

Part I

Chapter 7—Auto Pilot Mk. 10

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Description, Controls and Indicators

1 General

Disturbances to the aircraft flight path are picked up by three rate gyros, mounted at right angles to each other on a platform. The gyro signals pass through amplifiers to the servo-motors in each control run. As a safety measure a torque limiter is fitted in the elevator and rudder circuits and this automatically disengages the whole auto-pilot if too great a load is applied to either control. A roll error cut out disengages the auto-pilot when a certain undemanded bank angle is reached, excepting when flaps are 1° or more down when it is inhibited.

2 Controls

(a) Mk. 1A aircraft

- (i) The auto-pilot is operated from a control unit on panel AT and is monitored from the Mk. 4B compass master indicator.

The heading selector is on the 1st pilot's console AE and a trim indicator is fitted on the 1st and 2nd pilot's panels AA and AB respectively.

- (ii) The control unit has the following switches and indicators located on it:

POWER switch and associated READY magnetic indicator
 ENGAGE switch and associated IN magnetic indicator
 Rudder, aileron and elevator channel switches
 Trim indicator
 BOMB switch (NBS)
 TRACK switch
 GLIDE switch
 Height lock switch marked ALT
 Turn control switch
 Pitch control switch marked CLIMB-DIVE

(b) *Mk. 1 aircraft*

(i) The heading selector is on the pilots' centre panel A and there are two control units, one on the 1st pilot's console AE and the other on panel AT. A remote trim indicator is also on panel AT.

(ii) The control unit on console AE has the following switches and indicators:

- POWER switch and READY magnetic indicators
- ENGAGE switch and IN magnetic indicator
- Rudder, aileron and elevator channel switches
- Trim indicator
- Bomb switch
- Track switch
- Height lock switch
- Glide switch

(iii) The control unit on panel AT has the following switches:

- Turn control switch
- Pitch control switch

(c) In each aircraft the rudder, aileron and elevator switches are conventional two position (IN forward) toggle switches. The pitch control switch is a multiple switch, spring-return to centre-off and the turn control switch is a pointer knob which operates the wiper arm of a potentiometer. The remainder of the switches are of the pull (on)—push (off) type electromagnetically held in when operated.

3 Control unit function

(a) *POWER switch*

When the POWER switch is pulled "on" the READY magnetic indicator shows white after a period of approximately 60 seconds, indicating that the auto-pilot is ready to be engaged with the aircraft controls. The power switch should be pulled ON as soon as possible after take-off to allow the maximum time for the auto-pilot to stabilise before being used. Mod. 3149 (BC Mod/Victor/04) provides a guard to prevent inadvertent tripping of the button when panel AT is in the extended position. ▶

(b) *ENGAGE switch*

When the ENGAGE switch is pulled "on" and all three channel switches are IN, the white indication disappears from the READY indicator and a black and white striped disc shows at the IN indicator; this confirms that the auto-pilot is engaged. If any control channel remains disengaged, the READY indicator remains exposed and both READY and IN discs are visible.

(c) *Channel switches*

If one channel remains engaged (IN), the remaining channel(s) may be engaged by setting the appropriate channel switch(es) to the IN position. If all three channels are disengaged, the auto-pilot is disengaged completely, the ENGAGE switch returns to the "off" position, the IN disc disappears and the READY disc is visible. To re-engage the auto-pilot, set at least one of the channel switches to IN and pull "on" the ENGAGE switch.

(d) *Pilot's cut-out switches*

If either the 1st pilot's or 2nd pilot's cut-out switch is operated, the auto-pilot is disengaged and the ENGAGE switch returns to the "off" position, the IN indication disappears and the READY indication is visible.

(e) *Turn control switch*

The aircraft can be turned at a pre-set bank by selecting the angle on the control knob. The knob remains at the selection and the aircraft maintains the bank until a different angle is selected, or the control knob is returned to the central position.

(f) *Pitch control*

The pitch control is operated in a natural sense, i.e. moving the switch forward produces nose-down pitch and vice-versa. The toggle is spring-loaded to the centre (off) position and movement is opposed by two spring rates. Initial movement against a weak spring produces a slow rate of change of aircraft attitude and further movement which is against a stronger spring causes a fast rate of attitude change.

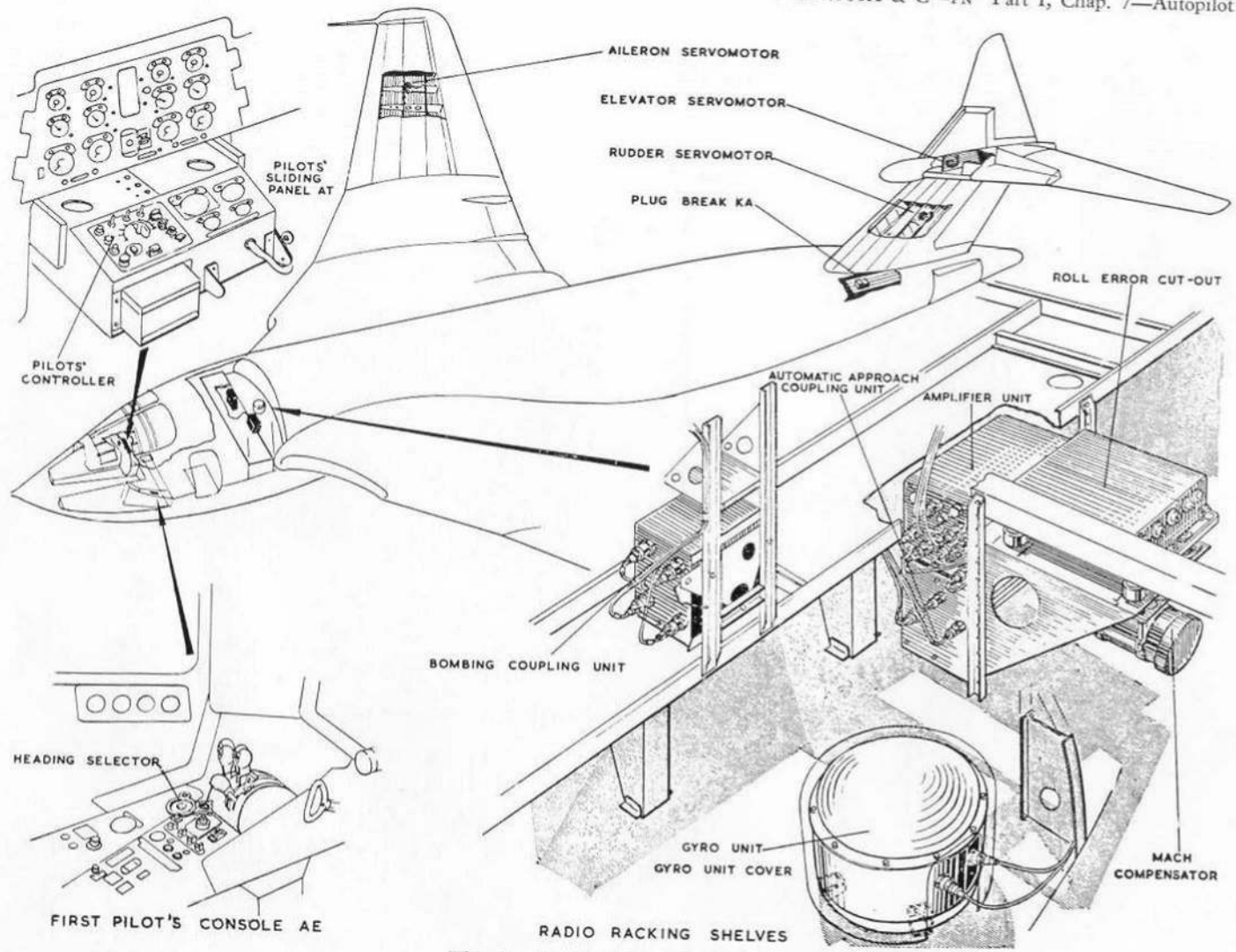


Fig. 1 Auto-pilot equipment

RESTRICTED

4 G switch

The G switch is on the centre leg of the navigator's table and, when operated, disengages the auto-pilot from the main control systems. The switch incorporates test and reset buttons for manual operation during functional testing of the auto-pilot system.

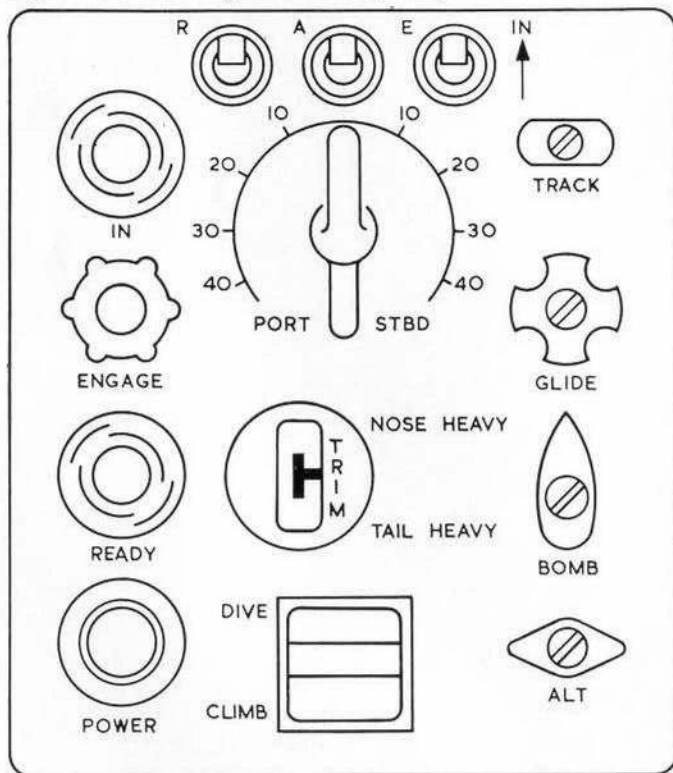


Fig. 2 Auto-pilot control panel

5 Heading selector

The heading selector comprises a compass repeater and a pre-select turn engagement button. If the track switch on the control unit is

OFF, courses are pre-selected on the heading selector and the aircraft turns to the heading when the pre-select turn button is depressed. The angle of bank is restricted to 30 degrees. With ILS on, the runway heading corrected for drift is pre-selected before pulling the track switch on.

Management and Malfunctioning of the Auto-Pilot

6 Auto-pilot limitations

Provided Mods. 666, 781 and 957 are incorporated the auto-pilot is cleared for use, but the following limitations must be observed:

(a) General

(i) The auto pilot must not be used below 1,500 feet above ground level except on the ILS glide path.

(ii) Maximum speed: 330 knots/0.9M.

NOTE: If short period oscillations (2 seconds) occur above 0.85M the auto-pilot must be disengaged and is not to be re-engaged above 0.85M.

(iii) Minimum speed:

Above 30,000 feet	0.83M
Below 30,000 feet	No limit

(iv) The maximum bank angle must not exceed 30°.

(v) One pilot must be firmly strapped in at all times when the auto-pilot is in control.

(vi) Longitudinal trim must at all times be maintained within ± 1 division of neutral on the special trim indicator.

(vii) Before engaging the auto-pilot, the auto-mach trimmer must be switched OFF, the Newark stand-by yaw damper must be switched to STANDBY and the Hobson main yaw damper must be switched ON. The stand-by yaw damper must not be used in

lieu of the main yaw damper; if the latter is unserviceable the auto-pilot may be used without yaw damper assistance with some deterioration in performance.

(viii) Coupled ILS approaches may be made to an AAL of 250 feet above runway level.

(b) NBS coupling

Direct and offset coupled NBS bombing attacks may be made provided that the speed does not exceed 330 knots or 0.85M.

7 Pre-flight checks

Ensure that the Nos. 2 and 3 type 350 inverters are on, that one set of PFCU's are operating and that the yaw dampers are at STANDBY. Set the R, A and E channel switches to IN, pull up the POWER knob and check that the READY indicator shows white after approximately 45 seconds. Check that the flying controls are central, that the trim load indicators are in the green sector, that the flaps are fully retracted and that the auto-pilot turn control switch is central. Pull the ENGAGE switch and check that the IN indicator shows black and white stripes and the READY indicator shows black. Press lightly on all three controls to check proper engagement. Carry out the following checks of operation:

(a) Check for aileron drift and neutralise by turning the Mk. 4B compass. Disengage the auto-pilot, re-synchronise the Mk. 4B compass and re-engage.

(b) Switch out each channel in turn and check that the READY indicator shows white in addition to the IN indicator showing black and white stripes. Check the freedom of control of the disengaged channel and that the other channels remain firm. Re-engage and check that the READY indicator shows black.

(c) Check the operation of each pilot's instinctive cut-out; re-engage.

(d) Check the operation of the elevator and rudder torque cut-outs by applying steadily increasing force to the elevator and rudder controls in each direction in turn. Re-engage after each operation. Post-Mod. 2657 movement of the flaps away from the fully-up position inhibits the operation of the roll-error cut-out and the rudder excess torque cut-out.

(e) Check that movement of the pitch control produces movement of the control column in the correct sense, and corresponding movement of the trim indicator. The control column may continue to move very slowly for a short time after releasing the pitch control switch.

(f) Check that operation of the bank control in each direction in turn causes corresponding movement of the control column. Check that maximum movement in each direction causes disengagement through operation of the roll-error cut-out. Re-engage.

(g) Switch off all three channels and press in the POWER switch. Re-set all controls to the take-off position. Switch off PFCU's.

8 Use in flight

(a) To engage the auto-pilot

(i) Pull on the POWER switch and wait approximately 60 seconds for the READY magnetic indicator to show white. Check that the three-channel switches R, A and E are switched IN. Check that the trim indicators are within the green sectors. Trim the aircraft to fly hands and feet off in the desired flight attitude and then pull the engage switch.

NOTE: If the trim indicators are outside the green sectors, the auto-pilot must not be engaged.

(ii) Check that the IN magnetic indicator shows black and white stripes and the ready indicator shows black.

(b) To turn the aircraft

Rotate the turn control knob to the bank figure required; return the knob towards the central position as the new heading is reached. During prolonged turns there will probably be some loss of datum, with the result that when the turn knob is returned to the central position, the aircraft may over or under bank before finally assuming level flight. It is not necessary to re-set the heading selector, except where specified in (e).

NOTE: If the auto-pilot is engaged whilst the bank control knob is in any position other than central, this control will be inoperative until it has first been returned to the central position.

(c) Climb or descent

Move the pitch control fore or aft as required to achieve a change of pitch attitude, release the control to maintain the new pitch attitude, then re-trim the aircraft. Two rates of change of attitude are available. Initial movement of the pitch control against a weak spring will bring a slow rate into operation, while further movement against a stronger spring will bring a fast rate into operation.

(d) Manual operation of one or more control surfaces

The rudder and aileron channels may be temporarily disengaged, in straight and level flight only, in order to permit the trim of the control surfaces to be checked but in no circumstances should a turn be initiated with the aileron channel disengaged. Should any one of the channels of the auto-pilot become inoperative due to some unknown defect, all channels should be immediately disengaged and the POWER switch set off. Disengage the channel or channels required by selecting off the appropriate switch or switches. To resume automatic control of the disengaged channels (if not more than two) select the appropriate channel or channels IN by the channel switch or switches. If all three channel switches have been selected off it will be necessary to re-engage by pulling out the ENGAGE switch when all three channel switches are IN.

(e) Use of the heading selector

The heading selector can be used for:

- (i) Executing pre-selected turns. A desired heading can be pre-selected by the course setting pointer and the aircraft can be turned on to that heading by pressing the pre-select turn button for at least one second.
- (ii) Monitoring the aircraft heading in the TRACK and GLIDE phase of an automatic approach. The heading of the runway should be pre-selected with drift allowance and the TRACK switch on the control unit then pulled. When the track switch is pulled the bank control is inoperative.

NOTE: The bank control will override a pre-selected turn at any time.

(f) Barometric height control

To engage the height lock pull the ALT switch at the desired altitude. With the height lock selected the pitch control will be rendered inoperative at the slow-rate position in either direction. To remove the barometric height control push off the ALT switch.

NOTE: When engaged, the height lock switch will automatically release to off if the elevator channel switch is selected off, or if the pitch control is moved to the fast-rate position in either direction.

(g) Disengaging the auto-pilot

To disengage, press either cut-out button on the control columns. Do not push off the power switch if the auto-pilot is to be used again, otherwise it will be necessary to carry out the procedure as in (a) above, instead of merely re-selecting the ENGAGE switch on. Alternative means of disengaging the auto-pilot is to push off the ENGAGE switch on the control unit, or to switch off the three channel switches.

9 Auto ILS approach

(a) The initial ILS approach is assumed to commence at a point approximately 10 to 15 miles from the runway threshold. Approach to this position may be from a high level or low level pattern;

either may be flown manually or on normal auto-pilot control as required. Select the required ILS frequency, and identify the beacon. If the auto-pilot is not already in use, press the POWER knob, check that the READY indicator shows white and select the R, A and E switches IN before reaching the check height.

(b) At check height, or on the downwind leg, lower the undercarriage and flap as required and trim the aircraft at the pattern speed for the AUV. Engage the auto-pilot and pull the ALT switch. Set the runway heading corrected for drift on the heading selector. Check that the ILS indicator warning flags have disappeared. When at an angle of less than 170 degrees from the final approach heading pull the TRACK knob on the auto-pilot. The aircraft should approach the beam at an angle up to 70 degrees to the QDM and turn gradually onto the centre line, possibly with one slight overshoot. Make any corrections to drift setting on the heading selector necessary to maintain the aircraft on the beam centre line.

(c) As the aircraft approaches the glidepath and the glidepath needle indicates half deflection, select full flap, retrim and set the power required to maintain the correct speed on the final approach. When the glidepath needle reaches the top of the circle pull the GLIDE switch. The speed should be held constant by use of throttles throughout the approach and the trim indicators

monitored frequently. The flight instruments and the ILS meter should be scanned as for normal instrument approaches to detect any malfunction of the auto-pilot. Should any malfunction be suspected, the auto-pilot should be tripped immediately, and the approach continued manually or broken off as required. The approach must be discontinued if the glidepath or localiser needles reach full scale deflection before the break-off height.

(d) When the break-off height is reached the auto-pilot must be tripped and the approach completed manually. If the recommended approach speeds have been used, no difficulty will be experienced in landing normally on the ILS touch-down point.

10 Use of the auto-pilot under asymmetric conditions

Disengage the auto-pilot, retrim the aircraft and re-engage the auto-pilot.

11 Unselected engagement

Should there be an unselected engagement of the auto-pilot, or if the auto-pilot fails to disengage, the cut-out must be held in while the channel switches are set off and the POWER switch pushed in. The auto-pilot must then be regarded as unserviceable.

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