

FLYING CONTROLS

Reference: AP 4505B, Vol 1.
AP 4603 Series (BOULTON PAUL POWER FLYING CONTROL
UNITS)

1. Introduction

Directional control of the aircraft is achieved by means of a single rudder. The control surface is operated by means of two Boulton and Paul powered flying control units, one main unit for normal operation and an auxiliary unit for use should the main unit fail.

2. Control of the aircraft about its lateral and longitudinal axes is effected by means of a total of eight control surfaces known as ELEVONS. These control surfaces are located at the wing trailing edges, four on each side of the aircraft, between the wing root and the tip. Each control surface is operated by a Boulton and Paul powered flying control unit, the eight units being entirely independent of each other in operation.

3. For explanation purposes the eight elevon sections are numbered 1 to 8 from the port to starboard sides, whilst for general reference purposes the surfaces are grouped in pairs and are known as Inboard and Outboard Elevons. The Inboard elevons are numbers 3 and 4 on the port side, 5 and 6 on the starboard side, whilst the outboard elevons are numbers 1 and 2 on the port side, 7 and 8 on the starboard side.

4. The term ELEVON applied to these control surfaces has been derived from an abbreviation of the two words ELEVATOR and AILERON and, as the name suggests, if the control column is moved in the elevator sense all eight control surfaces will move upwards or downwards as selected and correspondingly if the control column is moved in the aileron sense, four surfaces on one side will move upwards and on the other side the four control surfaces will move downwards, the degree of movement of the control surfaces in either elevator or aileron sense being dependent on the angularity of the various control levers in the control runs.

5. Individual or combined elevator and aileron control sense is achieved by feeding the elevator and aileron control circuits from the control column into a mixing unit, the output of which is fed via push pull rods running out, port and starboard to the eight powered control units in the wing.

6. To illustrate the effect of combined control column movement consider the control column pulled rearwards, ie. elevator sense, and as a result all eight elevons will move upwards, the outboard elevons to a slightly greater degree than the inboard. If the aileron sense is applied with control column to starboard elevon angles Nos. 5, 6, 7 and 8 will increase and the port elevon angles Nos. 1, 2, 3 and 4 will decrease.

7. Each control circuit has its own individual artificial feel system. Rudder and Elevator have a feel simulator box which will cater for increase of stick force relative to increase in air speed, and also for increase in air speed, and also for increase of control surface angle. The units also provide a centralising spring force.

8. In the case of aileron, artificial feel is supplied by the use of torsion bars which will give progressive stick force with increase in control surface angle. Centralising effect will be given by the torsion bars unwinding when the stick force is removed. The selective range of aileron sense control is governed by electrically actuated mechanical stops which are arranged to increase or decrease the range according to airspeed variations.

9. Provision is made for trimming out undesirable change of attitude in flight by connecting an electric actuator into each control circuit. To safeguard against failure each actuator is arranged with two motors, one for normal use and one for emergency.

10. The elevator sense and aileron sense trim actuators are located in their respective control runs forward of the mixing unit, thus movement of either actuator will result in the appropriate movement of all eight elevons.

11. To damp out oscillation tendencies about the Yaw and Pitch axis, automatically controlled electrical actuators are fitted in the rudder circuit and also to the four inboard elevon ie. Nos. 3, 4, 5 and 6 power flying control units.

12. Two mach trim actuators are fitted in the elevator sense circuit the combined output of which will correct the nose down tendency of the aircraft as the MACH NO. increases. The two actuators are located in the forward section of the control circuit so that all eight elevons will be operated as a result of actuator movement.

13. Auto Pilot Mk.10 servo motors are coupled into the aileron sense, elevator sense and rudder control circuits.

14. INBOARD ELEVONS (Nos. 3, 4, 5 and 6)

The powered control units which operate the inboard elevons are housed in individual compartments built in the inner wing section trailing edges. The compartments are arranged in pairs numbers 3 and 4 on the port side, 5 and 6 on the starboard side. Each pair of compartments is separated by a heavy section hinge rib and are enclosed by the wing skinning in the topside and a common hinged panel in the underside. The hinged panel gives access to the units for general servicing. An electrical position transmitter mounted in the rear end of each compartment is connected mechanically by an adjustable rod to the control surface section concerned, and electrically to the control surface position indicator on the pilots centre instrument panel.

15. Each unit is suspended in position by two close tolerance bolts, one bolt securing the forked jack ram end to an operating lever on the control surface section and the other bolt locating the forward eye end of the unit casting with a trunnion shaft. This shaft is located laterally in bearings between the heavy hinge rib and an out-rigger bracket secured to the wing rear spar.

16. OUTBOARD ELEVONS (Nos. 1, 2, 7 and 8)

The powered control units which operate the outboard elevons are housed in individual compartments built into the outer wing section trailing edge. Each compartment is separate and is formed between two wing ribs with the top side enclosed by the wing

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skinning. Due to the dimensions of outboard elevon powered units and the thin cord section of the outer wing, the power units are only partially enclosed by the compartment and the under-surface is therefore enclosed by a shaped cowl. A similar cowl is secured to the elevon surface and completes the enclosure of the power unit jack ram end connection with the control surface. A ram air intake located in the forward cowl of each unit is connected by light alloy pipes to the air inlet of each powered control unit motor. Exhaust air spills to atmosphere through the gap between the two sections of cowl. The forward cowl of each outboard elevon unit is secured by dzus fasteners, providing ease of removal for power unit servicing. The ram air intake forms a butting connection with the cooling air pipes so that disconnection is required when the access cowl is removed. An electrical position transmitter mounted on the side of each control unit is connected mechanically by an adjustable rod to the ram end of the unit, and electrically to the control surface position indicator on the pilots centre instrument panel.

17. RUDDER UNITS

The two rudder units are mounted side by side symmetrically about the fuselage centre line and are completely enclosed in the rear fuselage section. Each unit is attached by two close tolerance bolts. One bolt connects the forked end of the main casting to a mounting lug which is further pinned to a support beam secured to the rear bulkhead of the compartment. The second bolt connects the forked jack ram end with one arm of a double armed lever secured to the base of the rudder post. A ram air intake located just below the fin on the fuselage port side, is connected by light alloy pipes to the air inlets of the two powered control unit motors. Exhaust air is ducted from the two motors and connected by light alloy pipes to an exhaust in the underside of the rear fuselage just aft of the compartment.

18. An electrical position transmitter mounted just forward of the rudder hinge post in the top of the compartment is connected mechanically by an adjustable rod to a lever on the rudder hinge post and electrically to the control surface position indicator on the pilots centre instrument panel. Additional valves are provided on the rudder powered units to allow automatic change over from one unit to the other in the event of failure. The change over valves on the two units are connected by a flexible pipeline.

19. CONNECTION TO THE MAIN CONTROL CIRCUITS

A differential lever assembly built on the side of each powered control unit contains three levers, namely - INPUT - DIFF - FEED BACK. The Input lever, the range of which is governed by adjustable stops connects through a spring-loaded push-pull tube to the control circuit concerned. The Servo lever connects to the pilot valve of the Servo valve (Selector) assembly, which is built into the main casting of each unit. The Feed Back lever is connected to the jack ram end by a link rod in the case of the rudder and outboard elevon units Nos. 1, 2, 7 and 8 and by an electric actuator (Pitch damper), in the case of the inboard elevon units Nos. 3, 4, 5 and 6. A neutral setting plunger on the differential lever assembly is arranged to engage with the servo lever and is provided to assist when setting up each individual unit after installation.

20. GENERAL ARRANGEMENT OF THE CONTROL RUNS

The 1st and 2nd pilots cockpit controls are interlinked across the fuselage, and connected by a series of pull tubes and levers to the various powered control units which they select.

21. The push pull tubes follow the walls of the crew's cabin, and via the pressure bulkhead, to the nose wheel bay. At the rear of the nose wheel bay the control runs are stepped outboard, by horizontal beam levers, and pass along the outer wall of the No.2 fuel tank compartments thence through the centre section front spar in to the bomb compartment. The tubes continue along the inner walls of the bomb compartment to the centre section rear spar, which they penetrate. The aileron tubes are arranged on the starboard side with the elevator and rudder tubes arranged, one above the other, on the port side, the rudder tubes being the uppermost. Aft of the centre section rear spar the elevator and aileron tubes change direction inboard, through levers, and connect with the lever system of a mixer unit. The rudder tubes continue along to the rear fuselage to connect with the two powered control units which operate the rudder. The mixer unit which is mounted on the aircraft centre line, in the electrical compartment, is further connected to a port and starboard push pull tube run to the powered control units, mounted in the wing trailing edge four on each side of the aircraft.

22. All connections between the tubes and levers are by fork and eye type joints, the eye ends being fitted with self-aligning type ball races. Friction is minimised in the various control runs by supporting all push pull tubes in the fuselage in triple roller type guides, all push pull tubes in the wing on swinging levers, and by pivoting all levers and shafts in ball races. Travel limit stops are provided in each control run to limit the range of travel of the pilots controls.

23. THE MIXER UNIT

The mixer unit is located in the electrical compartment on the rear face of the centre section rear spar on the aircraft centre line. The unit comprises a vertical beam lever, a bell crank and a 'T' shaped lever. The beam lever is centrally pivoted on a bracket secured to the rear face of the centre section rear spar, and is free to move from port to starboard. The 'T' shaped lever is centrally pivoted to the upper end of the beam lever, with the odd arm of the 'T' on the starboard side of the unit. The bell crank lever shares the pivot shaft of the beam lever and is arranged with one arm pointing downwards and the other arm on the starboard side of the unit. The odd arm of the 'T' shape lever is connected by a fixed length link rod to the starboard pointing arm of the bell crank. The lower arm of the bell crank is connected by an adjustable push pull tube to the bell crank on the elevator vertical control shaft on the port side of the electrical compartment. The two opposite arms of the 'T' shaped lever are connected, the upper arm to the control tubes in the starboard wing, the lower arm to the control tubes in the port wing.

24. OPERATION

When the pilots control hand-grip is operated in push-pull (Elevator Sense) the vertical beam lever will be held stationary by the aileron sense control circuit, whilst movement of the elevator sense circuit will be transmitted through the bell crank

lever and link to the treble armed lever. This lever in moving will cause equal and opposite movement of the control tubes in the two sides of the wing and all powered control units will be selected to move in the same direction.

25. When the pilots hand-grip is operated in twist (Aileron Sense) the bell crank lever will be held stationary by the elevator sense control circuit, whilst the vertical beam lever will be moved by the aileron sense control circuit. The treble armed lever being pivoted to the top of the vertical beam lever moves from side to side with the beam lever, but will be maintained in the vertical position by the link connection with the stationary bell crank lever. The treble armed lever in moving will cause equal and undirectional movement of the control tubes in the two sides of the wing, and the powered control units on one side of the aircraft will be selected to move in the opposite direction to the powered units on the opposite side.

26. If now the pilot selects oblique stick, a combination of push pull and twist, then the two movements will be imparted to the mixer unit. The treble armed lever will move in elevator sense, giving equal and opposite movement to the control tubes in the wings. Since however the vertical beam lever also be moved in aileron sense, the resultant movement of the treble armed lever will give increased movement to the control tubes on one side of the wing, and decrease movement to the control tubes in the opposite side of the wing. Thus all powered control units will be selected to move in the same direction on both sides of the aircraft, but the four powered units on one side will be selected to move to a greater or lesser degree than the powered units on the opposite side dependant on the pilots selection.

27. ARTIFICIAL FEEL UNITS

As previously stated, the artificial feel unit is fitted to safeguard the aircraft against over-selection of the flying controls by, the power flying controls, providing the pilot with a certain amount of stick load, the amount varying with airspeed and control surface angle selected.

28. Three artificial feel units are fitted to the aircraft, one in each control circuit, each unit being designed for the particular control circuit into which it is connected. The elevator and rudder units are similar in basic design and operation but vary in the amount of stick load applied to the pilots controls. In both cases the maximum control surfaces angle selected at any particular speed is limited by the amount of stick load. The aileron feel unit differs considerably from that of the rudder and elevator units in both design and operation as follows:-

- a. The stick loads applied are relatively light and vary only with variations in control surface angle selected.
- b. The maximum angle that can be selected is positively limited by mechanical stops, the position of which is varied automatically, with variations in airspeed.

29. DESCRIPTION OF THE RUDDER AND ELEVATOR ARTIFICIAL FEEL UNITS

The components of the feel unit are completely enclosed by and built into a light alloy box type housing which is reinforced by an internal framing of angle section. Bolted to the front and

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rear walls of the box are two roller bearing units which are arranged to support a square section push pull rod. This rod projects through clearance holes in the box and is forked at one end to allow for connection by a single bolt with the control circuit concerned.

30. A torque shaft on which are fitted two levers is located in bearings secured to the side walls of the box. One lever carries a fulcrum roller and a follow up cam plate, whilst the other lever is connected to the ram end of an electrically driven (fulcrum) actuator. The body of the actuator connects midway down a vertical swinging lever, the top end of which pivots in a bearing secured to the rear wall of the box. A further (FEEL RELIEF) actuator for emergency use is connected between the forward wall of the box and the lower end of the vertical swinging lever.

31. A vertical rocker lever connects at its lower end with the operating rod of a double-acting boxed spring unit located in a trunnion secured to the rear wall of the box. A radial slot in the rocker lever engages with the fulcrum roller on the torque shaft lever.

32. An electrical (follow-up) transmitter is mounted on the rear wall of the box. An operating arm on the transmitter is spring-loaded into contact with the face of the follow-up cam plate situated on the torque shaft lever end. A further electrical (airspeed) transmitter is mounted external to and on the top side of the feel box housing. This transmitter is connected by piping to the aircraft ASI system and in conjunction with the follow-up transmitter controls the operation of the fulcrum actuator. Two electrical switches, mounted one each on the front and rear walls of the box are arranged to be operated, one by movement of the vertical swinging lever, the other by a trip lever on the torque shaft.

33. OPERATION

When the particular pilots control is moved in either direction from the centralised position, the movement of the control push-pull tubes is transmitted through the vertical beam lever in the control circuit concerned to the square sectioned push pull rod in the particular feel unit. This push pull rod movement causes angular movement of the rocker lever which in pivoting about the fulcrum roller causes the spring in the box spring unit to be compressed. Thus the spring loading, which progressively increases with the amount of spring compression will be felt as an increasing resistance to movement at the pilots control, increasing with control surface angle selected.

34. The fulcrum actuator is controlled by an electrical bridge circuit, formed by the resistance of a transmitter varied by airspeed and the resistance of a transmitter varied by the fulcrum actuator movement. If the fulcrum roller is correctly positioned in the rocker lever for a particular airspeed then the values of the resistances are equal and no current flows across the bridge.

35. As the aircraft speed increases its associated resistance changes its value and becomes out of balance with the follow-up resistance. Thus an out-of-balance current will flow across the bridge and will operate a relay to energise the retract field of the fulcrum actuator. The actuator in retracting rotates the

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torque shaft causing the fulcrum roller and cam plate to move up the rocker lever. As the cam plate moves it varies the follow-up resistance, until it reaches the same value as the airspeed resistance. When the bridge becomes re-balanced and the current ceases to flow, the relay is energised and the actuator is stopped.

36. The operation for a decreasing airspeed is similar but opposite, the airspeed resistance again changes its value and becomes out of balance with the follow-up resistor. The out of balance current flows across the bridge in a reverse direction operating a second relay to energise the extend field of the actuator, moving the fulcrum roller and cam plator down the rocker lever.

37. Movement of the rocker lever fulcrum point varies the ratio between the amount of control circuit movement and the amount of spring compression. Thus the loading on the pilots controls increases or decreases progressively with increase or decrease of airspeed.

38. Provision is made for warning the pilot against incorrect functioning of the feel unit by the incorporation of a feel warning system. This comprises a second bridge circuit formed by a second airspeed transmitter and the original follow-up transmitter. This circuit is made less sensitive to prevent the warning system from being operated during normal function of the feel unit. The lag between an increase of airspeed and increase of feel is normally 10 knots and whilst this is normal the warning system is ineffective. Should this lag be increased to 30 knots sufficient out of balance current will flow across the second bridge to operate the warning indication.

39. The elevator and rudder control circuits possess a certain resistance to movement caused by friction due to support bearings, changes of direction, etc. Although this circuit friction is controlled to a minimum by design and care on assembly, it is impossible to remove completely. Any frictional resistance in the control circuit will hold the boxed spring in the feel unit slightly compressed and this results in lack of positive centralisation of the pilots controls. Positive centralisation is ensured therefore by fitting a centralising spring into the control circuit to counter-balance the circuit friction. The centralising spring takes the form of a lightly loaded box spring unit and is located on the square section push pull rod in the feel unit. Since the centralising spring is on the input side of the feel unit it is unaffected by changes in airspeed and the spring loading will therefore remain constant with airspeed, and will vary only with the amount of control circuit movement selected by the pilot.

40. To reduce the high level of stick forces encountered at high Mach numbers, a spring strut is introduced into the elevator sense control run. This strut collapses at a stick force of 20 lbs \pm 2 lbs. and results in an increased surface movement at the ratio of 1 degree gain per 20 lbs. increment of force.

41. FEEL RELIEF (RUDDER - ELEVATOR)

The loading of the pilots controls can be reduced to the minimum by the use of feel relief switches provided in the cockpit. Two switches, one on each pilots control handgrip, select both aileron and elevator feel relief when operated. A single switch for selecting rudder feel relief is located on the fuel contents gauges panel, and is available to both pilots.

42. When a particular relief switch is selected the relief actuator in the feel unit concerned retracts and in retracting moves the vertical swinging lever away from the wall of the box housing. The initial movement of the lever releases a micro-switch which breaks the electrical supply to the feel control, bridge circuit, thus preventing any movement of the fulcrum actuator during the relief selection. Movement of the swinging lever is transmitted through the now stationary fulcrum actuator to the torque shaft lever. The torque shaft rotates and in doing so moves the fulcrum roller to the bottom of the radial slot in the rocker lever. As this position of minimum feel is reached a micro-switch operated by the trip lever on the torque shaft breaks the electrical supply to the relief actuator and the actuator is stopped.

43. The pilot can reset back to normal feel conditions by operating the powered controls group start switch, on the flying control switch panel located on the port side, of the cockpit. The group start switch completes an electrical supply to the relief actuator and this runs to its fully extended position where it is switched off by a limit switch internal to the actuator. This movement of the relief actuator resets the mechanism back to its normal position. Since there has been no fulcrum actuator movement during the relief period then the rocker lever fulcrum point will be reset to the position it was in when feel relief was selected. The final movements of the swinging lever depresses the micro-switch and completes the electrical supply the feel control bridge circuit. If the aircraft speed has changed during the period of feel relief then the fulcrum actuator will again operate to adjust the feel to the new air speed in the normal manner.

NOTE:- When selecting elevator or aileron feel relief both units will move to the minimum feel position due to the combined selector switch. However, the unit not required in the relief condition may be reset back to normal feel by selecting the appropriate powered controls group start switch.

44. DESCRIPTION OF AILERON ARTIFICIAL FEEL UNIT

The components of the aileron artificial feel unit are assembled about a heavy channel section beam which is provided with mounting brackets at each end for attachment at the feel unit to the fuselage structure. A large beam lever, centrally pivoted in a vertical position on the rear end of the mounting beam, connects at its lower end with the aileron control circuit, and at its upper end with the ram end of a trim actuator. The opposite end of the trim actuator is connected to the lever system of a torsion bar assembly which is mounted as a unit on the forward end of the mounting beam. A torque shaft carrying two levers is located in bearings on the top side of the mounting beam, between the vertical beam lever and the torsion bar assembly. One lever carries a follow-up cam plate whilst the second lever is connected to the ram end of a twin-motored stop actuator, the opposite end of which is connected with a bracket secured to the forward underside of the mounting beam. A lever pantograph unit is connected at its forward end with the actuator lever on the torque shaft and at its rear end shares the central pivot of the vertical beam lever. Two stop rollers, one located on each arm of the pantograph lever to restrict or de-restrict range of travel. An electrical follow-up transmitter is mounted centrally on the top side of the mounting beam with its operating arm spring loaded into contact, by a roller, with the cam plate on the torque shaft lever.

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45. OPERATION

The aileron feel unit differs from the elevator and rudder units in that the feel does not vary with air-speed, over-selection of control surface angle being prevented by the stops on the pantograph unit.

46. When the pilots aileron control is moved from the centralised position in either direction, the movement of the control circuit is transmitted through the vertical beam lever and trim actuator to the torsion bar assembly. The torsion bars, which are unloaded with the pilots controls centralised, are twisted when the pilots controls are moved in either direction, and offer a variable resistance to movement. The torsion bar loading, which progressively increases with the amount of torsion bar twist, will be felt as a resistance to movement at the pilots control, increasing with control, surface angle selected.

47. The normal motor of the stop actuator is controlled by an electrical bridge circuit in a similar manner to the fulcrum actuator of the rudder and elevator feel units. When an aircraft speed increases, the extend field of the normal motor in the stop actuator is energised by the bridge circuit and the actuator extends until the selection is cancelled by the action of the follow-up transmitter. The actuator in extending moves the pantograph arms and stop rollers closer to the two arms of the vertical beam lever, thereby decreasing the lever movement to determine the amount of control surface angle that can be selected. The operation of the unit for decreasing airspeed is similar, the bridge circuit energising the retract field of the normal motor and the actuator in retracting move the stop rollers away from the vertical beam lever to increase lever movement. Thus for a particular airspeed there will be a particular position for the stop roller in relation to the vertical beam lever and any control surface angle either side of central can be selected by the pilot up to the maximum permitted by the stops. It should be appreciated however, that since the resistance put into the aileron control circuit by the torsion bars is unaffected by change in airspeed the amount of stick load will be proportionate to the amount of control movement only.

48. FEEL RELIEF (AILERON)

A warning system similar in design and operation to that of the elevator and rudder feel units if fitted to warn the pilot against incorrect function of the aileron feel unit. In addition, provision is made for regaining full range of aileron control selection, regardless of airspeed, by the use of feel relief switches on the 1st and 2nd pilots control handgrips.

49. When a particular relief switch is operated the electrical supply to the control bridge circuit of the normal motor in the stop actuator is broken. At the same time the emergency motor in the stop actuator is switched on and the actuator retracts causing the pantograph stops to be moved away from the arms of the vertical beam lever. The actuator runs to the fully retracted position when the emergency motor is switch off by an internal limit switch. This retracted position of the actuator coincides with the full control range position of pantograph stops.

50. The pilot can reset back to normal feel conditions by operating the appropriate powered controls group start switch located on the flying controls switch panel at the port cockpit rail. The group start switch re-instates the stop actuator control bridge circuit and since the actuator is now in the incorrect position relative to the airspeed then the normal motor of the stop actuator runs to extend the actuator. Thus the pantograph stops are moved to their correct position relative to the vertical beam lever for the prevailing airspeed.

51. TRIM - AILERON SENSE, ELEVATOR SENSE, AND RUDDER

Provision is made for trimming out undesirable changes of attitude in flight by connecting an electric actuator into each control run. This actuator is, in each case, located between the vertical beam lever in the control circuit and the artificial feel unit.

52. The function of the actuator is to increase or decrease the effective length of the connection between the feel unit and the flying control circuit. With the feel spring fully extended, (torsion bar unloaded in the case of the aileron unit), and the trim actuator in its neutral travel position, the control circuit is adjusted, on the ground, to position the pilots controls central and the control surfaces in their neutral position. Since there is little resistance to movement in the control circuit itself, if the trim actuator is extended or retracted, when the whole of the control circuit is moved in preference to compressing the box spring in the feel unit (twisting the torsion bar in the case of the aileron unit). Thus the pilots controls are moved to a new position of zero feel and a hydraulic selection is made in the powered flying control units resulting in a change of control surface angle.

53. In each case the trim actuator consists of a single screw jack driven through a differential gearbox by either of two electric motors, one for normal use in the case of normal motor failure. Thumb-operated two-axis switches, are positioned on the first and second pilots control handgrips, and are electrically wired to the normal motors of the aileron sense and elevator sense trim actuators. Provision is made in the electrical circuit to prevent the first and second pilots making opposite selections at the same time. A further switch, mounted on the fuel contents panel, is electrically wired to the normal motor of the rudder trim actuator.

54. In the event of a normal motor failure, then further trim selection can be made by operating a three-axis switch on the pilots centre console. This switch is electrically wired to the aileron sense, elevator sense and rudder emergency trim motors and is brought into use by operating a press button on top of the switch. The press button must be pressed all the time that the three-axis switch is being used.

55. AUTOSTABILISERS

In certain flight conditions, aircraft tend to oscillate about the Yaw and Pitch axes with very little damping. The function of autostabilisers is to detect this oscillation and to suppress it by actuating the appropriate flying control surfaces, rudder in the case of Yaw, and elevon in the case of Pitch.

56. The system consists essentially of a rate gyro which detects the oscillation and relays a signal through an amplifier to electric actuators fitted in the control circuits.

57. In the case of Yaw two actuators located back to back are inserted in the rudder control circuit between the artificial feel unit connection and the powered control unit input rods. Movement of the actuators give movements of the rear section of the control circuit only, with no disturbance of the pilots control unit, resulting in direct selection of the rudder powered flying control units. The positioning of the actuators in the control circuit enables full use to be made of the rudder change-over system.

58. In the case of Pitch, four actuators are provided and these replace the feed back link in the inboard elevon, Nos. 3, 4, 5 and 6 powered control units. Movement of the actuators cause direct selection of the particular powered control units with no disturbance of the normal control circuits. With the control switches in the "ON" position, this system is automatically switched on at 20,000 ft. by height switches.

59. MACH TRIM

Due to the inherent characteristics of high speed aircraft being that of a nose-down attitude, which increases rapidly with a rise in Mach number, some form of elevator control trimming is required. This function is performed by the Auto Mach Trim units. The system consists of two sensing units which relay signals through amplifiers to two electric actuators fitted in the elevator sense control run. The actuators are located in the control run just after the artificial feel unit connection so that movement of the actuators will cause movement of the rear section of the control run only with no disturbance of the pilots controls. As the airspeed increase above a certain Mach number the actuators commence to extend and in so doing select a positive up selection on the eight elevon powered control units.

60. AUTO MACH TRIM SYSTEM

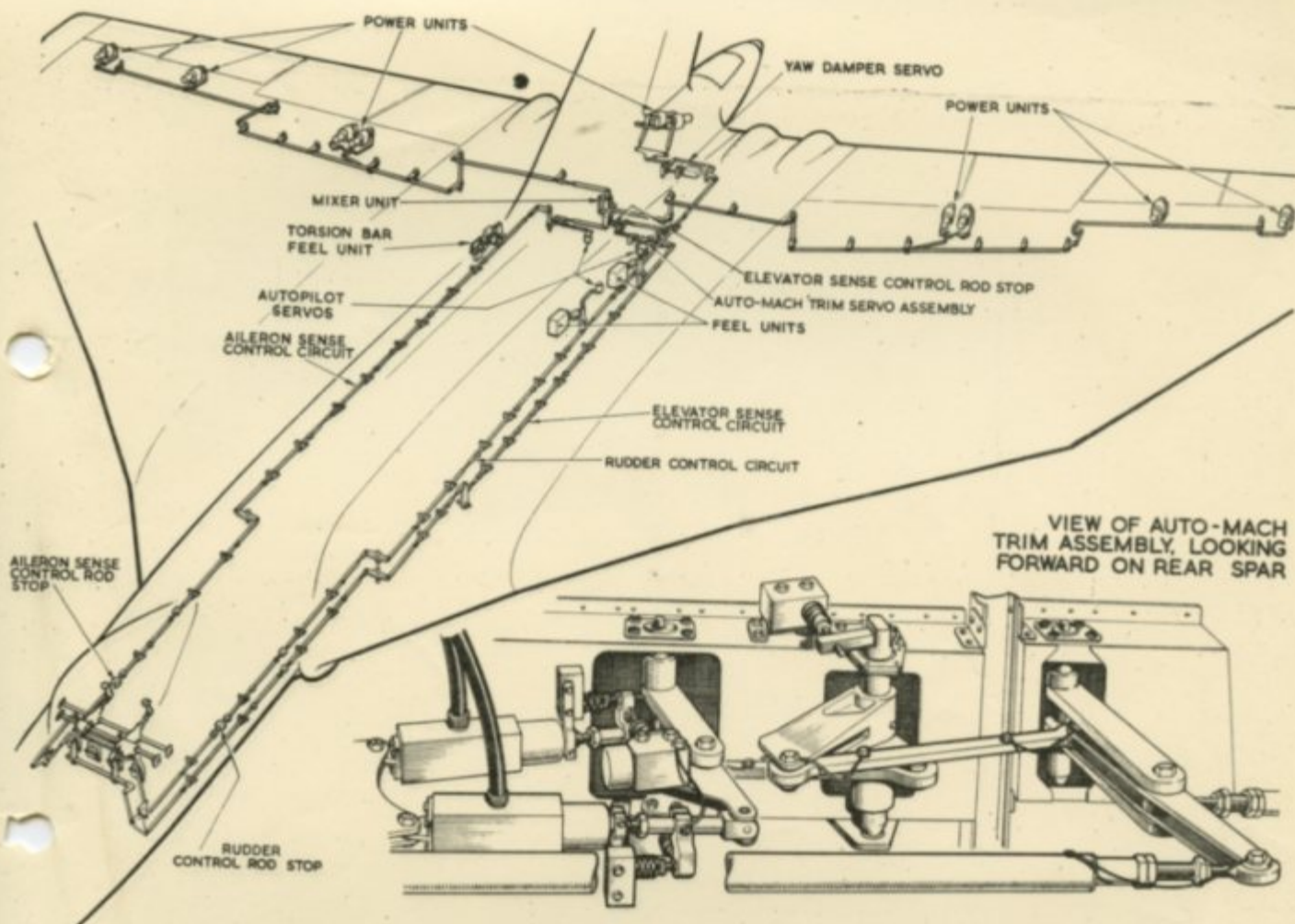
Control switches on the port console consist of a master switch controlling the supply to both actuator channels, and two individual channel switches.

The master switch contains a lamp which will illuminate to indicate either a misalignment of the two channels or that the system is switched off. The individual channel switches will both emit a blue light when the system is "IN" and is operating correctly. The system is energised automatically at 20,000 ft. by height switches. Should any extension of either actuator occur below this altitude, then the main warning lights on the centre instrument will illuminate.

KEY TO FIG.1
FLYING CONTROLS AND INSTRUMENTS
IN COCKPIT

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

RESTRICTED



F.S./2

Fig. 2 Flying control system

NOTA: ...
 A.P.4505B, Vol. 1, Book 1, Sect. 3, Chap. 4
 A.L. 71, Sep. 60

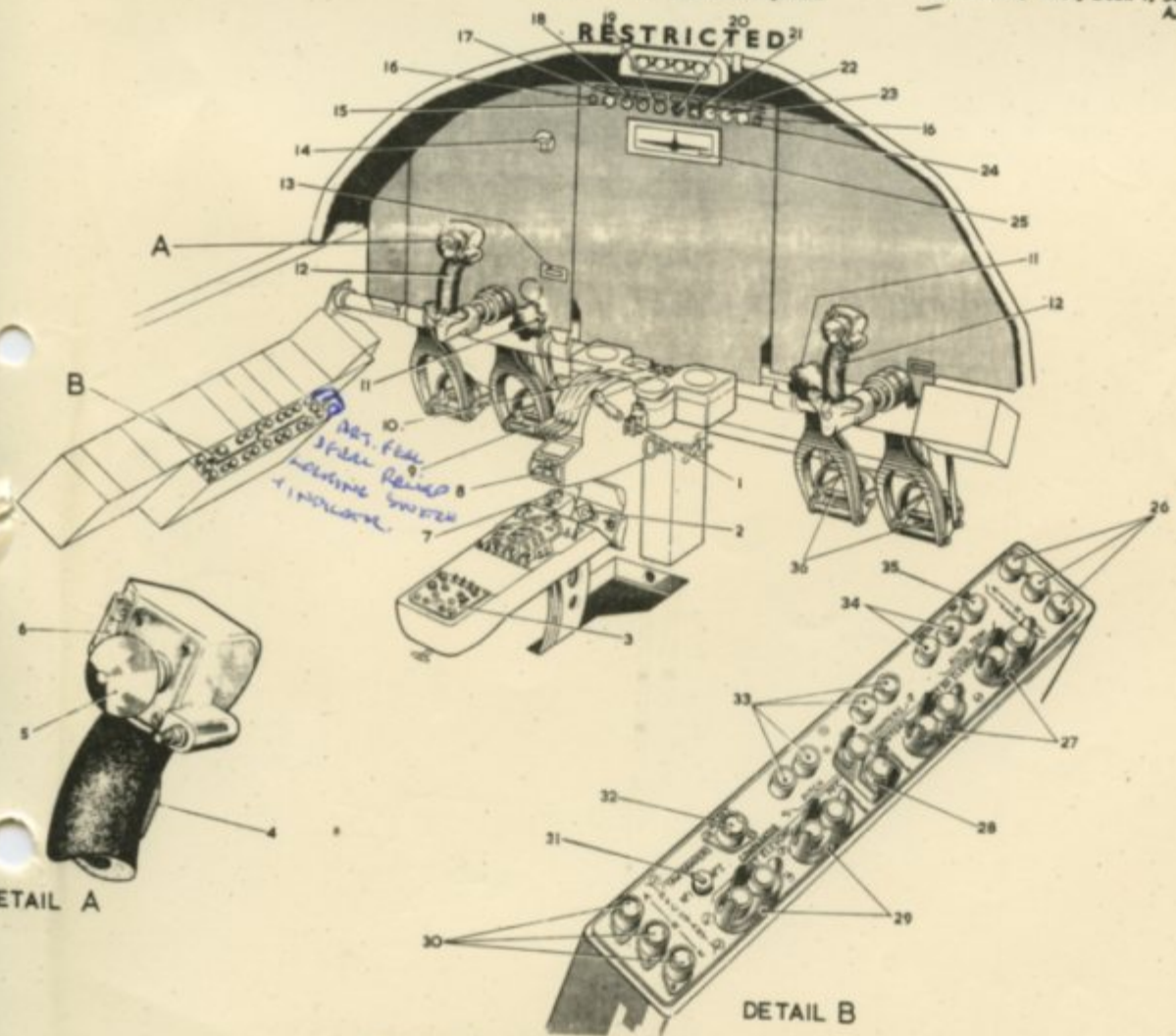
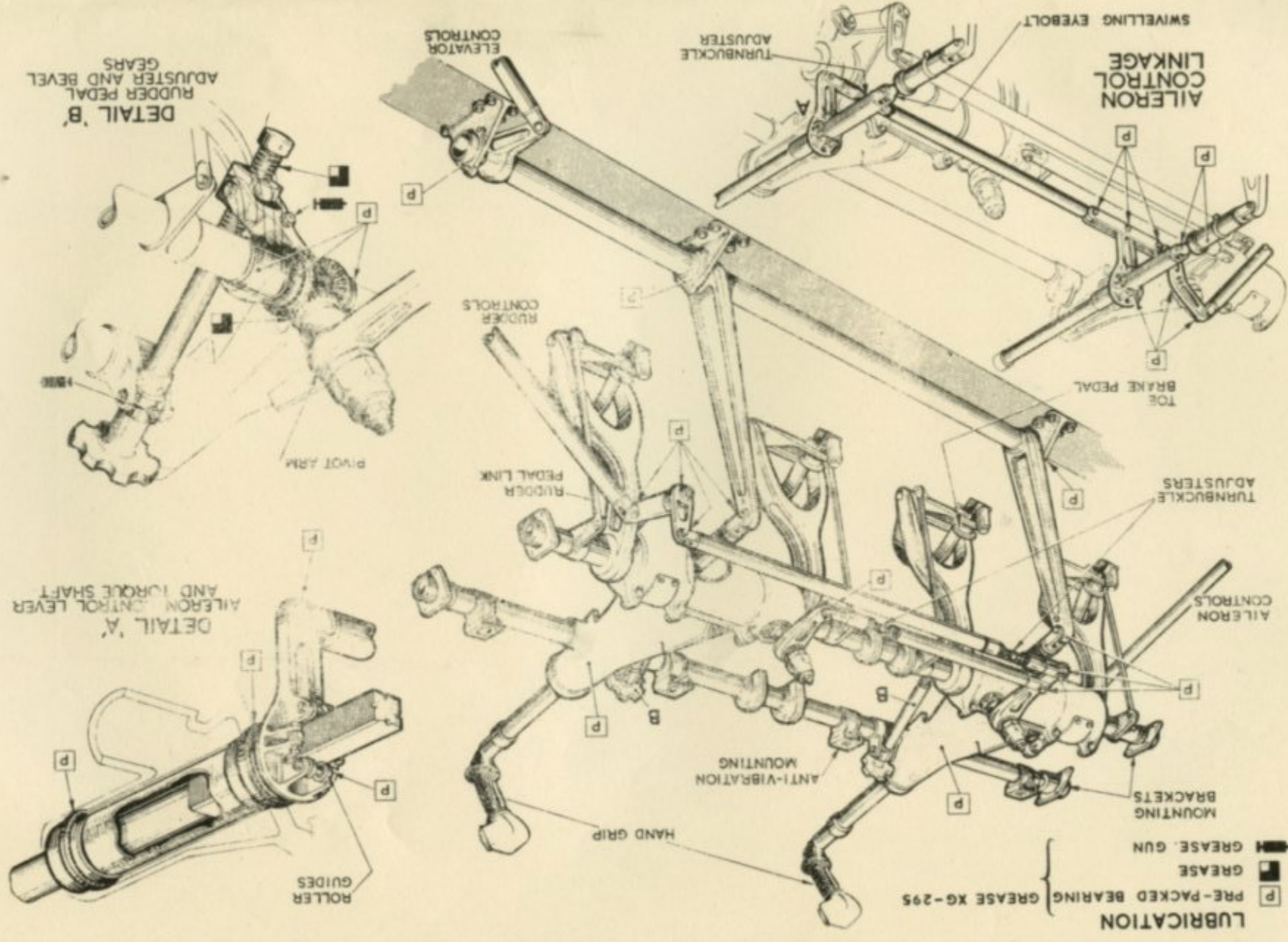
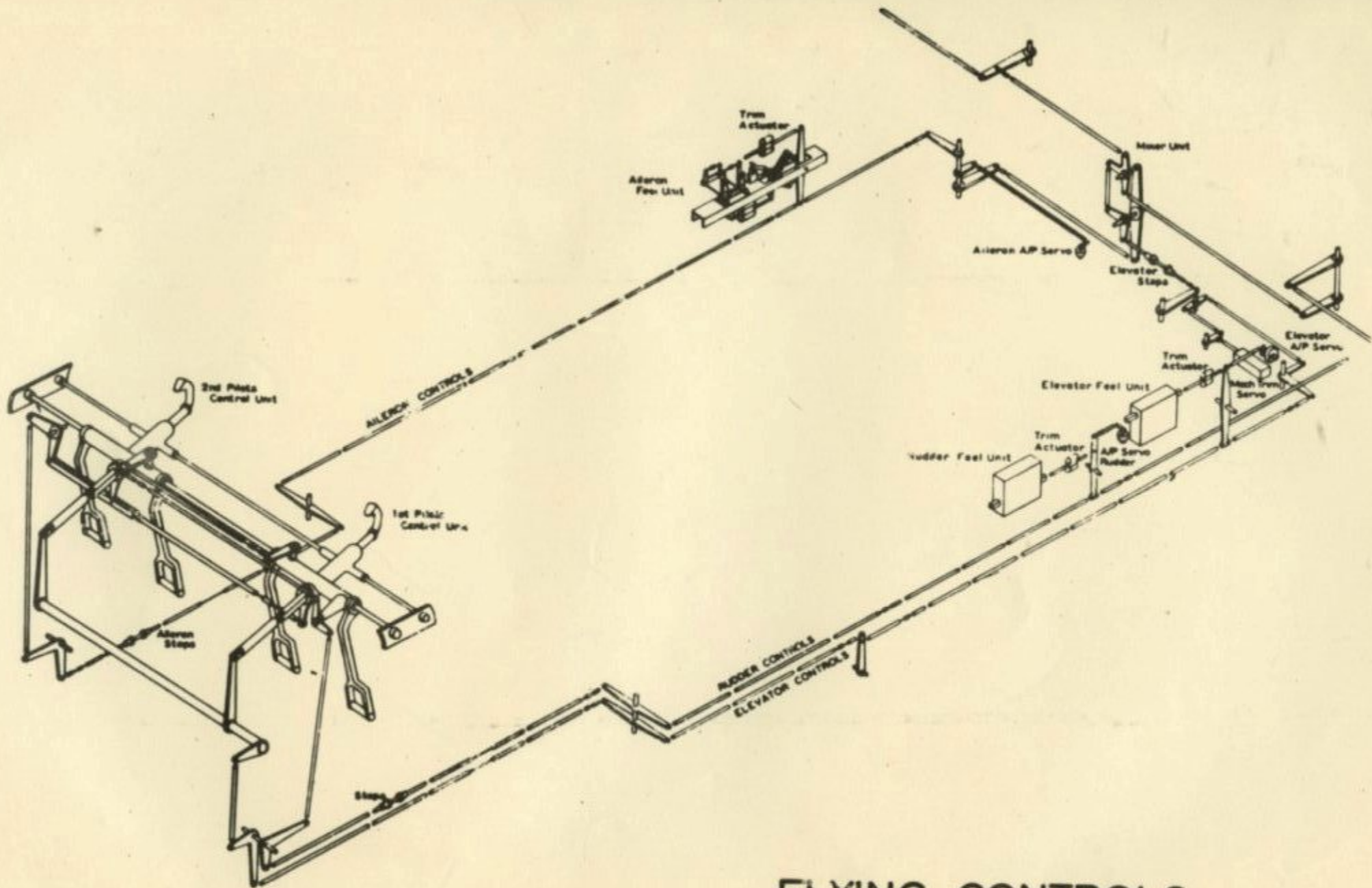


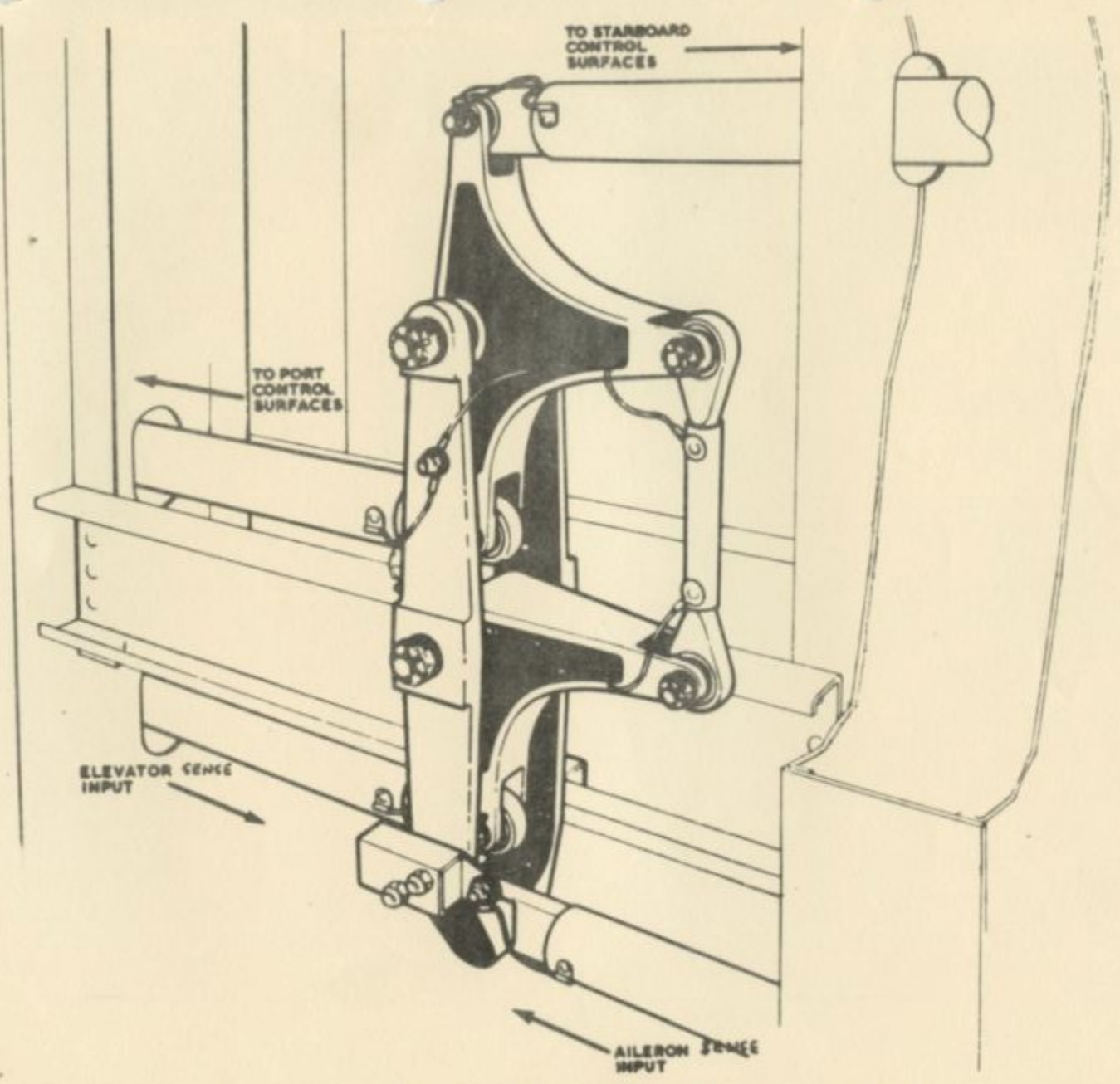
Fig. 1 Flying controls and indicators

Fig. 3 Control mechanism in cockpit





FLYING CONTROLS



MIXING UNIT FOR ELEVON CONTROLS

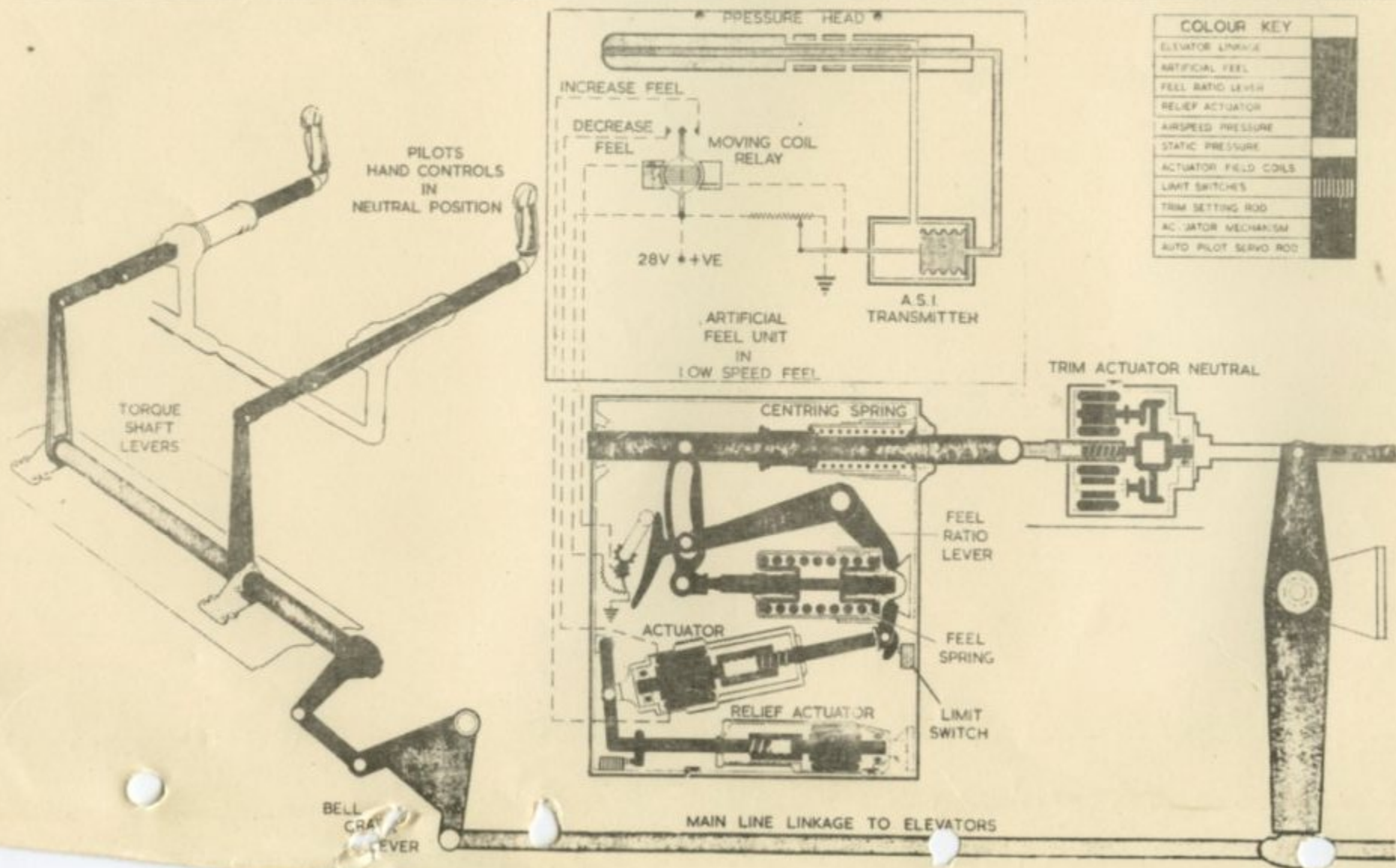


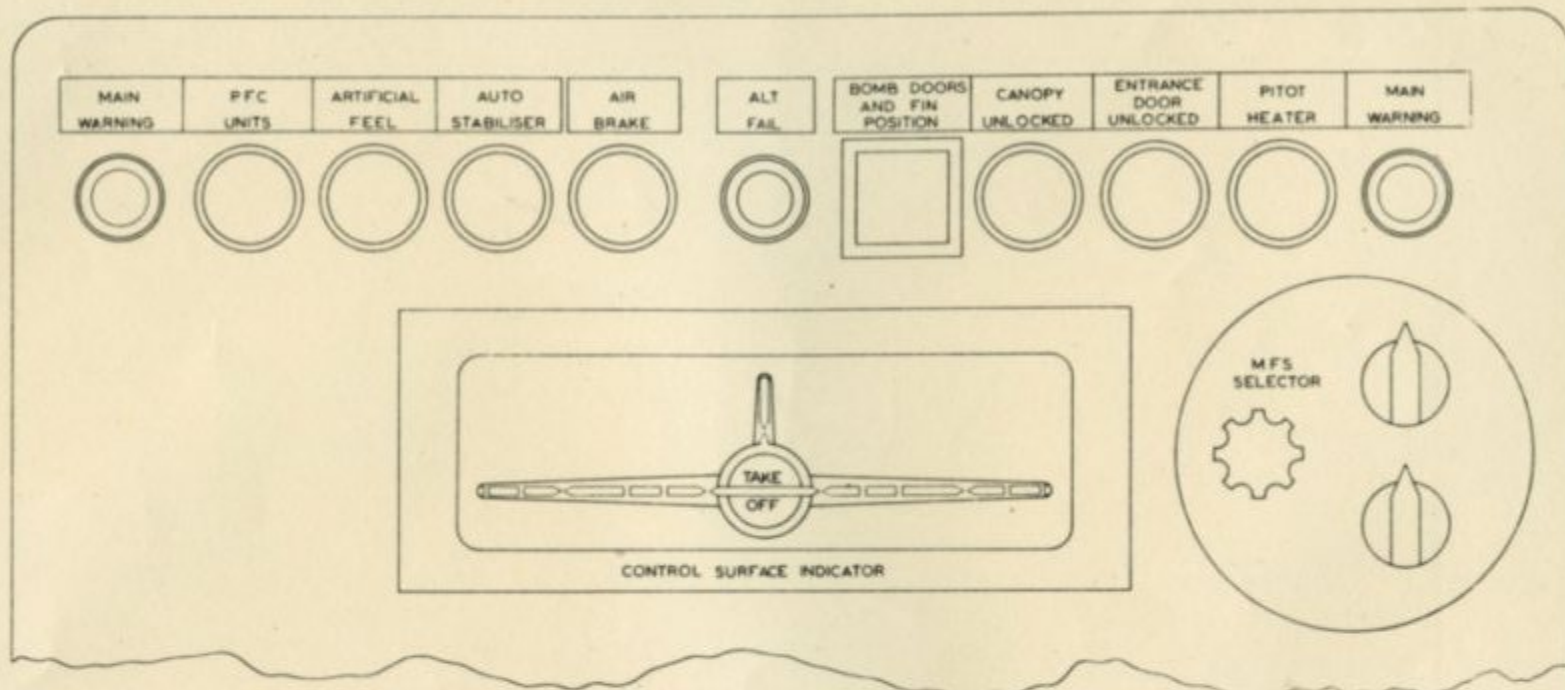
A-V-ROE & CO LIMITED
MANCHESTER

FLYING CONTROLS

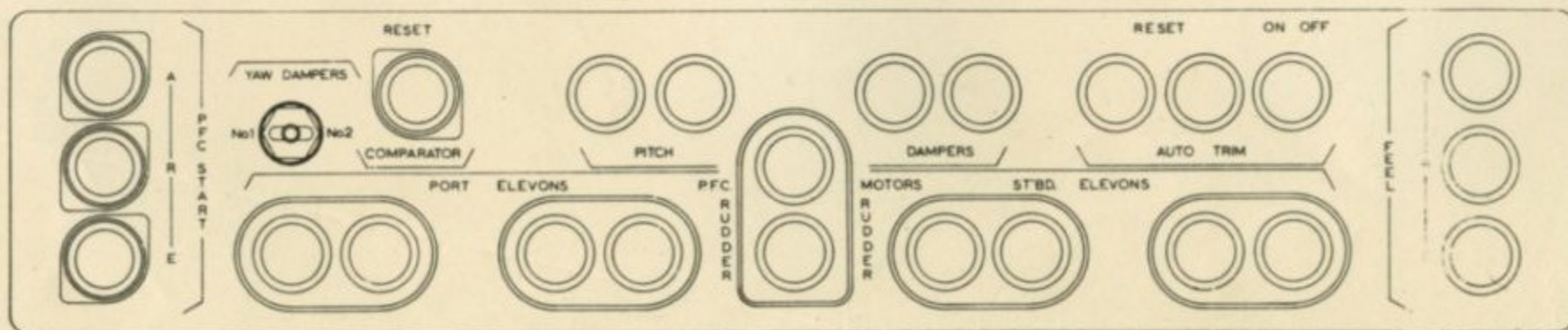
ELEVATOR CIRCUIT

Issue No. 1



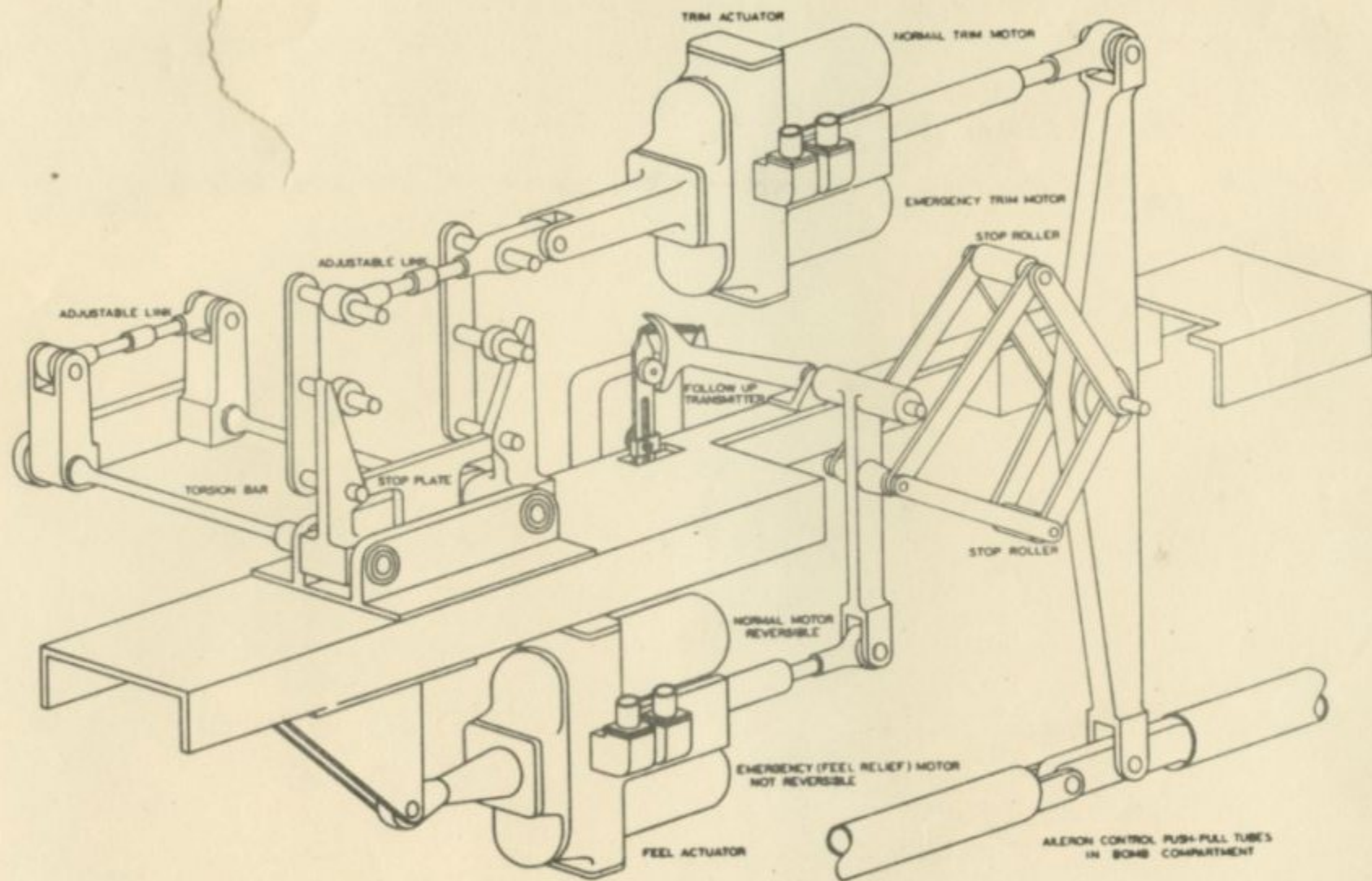


CENTRE PANEL 1P

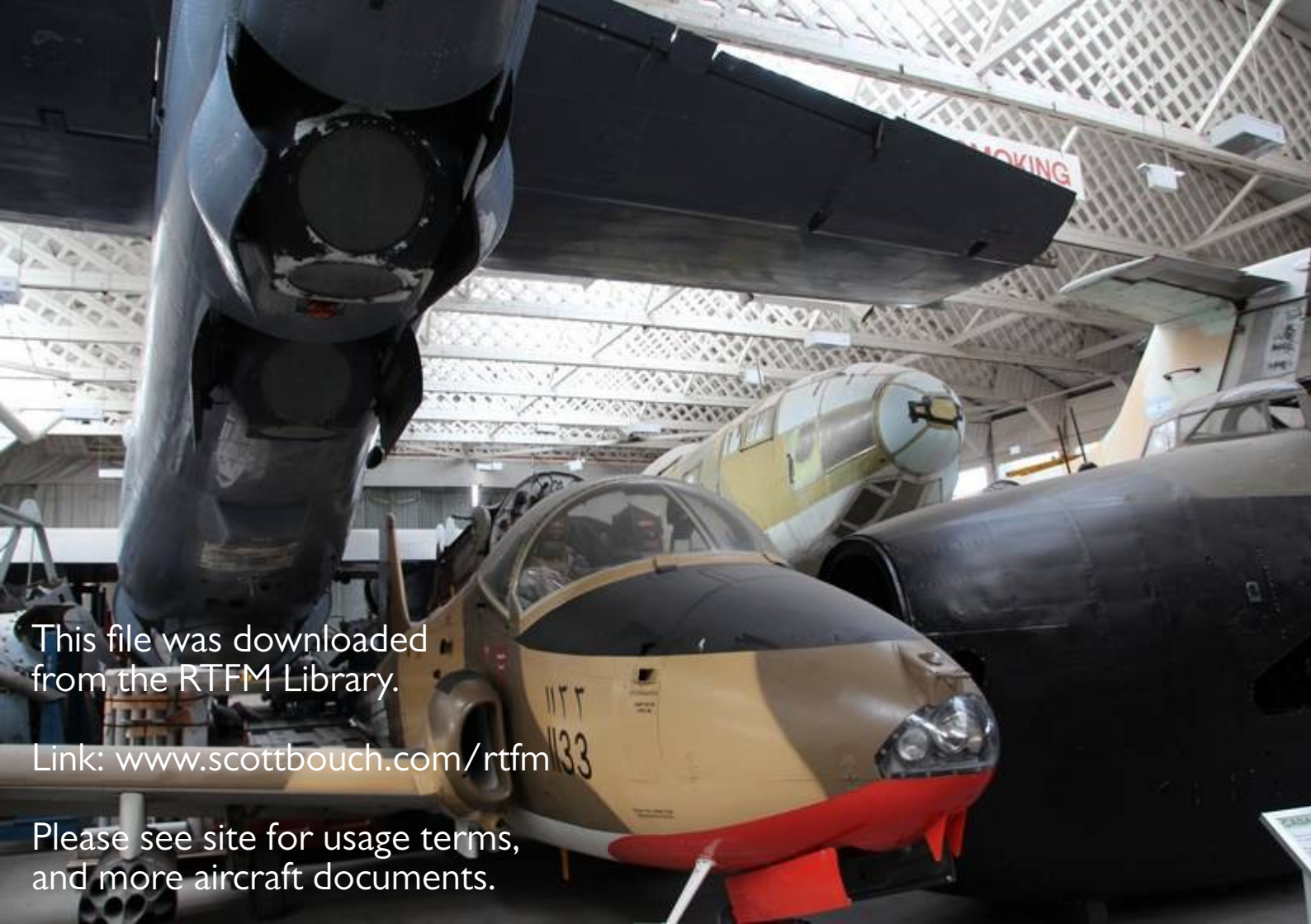


PFC SWITCH PANEL 6P

DIAGRAM 15:2.



ARTIFICIAL FEEL UNIT (Aileron Sense)



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