brakes to the MED. DRAG position.

(5) Disconnect the air brake test set and replace fuse 97. With the air brake emergency switch at NORMAL select IN on the air brake selector switch. Measure and note the amount that the air brake flaps are out 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 181 in panel 4P.

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

(8) Disconnect the air brake test set and replace fuse 181. With the air brake emergency switch at EMERGENCY select IN on the air brakes selector switch. Measure and note the amount that the air brake flaps are out from the main plane skin line. Return the air brakes to MED. DRAG.

(9) Compare the measurements obtained in op.(5) and (8). The measurement 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 the motors must be changed over. On completion of checks and any necessary adjustments connect the electrical plugs to both motors.

(10) Select NORMAL on the air brake emergency switch and IN on the air brake selector switch and by adjustment on micro switches 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 micro switches to obtain the required flap angle, for HIGH DRAG 55 deg. adjust micro switches G and H and for the APPROACH HIGH DRAG 80 deg. adjust micro switches C and D. Adjustment of the micro switches is carried out by unscrewing the 4BA grub screw which secures the micro switch operating lever to the pivot block and adjusting the nuts on the operating lever.

NOTE...
Micro switches 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, no provision for adjustment is provided.

(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 on bomb bay arch 44·592F to indicate on the sleeves at the inboard ends of the port and starboard main drive shafts.

(15) Manually operate the port air brakes inward until micro switches A and B are just operated. Manually operate the starboard air brakes inward and adjust micro switches J and K to operate simultaneously with or up to 1/8 in. of air brake leg travel after micro switches A and B on inward movement of the air brakes. It is imperative that micro switches J and K do not operate before micro switches 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.

(16) On completion of micro switch adjustment, lock the nuts on the micro switch operating arms using 22 s.w.g. locking wire (Ref. No.30A/3339). Lock the operating levers to the pivot blocks using the 4BA 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 by two centre punch marks.

(17) Manually operate the air brakes to MED. DRAG position and replace the taper pins removed in op.(13).

MASS BALANCE

General

71. To prevent flutter and vibration and subsequent damage, the flying control surfaces are mass balanced. It is important that this balance is within the laid down limits and the following paragraphs give the methods of checking and adjusting the control surface mass balance after repairs, or other causes which may have affected the balance. These checks must be carried out in conjunction with the information in Vol.6, Part 1, Chap.3 of this publication and fig.16 of this chapter.

Ailerons

72. The ailerons, which are checked separately, must be pivoted on and allowed to move freely about their hinges in a horizontal plane and checked as follows:-

Inboard aileron

The inboard aileron is satisfactory if it attains static balance, with its horizontal chord 3 deg. tail up, with a weight of between 2·75 to 4·25 lb. (pre.Mod.627) or between 2 to 4·25 lb. (post Mod.627), placed at the inboard end of the trailing edge.

In the event of additional mass balance being required, additional weights may be fitted to the aileron beak. The weights, which are in four sizes, are assembled to the ailerons as shown in fig.16, utilizing the existing mass balance to control surface attachment points. It should be noted that where there is more than one pair of one weight, one pair only must be fitted at one time, also that one weight is fitted on the top surface of the beak and the other on the bottom. The weights are as follows:-

Dwg.No.	No. off	Weight (lb.)
1/F8285	4	2·612)
2/F8285	2	1·698) each
3/F8285	3	0·764)
4/F8285	1	1·018)

Outboard aileron

With a weight of between 6·75 to 7 lb. (pre.Mod.627), or between 6 to 7 lb. (post.Mod.627), placed on the trailing edge, 50 in. from the inboard end, the outboard aileron should become statically balanced with its horizontal chord 3 deg. tail up.

In the event of additional mass balance being required additional weights may be fitted to the small beak on the inboard end of the aileron. The additional weights are in three sizes of which only one pair of one size can be fitted at one time, picking up on the existing six bolts through the beak. They are shaped to fit inside the beak flange and are as follows:-

Dwg.No.	Material	Weight
178/F7850	14 s.w.g.M.S.	0·243 lb.
179/F7850	0·30 in. M.S.	0·90 lb.
180/F7850	0·50 in. M.S.	1·50 lb.

It should be noted that on 179/F7850 the attachment holes are counterbored 0·75 in. dia. to a depth of 0·05 in. and 180/F7850 is counterbored 0·75 in. dia. to a depth of 0·25 in. This counterboring is to accommodate the securing bolt heads and nuts.

Elevators

73. The elevators, which are checked separately, must be pivoted on and allowed to move freely about their hinges in a horizontal plane and checked as follows:-

Inboard elevator (pre.Mod.627)

With a weight of between 0 to 2 lb. placed at 83 in. aft of the hinge centre line the inboard elevator should become statically balanced with its horizontal chord 3 deg. tail up.

Inboard elevator (post Mod.627)

(1) With the elevator horizontal chord 3 deg. tail up and a check weight of 2 lb. placed 83 in. aft of the hinge centre line the elevator should be statically balanced or tail heavy.

(2) With the elevator horizontal chord 3 deg. tail up and a check weight of 5·5 lb. placed 30 in. forward of the hinge centre line the elevator should be statically balanced or nose heavy.

In the event of additional mass balance being required, additional weights may be fitted on the beak of the elevator. The weights, which are of 16 s.w.g. mild steel 24·47 in. long, 1 in. wide and 0·44 lb. in weight, are fitted on the inboard and outboard ends of the beak picking up on the existing mass balance to control surface attachment points. These weights may be cut to suit during balance adjustment and the existing ferrules discarded and replaced by ferrules A.G.S.920E.M. (Ref.No.28H/7859). When the mass balance is too heavy, holes 0·5 in. dia. and up to 1·5 in. deep may be drilled in the existing lead weights, between the attachment tie rods as indicated on fig.16 detail A.

Outboard elevator (pre.Mod.627)

With a weight of between 0 to 2·5 lb. placed 65 in. aft of the hinge centre line the outboard elevator should become statically balanced with its horizontal chord 3 deg. tail up.

Outboard elevator (post Mod.627)

(1) With the elevator positioned with its horizontal chord 3 deg. tail up, and a weight of 2·5 lb. placed 65 in. aft of the hinge centre line the elevator should be statically balanced or tail heavy.

(2) With the elevator positioned with its horizontal chord 3 deg. tail up and a weight of 7 lb. placed 20 in. forward of the hinge centre line the elevator must be statically balanced or nose heavy.

In the event of additional mass balance being required, on the outboard elevator, additional weights may be fitted on the elevator beak. The weights, of 16 s.w.g. mild steel

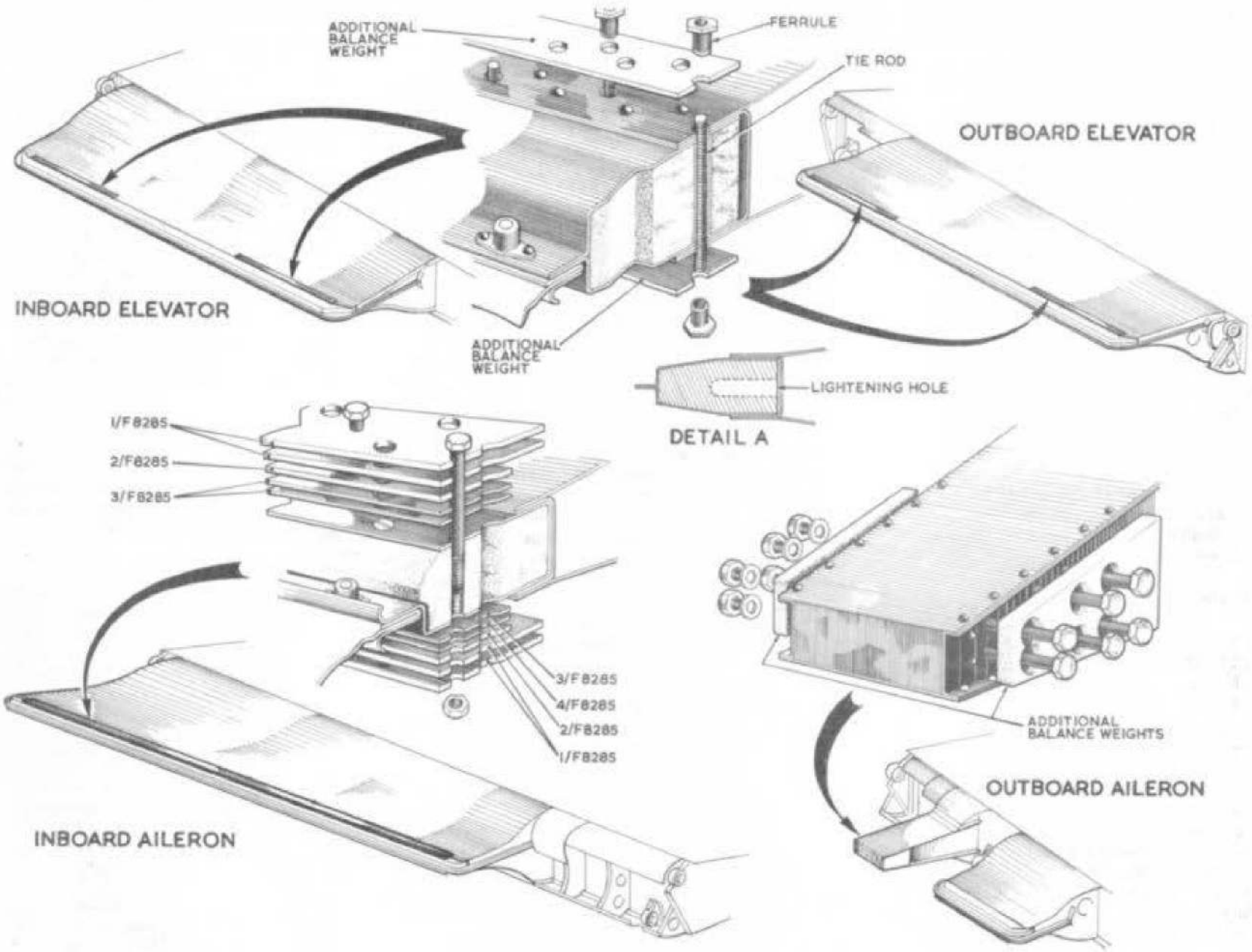

Fig. 16. Additional mass balance

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1 in. wide are fitted on the top outboard ends of the elevator beak picking up on the existing mass balance to control surface attachment points. The inboard weight is 23·68 in. long and weighs 0·427 lb., the outboard weight is 25·35 in. long and weighs 0·44 lb. These weights may be cut to suit during balance adjustment and the existing ferrules replaced by ferrules A.G.S.920 E.M. (Ref.No.28H/7859).

NOTE...
On completion of the elevator balance adjustments all attachment tie rods must be locked by riveting over the ends.

Rudder

74. The rudder must be pivoted on and allowed to move freely about its hinges in a horizontal plane and checked as follows:-

Pre.Mod.977

(1) With the rudder chord horizontal, and no check weight placed on the rudder, the rudder must be statically balanced or tail heavy.

(2) With the rudder chord horizontal, and a check weight of 19·5 lb. placed 10 in. forward of the hinge centre line, the rudder must be statically balanced or nose heavy.

Post Mod.977

(1) With the rudder chord horizontal, and no check weight placed on the rudder, the rudder must be tail heavy.

(2) To retain the rudder chord horizontal, a spring balance attached 44 in. aft of the hinge centre line must record a reading not exceeding 17 lb.

POWER UNITS

75. Recommended procedures for the removal of the powered flying control units are given in fig. 23, 24 and 25 and their related keys. Installation is a reversal of the removal procedure and immediately after fitting, all units must be fitted and bled in accordance with instructions in A.P.4603 series before carrying out any functional checks.

FEEL UNIT REPLACEMENT

76. When an artificial feel unit is to be replaced the following instructions should be followed:-

(1) Trim the relevant control surface to nominal neutral, which puts the trimmer jack to the correct installation setting.

REMOVAL AND ASSEMBLY

(2) Remove the defective artificial feel unit.

(3) Fit the new feel unit.

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

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

(6) Check the trim range.

ELEVATOR AND AILERON TRUNNION ASSEMBLIES

77. When elevator (fig.24) or aileron trunnion assemblies are installed, the securing nuts on the end of the assemblies must not be overtightened, a minimum gap of 0·005 in. must be maintained between the ends of the trunnion and the washer. Note that the gap is measured from the end of the trunnion and not the trunnion bearing which overhangs the end of the trunnion slightly.

PRESSURE SEAL BEARING

78. When assembling the control rod pressure seal bearing on the rear pressure bulkhead the cavity in the bearing housing must be packed with grease XG-295 and the end cap tightened to just nip the sealing washer. Lock the end cap, to prevent rotation in both directions, using locking wire 18 s.w.g. (Ref.No.30A/2295).

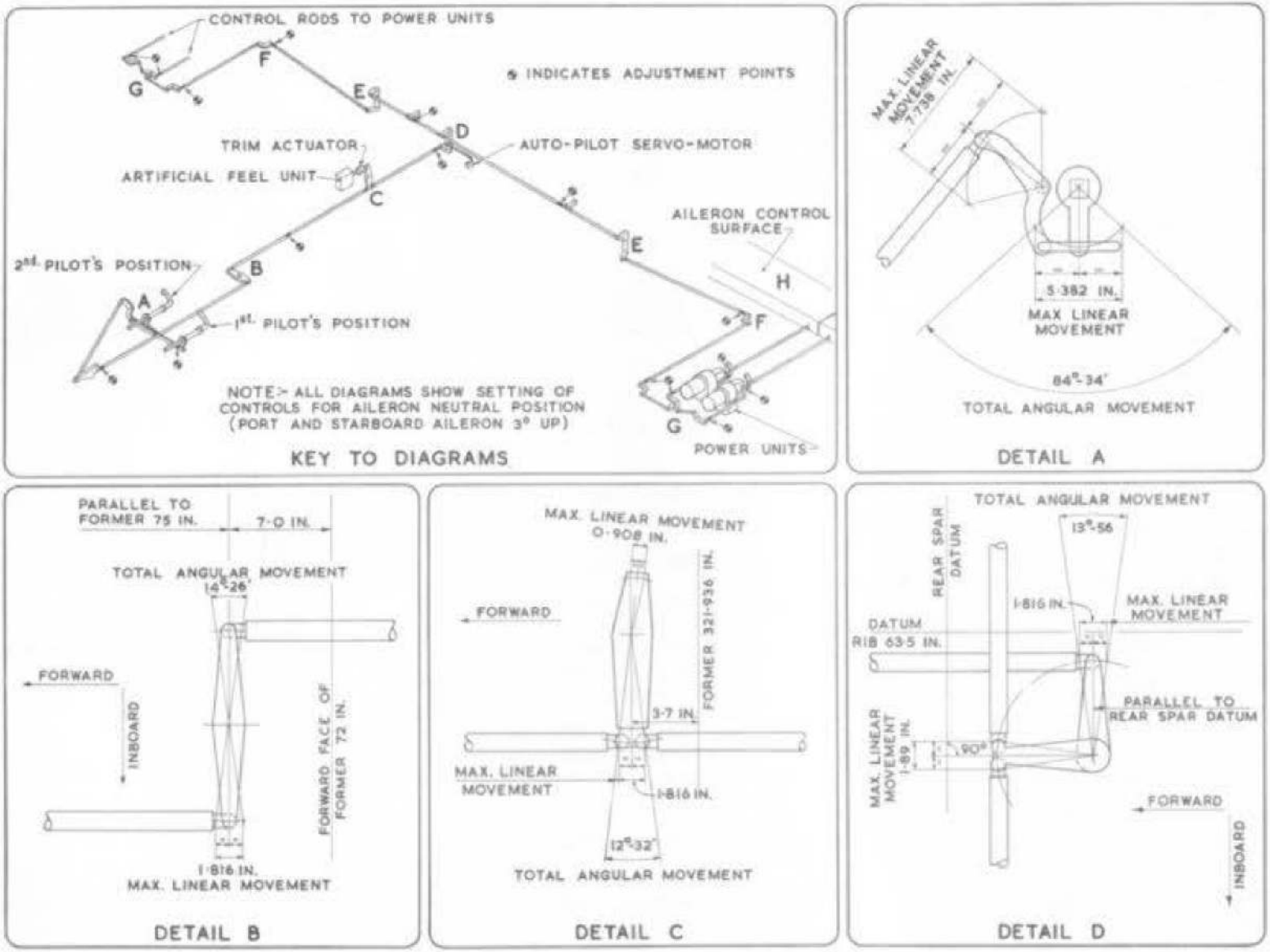

Fig. 17 Aileron control rigging (1)

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KEY TO FIG.17 and 18
AILERON CONTROLS RIGGING

1. Jack the aircraft laterally and longitudinally level. (Sect.2, Chap.4).
2. Disconnect the trim actuator from the vertical lever, and the spring control rods from the input levers of the power units.
3. Check both control column square shafts for backlash. Adjust, if necessary, to eliminate all backlash, on the adjustable guide rollers fitted at the forward end of the bearing tube of the aileron lever assembly. Lock the eccentric bolts by tag washers.
4. Set the control handle at the second pilot's position in the neutral position, i.e., vertical, and secure (detail A).
5. Adjust, if necessary, the rod connecting the two control handle shafts so that the first pilot's handle is vertical.
6. Set the centrally-pivoted lever at former 75F position in its mid-travel position (detail B). Adjust, if necessary, the forward control tube and connect.
7. Set the upright lever at the feel unit position at mid-travel (detail C). Adjust, if necessary, the forward control tube and connect.
8. Check the torque tube assembly at the rear spar and rib 63·5. Adjust, if necessary, the forward control tube so that the levers of the assembly are in the mid-travel position (detail D).
9. On the starboard side, check the torque tube assembly at rib 162·5. Adjust, if necessary, the control tubes inboard of this point so that the levers of the assembly are in the mid-travel position (detail E).
10. Check the outer bell-crank lever. Adjust, if necessary, the inboard control tube so that the lever is in the mid-travel position (detail F).
11. Check the bell-crank lever assembly at the power unit position. Adjust, if necessary, the control tube so that the levers are in the mid-travel position (detail G).
12. Repeat items 9, 10 and 11 on the port side of the aircraft.

NOTE . . .

At this point it may be convenient to check the static friction load (para.46).

13. Release the pilots' control handles and rotate them clockwise through 42 deg. 17 min. (detail A). Check that at this position the forward stop sleeve on the control rod contacts the limit stop at former 288F. Adjust the sleeve as necessary.
14. Rotate the control handles anticlockwise through the normal full range, i.e., to a position 42 deg. 17 min. to port. Check that the rear stop sleeve contacts the limit stop. Adjust the sleeve, if necessary, and lock the pilots' control handles in the central position.
15. Open the bleed screws on the main pressure relief valves and remove the 2 B.A. bleed screw together with its bonded seal from the top surface of the tail piece on each aileron power control unit. Move in turn, the appropriate control surface upward, by hand, to the limit of power unit jack movement ensuring damage is not caused to the shrouds and sealing fabric. Measure the control surface angle which must be 12 deg. $\begin{matrix}+40\\-0\end{matrix}$ min. above neutral as determined by the appropriate setting gauge.
16. Move the control surface downward, by hand, to the limit of power unit jack movement. Measure the surface angle which must be 12 deg. 20 min. $\begin{matrix}+40\\-0\end{matrix}$ min. below aileron neutral.
17. If the angles above and below aileron neutral do not conform to the above, adjust on the power unit ram adjustable fork end, (refer to A.P.4603 for method of adjustment). When adjustment is complete lock the adjuster.
18. Move the control surface to the neutral position 3 deg. above wing datum, using the appropriate setting gauge (Ref.No.26DC/95165 for inner and 26DC/95166 for outer aileron). Press the neutral setting plunger on the power unit and move the input lever until the plunger registers with the indentation in the unit carrier assembly.
19. Adjust the spring control rods to fit and connect them in position.
20. Close the bleed screws on the main pressure relief valves and replace the 2 B.A. bleed screw in the top surface of the tail piece, ensure that the bonded seal is fitted to the 2 B.A. bleed screw and wire lock the bleed screw. Fill and bleed units in accordance with the instructions in A.P.4603C.
21. Set the trim actuator (fig.13) and connect between the feel unit and the lever in the control run.
22. Release the pilots' control handles and with a ground electrical supply attached to the aircraft and the aileron power units engaged, check the ailerons for full and free travel. Full travel of the aileron is 12 deg. 20 min. $\begin{matrix}+40\\-0\end{matrix}$ min. up and down from neutral with 42 deg. 17 min. movement of the control handle in each direction.
23. Check that the stops on the control rod contact the limit stops at for-

KEY TO FIG.17 AND 18 (continued)

mer 288F, with full movement of the control and that the rollers of the triple roller bearings are working freely.

24. Check that all adjustment and connection points are safe and correctly locked.

25. Finally, check the fluid level in the power units and replenish if necessary.

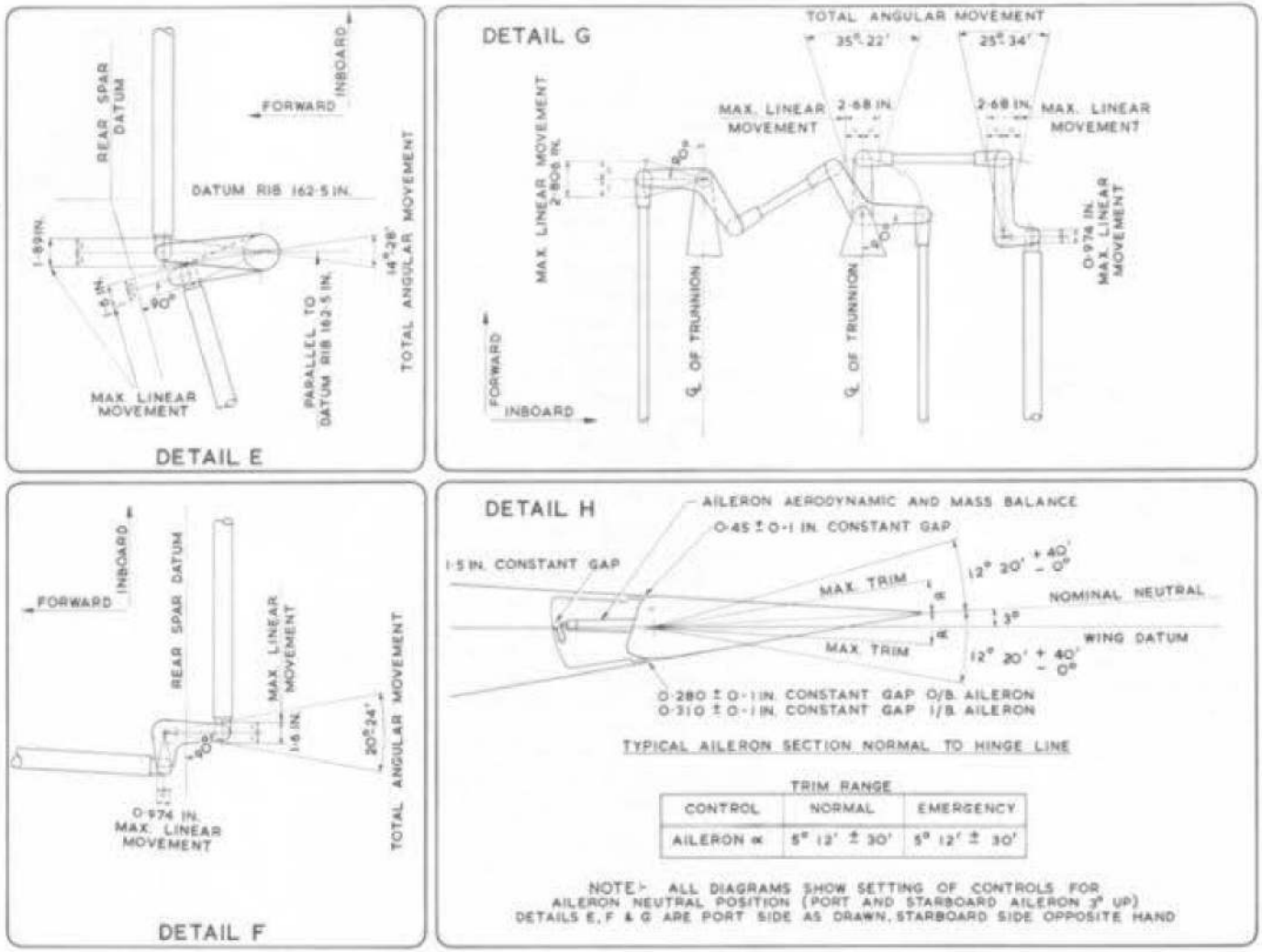

Fig.18. Aileron control rigging (2)

KEY TO FIG.19 AND 20
ELEVATOR CONTROL RIGGING

NOTE...
It is advisable to check all dimensions before carrying out any adjustments to the circuitry. The mach trim must be in the retracted attitude and the bomb doors closed before any checks are made.

1. Jack the aircraft laterally and longitudinally level (Sect.2, Chap.4).

2. Disconnect the spring control rods from the input levers of the power control unit.

3. Disconnect the trim actuator from the vertical lever at the feel unit position.

4. Set the pilot's control handle 6 in. back from the fully forward butting position (detail A). Secure the handle in this position.

5. Check the centrally pivoted lever at former 75F position. Adjust, if necessary, the control rod forward from this position so that the centre line of the lever is parallel to, and approximately 7 in. from former 75F (detail B).

6. Check the lever between formers 21·717A and 44·592A. Adjust, if necessary, the control rod forward from this point so that the centre line of the lever is parallel to former 44·592A and approximately 10·3 in. from it (detail C).

7. Check the lever at the feel unit position. Adjust, if necessary, the control rod forward of this point so that a line midway between the rod attachment points is 3·625 in. forward of former 321.936A (detail D).

8. Check that the lever attached to the auto mach trim servo-motor is vertical. Adjust, if necessary, on the servo-motor eye-end, (detail E).

9. Check that the auto mach trim servo-motor micro switch is just operated. Adjust, if necessary, on the striker pin on the auto mach trim servo motor (detail E).

10. Check the torque tube assembly at the rear spar and rib 63·5 in. Adjust, if necessary, the control rod forward of this point so that the centre line of the lowest lever of the assembly is parallel to the datum face of the rear spar and approximately 2 in. from it, (detail F).

11. Check the torque tube assembly at rib 162·5 in. (both sides of the aircraft). Adjust, if necessary, the control rods inboard of this point so that the centre line of the lower lever is 9·35 in. approximately from the datum face of rib 162·5 in. (detail G)

12. Remove the bolt from the stop lever (both sides of the aircraft), (detail H).

◀ 13. **Open the bleed screws on the main pressure relief valves of the power control units and remove the 2 B.A. bleed screw together with the bonded seal from the top surface of the tail piece of each power control unit. ▶ Move the appropriate control surface upward, by hand, to the limit of power unit jack movement. Care must be exercised to avoid damage to the shrouds and sealing fabric. Measure the control surface angle which must be 16 deg. $^{+0}_{-30}$ min. above nominal neutral.**

14. Move the control surfaces downwards, by hand, to the limit of power jack movement. Measure the control surface angle which must be 13 deg. $^{+0}_{-1}$ deg. below nominal neutral.

15. If the angles above and below nominal neutral do not conform to those quoted, adjust on the power unit adjustable fork-end (A.P.4603D). Lock the adjuster when adjustment is complete.

NOTE...
After establishing the above angles by adjustment of the P.F.C. units, no further adjustment must be made on the units.

◀ 16. **Close the bleed screws on the main pressure relief valves of the power control units and replace the 2 B.A. bleed screw on the top surface of the tail piece of each power control unit. Ensure that the bonded seal is fitted to each 2 B.A. bleed screw and wire lock the bleed screws. Fill and bleed the units in accordance with the instructions in A.P.4603D. ▶**

17. Set the spring control rods to the following dimensions:-

Inboard	-	2 ft. 2·73 in.
Outboard	-	2 ft. 4·6 in.

18. Switch on the elevator group of power units.

19. Move the control surface to the neutral position, 3 deg. above the wing chord using setting gauges, Ref.No.26DC/95163 and 26DC/95164. Press the neutral setting plungers

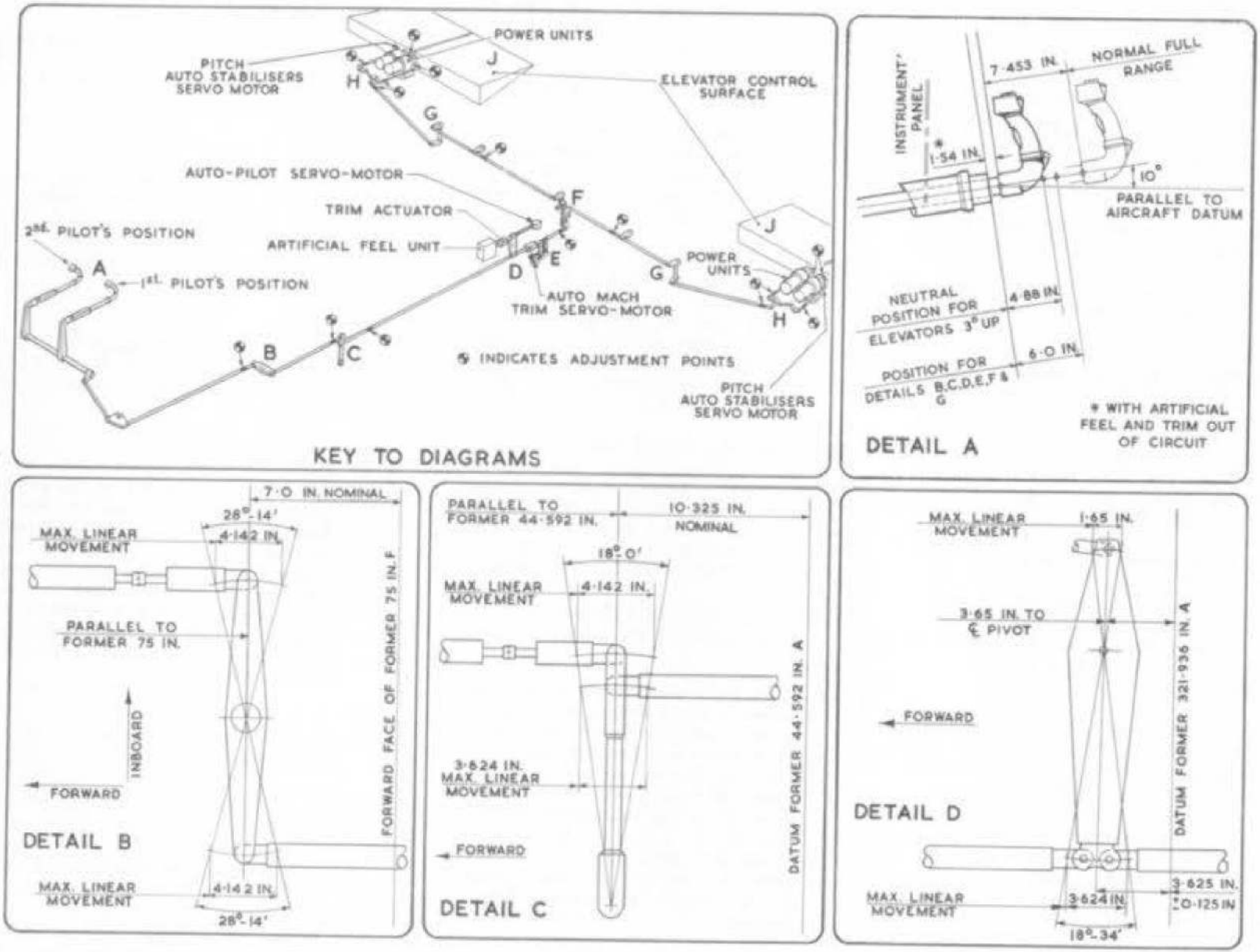

Fig. 19. Elevator control rigging (1)

RESTRICTED

on both P.F.C. units at the same time and switch off the elevator group of power units, holding the neutral setting plungers in and maintaining the rigging neutral until the units have run down.

NOTE...
With the elevators in neutral, the distance between the centre of the hole in the ram attachment fitting on the elevator to the centre of the hole in the tail cone attachment trunnion must be 26·06 in. (A.P.4603D, Vol.1, Sect.1, Chap.2).

20. With the elevator still in neutral, couple up the spring rods.

21. Switch on the elevator group of power units and move the control surfaces to the up position. Measure the control surface angle which must 16 deg. $^{+0}_{-30}$ min.

22. Move the control surfaces to the down position and measure the control surface angle which must be 13 deg. $^{+0}_{-1}$ deg.

NOTE...
Should new levers 9 and 10/R3515 have been fitted prior to rigging check, the ends of the kidney slots may be carefully filed to enable the correct movement to be obtained. A minimum wall thickness of 5/16 in. must be maintained. After filing, all burrs must be removed and the levers treated with selenious *acid to Spec.D.T.D.911.*

23. With all P.F.C. units set up to the above sequence, set the pilot's control to the 1·54 in. position (detail A) and with the artificial feel and trim still out of circuit, fit the bolt to the stop lever (detail H) on both sides of the aircraft. With

KEY TO FIG.19 and 20 (continued)

the elevators still in the down position (item 22) slight adjustment of the adjuster may be necessary to marry up the controls.

NOTES...
(1) Check that the stop on the power unit trunnion lever is positive with elevators down and circuitry connected. At this point it may be convenient to check for fouls and static friction load (para.46).

(2) Detail H is for reference purposes only and the position of the levers is not relevant to any part of the sequence.

24. Set the pilot's control column to 4·88 in. back from the butting stop and marry up the artificial feel and trim.

NOTE...
The 1·54 in. dimension will move forward to a new dimension of 1·2 to 1·4 in.

25. Carry out a full range check of the elevators and neutral settings (detail J).

26. With the elevators 16 deg. $^{+0}_{-30}$ min. above neutral, adjust the rear stop sleeve on the control rod until it contacts the limit stop at former 288F.

27. Check that, with the elevators 13 deg. $^{+0}_{-1}$ deg. below neutral, movement is limited by the secondary stop at the power unit trunnion lever and that there is a gap of 0·6 in. approximately between the forward stop sleeve and the limit stop at former 288F.

NOTE...
When the servo actuator in the auto-mach trim system is fully extended, up movement is governed by the primary stop at former 288F and the secondary stop on the power unit trunnion. To accommodate the increase in the overall length of the circuitry with the mach trim fully extended and make it possible to obtain the full down range, the control column will move forward against its butting stop and take up the 0·6 in. gap between the forward stop sleeve and the limit stop at former 288F.

28. On aircraft with Mod.666 embodied set the elevator control surfaces in neutral, and secure the pilot's control handle. Adjust, if necessary, the bomb door trim mechanism connecting rod to set the measurement of 1·19 in. (view on arrow A detail E).

29. Adjust if necessary, the bomb door trim mechanism lever stop bolt to secure the clearance of 0·020 to 0·025 in. (detail E).

30. Select bomb doors open and measure the elevator control surface up movement which must be 0·7 deg. ± 0·05 deg.

31. Select bomb doors close.

32. After wire locking all adjustment points and checking the safety of all rods, set the controls to the dimensions shown on details A, B, C, D, E, F and J and measure the stick position and record on aircraft history card.

NOTE...
This is a check on the standardisation of the setting of control geometry. Check that the rollers of the triple roller bearings work freely.

33. Finally check the fluid level in the power units and replenish if necessary.

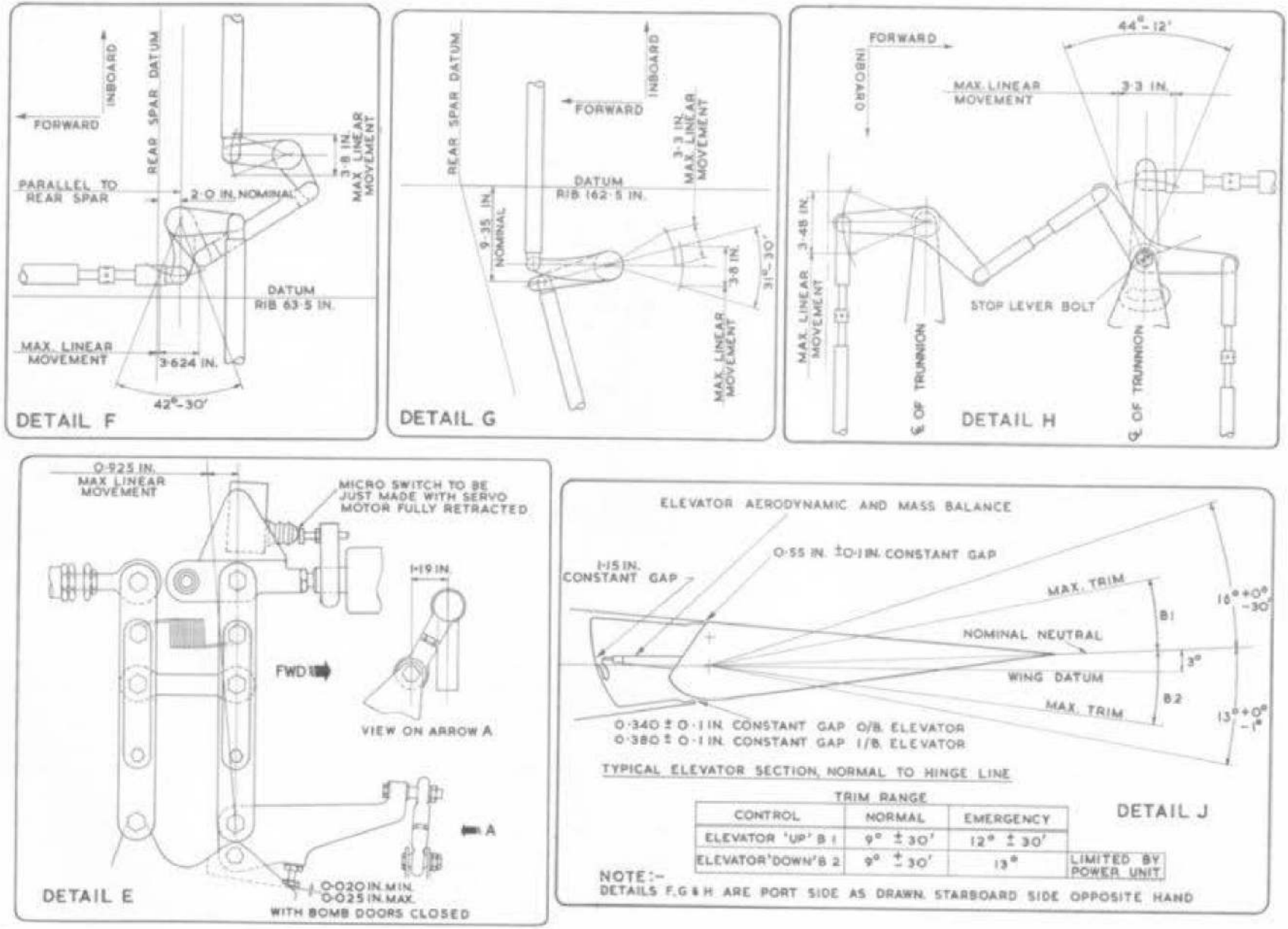

Fig. 20. Elevator control rigging (2)

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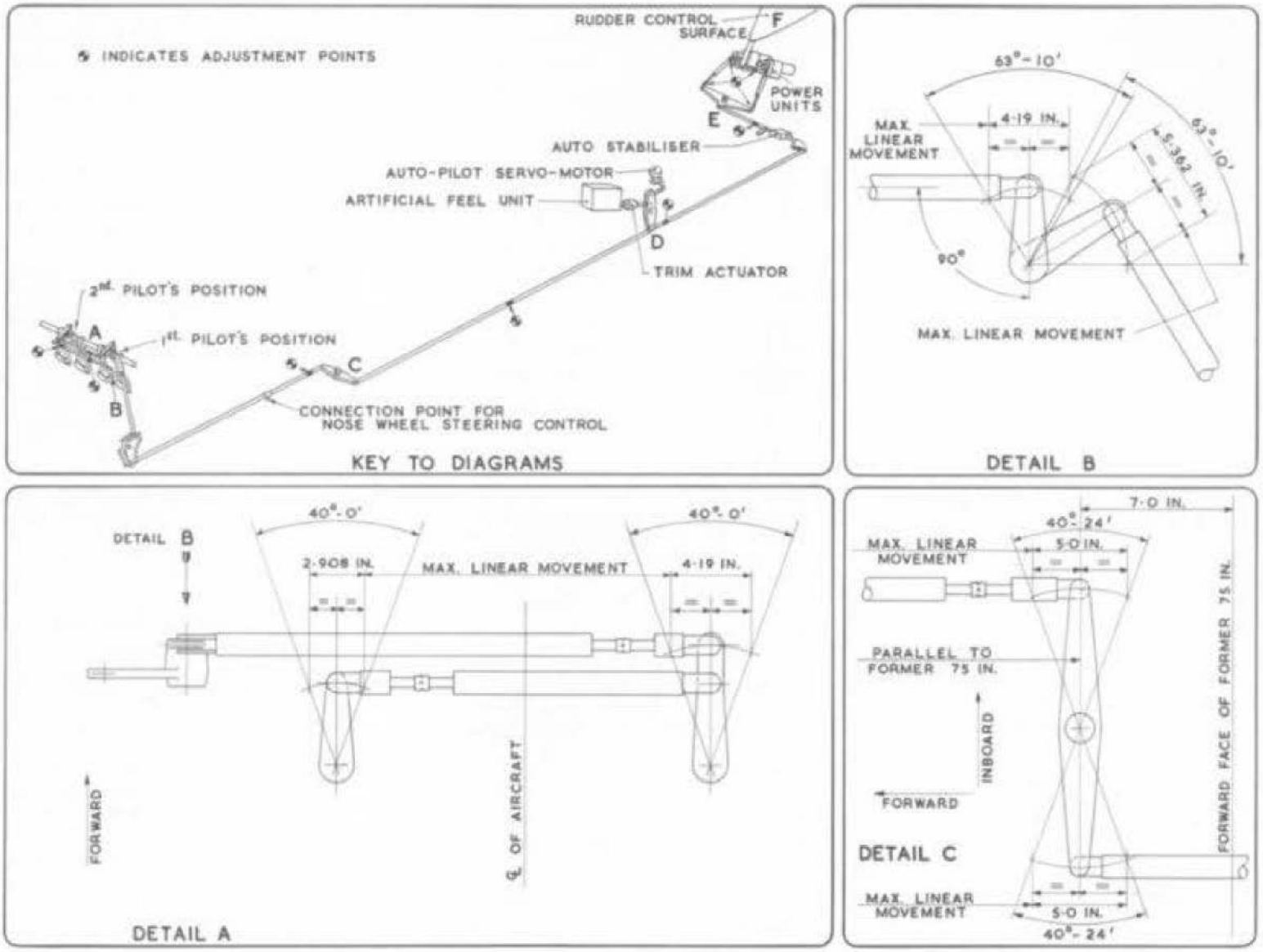

Fig. 21. Rudder control rigging (1)

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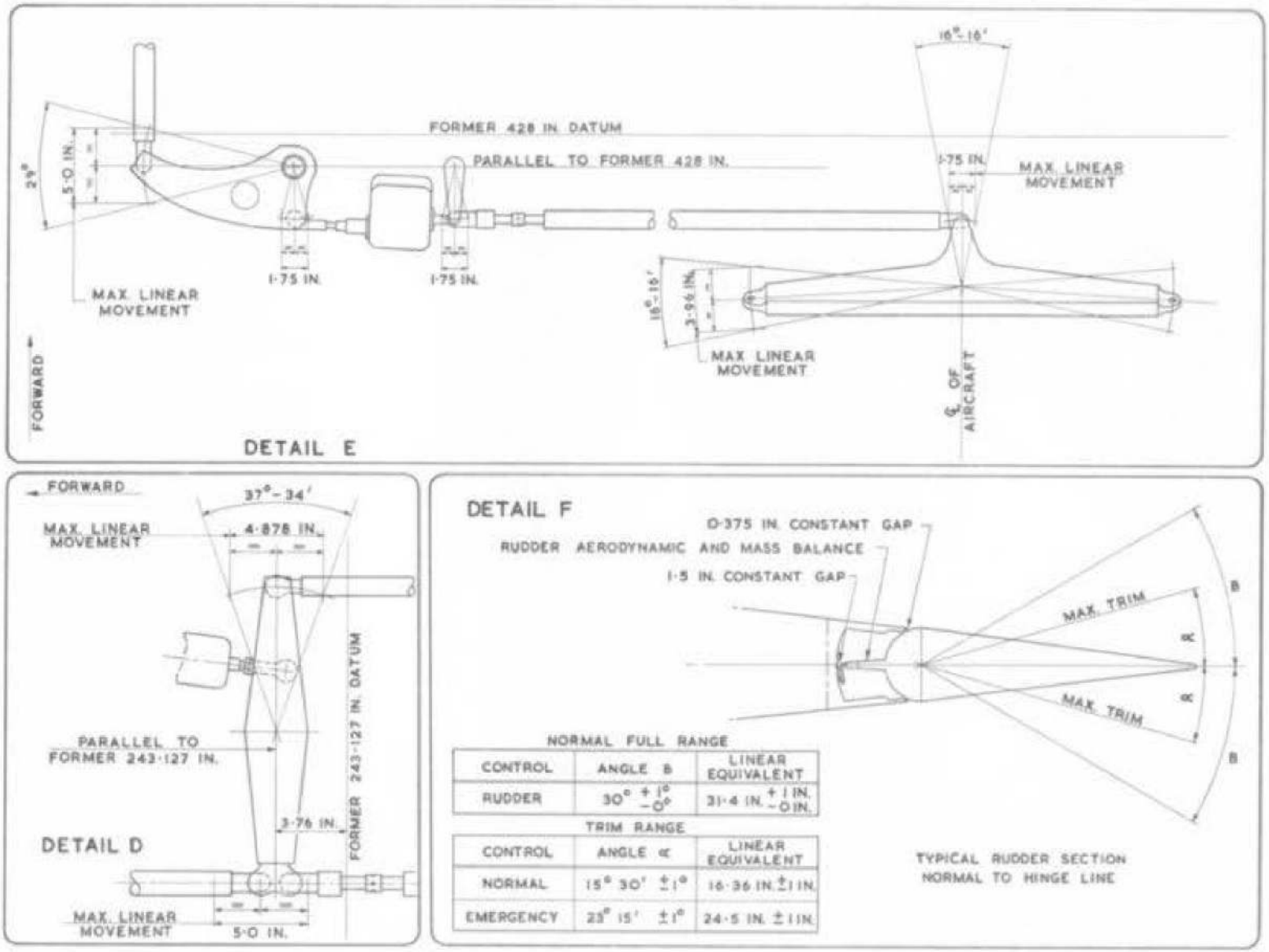
KEY TO FIG. 21 AND 22
RUDDER CONTROL RIGGING

1. Jack the aircraft laterally and longitudinally level (Sect.2, Chap.4).
2. Disconnect the spring control rods at the input levers of the power units.
3. Disconnect the trim actuators and the nose-wheel steering from the control run.
4. Set the rudder pedal adjusters in mid-position.
5. Set the rudder pedals in line, using setting bar. Part No.Z.8532.
6. Set the connecting rods and levers on the control unit in the cockpit as shown in details A and B, adjusting as necessary.
7. Check the centrally-pivoted lever at former 75F position. Adjust, if necessary, on the control rod forward from this point so that the lever is in mid-travel position (detail C).
8. 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).
9. Check the bell-crank lever at the rear of the fuselage control run. Adjust, if necessary, the forward control rod so that the lever is at mid-travel (detail E).
10. Check the transverse lever in the centre of the aircraft (detail E). Adjust, if necessary, the rod between this lever and the auto-stabiliser unit so that the transverse lever is in mid-travel position.

NOTE...
At this point it may be convenient to check the static friction load (para.46).

11. Open the bleed screws on the main pressure relief valves of both power control units and remove the 2 B.A. bleed screw, together with its bonded seal, from the top surface of the auxiliary unit tail piece. Move the rudder to starboard, by hand, to the limit of power unit jack movement. Care must be exercised to avoid damaging the shrouds and sealing fabric. Measure the control surface movement which must be $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. from neutral, measuring to the base of the trailing edge centre line.
12. Move the control surface to port, by hand, to the limit of power unit jack movement. Measure the amount of control surface movement, which must be $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. from neutral, measuring to the base of the trailing edge centre line.
13. If the angles to port and starboard of neutral do not agree with the above, adjust on the power unit ram adjustable fork-end. When adjustment is complete, lock the adjuster.
14. 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 indentation in the unit carrier assembly.
15. Adjust the spring control rods to fit, and connect them in position.
16. Close the bleed screws on the main pressure relief valves of both power control units and replace the 2 B.A. bleed screw, together with its bonded seal, on the top surface of the auxiliary unit tail piece. Fill and bleed the units in accordance with the instructions in A.P.4603E
17. Release the pilots' rudder pedals and with a ground electrical supply attached and rudder power units engaged, check the rudder for full and free travel on both main and auxiliary units. Full travel is from $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. port to $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. starboard. On change-over from the main to the auxiliary unit allow a fifteen second run down time. Should rudder 'kick' be evident on change-over adjust the input levers in accordance with A.P.4603E to eliminate the 'kick' with the rudder in neutral. Finally check that full movement is obtainable at all positions of the rudder pedal adjusters on both main and auxiliary units. Linear measurements are made as given in para.57 of this chapter.
18. Check that the rollers of the triple roller bearings are working freely.
19. Check that when the rudder is moved $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. to port the rear stop sleeve on the control rod contacts the limit stop at former 288F. Adjust the sleeve as necessary.
20. Check that when the rudder is moved $31{\cdot}4\ ^{+\ 1}_{-\ 0}$ in. to starboard the forward stop sleeve contacts the limit stop. Adjust sleeve if necessary.
21. Set the trim actuator (fig.13) and connect between the fuel unit and the lever in the control run. Carry out trim checks on normal and emergency actuators on both main and auxiliary P.F.C. units. Trim range movements are given in detail F, fig.22.
22. Check that all adjustment and connection points are safe and correctly locked.
23. Finally check the fluid level in the power unit and replenish if necessary.



NORMAL FULL RANGE

CONTROL	ANGLE B	LINEAR EQUIVALENT
RUDDER	$30^{\circ}\ ^{+1^{\circ}}_{-0^{\circ}}$	31·4 IN. $^{+1\text{ IN.}}_{-0\text{ IN.}}$

TRIM RANGE

CONTROL	ANGLE α	LINEAR EQUIVALENT
NORMAL	15° 30' ±1°	16·36 IN. ±1 IN.
EMERGENCY	23° 15' ±1°	24·5 IN. ±1 IN.

Fig. 22. Rudder control rigging (2)

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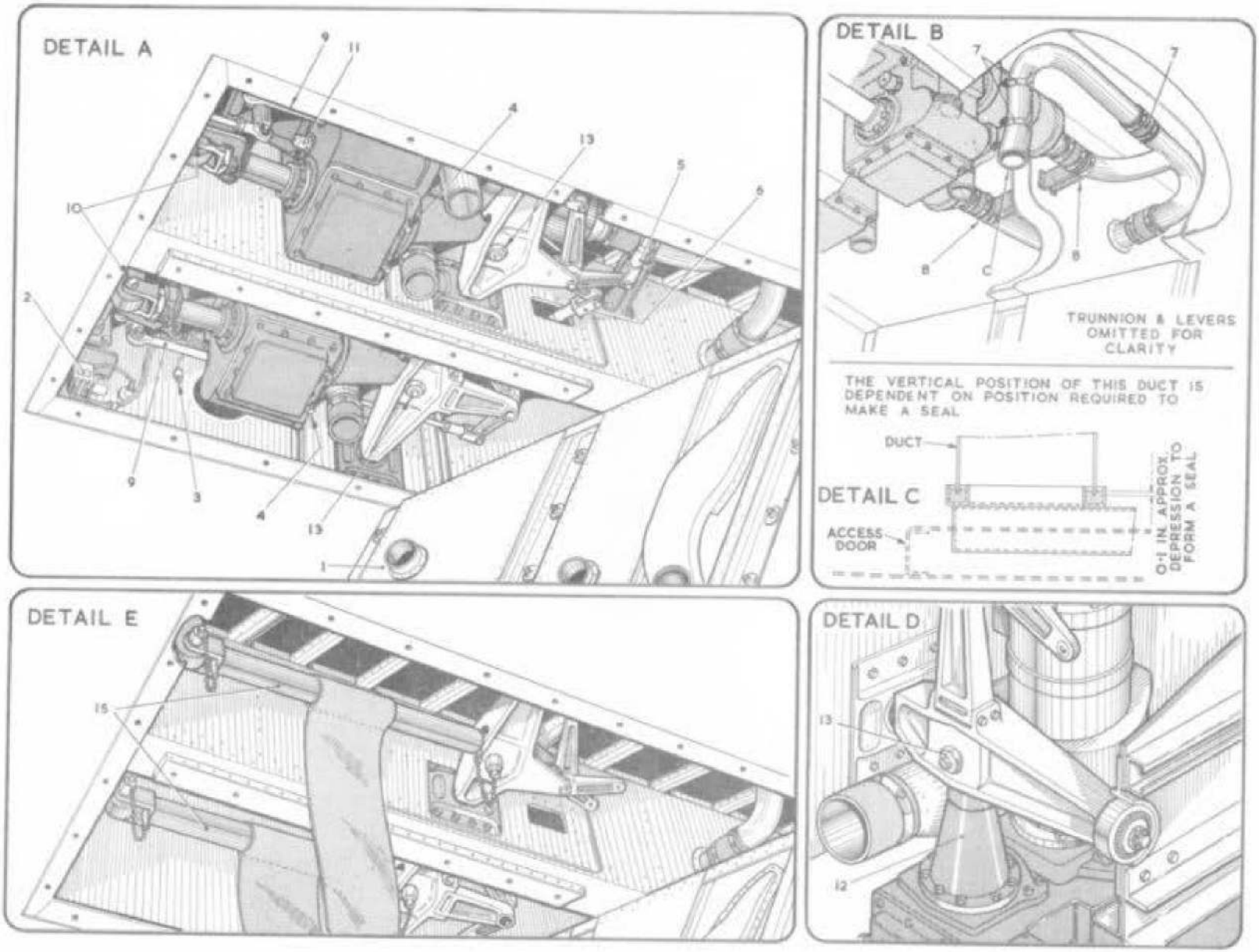

Fig. 23. Removal of aileron power units

◀ KEY TO FIG.23 ▶
REMOVAL OF AILERON POWER UNITS

1. Lower the power unit access doors.
2. Disconnect the electrical wires at the terminal block and clips on wing ribs and withdraw from the conduit, leaving the wires attached to the motor.
3. Disconnect the pressure warning switch wire.
4. Drain the oil from the unit sump.
5. Disconnect the main input control rod at the inboard unit.
6. Remove the lever, connecting the lever assemblies, which passes through the separating rib.
7. Remove the first inboard section of the cooling air input pipe by removing the two half clips and slackening off the two jubilee clips at the hose connection (see detail C before assembling).
8. Slacken the jubilee clips at the support brackets and at the input hose connections to the motor, and slide the hose back on the pipe to clear the motor.
9. Disconnect and remove the spring control rod.

NOTE...
The inboard and outboard spring control rods are of different lengths. For ease of identification the rods and their relating lever arms are marked, one by a red cross and the other by a red circle.

10. Remove the coupling bolt from the unit piston rod at the operating lever. Support the unit whilst this is in progress.
11. If difficulty is experienced in removing the bolts in item 10, the operation may be facilitated by opening the main bleed screws on the unit.
12. Lower the unit and allow to hang from the main attachment (detail D).
13. Securely support the unit, then remove the split pin, nut and bolt at the cross piece.
14. Lower the unit on to a suitable trolley.
15. Fit a jury strut (Ref.No.26DC/95037).

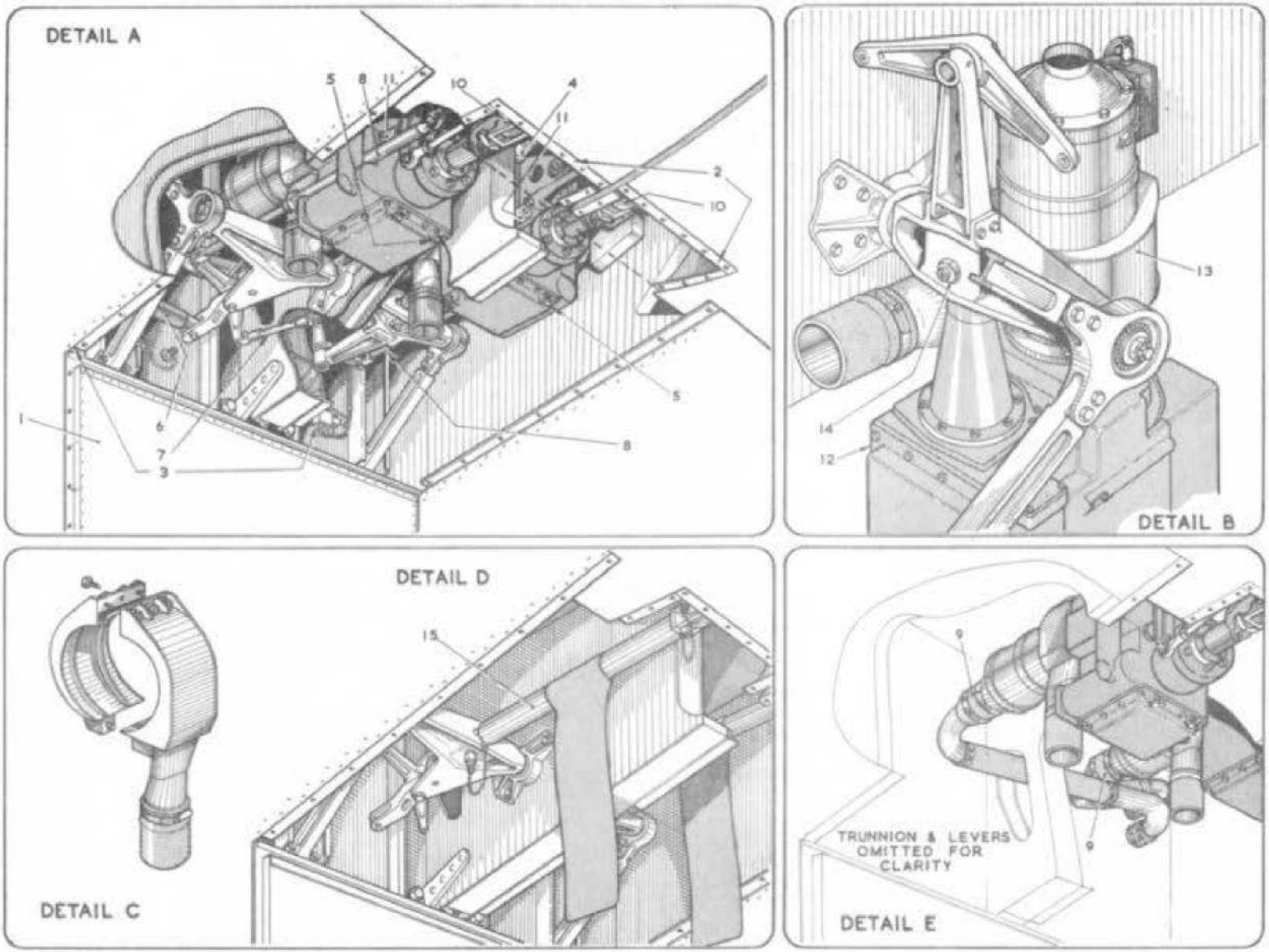

Fig. 24. Removal of elevator power units

◀ KEY TO FIG.24 ▶
REMOVAL OF ELEVATOR POWER UNITS

1. Lower the power unit access doors.
2. Remove the hinge access panels from the elevator in the region of the power unit.
3. Disconnect the electrical wires at T.B's and clips at the rear spar.
4. Disconnect the pressure warning switch at the plug on the aft end of the power unit.

NOTE...
On outboard units, also disconnect the pitch damper servo leads.

5. Drain oil from the sump of the unit.
6. Disconnect the main input control rod at the lever assembly.
7. Remove the lever, connecting the lever assemblies, which passes through the separating rib.
8. Remove the spring control rods.

NOTE...
The inboard and outboard spring control rods are of different lengths. For ease of identification the rods and their relating levers are marked, one by a red square and the other by a red equilateral triangle.

9. Disconnect the cooling ducts where indicated.
10. Remove the coupling bolts from the unit piston rod at the elevator hinge arms. Support the unit whilst this is in progress.
11. If difficulty is experienced in removing the bolts in item 10, the operation may be facilitated by opening the main bleed screws.
12. Lower the unit and allow it to hang from the main attachment.
13. Remove the cooling exhaust manifolds.
14. Support the unit and remove the attachment bolt from the mounting trunnion, then lower the unit on to a suitable trolley.
15. Fit a jury strut (Ref.No.26DC/95038).

NOTE...
On assembly of the outboard elevator fork-end to the power unit, it is important to ensure that a rubber washer (Pt.No.25/P3484) is fitted between the fork lug and the roller bearing and over the protruding bush. The function of this washer is to prevent malalignment of the pitch damper servo motor with resultant chafing of the power compartment door.

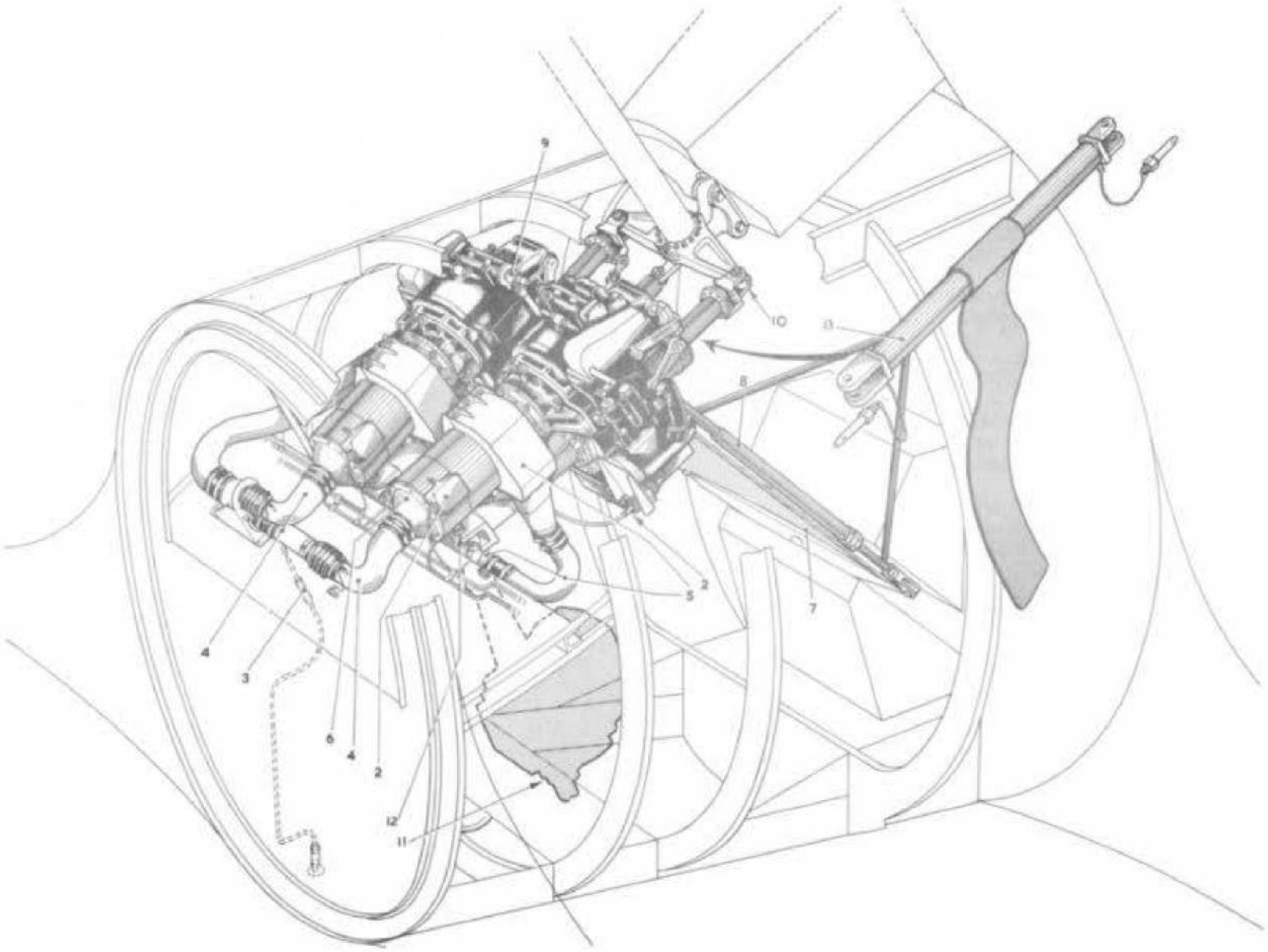

Fig. 25. Removal of rudder power units

KEY TO FIG.25
REMOVAL OF RUDDER POWER UNITS

1. Ensure that the electrical power supply is off.
2. Disconnect the electrical leads from the power control units.
3. Disconnect the drain pipe from the starboard power control unit cooling air duct.
4. Disconnect and remove the cooling air inlet ducts from the two-way branch on the port side of the power unit support beam and from the Rotax motors.
5. Disconnect and remove the cooling air exhaust ducts and manifolds from the Rotax motors and the exhaust outlet on the fuselage outer skin.
6. Remove the Rotax motors from the port and starboard power control units.
7. Remove the telescopic control rod guard.
8. Disconnect and remove the telescopic input rods.
9. Disconnect and remove the flexible interconnecting pipe from each unit. Blank off the banjo union connections.
10. Extract the split pin and remove the nut and bolt securing the power unit to the rudder operating lever.
11. Lower the unit to the servicing platform.
12. Support the unit, extract the split pin and remove the nut and bolt securing the unit to the power unit support beam.
13. Fit jury strut (Ref.No.26DC/95039).
14. Lower the unit through the access door on to a suitable trolley.
15. Repeat operations (10) to (14) to remove the remaining unit.
16. Fitting of the power control units is a reversal of the removal procedure.

NOTE...
Prior to refitting the Rotax motors turn the generator drive briskly by hand, check for freedom of movement and ensure that oil is passing through the 1/64 in. dia. hole on the end of the distributor stalk.

AIR BRAKE LEG/FLAP ASSEMBLY

Removal

79. 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.26 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 97 and 181 from panels 3P and 4P respectively and the 112-volt fuses 383 and 406 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

80. Installation is a reversal of the removal sequence and must include the setting procedures given in para.66 to 70 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 at the bottom on a top air brake leg.

(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/3339).

(4) The air brake flap stop blocks must be set to the instructions in para.68 op.(32) to (39).

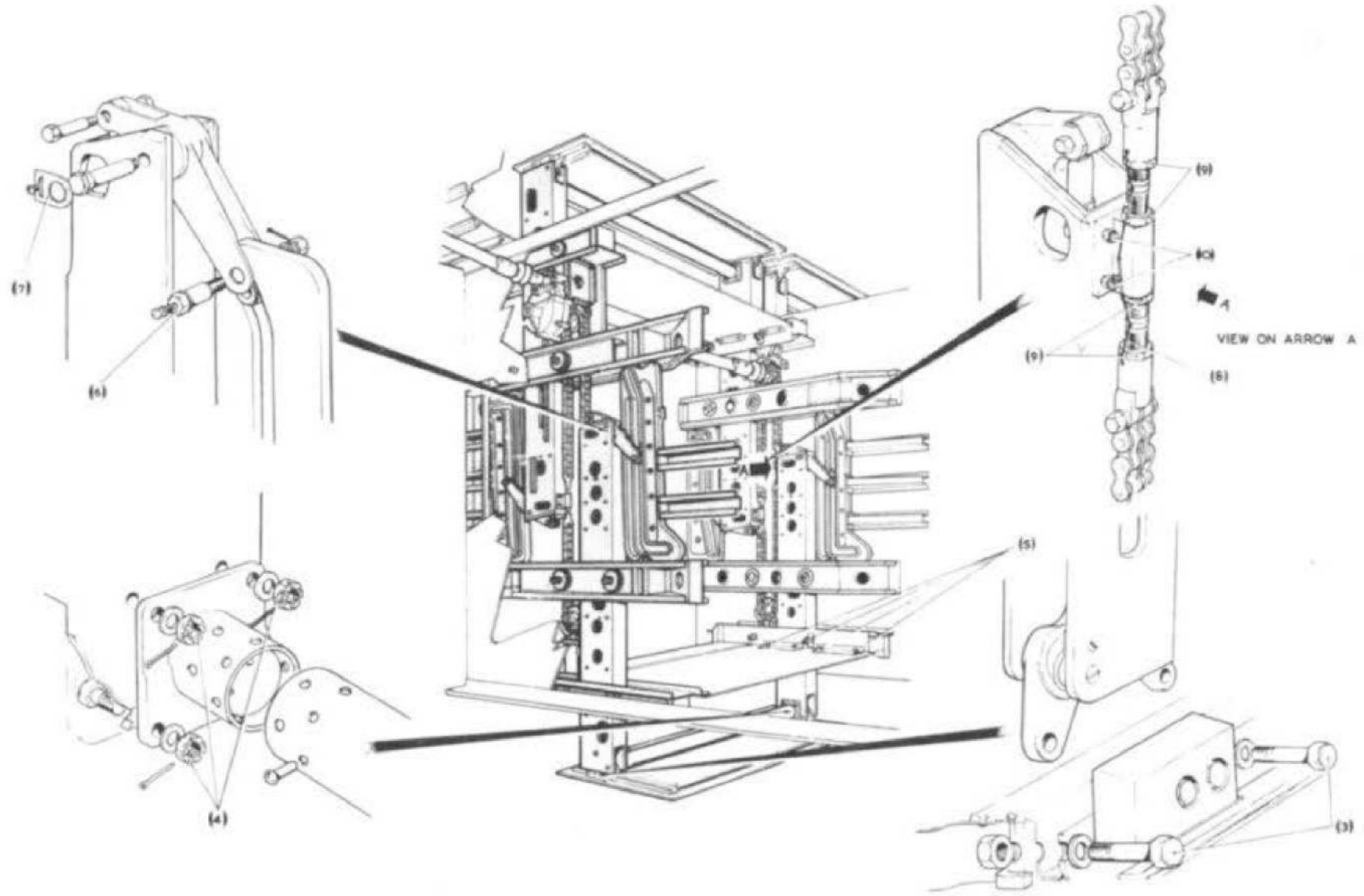

Fig. 26 Air brake leg/flap removal