

Part I—Description and Management of Systems

Chapter 14—Auto-Pilot Mk 10

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Description

1 General

A Mk. 10 auto-pilot is installed and is operated by the switch unit (D/33) on the rear of the central console. A pilot's controller (D/14) is located at the front of this console.

An instinctive cut-out switch (A/4) is fitted to each pilot's control column handle. Electrical power is supplied to the auto-pilot when No. 4 inverter is running. In the event of failure of No. 4 inverter a supply can be made available from No. 2 inverter (see Chap 7 Para 6 of this Part). The system is monitored from the Mk 4B compass master indicator and a heading selector is fitted on the engine control panel.

2 Special features

The following special features apply to the auto-pilot :

(a) When the auto-pilot is selected on and the rudder channel is engaged, the yaw damper is automatically cut out ; the yaw damper

is automatically brought back into use when the auto-pilot is disengaged. Correct functioning of the auto-Mach trimmer and pitch damper is required for flight under auto-pilot control at the higher Mach numbers (see Part II Chap 2 Para 9).

(b) In order to avoid the consequences of a feel trim runaway under auto-control, the aileron and elevator trim circuits are automatically isolated and replaced by the emergency trim circuits when the auto-pilot is selected on and the rudder and elevator channels are engaged. When the auto-pilot channels are disengaged the aileron and elevator trim circuits automatically return to normal trim.

3 Switch unit

(a) The switch unit (D/33) 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

(b) The rudder, aileron and elevator channel switches are conventional two-positioned (IN forward) toggle switches. The remainder of the switches are of the pull (on)-push (off) type which are electro-magnetically held in the on position.

(c) *The switches on the switch unit function as follows:*

(i) *POWER switch*

When the POWER switch is pulled, electric power from No. 4 inverter is connected to the auto-pilot. After approximately 60 seconds the READY magnetic indicator will change from black to black/white stripes, indicating that the auto-pilot is ready to be coupled to the aircraft controls.

(ii) *ENGAGE switch*

Providing the rudder, aileron and elevator channel switches are IN, pulling the ENGAGE switch will couple the auto-pilot to all three control surfaces, whereupon the IN magnetic indicator will show white and the READY magnetic indicator will show black. The controls can be disengaged from the auto-pilot by pushing the ENGAGE switch in, although this will normally be done by depressing the instinctive cut-out on the control column when the ENGAGE switch will automatically release to the off position.

(iii) *Channel switches*

If a control channel switch is selected off, its particular control surface will be disengaged from the auto-pilot and the IN indicator will remain white and the READY indicator will show black/white stripes; re-engagement can be achieved by putting

the channel switch IN again when the READY indicator will show black. If all three channel switches are off at the same time, the ENGAGE switch will release to off and the control surfaces cannot then be re-connected to the auto-pilot simply by putting them on again. The normal engage method (by pulling out the ENGAGE switch when any one of the three channel switches is IN) will have to be used.

(iv) *Trim indicator*

This indicator (A/12) shows any out-of-trim load being carried by the auto-pilot elevator servo-motor. The indicator must be in the white sector before the auto-pilot is engaged. It must be kept in the white sector during flight by adjusting the aircraft trim as necessary, on the emergency trim control. A remote trim indicator is fitted on the 1st pilot's flight instrument panel. This indicator operates in the same sense as the indicator on the control unit.

(v) *Height lock switch*

When this switch is pulled the auto-pilot will lock on to the barometric height prevailing.

(vi) *BOMB (NBS) switch*

The BOMB switch, when pulled links the NBS equipment to the auto-pilot which then controls the aircraft heading according to the signals produced by the NBS.

(vii) *TRACK and GLIDE path switches*

When these switches are pulled on, they link their respective ILS signals to the automatic pilot, which then controls the aircraft in azimuth according to the heading error signal from the heading selector and the ILS localiser beam, and in pitch in accordance with the glide path beam. In addition, in order to obtain sufficient auto-pilot authority at approach speeds, the elevator artificial feel is partially relieved in two steps as the

heading selector and the ILS localiser beam, and in pitch in accordance with the glide path beam. In addition, in order to obtain sufficient auto-pilot authority at approach speeds, the elevator artificial feel is partially relieved in two steps as the TRACK and GLIDE switches are pulled on, provided that the undercarriage is lowered. In order to indicate the correct functioning of this partial feel relief, the elevator feel warning magnetic indicator will turn white when TRACK is pulled on. The feel returns to its normal value when the auto-pilot is disengaged or if the TRACK and GLIDE switches are pushed in. The TRACK switch must not be pulled on with the undercarriage lowered at speeds in excess of 180 knots.

4 Pilot's controller

The pilot's controller (D/14) has two controls fitted, a bank control and pitch control.

(a) Bank control

The aircraft can be turned at a pre-set angle of bank by selecting the control knob to the bank required. The knob will remain on the selected angle and the aircraft will maintain the turn at that angle of bank until a different angle is selected, or the knob returned to the central position, when the aircraft will resume straight flight. When the track switch is pulled the bank control is inoperative.

(b) Pitch control

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

5 Heading selector

The heading selector (A/28) comprises a compass repeater, course setting knob and pre-select turn engagement button. With the TRACK switch on the switch unit off, courses can be pre-selected on the heading selector and the aircraft will turn on to the selected heading when the pre-select turn button is depressed. The angle of bank when using the heading selector for turns is restricted to 30 degrees. With the ILS on, the runway heading should be pre-selected before pulling the TRACK switch on.

6 Automatic cut-out devices

(a) A spring-strut automatic cut-out is fitted to safe-guard the structure in the event of an elevator channel run-away. In the event of elevator stick forces in excess of about 25 lb. being applied, the auto-pilot will disengage automatically. In addition, operation of the spring strut renders the auto-mach trimmer inoperative, if it is switched on, by energising a lock-out relay which removes the power supply to the auto-mach trimmer. This is done in order to protect the aircraft from the consequences of an auto-mach trimmer runaway while under auto-control. Should the auto-mach trimmer lock-out relay operate, the MACH TRIM LOCK-OUT magnetic indicator will go white. The lock-out relay can be de-energised by setting the auto-mach trimmer switch to OFF and then ON again, when the magnetic indicator should go black. The magnetic indicator will also be white if the auto-mach trimmer is not switched ON.

(b) A roll error cut-out is fitted to safeguard against an aileron channel run-away in order to avoid excessive angles of bank. In the event of a malfunction in the aileron channel, the roll error cut-out will automatically disengage the auto-pilot after a certain undemanded bank angle has been reached.

7 Auto-pilot limitations

(a) Maximum speed under auto-control

(i) With pitch dampers and auto-mach trimmer operative:

0·93M or 300 knots above 20,000 ft.
250 knots below 20,000 ft.

(ii) With auto-mach trimmer and one or both pitch dampers inoperative: 0·90M.

(b) Minimum altitude at speeds above approach speeds: 1,500 feet above ground level.

(c) The auto-pilot must not be used unless the artificial feel is functioning correctly, and it must not be used when artificial feel relief is in operation.

(d) Auto/ILS approaches may be carried out.

(e) The track switch must not be pulled on with the undercarriage lowered at speeds in excess of 180 knots.

(f) Longitudinal trim must be maintained so that the pointer is within the safe range indicated on the auto-pilot trim indicator, i.e. the white sector.

(g) One pilot must at all times be strapped in his seat.

8 Safety precautions

NOTE 1: Before engaging the auto-pilot the pitch damper must be checked for correct functioning. With the auto-mach trimmer and one or both pitch dampers inoperative 0·90M must not be exceeded, otherwise, in the event of an oscillatory fault developing in the auto-pilot elevator channel, overstressing of the aircraft may result.

NOTE 2: If the auto-mach trimmer becomes unserviceable at speeds in excess of 0·90M while the auto-pilot is engaged, the auto-pilot will not control the aircraft satisfactorily.

Disengagement at high mach numbers

If the auto-pilot becomes disengaged at high mach numbers, through operation of the spring strut, the lock-out relay will cut

out the auto-mach trimmer and the MACH TRIM LOCK-OUT indicator will show white. Provided that it is known that the spring strut has operated due to elevator out-of-trim forces, the auto-pilot may be re-engaged and the auto-mach trimmer made operative again by setting the auto-mach trimmer switch to OFF and then ON. However, if the reason for the auto-pilot disengagement is not known, reduce speed to below 0·88M before re-engaging the auto-pilot. In addition the auto-mach trimmer should be reset gradually at a speed below 0·88M before switching it ON again.

Use in Flight

9 Pre-flight checks

The pre-flight checks are listed in the Flight Reference Cards.

10 Operation 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 black/white stripes. Check that the three channel switches R, A and E are switched IN. Check that the trim indicator is within the white sector. Trim the aircraft to fly hands and feet off in the desired flight attitude and then pull the ENGAGE switch.

NOTE: If the trim indicator pointer is outside the white sector, the auto-pilot must not be engaged.

(ii) Check that the IN magnetic indicator shows white, and the READY indicator shows black.

(iii) Check elevator trim on the emergency trimmer (within the limitations of the white sector on the trim indicator).

(b) To turn the aircraft

Rotate the bank 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,

attitude, then retrim 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.

NOTE: No attempt should be made to change the pitch attitude of the aircraft, when under auto-pilot control, by use of the elevator emergency trimmer. Elevator trim may, however, be adjusted in conjunction with trim indicator, by means of the emergency trimmer (within the limits of the white sector on the trim indicator), without disengaging the elevator channel.

(d) Disengagement 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. Disengage the channel or channels required by selecting off the appropriate 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. 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.

(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 and pre-select turn facility are inoperative.

NOTE: The bank control will override a pre-selected turn at any time, except when the track switch is pulled.

(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.

11 Operation of automatic cut-out devices

In the event of these devices operating in flight, extreme caution should be observed upon re-engaging the auto-pilot and if further automatic disengagement occurs the auto-pilot should not be used for the remainder of the flight.

12 Automatic approaches

(a) The aircraft should be positioned at least seven miles from the downwind end of the runway. Switch on the ILS receiver and check that the flags on the ILS indicator disappear. Reduce speed to below 180 knots with the undercarriage lowered and select the heading of the ILS beam, allowing for drift, and pull the TRACK

switch on. Check that the partial feel relief is functioning correctly; in the air, the master feel warning magnetic indicator will show white while the artificial feel is changing to its new value.

(b) The aircraft should close the beam at approximately 70° to the QDM and then turn smoothly onto the centre line of the beam with possibly one overshoot of the beam. When the glide path needle comes down on top of the circle pull on the glide switch. The approach must be discontinued if the glide path or localiser needles reach full scale deflection before the break-off height.

13 Use of the auto-pilot after engine failure

(a) Following engine failure when the auto-pilot is engaged, carry out the following drill—

- (i) Physically pre-load the rudder pedals and switch OFF channel R.
- (ii) Retain the rudder as required to keep the aircraft straight.

(iii) Re-engage channel R.

This drill must be repeated after any further change of asymmetric power.

(b) Alternatively, disengage the whole auto-pilot, re-trim the aircraft and re-engage the auto-pilot.

14 Emergencies

(a) In the event of malfunctioning of the auto-pilot it must be disengaged and corrective recovery action taken immediately. It is advisable not to snatch the controls, because of the risk of inadvertently exceeding the maximum permissible G when the elevator spring strut operates. *Do not re-engage.*

(b) Should the auto-pilot fail to disengage when the instinctive cut-out is pressed, the POWER switch must immediately be pushed to off. The channel selector switches should then be selected out and no further attempt made to engage the auto-pilot.

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