Chapter 4 FLYING CONTROLS

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DESCRIPTION AND OPERATION

General

1. The port and starboard runs of each of the three main flying control systems are chiefly composed of cables, pulleys and connecting-rods (*fig.* 1 *and* 15). For the elevator and rudders, the control runs are connected direct from the control column and rudder pedals to the relevant surface operating linkwork. For the ailerons however, both runs are connected from the column handle to their respective surfaces via hydraulic servodyne units, located one in each main plane trailing edge inboard of the wing fold position. Whilst the elevator and rudders are directly controlled by the pilot at all times, the ailerons, which are of the differential type, are normally indirectly operated from the column handle via the servodyne units (*fig.* 2 *and Sect.* 3 *Chap.* 6). Hydraulic power assists the pilot in the operation of these surfaces under the extreme aerodynamic loadings of high speed manoeuvres. The sense of feel thus lost is artificially simulated by the incorporation of a spring strut unit (*fig.* 4) in the control run. This unit is located on the port side of the cabin just above floor level. In the event of hydraulic power failure or the pilot selecting MANUAL (power *off*), the ailerons can be directly operated. Under these conditions, however, a small amount of backlash will be evident in the control system.

Variable ratio gearing

2. To improve aircraft handling at low air speeds, each of the main flying control systems embodies a form of variable ratio gearing. For the elevator and rudder controls, where it is not adjustable, this is achieved by the incorporation of elliptical pulleys in the control runs in the booms. By this means, surface movement increases progressively as the pilot's control is moved from *neutral* to each full travel position. With the ailerons however, the range of control surface movement, relative to that of the column handle, may be increased or decreased by the operation of a knob on the column handle casting (*fig.* 3), the selection being primarily dependent on whether the surfaces are to be operated with or without power assistance. Once the desired gearing has been selected, the ratio of aileron-to-column movement remains constant throughout the column handle range.

(A.L.62, May, 58)

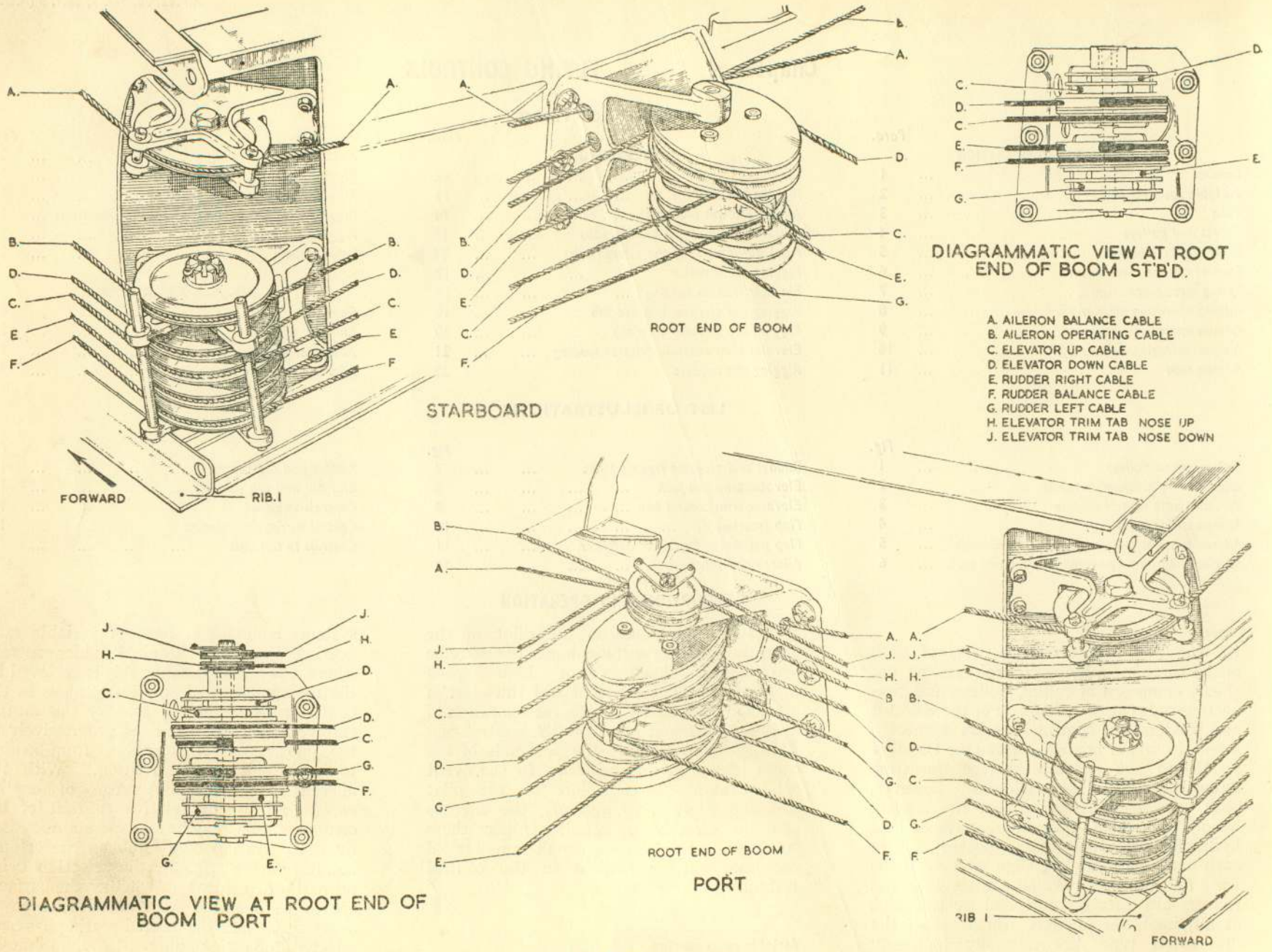


Fig. 1. Flying control pulleys

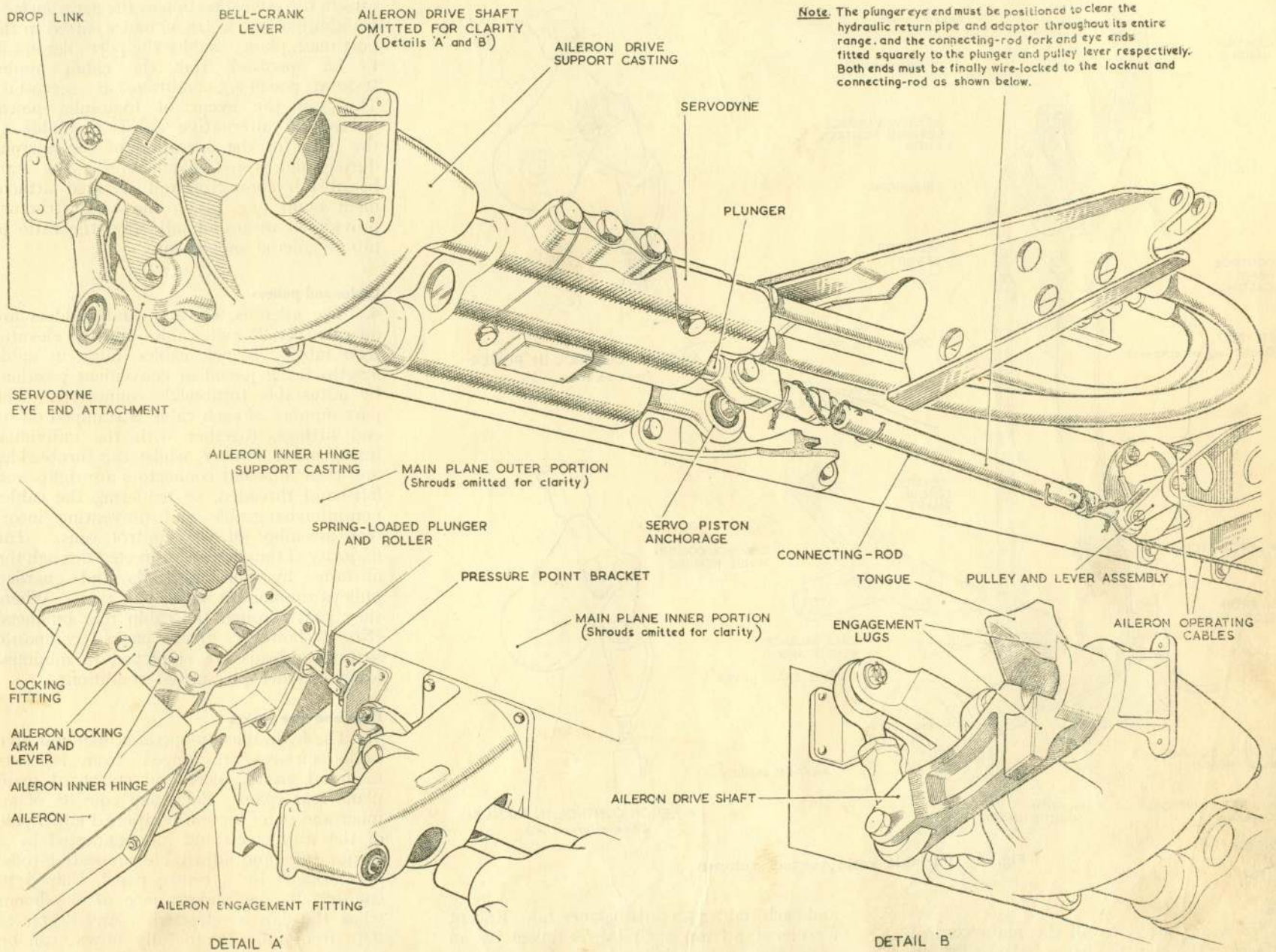


Fig. 2. Aileron drive mechanism (port)

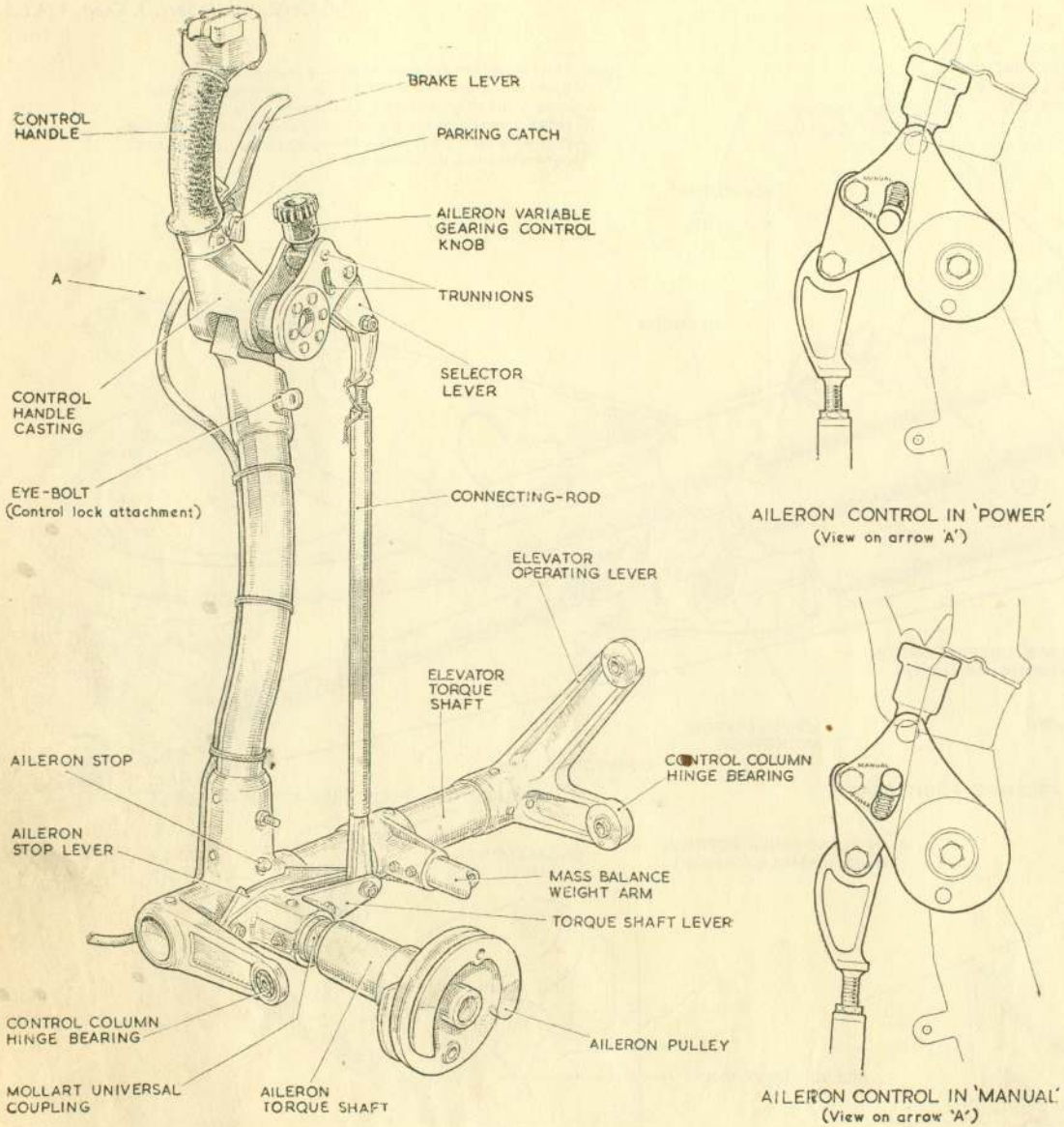


Fig. 3. Variable ratio control column

Tabs

3. Tabs are fitted to all the main control surfaces. The elevator has a balance tab on the starboard side of its trailing edge and a trim tab, controlled from the cabin, on the port side. Each aileron has a balance tab and each rudder an anti-balance tab. Except for elevator trim, each tab is linked by an adjustable connecting-rod to the adjacent airframe structure and is automatically operated by the movement of the main control surface to which it is attached. The balance tabs move in the opposite direction to the main surface and the anti-balance tabs in the same direction as the main surface. In addition, an electric actuator, fitted in the port main plane, enables the port aileron tab to be operated from the cabin (under MANUAL, power *off*, conditions) as a servo-tab. Thus, in the event of hydraulic power failure, an alternative aid is available to the pilot for the operation of the ailerons during high speed manoeuvres. The starboard tab connecting-rod serrated attachment point (*fig.* 5) on the wing structure provides a means of adjusting the ratio of tab to aileron movement.

Cables and pulleys

4. The ailerons, elevator and rudders are operated by 25 cwt. cables and the elevator trim tab by 5 cwt. cables, adjacent cable lengths being joined at convenient positions by adjustable turnbuckle connectors. The part number of each cable is stamped on its end fittings, together with the individual fitting mark number, whilst the turnbuckles and their adjacent connectors are right- and left-hand threaded, so rendering the cables non-interchangeable and preventing incorrect assembly of the control runs. The majority of the cables are directed through the airframe by fibre fairleads and guarded pulleys running on sealed ball races. Where they pass through the cabin rear bulkhead (No. 2) however, grease packed composite sealing fairleads are employed to minimise leakage under pressurised conditions.

Flaps and dive brakes

5. The hydraulically-operated flap and dive brake surfaces are hinged from brackets mounted on the port and starboard main plane rear spars. Each flap consists of an inner and outer section positioned either side of the stub boom and interconnected by a torque tube and adjustable connecting-rods, and bridged by a centre panel, shaped to conform to the undersurface of the boom when the flap is retracted. Any degree of flap, from fully UP to fully DOWN, can be selected and maintained. Two electrical transmitters, one in the port and one in the starboard boom, are each connected by adjustable links to the respective flap torque

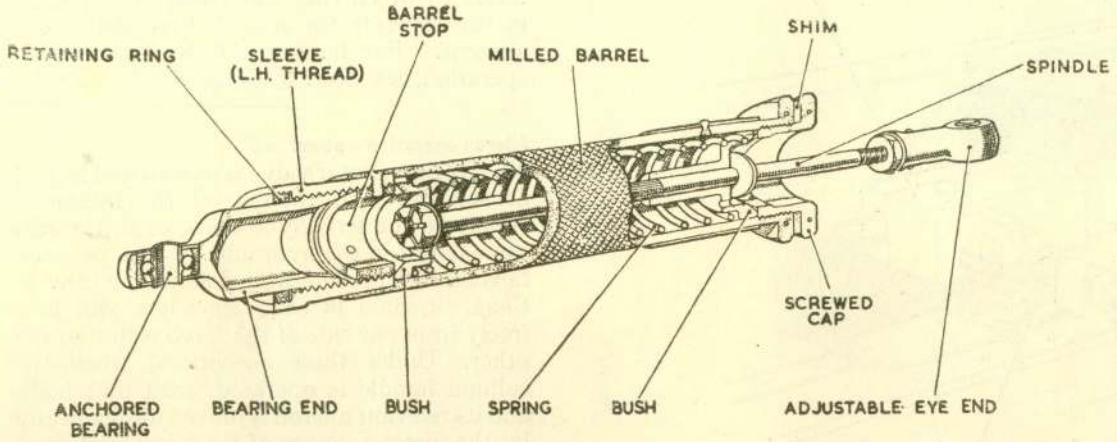


Fig. 4. Aileron spring strut

shaft and record the angle of flap on individual dials of the flap position indicator (*Sect.* 1, *Chap.* 1). ▶ The dive brakes, which are located immediately outboard of the flap positions, may only be selected fully IN or fully OUT. For this reason, no indicator is provided.

Control column mechanism (*fig.* 3)

6. The aileron torque shaft lever, at the foot of the control column, is linked by an adjustable connecting-rod to a two position POWER/MANUAL selector lever pivoted on the column handle casting. This selector lever is in turn connected by a threaded trunnion mechanism to its control knob on the same casting. Variation of aileron gearing is achieved by the alteration of the column mechanism geometry. Thus, by screwing the knob clockwise, the selector lever is pivoted from the POWER to the MANUAL position carrying the upper end of the connecting-rod inboard towards the column handle fulcrum. This reduces the ratio of the aileron-to-column-hand movement.

Spring strut mechanism (*fig.* 4)

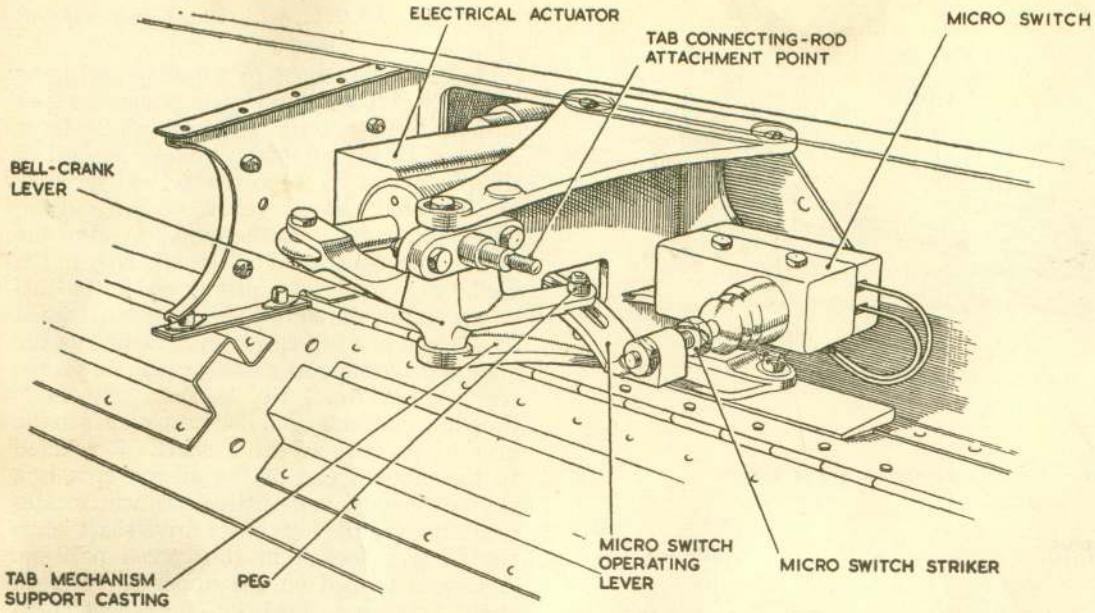
7. The mechanism installed in the aileron control system, to impart an artificial sense of ' feel ' when the surfaces are being operated with POWER *on*, includes a spring strut unit which comprises a cylindrical body housing a spring-loaded plunger. The eye end of the body is pivoted on a bracket mounted on the port wall of the cabin, just forward of the elevator quadrant pulley assembly, whilst that of the unit plunger is connected to the lever of a sprocket and lever assembly, mounted on the elevator pulley bracket farther forward on the cabin wall. The sprocket is operated by a short length of chain which replaces part of the control cable run. Movement of the column handle towards either full travel position progressively compresses the unit spring, promoting a tendency for the handle to return to neutral. Due to this tendency, the pilot ' senses ' when he is applying aileron to maintain level flight, and, by screwing the knurled unit body to port or to starboard, he is able to apply trim by lengthening or shortening the unit without upsetting the spring tension. This action is instinctive and has the effect of biasing the neutral position of the surfaces and column handle to port or starboard as necessary, so obviating the need for constant manual pressure to be applied at the column handle.

Aileron operating mechanism (*fig.* 2)

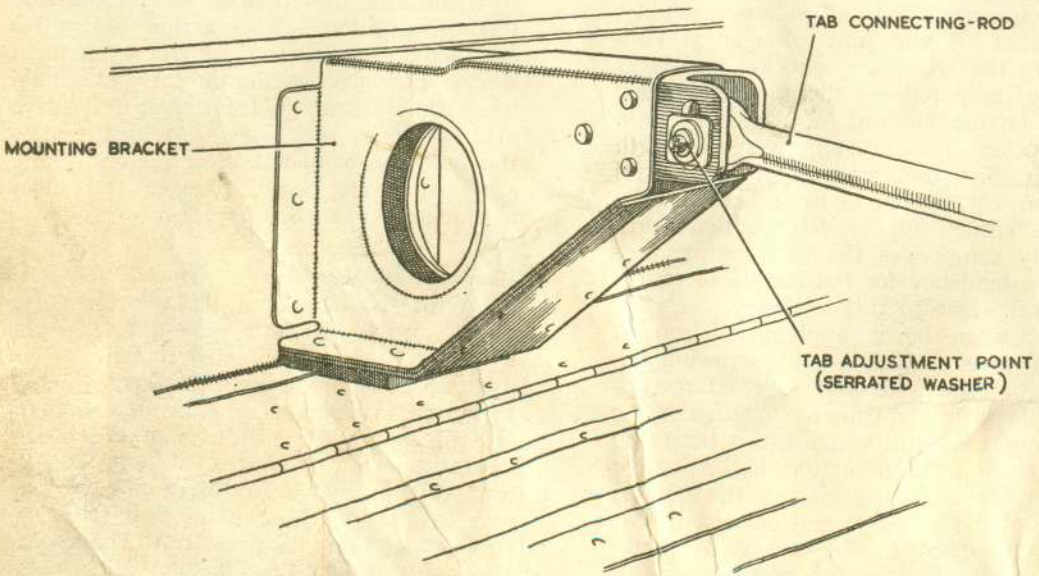
8. The control surface end of each aileron cable run is attached to a pulley and lever assembly pivoted on the main plane rear spar outboard of No. 5 rib, and each pulley lever is linked by an adjustable connecting-rod to the plunger of its respective servodyne unit. The exposed end of each servo piston ram, which protrudes from the inboard end of the unit, is pivot-mounted on the rear spar in the vicinity of No. 6 rib, whilst an eye in the outboard end of the unit body itself is attached to one arm of a bell-crank lever carried on the aileron drive support casting mounted on the rear spar at No. 7 rib. A short adjustable drop link connects each bell-crank lever to the arm of its aileron drive shaft. Bracketed to the inboard end of the aileron spar is a slotted engagement fitting, which locates securely over the lugs of its drive shaft when the wing is locked in the *spread* position. A tongue formed on the upper lug of each shaft acts as a lead for the engagement fitting as the wing is lowered. Before the wing-fold selector lever can be operated to raise the wings, the wing lock lever adjacent to it must be moved from the LOCK to the UNLOCK position. This action centralizes and locks the aileron control system in *neutral*, in which position the surfaces remain when they disengage from their respective drive shafts as the wings are folded, due to the synchronous operation of aileron locking arms by spring-loaded plunger and roller mechanisms (*Sect.* 3, *Chap.* 2).

Aileron operation—power *on*

9. With the handle of the selector valve pulled and locked OUT, pressure from the hydraulic system is directed to both servodyne units, forcing their spring-loaded *on/off* valves on to their seatings and isolating one side of each servo piston from the other. Operation of the control column handle causes the pulleys at No. 5 rib on each rear spar to rotate and move the unit plungers, so directing hydraulic pressure to the appropriate side of each servo piston. This causes the servodynes to move bodily over their stationary pistons and selector plungers, in the same direction as that in which the plungers were initially operated by the



PORT TAB – ELECTRICAL ACTUATING MECHANISM



STARBOARD TAB – ADJUSTABLE GEARING ARRANGEMENT

Fig. 5. Aileron tab mechanism (port and starboard)

control run and column handle. Axial movement of the units rotates the bell-crank levers to which they are attached and these in turn operate the lugged drive shafts and ailerons. For further details of servodyne operation, see Sect. 3, Chap. 6.

Aileron operation—power *off*

10. If the selector valve is pushed and locked at MANUAL (IN), cutting off the hydraulic supply to the servodyne units, or if, through some defect in the hydraulic system, pressure falls below a predetermined minimum (*Sect.* 3, *Chap.* 6), fluid in each servodyne will flow freely from one side of the servo piston to the other. Under these conditions, when the column handle is operated, each unit body and its relevant aileron is moved mechanically by the direct pressure of the selector plunger against the end of its servodyne chamber, the small amount of 'dead travel' so encountered being due to the displacement of fluid through the *on/off* valve.

Aileron tabs (*fig.* 5)

11. The tabs on the port and starboard ailerons normally act as balance tabs, both being linked to the adjacent wing structure by a connecting-rod (and operated in the reverse direction to their main surfaces). For the port tab, the forward end of the connecting-rod is not attached directly to the wing structure itself, but to a bell-crank lever pivoted on a support casting mounted on the structure. Except when the hydraulic pressure to the ailerons is selected to MANUAL (IN) or the pressure falls below a certain figure (*Sect.* 3, *Chap.* 6) due to a fault in the hydraulic system, this lever remains stationary and for normal flight conditions may be considered as a fixed part of the airframe structure. The support casting also carries the electrical actuator on the outboard side and a micro switch and operating lever on the inboard side, the body of the actuator being pivoted on the casting whilst its ram is attached to one arm of the bell-crank lever. A peg in the end of the other arm of the bell-crank locates in the cam slot of the micro switch operating lever, the free end of which accommodates an adjustable striker for the operation of the switch button.

Under MANUAL (power *off*) conditions, a pressure switch in the hydraulic system closes when the pressure falls below a preset minimum, completing an electrical circuit between the actuator and a control switch in the cabin and, at the same time, illuminating a warning lamp in the cabin. By manipulation of the control switch, the port tab can be deflected *up* or *down* as desired, its function then being that of a servo-tab. An amber indicator light in the cabin, operated via the bell-crank lever and micro switch on the actuator support casting, shows when the tab is out of neutral under power *off* conditions, and the operation of a master switch isolates the actuator circuit in the event of mal-functioning of the actuator.

SERVICING

WARNING

Personnel must take special care to keep their hands clear of the ailerons, whenever these surfaces are being power operated.

Clearances

12. The requisite clearances for the ailerons, aileron tabs, dive brakes and flaps are given in Chapter 2 of this section, whilst those for the elevator, rudders and their respective tabs will be found in Chapter 3.

Rigging the ailerons (*fig.* 6)

WARNING

Instances have occurred where control cables have been crossed in the ammunition bay aft of No. 2 bulkhead during rigging or cable replacement. It is of the utmost importance that adequate visual inspection is made at this point by the removal of the VHF radio, ammunition tanks and oxygen bottles.

13. Before commencing to rig the ailerons, the variable gearing control knob on the column handle must first be operated to set the selector lever at its extreme POWER position (the ailerons must NOT be rigged with the selector lever in the MANUAL position), and the hydraulic power selector valve must be locked at the MANUAL (IN) (power *off*) position. The procedure for rigging the ailerons is as follows:—

(1) Disconnect the spring strut plunger from its operating lever on the sprocket shaft, and, with the wing lock control lever in the UNLOCK position, adjust the turnbuckle of the rod connecting it to the sprocket locking lever, until the latter can be locked by the insertion of a $\frac{1}{4}$ in. dia. pip pin (with a red flag attached) via the hole provided in its mounting bracket. Check the turnbuckle for safety, ensure that the rod eye ends are correctly positioned, then tighten the lock-nuts and wire-lock the turnbuckle securely.

(2) Secure the torque shaft lever at the base of the control column in the *neutral* position by fitting the locking plate (*item* F7, *Sect.* 2, *Chap.* 4). Adjust the rod connecting this lever to the selector lever on the column handle until the handle is also in *neutral*, i.e., when a $\frac{1}{4}$ in. dia. pip pin (with a red flag attached) can be inserted to lock the handle through the rigging holes in the column and handle castings. Check the connecting-rod eye end for safety, ensure that it is correctly positioned, then tighten and wire-lock its lock-nut and secure its attachment bolt.

Note . . .

Ensure that the brake cable is clipped to the variable gearing connecting-rod in two places, to provide a loop top and bottom and so eliminate fouling and cable damage.

(3) Lock the lever of the pulley assembly to its mounting, at No. 5 rib on each main plane rear spar, by inserting the special locking pins (*item* F6, *Sect.* 2, *Chap.* 4).

(4) Connect up and correctly tension the aileron operating and balance cables, between the control column and the pulley and lever assembly at each No. 5 rib, to 52·5 ±2·5 lb., checking the figures on the 20 cwt. scale of a Mk. 4 R.A.E. tensiometer positioned in turn mid-way between pulleys throughout the system. At the same time, ensure that a gap of $\frac{1}{16}$ in. exists between the fore-and-aft opposing faces of the spring strut operating and sprocket locking levers.

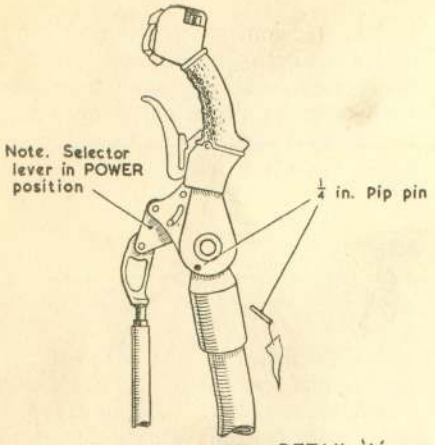
Note . . .

The tension limits quoted above apply at an ambient air temperature of 60 deg. F. For each 10 deg. F. above 60 deg. F., 4 lb. should be added to the required tension figures, and for each 10 deg. F. below, 4 lb. should be subtracted. As far as is practicable, cable tensions should be set under constant temperature conditions, i.e., in an enclosed place, and should be checked at each full travel position as well as at neutral.

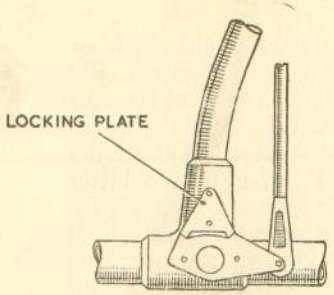
(5) Check the cable turnbuckles throughout for safety and, taking care not to introduce any cable twist, tighten their lock-nuts, and wire-lock securely.

(6) Ensure that the eye end of each servodyne unit is correctly aligned with the fork end of its mating bell-crank lever arm, if necessary, by fitting or removing 0·002 in. laminated aluminium shims under the servo piston anchorage. As these components were correctly aligned on initial assembly, no adjustment should be required in this respect unless either or both of them have been renewed (*para.* 31).

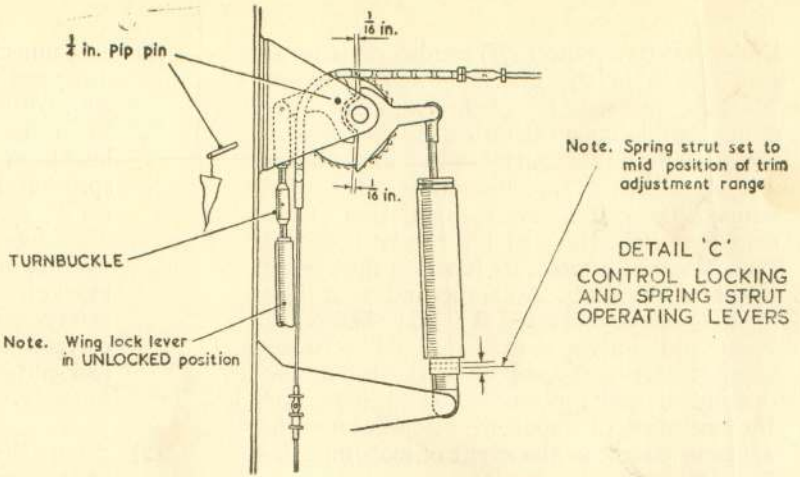
(7) Adjust the length of the rod connecting each of the two pulley assemblies mentioned in sub-para. (3) above to their respective servodyne plungers, until the arm of the bell-crank lever attached to the eye end of each unit body is at right angles to the spar datum. Check the rod eye and fork ends for safety, ensure that they are correctly positioned, then tighten and wire-lock their lock-nuts and secure their attachment bolts (*see note in fig.* 2).



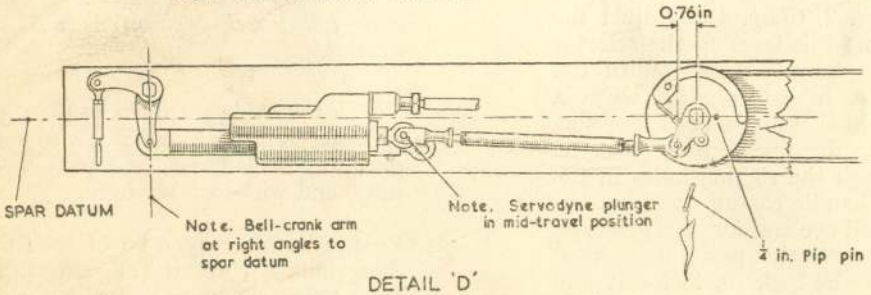
DETAIL 'A'
CONTROL COLUMN HANDLE



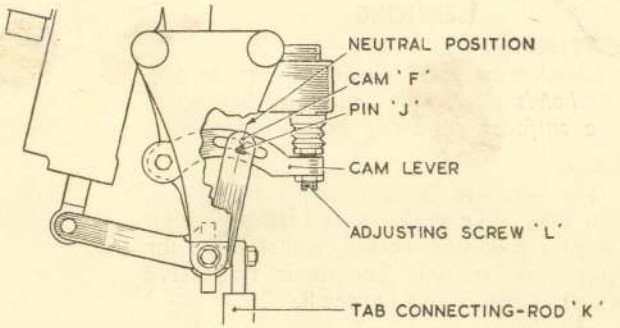
DETAIL 'B'
TORQUE SHAFT LEVER AT COLUMN BASE



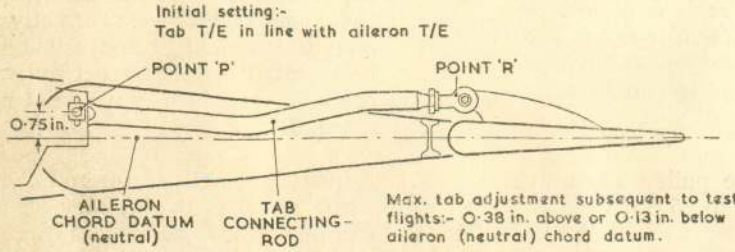
DETAIL 'C'
CONTROL LOCKING AND SPRING STRUT OPERATING LEVERS



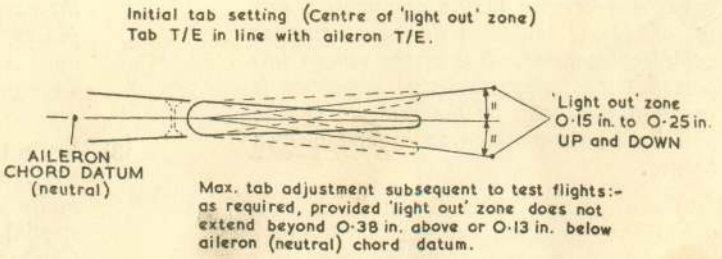
DETAIL 'D'
AILERON OPERATING MECHANISM ON REAR SPARS



DETAIL 'E' MICRO SWITCH MECHANISM



DETAIL 'F'
STARBOARD TAB OPERATING MECHANISM



DETAIL 'G'
PORT TAB OPERATING MECHANISM

Fig. 6. Rigging diagrams—powered ailerons and tabs

Rigging the elevator trim tab

20. The elevator trim tab should be rigged in the following manner:—

(1) Set the elevator trim tab control wheel in the cabin so that the position indicator reads *zero*, and check that, ◄ when in the mean position, ► the protrusion of the ◄ lower Teleflex cable is 7·5 ± 2 in. and that of the upper is 4·5 ± 2 in. ► beyond the ends of their conduits in the port inner flap bay.

(2) Set the trim tab jack (*fig.* 8) in the tail plane to its mid-travel position, and check the security of the sprocket retaining nut and split pin.

(3) With the cables secured to the chain, assemble the chain on the jack sprocket so that an equal number of links is disposed to port on each side of its horizontal centre-line.

(4) Couple up and correctly tension the cables connecting the jack chain to the ends of the Teleflex cables in the port inner flap bay, then check the turnbuckles for safety and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(5) Lock the elevator (and rudders) in the *neutral* position by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the operating levers in the rear of the booms, and adjust the length of the tab connecting-rod so that, with its forward

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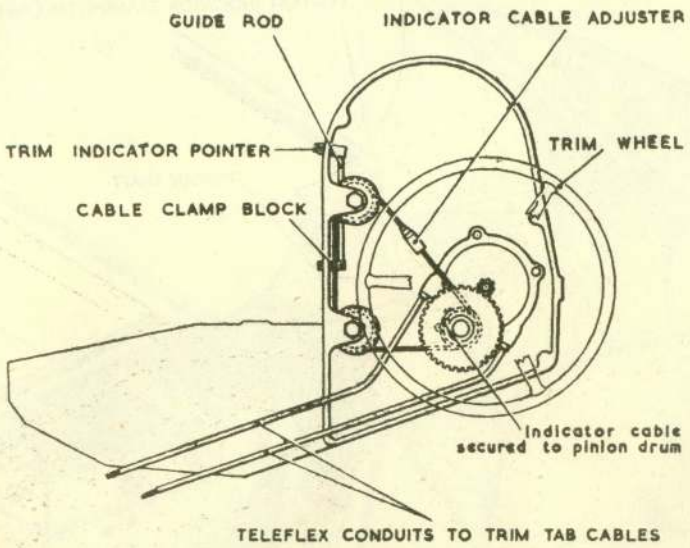

Fig. 9. Elevator trim control box

eye end attached to the second holes from the top in the jack fork end, the tab trailing edge is in line with that of the elevator. Check the eye end for safety, ensure that it is correctly positioned, then tighten and wire-lock its lock-nut and secure its attachment bolt.

(6) Operate the control hand wheel in the cabin and ensure that the tab range agrees with that shown in ◀fig. 16,▶ then remove the locking pins and re-check the control for full free range and correct sense of movement with the elevator in the fully *up* and fully *down* positions.

Note . . .

When the hand wheel is rotated clockwise, the tab should move upwards and the indicator towards the NOSE DOWN *position. Minor corrections to the indicator reading may be effected by slackening the clamp block (fig. 9) securing the indicator to its cable in the engine control box, adjusting the position of the indicator in relation to that of the cable and afterwards re-tightening the clamp block.*

Elevator trim control—friction loading

21. The effort required to operate the trim tab, after the system has been correctly rigged, must not exceed 12 lb. when measured at a point 3·5 in. from the handwheel axis.

Rigging the rudders (*fig. 7*)

(See WARNING preceding para. 13)

22. (1) Lock the rudder pedals in *neutral* by fitting the special bar (*item* F9, *Sect.* 2, *Chap.* 4).

(2) Lock the pulley group, bracketed to the rear spar in the forward end of each boom, in *neutral* by the special pins (*items* F.10, *Sect.* 2, *Chap.* 4). This will necessitate centralising the elevator pulleys of each group also.

(3) Connect up and correctly tension the rudder operating and balance cables, between the rudder pedals and the relevant circular pulleys of each group mentioned in sub-para. (2) above, to 80 ± 10 lb., checking the figures on the 25 cwt. scale of Mk. 5 R.A.E. tensiometer positioned mid-way between the pulleys on ribs No. 1 and in the inner flap bays. (*See Note to para.* 13 (4)).

(4) Check the burnbuckles for safety and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(5) Lock the rudders (and elevator) in *neutral* by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the operating levers in the rear of the booms.

(6) Connect up and correctly tension the rudder cables, between the relevant elliptical pulleys of each group on the rear spars and their surface operating levers, to the figures quoted in sub-para. (3), checking the figures on the 25 cwt. scale of Mk. 5 R.A.E. tensiometer positioned in the middle of each cable run in turn. Check the turnbuckles for safety and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(7) Disconnect the adjustable rudder operating rods at the rear of the booms from the rudder torque shaft levers, and adjust each in turn to bring the rudder horns in line with the tops of their respective fins (the adjustable ends of the rods protrude aft through the kingposts and are accessible when the boom tail fairings are removed). Check the eye ends for safety, ensure that they are correctly positioned, then tighten and wire-lock their lock-nuts and secure their attachment bolts.

(8) Initially screw in the rudder pedal and rudder operating lever stops.

(9) Remove all locking devices from the control system (the special pins should withdraw easily if the cable tensions are correct) and, by operating the rudder pedals full travel each way (*not* by moving the control surfaces manually), adjust the lever stops on the rear boom diaphragms to limit the range of surface

movement to that ◀shown in fig. 16.▶ Tighten and wire-lock the stop lock-nuts, and re-check the rudder controls for full free range and correct sense of movement.

(10) Operate the rudder pedals again, and adjust the pedal stops to give a clearance of 0·20 in. at each full travel position (thus ensuring that the control range is initially limited by the stops at the rear of the booms), then tighten and wire-lock their lock-nuts.

Rudder friction loading

23. The effort required at either rudder trailing edge to operate the rudder control system complete with anti-balance tabs from neutral, in either direction, must not exceed 10 lb. Possible causes of excessive friction include fouls, twists or a double-cross in the control runs, or dry or faulty bearings. A double-cross may be indicated audibly when the controls are operated. The surfaces, of course, will still move in the correct sense.▶◀

Rigging the rudder anti-balance tabs

24. (1) Lock the rudders in *neutral* by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the levers in the rear of the booms, attach the forward ends of the tab connecting-rods to holes D in their king post brackets, and check that the trailing edge of each tab is in line with that of its respective rudder. Adjust the length of the connecting-rods as necessary to achieve this requirement, and check the eye ends for safety, ensure that they are correctly positioned, then tighten and wire-lock their lock-nuts and secure their attachment bolts.

(2) Remove the locking pins from the rear of the booms, operate the rudder pedals full travel each way and check that the anti-balance tab range agrees with that ◀shown in fig. 16.▶

Rigging the flaps (*fig. 10*)

25. The procedure for rigging the port and the starboard flaps is as follows:—

(1) Disconnect the jack and the torque shaft connecting-rods from the flap and lash the rods clear.

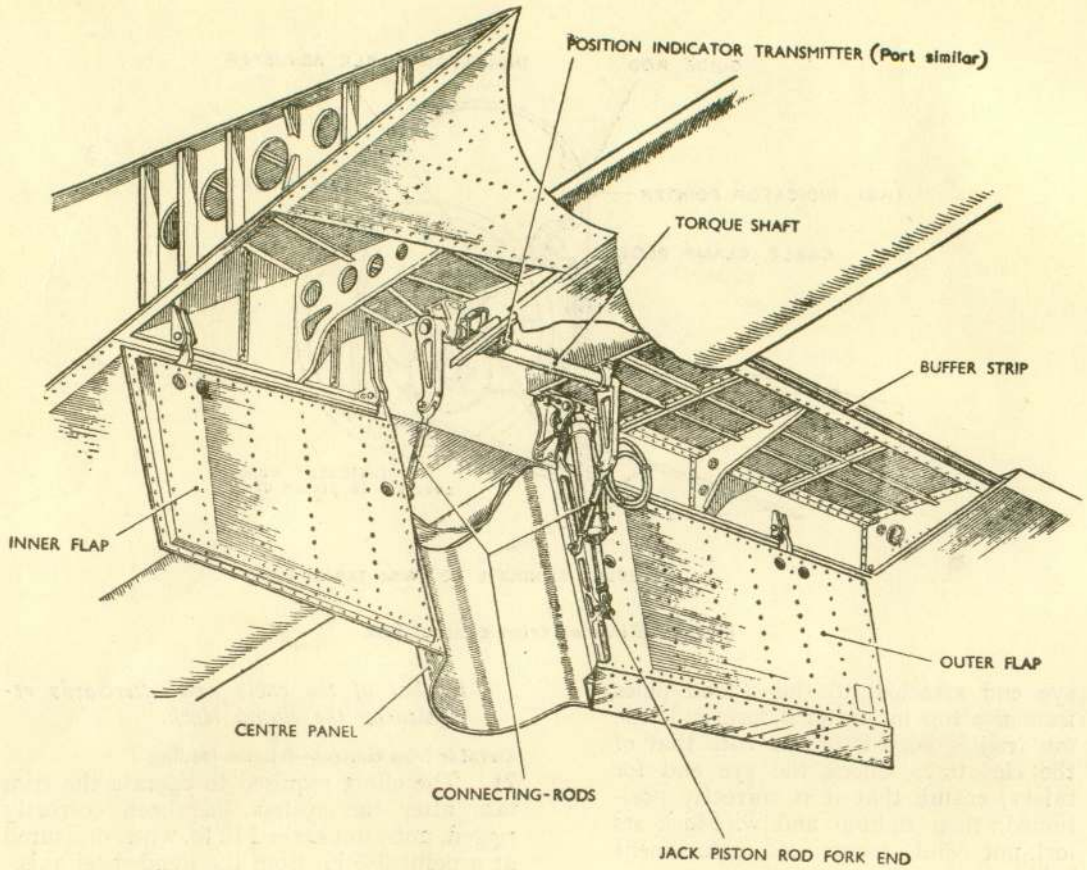

Fig. 10. Flap (starboard)

(2) Unscrew the fork end of the jack complete with attached link just sufficiently to ensure that, when it is reconnected and the flap is fully retracted, there will be a gap between the trailing edge of the flap and that of the main plane. Temporarily reconnect the link to the flap.

(3) Raise the flap fully and note the width of the trailing edge gap on the jack centre-line.

(4) Lower the flap, screw in the fork end a half turn, reconnect it and fully raise the flap again, noting the decrease in width of the trailing edge gap.

(5) Repeat operation (4) above until the gap on the jack centre-line is just eliminated, then tighten the fork end lock-nut and secure the link attachment bolt.

(6) Unlash the torque shaft connecting-rods, adjust their eye end centre lengths to 5·75 in. and re-connect them to the flap.

(7) Raise the flap fully, and check that the gap between the trailing edge of its curved centre portion and the undersurface of the boom agrees with the dimensions shown in Sect. 3, Chap. 2. Lower the

flap, re-adjust the connecting-rods and raise the flap again until this requirement is achieved, check the rod eye ends for safety, ensure that they are correctly positioned, then tighten their lock-nuts and secure their attachment bolts.

(8) Finally, lower the flap fully and check that the distance between the flap and the main plane trailing edges agrees with that shown in fig. 16.

Note . . .
The range of flap movement is limited by the length of jack stroke and is not adjustable.

Rigging the flap position indicator transmitter (*fig. 11*)

26. The procedure for rigging either the port or starboard flap position indicator transmitter is as follows:—

(1) Ensure that with the flaps fully raised the position indicator in the cabin reads zero. Adjust the length of the transmitter link as necessary to obtain this reading.

Note . . .
The nuts and bolts attaching the torque shaft and transmitter levers to the two links must be tightened to the end of the thread, and then checked for freedom of rotation. Adjustment is made by slackening the bolt which secures the two links together. The attachment bolt centre length of the transmitter lever should be 1·9 *in.*

(2) Lower the flaps until the distance between the trailing edge of the starboard inboard flap and that of the main plane is 12·32 in., then check that the cabin indicator reads 30 deg. If the reading is less than this figure, decrease the bolt centre length of the transmitter lever and vice versa. Check tighten all transmitter linkwork attachment bolts.

Rigging the dive brakes

27. The procedure for rigging the port and starboard dive brakes is as follows:—

(1) Disconnect the jack from the dive brake, unscrew the eye end sufficiently to ensure that, when the jack is reconnected and then fully retracted, there will be a gap along the dive brake leading edge, then temporarily reconnect it.

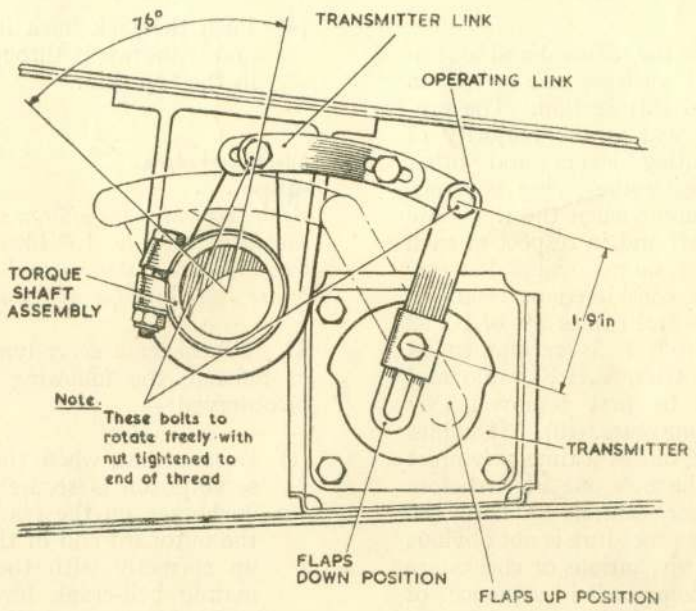

Fig. 11. Flap position indicator transmitter

(2) Close the dive brake fully and note the width of its leading edge gap.

(3) Open the dive brake, screw in the eye end half a turn, reconnect it and fully close the dive brake again, noting the decrease in the width of the leading edge gap.

(4) Repeat operation (3) above until the gap is just eliminated, then tighten the eye end lock-nut and secure its attachment bolt.

(5) Open the dive brake fully, and check that the distance between the inboard end of its trailing edge and the trailing edge of the flap, when closed, agrees with that shown in fig. 16.

Note . . .
To operate the dive brake by the hand pump, it will be necessary to hold the manually-operated non-return valve in the open position (*Sect.* 3, *Chap.* 6). *As for the flaps, the range of dive brake movement is limited by the length of jack stroke and is not adjustable. The stroke of the flap and dive brake jacks will be found in Chapter* 6 *of this Section.*

Lubrication

28. The location of the components and their various points requiring periodic lubrication is shown in Sect. 2, Chap. 4.

General

29. Instructions for the removal and assembly of the control surfaces are given in Chapters 2 and 3 of this Section. The procedure for the removal of the majority of the pulleys, operating levers and other components comprising the flying controls, will be readily apparent when the items are viewed in the aircraft and, in respect of such components therefore, no removal and assembly instructions are considered necessary. Should access to control cables aft of No. 2 bulkhead be required, it is recommended that the oxygen bottles, V.H.F. radio and ammunition tanks be first removed (*See WARNING preceding para.* 13). If cables require replacement, one at a time *only* must be disturbed and the new one fitted before disconnecting further cables. Where the removal or assembly procedure is not obvious however, or special precautions or checks are necessary, the recommended sequence of operations or details of these special precautions or checks are given below. Unless otherwise stated, the assembly of a component entails only the reversal of the removal procedure.

Elevator trim jack

30. With the elevator and trim jack chain dismantled, the procedure for removing the trim jack is as follows:—

(1) Unscrew the bolts and detach the jack rear bearing from the tail plane rear spar.

(2) Unscrew the bolts and remove the caps from the jack front bearings.

(3) Push the jack aft through the hole in the rear spar, take out the jack fork end retaining bolt and extract the fork end and support bearing together.

(4) Push the jack back into the tail plane and withdraw it through the access hole in the top skin.

Aileron servodyne

◀**Note . . .**

*After removal of the aileron servodyne, reference should be made to A.P.*4602A, *Vol.* 1, *Sect.* 2, *Chap.* 2 (*pre-installation checks of servodynes*) *before installing the new unit.*▶

31. Whenever a servodyne unit is renewed or refitted, the following precautions *must* be observed:—

(1) Ensure that, when the eye end of the servo-piston is securely attached to its anchorage on the rear spar, the eye in the outboard end of the unit body lines up correctly with the fork end of its mating bell-crank lever arm. In the event of any mal-alignment being encountered, the number of 0·002 in. laminated shims under the servo-piston anchorage must be increased or decreased until the foregoing requirement is met.

(2) The bolts securing the connecting-rod to the servodyne plunger, and the eye end of the unit body to the bell-crank lever arm„ must be fitted with their heads aft.

(3) The bolt securing the drop link to the horizontal arm of the bell-crank lever must be fitted with its head forward.

(4) The bolt securing the drop link to the arm of the aileron drive shaft must be fitted with its head outboard.

(5) Ensure that throughout the entire range of control movement, a minimum clearance of 0·10 in. exists:—

(a) Between the fork end of the servodyne plunger connecting-rod and No. 6 rib.

(b) Between the end of the servodyne eye attachment bolt and the edge of the aileron drive support casting.

(c) Between the forward face of the horizontal arm of the bell-crank lever (and the head of its drop link attachment bolt) and the edge of the spring-loaded plunger roller pressure point bracket.

(6) Ensure that, throughout the entire range of control movement, a minimum clearance of 0·050 in. exists between the underside of the servodyne eye-end extension and the lower edge of the orifices in the aileron drive support casting through which it passes.

Aileron drive support casting

32. If an aileron drive support casting is renewed or refitted, the number of 0·002 in. laminated aluminium shims fitted between it and the rear spar, at each of the four attachment bolt positions, must be adjusted to position the lugs of the drive shaft correctly in each plane, up to a maximum of 0·08 in., to ensure perfect mating with the aileron engagement fitting.

Note . . .

The minimum mating surface area, of the engagement lugs on the aileron drive shaft and the slot in the engagement fitting on the aileron itself, must conform to the requirements detailed in Sect. 3, *Chap.* 2. *The maximum permissible difference between shim thickness at any two bolt positions is* 0·02 *in.*

33. When the casting is finally secured in its correct position, all checks detailed in para. 31 must be carried out.

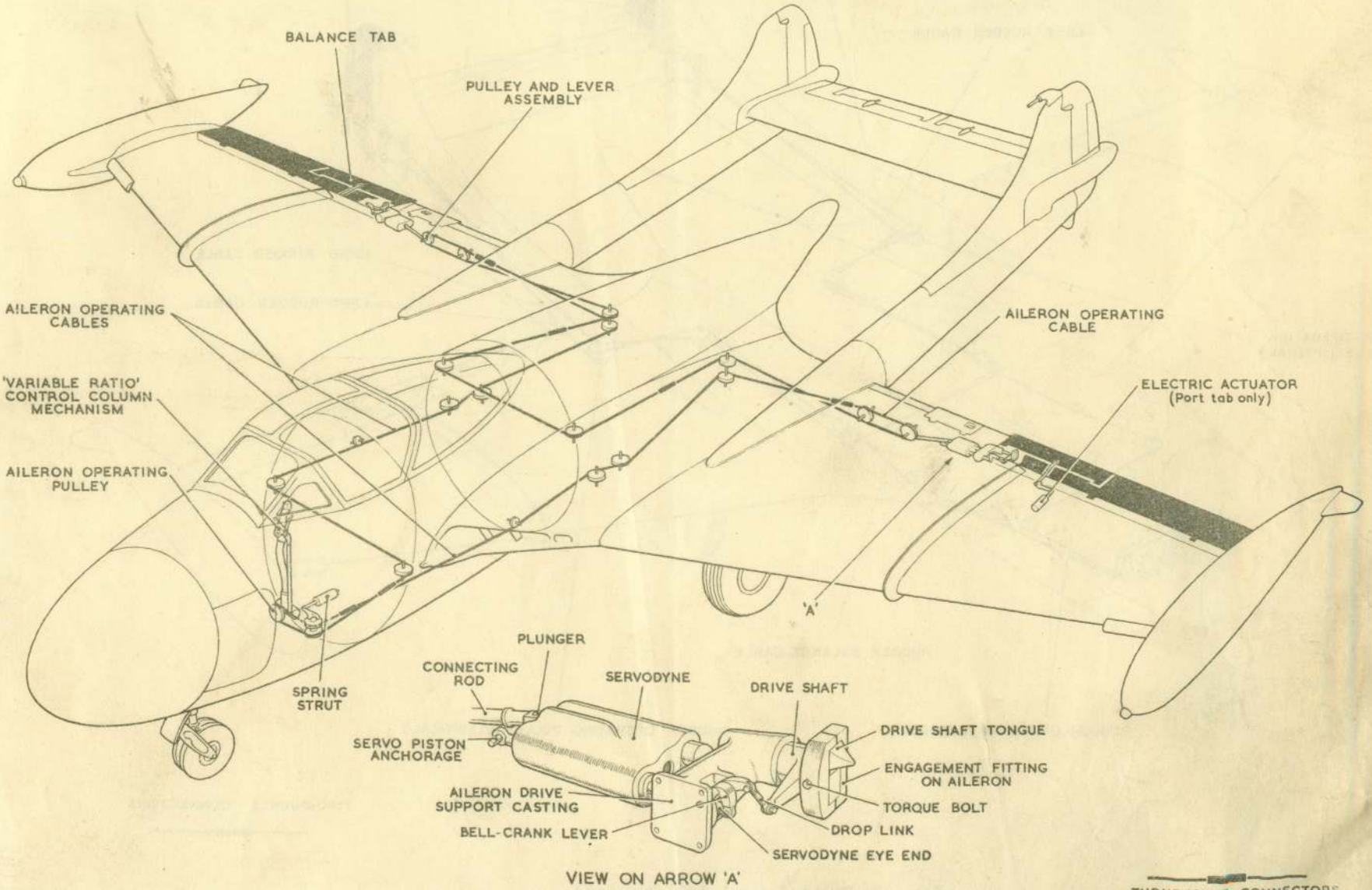

Fig. 12 Aileron and tab controls

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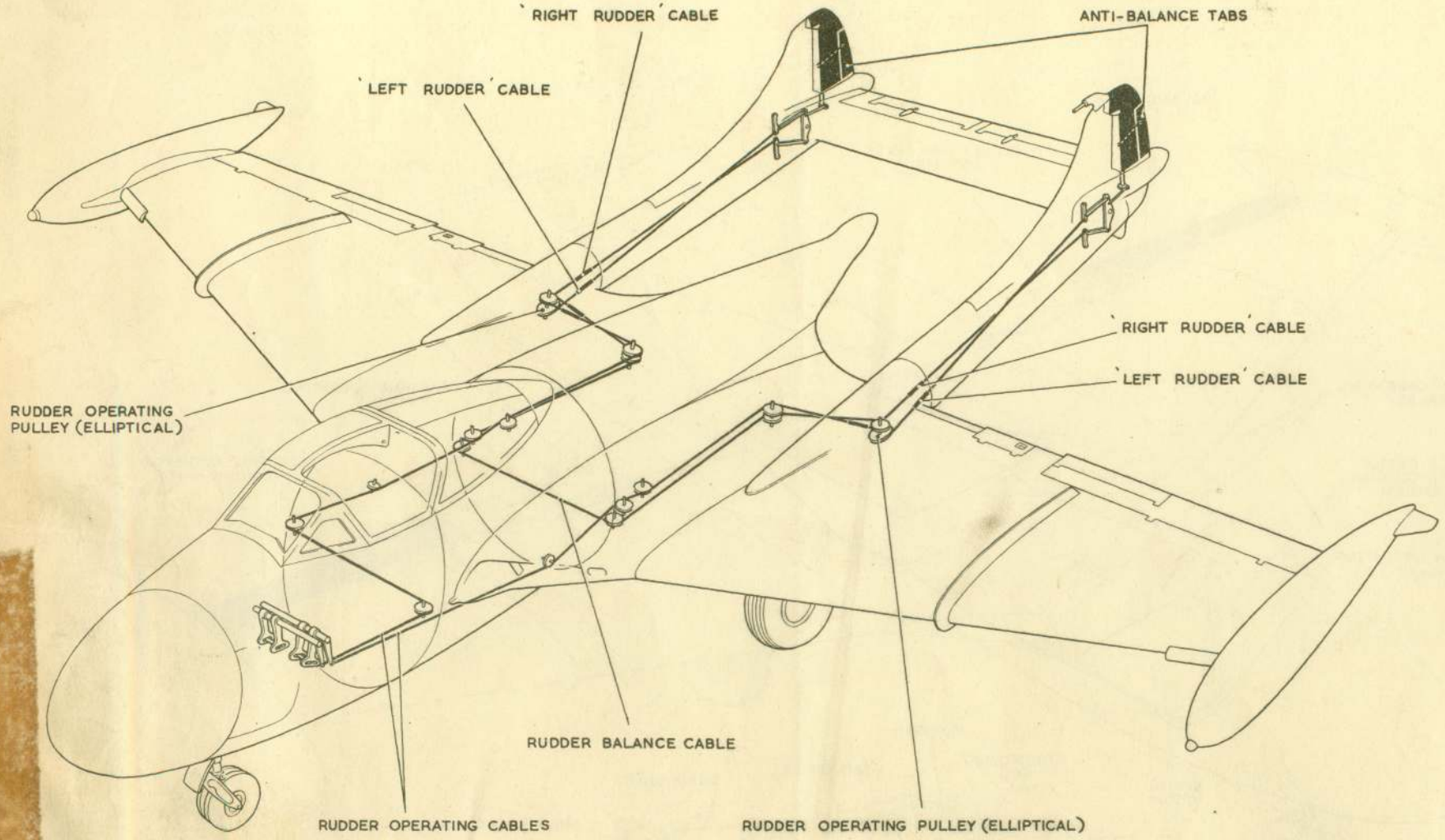

Fig. 13 Rudder and tab controls

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Rigging the elevator trim tab

20. The elevator trim tab should be rigged in the following manner:—

(1) Set the elevator trim tab control wheel in the cabin so that the position indicator reads *zero*, and check that, ◄when in the mean position,► the protrusion of the ◄lower Teleflex cable is 7·5 ± 2 in. and that of the upper is 4·5 ± 2 in.► beyond the ends of their conduits in the port inner flap bay.

(2) Set the trim tab jack (*fig.* 8) in the tail plane to its mid-travel position, and check the security of the sprocket retaining nut and split pin.

(3) With the cables secured to the chain, assemble the chain on the jack sprocket so that an equal number of links is disposed to port on each side of its horizontal centre-line.

(4) Couple up and correctly tension the cables connecting the jack chain to the ends of the Teleflex cables in the port inner flap bay, then check the turnbuckles for safety and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(5) Lock the elevator (and rudders) in the *neutral* position by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the operating levers in the rear of the booms, and adjust the length of the tab connecting-rod so that, with its forward

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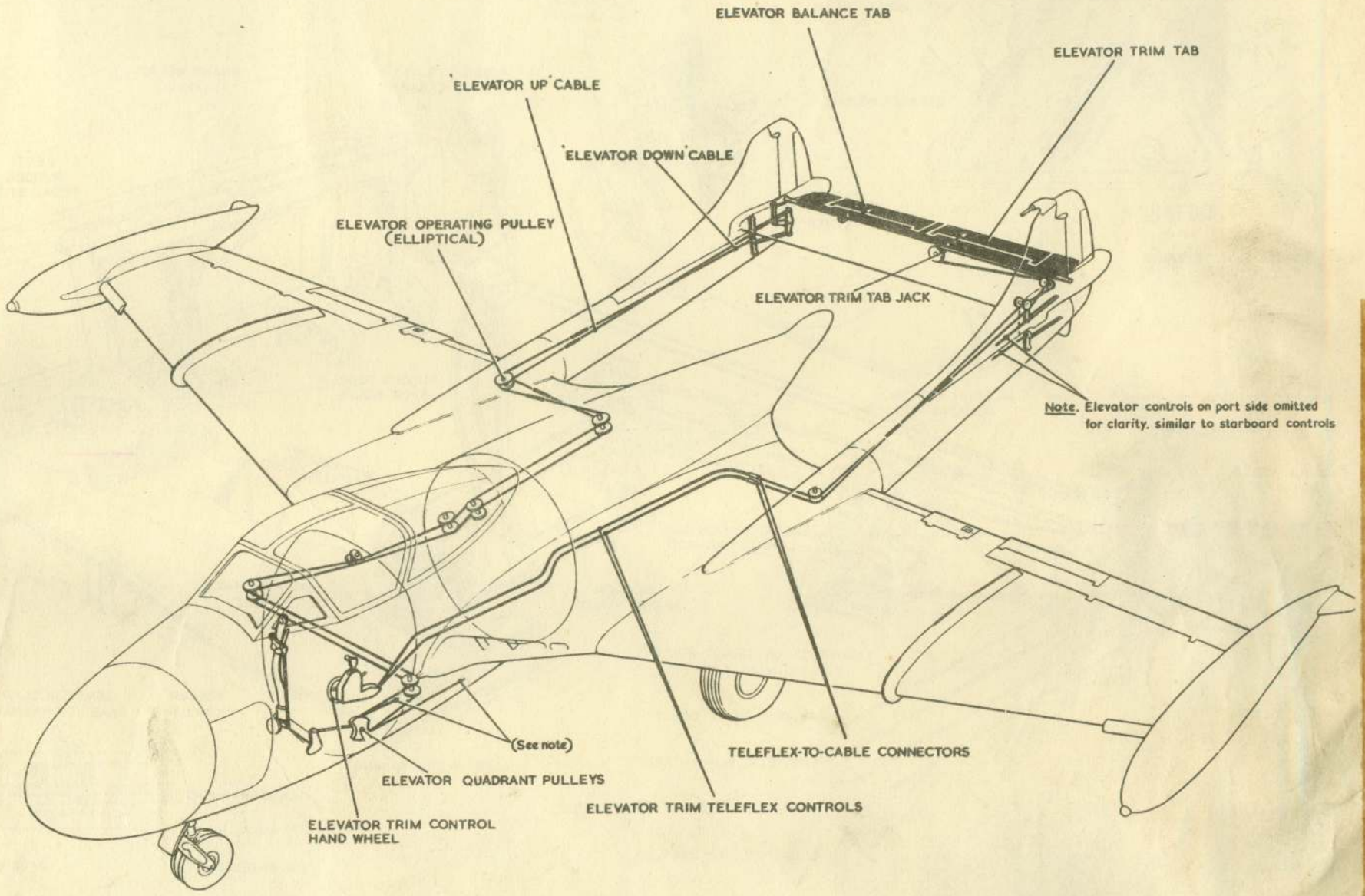

Fig. 14 Elevator and tab controls

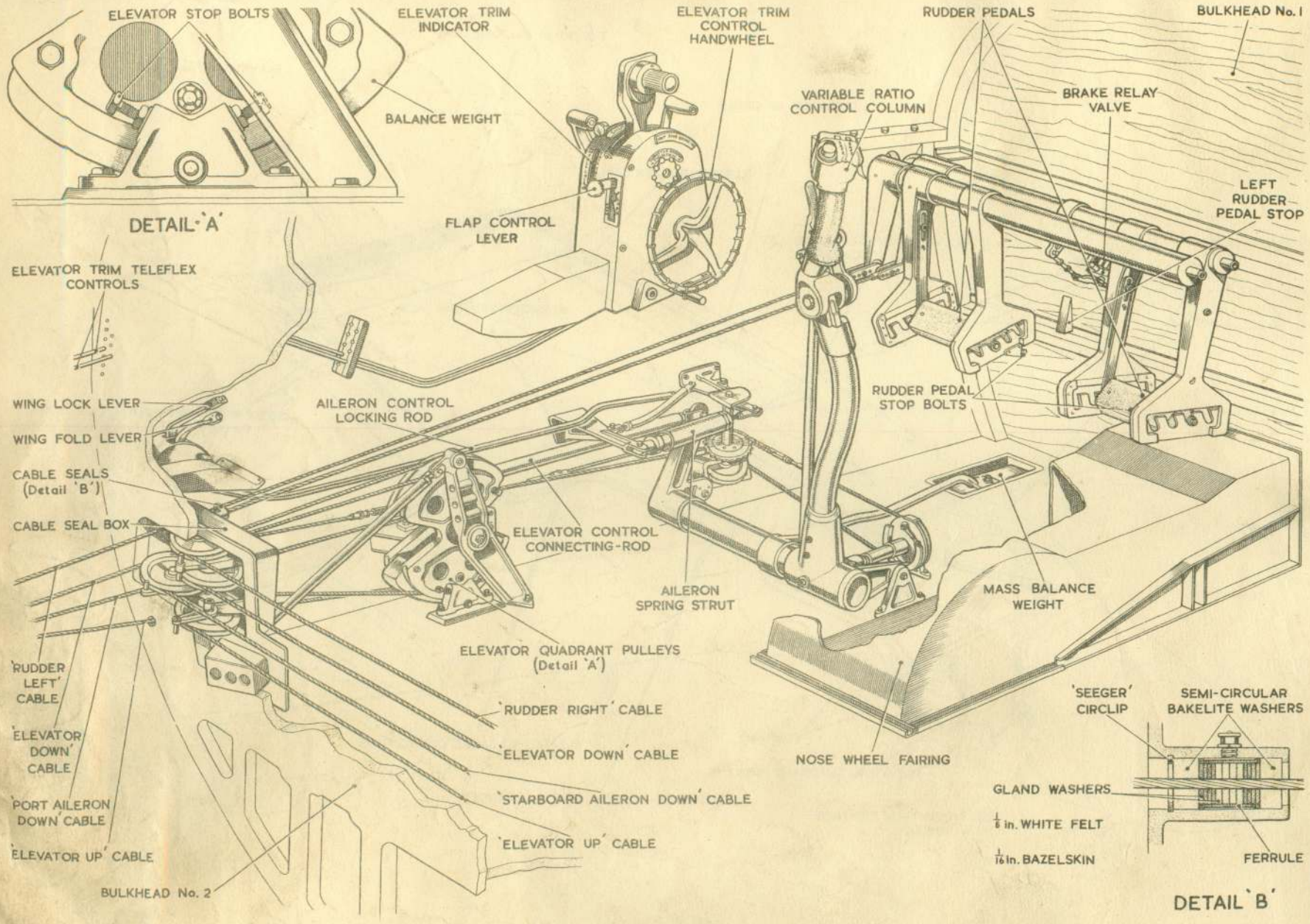

Fig. 15 Controls in cabin

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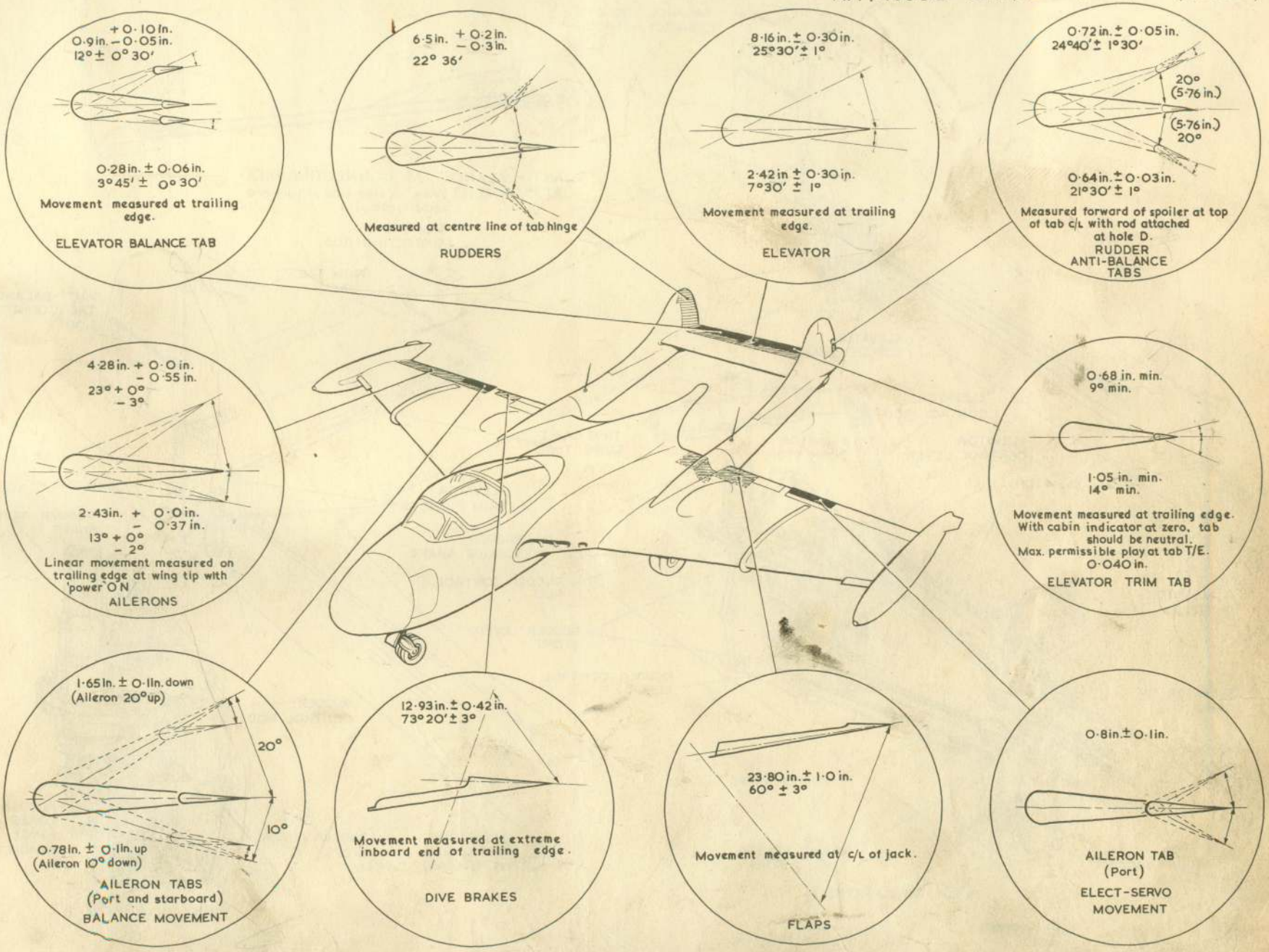

Fig. 16 Control surface movements

(A.L.55, May 57)

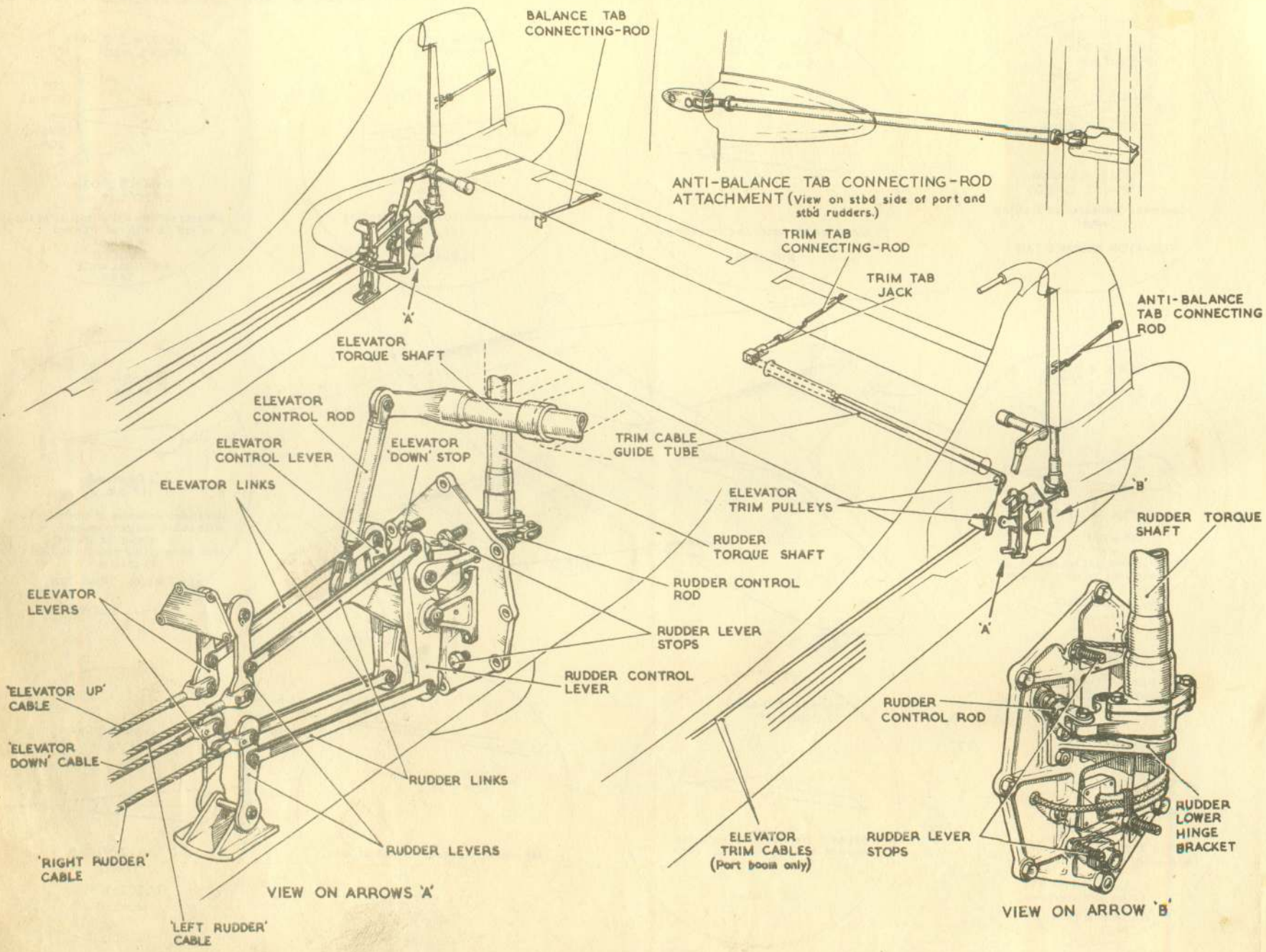

Fig. 17 Controls in tail unit.

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Note . . .

This operation must be carried out with the plunger ports in each servodyne unit closed, i.e., by selecting hydraulic POWER (OUT).

(8) Adjust the length of the drop link which connects each bell-crank lever to the arm of its adjacent aileron drive shaft, until the trailing edge of the aileron is in line with that of its main plane. Check the link eyes for safety, ensure that they are correctly positioned then tighten their lock-nuts and secure their attachment bolts.

Note . . .

(1) *If insufficient adjustment is obtainable on the drop link, the rod connecting the servodyne plunger to its adjacent operating pulley assembly may be slightly readjusted to re-position the bell-crank lever as necessary.*

(2) *Periodic lubrication is required for the self-aligning bearings at each end of the aileron control rod (shown as 'drop link' in fig.* 2), *Part No.* 12.4*CF*.33*A* (*port and starboard*), *introduced by Mod. N*.615. *Due to their pre-treatment with molybdenum disulphide, these bearings should be lubricated with oil, OX*-14 (*Sect.* 2, *Chap.* 4).

(9) Remove all locking devices from the control system, return the wing lock control lever to LOCK and select hydraulic POWER (OUT). Then with the variable gearing selector lever still at POWER, ensure that, with the column handle at each full travel position, the torque shaft lever contacts its stop at the column base, that a clearance of 0·02 in. exists between the aileron beak and shroud stops and that the movements of the ailerons agree with those shown in fig. 16. Any discrepancy in this latter respect must be rectified by ◀adjusting the outside diameter of the column stop distance piece.▶

Note . . .

Aileron movement must be limited by the torque shaft lever stop alone, whenever the surfaces are operated with power ON.

(10) Select MANUAL (IN) (power *off*) and check that, with the ailerons held manually with their beaks in contact with each shroud stop in turn, there is still a clearance between the aileron and shroud structures throughout their entire lengths.

(11) Return the wing lock lever to the UNLOCK position and, maintaining a $\frac{1}{16}$ in. gap. between each end of the spring strut operating and sprocket locking levers (by fitting one of the control column mechanism locking devices), rotate the knurled body of the spring strut unit until it is in the middle of its trim adjustment range. Screw the eye end of the strut plunger, as necessary, to align the hole for its attachment bolt with that in the operating lever, without deflecting the plunger spring. Connect the plunger to the lever, check its eye end for safety, ensure that it is correctly positioned, then tighten and wire-lock its lock-nut and secure its attachment bolt. Remove the column locking device.

(12) Return the wing lock lever to LOCK and, with normal hydraulic power available, operate the selector valve and check that there is no appreciable snatch at the column handle as hydraulic POWER (OUT) or MANUAL (IN) is selected.

(13) With hydraulic POWER (OUT) selected, operate the column handle and check that, except when it is moved *very* rapidly, the body and plunger of each servodyne move simultaneously.

(14) Check the aileron controls for general smoothness and stability. Judder or instability may be attributed to excessive backlash due to worn or loose components or to incorrect tensioning of the cable runs.

(15) With MANUAL (IN) (hydraulic power *off*) selected and the variable gearing selector lever on the column handle in the extreme POWER position, check that the amount of backlash (due to 'dead travel' of the servodyne plungers), measured at the top of column handle, is within the limits $1{\cdot}3 \pm 0{\cdot}25$ in.

Aileron friction loadings

14. With the port and starboard tabs correctly fitted and connected, the friction loading of the control system must meet the following requirements:—

(1) With the spring strut disconnected the effort required to operate the column handle must not exceed 4 lb. with the controls in POWER, and 15 lb. with the controls in MANUAL, measured at a distance of 7·0 in. from the handle fulcrum.

(2) With the spring strut re-connected and the controls in POWER, the effort required to operate the column handle from *neutral* must not exceed 6 lb., and to either full travel position the effort must be within the limit 16 to 22 lb., measured at a distance of 7·0 in. from the handle fulcrum. In addition, the effort required to hold the column handle at either full travel position, under these circumstances, must not be less than 9 lb., measured at a distance of 7·0 in. from the handle fulcrum.

(3) With the spring strut connected and the controls in MANUAL, the effort required to operate the column handle from *neutral* must be within the limits 5 to 6 lb., and to either full travel position, 20 to 26 lb. measured at a distance of 7·0 in. from the handle fulcrum.

(4) When the column handle is released from any degree of deflection under normal POWER conditions, it must return sufficiently close to its *neutral* position to enable a No. 11 drill to be inserted through the

¼ in. dia. rigging pin holes in the column and handle castings. If the friction loading exceeds the maximum figure given in any of the foregoing sub-paragraphs, the circuit must be inspected and the friction reduced to within the permissible limits. Possible causes of excessive friction include fouls, twists or a double-cross in the control runs, or dry or faulty bearings. A double-cross may be indicated audibly when the controls are operated. The surfaces, of course, will still move in the correct sense.

Initial rigging of the aileron tabs

15. (1) Rig the port aileron tab as follows:

(*a*) With power *off* (selector IN) and the ailerons locked *neutral*, operate the electric actuator until the pin 'J' in the lever slot is on the peak of the cam 'F' (*fig.* 6, *detail* E).

(b) Adjust the connecting-rod 'K' (*fig.* 6, *detail* E) until the centre of the indicator 'light-OUT' zone occurs when the trailing edge of the tab is in line with that of the aileron, then check the eye end for safety, ensure that it is correctly positioned, tighten and wire-lock its lock-nut and, ensuring that the serrated washers are seated properly and that the serrated lugs are not compressed, secure the rod attachment bolt.

Note . . .

For fine adjustment of the tab neutral position, slacken the two bolts which secure the tab operating lever to the tab and rotate their eccentric bushes 180 *deg.* (*the slots in the bush flanges must both face either forward or aft*), *tighten and re-lock the bolts.*

(c) Unscrew the adjusting screw 'L' on the cam lever (*fig.* 6, *detail* E) until it is clear of the micro-switch button, then screw it in again until the switch is just operated, i.e., until the tab position indicator light in the cabin is extinguished.

(d) Check that the electrical movement of the tab trailing edge, during which the micro switch remains open and the light OUT, agrees with the dimensions given in fig. 6, detail G. Re-adjust the screw 'L' as necessary (for any greater degree of electrical movement the light should be illuminated). Simultaneously, ensure that operation of the control switch to port causes the tab to move *down* and vice versa, and that the overall range of electrical servo movement agrees with that shown in fig. 16.

Note . . .

The indicator light in the cabin should be OUT *when the port tab is within the 'light-*OUT' *zone and* ON *for any greater degree of electrically-operated displacement, with the aileron in the neutral position. The light is* NOT *operated by the displacement of the tab, due to the displacement of the aileron, but by the displacement of the tab actuator.*

(e) Finally, manually displace the port aileron 20 deg. *up* and 10 deg. *down*, at each position measuring the aileron to tab trailing edge dimension; check that, when the electric actuator is in neutral, these dimensions agree with those shown in fig. 16.

(2) Rig the starboard aileron balance tab as follows:—

(a) With power *off* (selector IN), displace the starboard aileron 20 deg. *up* and 10 deg. *down*, at each position measuring the aileron to tab trailing edge dimension. Check that these dimensions agree with those shown in fig. 16 and consequently that the height of point 'P' above the aileron chord datum (*fig.* 6 *detail F*) is correct. With the ailerons locked in *neutral* (*para.* 13(3) *and fig.* 6 *detail D*), re-adjust length of the tab connecting-rod at point 'R' until the trailing edge of the tab is in line with that of the aileron; if further adjustment is necessary, refer to the Note to sub-para. (1) (b).

Check the eye end for safety, ensure that it is correctly positioned, tighten and wire-lock the lock-nut, and, ensuring that the serrated washers are seated properly and that the serrated lugs are not compressed, secure the rod attachment bolts.

Final adjustments of the aileron tabs

16. The procedure for checking and adjusting lateral and longitudinal trim changes, with the aileron control in MANUAL, during and after test-flight, is as follows:—

(1) Check the lateral trim at 200 knots; if the tab displacement required is sufficient to switch ON the tab warning light, the aircraft should return to base in this condition. Measure the displacement of the port tab in relation to the trailing edge of the aileron, when the aileron is in the *neutral* position, and transfer this adjustment to the starboard tab to maintain lateral trim, i.e., if the port tab was found to be 0·1 in. *up*, adjust the starboard tab 0·1 in. *down*; then return the port tab to *neutral* by operating the tab selector switch until the warning light is OUT.

(2) Check the longitudinal trim change when reverting to MANUAL at 450 knots; this should be negligible and in any instance must not be 'nose down'. If this trim change is 'nose up', adjust both aileron tabs *up* by an equal amount, or if the trim change is 'nose down', adjust the tabs *down* by an equal amount. These adjustments should be made, preferably, by increments of ½ turn of the connecting-rod eye end.

WARNING . . .

When finally rigged to give zero trim changes, the tab positions must be within the limits stated in fig. 6, details G and F; the maximum amount of trim adjustment at any one time is to be limited to that specified.

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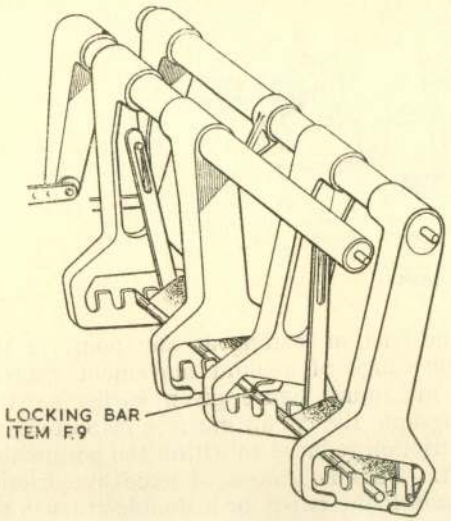
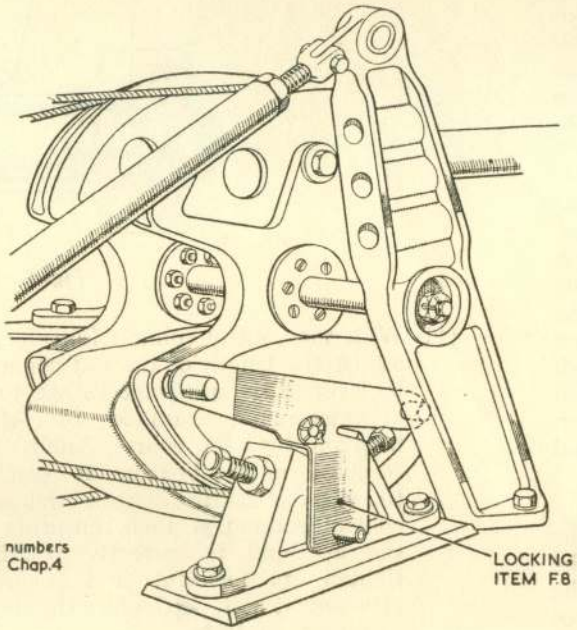
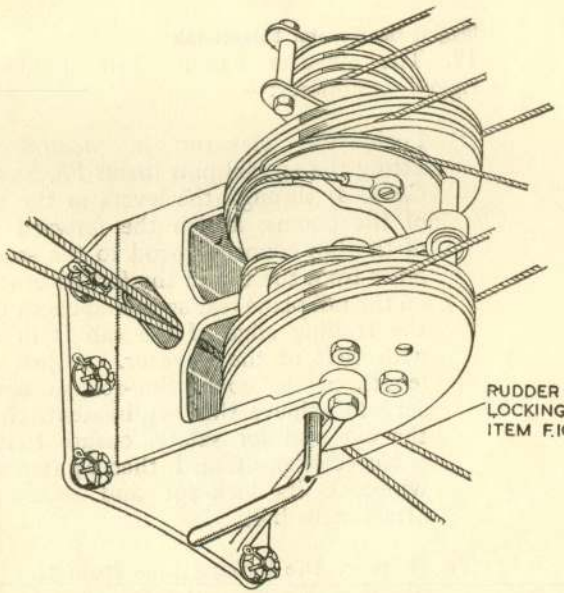


RUDDER PEDALS

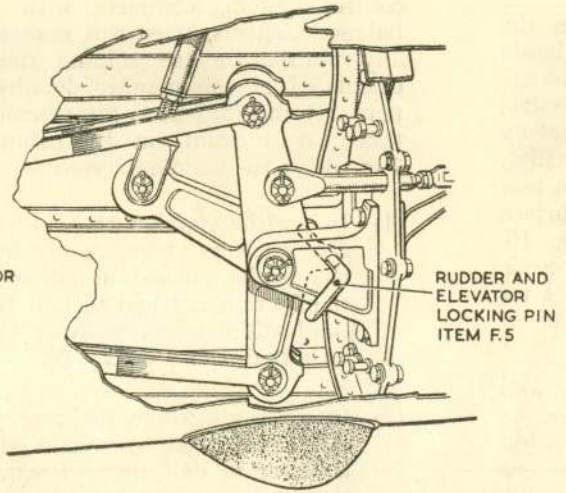
Note.
For key to item numbers refer to Sect.2 Chap.4



ELEVATOR QUADRANT PULLEYS



ELLIPTICAL PULLEYS IN FORWARD END OF BOOMS



OPERATING LEVERS IN AFT END OF BOOMS

Fig. 7. Rudder and elevator rigging locks

Rigging the elevator (*fig.* 7)

(*WARNING preceding para*, 13)

17. ◀Before the elevator is rigged, it will be necessary to remove the elevator quadrant guard; the procedure is then as follows:—▶

(1) Lock the quadrant pulleys in the cabin in the *neutral* position by fitting the special plate (*item* F8, *Sect.* 2, *Chap.* 4).

(2) Lock the pulley group, bracketed to the rear spar in the forward end of each boom, in *neutral* with the special pins (*items* F10, *Sect.* 2, *Chap.* 4). This will necessitate centralizing the rudder pulleys of each group also.

(3) Connect up and correctly tension the elevator operating cables, between the quadrant pulleys of each group mentioned in sub-para. (2) above, to 65 ±10 lb.; checking the figures on the 15 cwt. scale of a Mk. 4 R.A.E. tensiometer, positioned mid-way between pulleys on No. 1 ribs and in the inner flap bays (*See Note to para.* 13(4)).

(4) Check the turnbuckles for safety, and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(5) Lock the elevator (and rudders) in *neutral* by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the operating levers in the rear of the booms.

(6) Connect up and correctly tension the elevator cables, between the relevant elliptical pulleys of each group on the

rear spars and their surface operating levers, to the figures quoted in sub-para. (3) above; checking the figures on the 15 cwt. scale of a Mk. 4 R.A.E. tensiometer positioned in the middle of each cable run in turn. Check the turnbuckles for safety, and, taking care not to introduce any cable twist, tighten their lock-nuts and wire-lock securely.

(7) Disconnect the adjustable elevator operating rods in the rear of the booms, and, placing the incidence board (*item* F2, *Sect.* 2, *Chap.* 4) on the tail plane centre-line, adjust each in turn to bring the trailing edge of the elevator level with the chord line on the board. Check the eye ends for safety, ensure that they are correctly positioned, then tighten and wire-lock their lock-nuts and secure their attachment bolts.

(8) Initially shorten the rod connecting the quadrant pulleys in the cabin to the column lever, to prevent damage to the instrument panel when the surface movements are checked, and screw in the quadrant pulley and surface operating lever stops.

(9) Remove all locking devices from the control system (the special pins should withdraw easily if the cable tensions are correct), and, by operating the control column full travel fore and aft (*not* by moving the control surface manually), adjust the lever stops on the boom rear diaphragms to limit the range of surface movement to that shown in fig. 16. Tighten and wire-lock the stop lock-nuts, and re-check the elevator controls for full free range and correct sense of movement.

(10) Operate the control column again, and adjust the quadrant pulley stops to give a clearance of 0·030 in. at each full travel position (thus ensuring that the control range is initially limited by the stops at the rear of the booms), then tighten and wire-lock their lock-nuts.

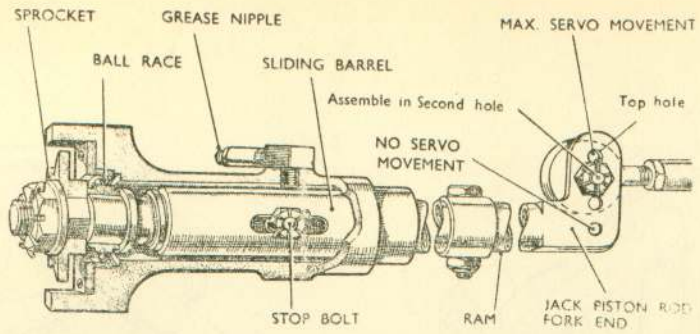


Fig. 8. Elevator trim tab jack

(11) With the control column fully forward, adjust the length of the rod connecting its lever to the quadrant pulleys to give a minimum clearance of ◀0·5in between the 'set course' knob of the compass on the instrument panel and the variable gearing control knob on the control column,▶ then, ensuring that the eye end is correctly positioned, tighten its lock-nut and secure its attachment bolt. ◀Replace the elevator quadrant guard.▶

Elevator friction loading

18. The friction loading of the elevator control system, complete with trim and balance controls, must not exceed 4 lb. at any position in the column range, when calculated in the manner detailed in sub-para. (1) and (2) below, measurements being taken at a point on the column handle 7 in. above the handle fulcrum:—

(1) In positions where the control column *does not move* under its own weight, but has to be pushed in either direction, the friction is equal to half the *sum* of the loads required to move the column a short distance each way.

(2) In positions where the control column *moves* under its own weight, the friction is equal to half the *difference* between the load required to move it a short distance against its own weight and that required to hold it stationary.

If the friction loading at any point in the whole range of column movement exceeds the maximum figure given earlier in this paragraph, the circuit must be inspected and the friction reduced to within the permissible limit. Possible causes of excessive friction include fouls, twists or a double-cross in the control runs, or dry or faulty bearings. A double-cross may be indicated audibly when the controls are operated. The services, of course, will still move in the correct sense.

Rigging the elevator balance tab

19. The elevator balance tab should be rigged as follows:—

(1) Lock the elevator in *neutral* by fitting the special pins (*items* F5, *Sect.* 2, *Chap.* 4) through the levers in the rear of the booms, attach the forward end of the tab connecting-rod to the second holes from the top in the forked bracket on the tail plane rear spar, and check that the trailing edge of the tab is in line with that of the elevator. Adjust the length of the connecting-rod as necessary to achieve this requirement, check the eye end for safety, ensure that it is correctly positioned, then tighten and wire-lock its lock-nut and secure its attachment bolt.

(2) Remove the locking pins from the rear of the booms, operate the control column full travel fore-and-aft and check that the balance tab range agrees with that shown in fig. 16.