Part I

Chapter 7—Auto-pilot Mk. 10B

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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. The roll error cut-out and rudder torque limiter are inhibited when the flaps are more than 1° down.

2 Controls

(a) Flight control panel

The auto-pilot control panel is at the rear of fuel panel AT. It carries the following components:

POWER switch
READY magnetic indicator
IN magnetic indicator
ENGAGE switch
Rudder (R), aileron (A) and elevator (E) channel switches
Auto-land PRIME switch
GLIDE path switch
TRACK switch
BOMB switch
IAS/ALT lock switch

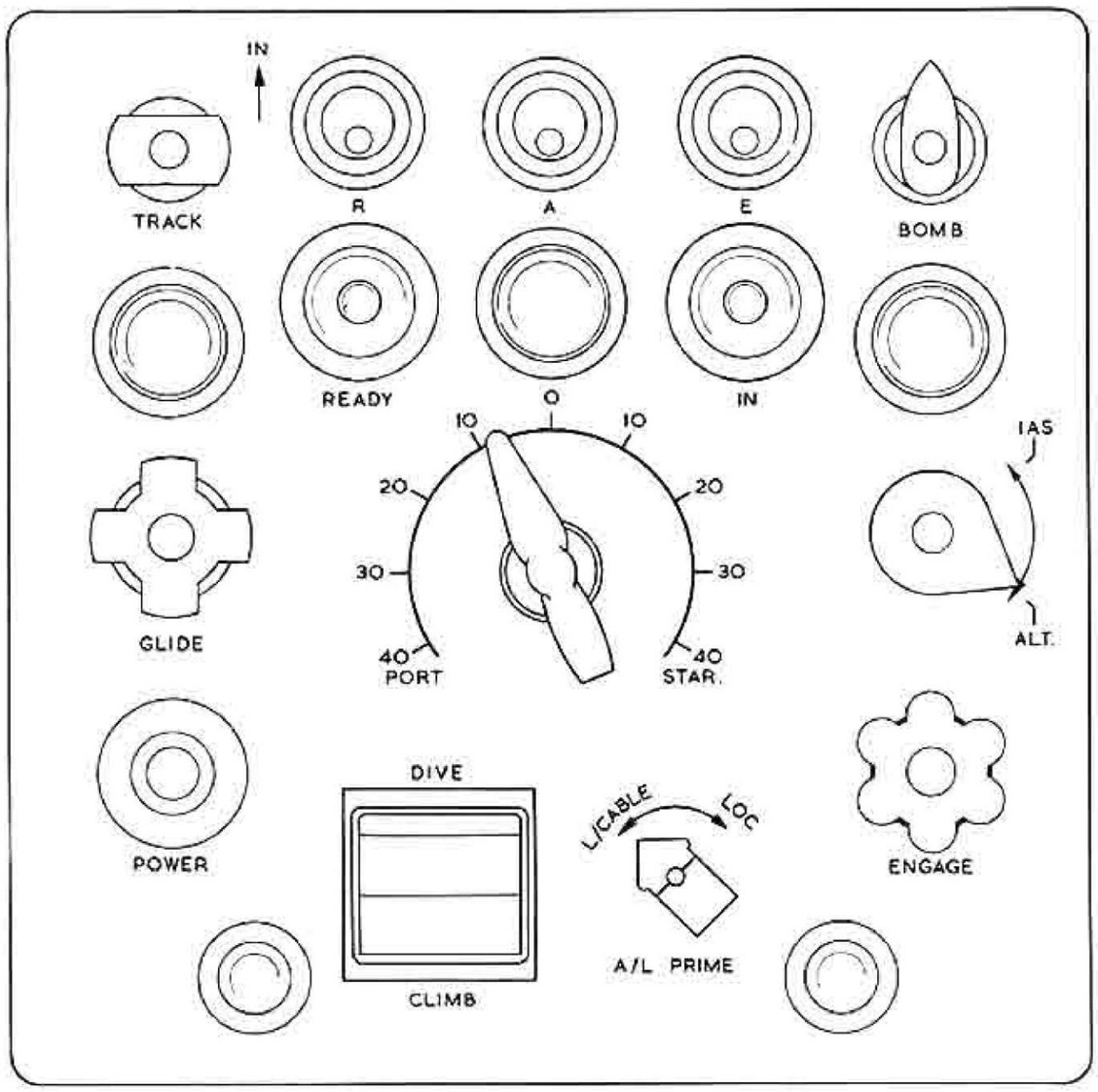

Fig. 1 Auto-pilot controller

(b) Trim indicator

A trim indicator is on each pilot's instrument panel. The indicator, is marked TRIM, NOSE-HEAVY/TAIL HEAVY and shows degrees of out of trim. Trim should be kept in the green sector otherwise auto-pilot disconnect may occur on the elevator torque limiter.

(c) Track switch

The track involves altering AP gearing for coupled ILS approaches.

(d) Turn and pitch control

The turn and pitch controller is on panel AT. A rotary switch, turning over a scale marked from 0 to 40 degrees on either side, provides turn control, while a DIVE-CLIMB switch provides pitch control.

(e) Cut-out switches

There is an instinctive cut-out switch on each control column. When either is operated, the three auto-pilot control channels are disengaged from the aircraft control surfaces. Re-engagement can then be effected by pulling the ENGAGE switch.

(f) Bomb aimer's control

To enable the bomb aimer to control the aircraft in azimuth during a visual bombing run, a further turn control is provided at the bomb aimer's station.

(g) Interlocks

Various interlocks are operative.

(h) G cut-out

A G cut-out prevents auto-pilot operation if G outside the limits of + 0·5 or + 1·5 is present (i.e. ± 0·5 of level flight conditions and is mounted below the crew table. A pushbutton is fitted on the unit to allow the operation of the cut-out to be checked on the ground.

(j) Mach compensator unit

The mach compensator unit automatically adjusts the auto-pilot to compensate for the changes of pitch attitude when varying the speed in the range 0·85M to 0·95M.

3 Use of controls

(a) POWER switch

When the POWER switch is pulled out and provided that the master switch is on, AC at 115 volts and 28 volt DC are fed to the auto-pilot. After approximately 45 seconds, the READY indicator will show white, indicating that the auto-pilot is ready for engagement.

(*b*) *ENGAGE switch*

Provided that the rudder, elevator and aileron channel switches are in the IN position (forward), pulling out the ENGAGE switch will couple the auto-pilot to all three control surfaces; the READY indicator will turn black and IN indicator will turn white.

(*c*) *Channel switches*

If any channel switch is put to the out position, its particular control surface will be disengaged from the auto-pilot and the READY indicator will show white. To re-engage the channel, move the switch to the IN position. If all three channel switches are disengaged, the auto-pilot will disengage.

(*d*) *Pitch and turn controls*

(i) The pitch and turn controls are used to alter the setting of the gyro platform relative to the aircraft, thus causing the servos to change the aircraft attitude. For example, if a nose-down change of pitch is required, operation of the pitch control rotates the gyro platform tail-down relative to the aircraft; the resultant gyro signal then actuates the elevator servo-motor to bring the nose of the aircraft down until release of the pitch control causes rotation of the gyro platform to cease and the new pitch attitude to remain in force. In effect, the aircraft rotates round the platform, which remains horizontal in space.

(ii) *Pitch control*

The pitch control switch is spring-loaded to the central (neutral) position. It is moved forward to produce nose-down pitch change. Switch movement is opposed by two spring rates, so that initial movement against a weak spring produces a slow rate of change of attitude, while further movement against a strong spring will cause a fast rate of change. The slow rate is inoperative when ALT/IAS lock is being used—the fast rate overrides the IAS/ALT locks.

(iii) *Turn control*

The aircraft can be turned at a selected angle of bank by moving the turn control round to the required bank angle. The control will remain at the selected position and the aircraft will remain at that angle of bank, until the control is moved to a new position, when the aircraft will follow the new selection. A spring-loaded ball catch is provided to locate the pointer in the neutral position. The turn control overrides any pre-selected heading on the Beam Compass, provided that the TRACK switch is not pulled.

(*e*) *Auto-land prime switch*

The switch is marked AL PRIME, L. CABLE (leader cable)/LOC (ILS localiser); it is operated by turning it to the appropriate position and then pulling it up, only after GLIDE has been selected. In the L. CABLE position, the aircraft uses leader cable signals for directional steering below about 320 feet ; in the LOC position, ILS signals are used throughout the approach. This switch must not be used at present.

(*f*) *TRACK and GLIDE switches*

(i) The TRACK switch can be used to slave the auto-pilot to heading error signals from the MFS.

(ii) When an ILS facility is selected and the auto-pilot is engaged with the TRACK switch pulled out, the Beam Compass set up as described in Chapter 8, para. 15, and the MFS selector set to LOC, the ILS error signal and the heading error signal derived from the beam compass will be fed to the auto-pilot and the aircraft will be manoeuvred to follow the ILS localiser centre plane. When on an ILS approach, with the Beam Compass set up for the approach, pulling out the GLIDE switch will feed the glide path signals to the auto-pilot. A 3° nose-down pitch change is introduced at the same time. With the TRACK switch pulled, the turn control is inoperative and, with the GLIDE switch pulled, the height lock is inoperative.

WARNING. The MFS should not be selected to LOC at speeds in excess of 200 kts or overbanking and pitching may occur.

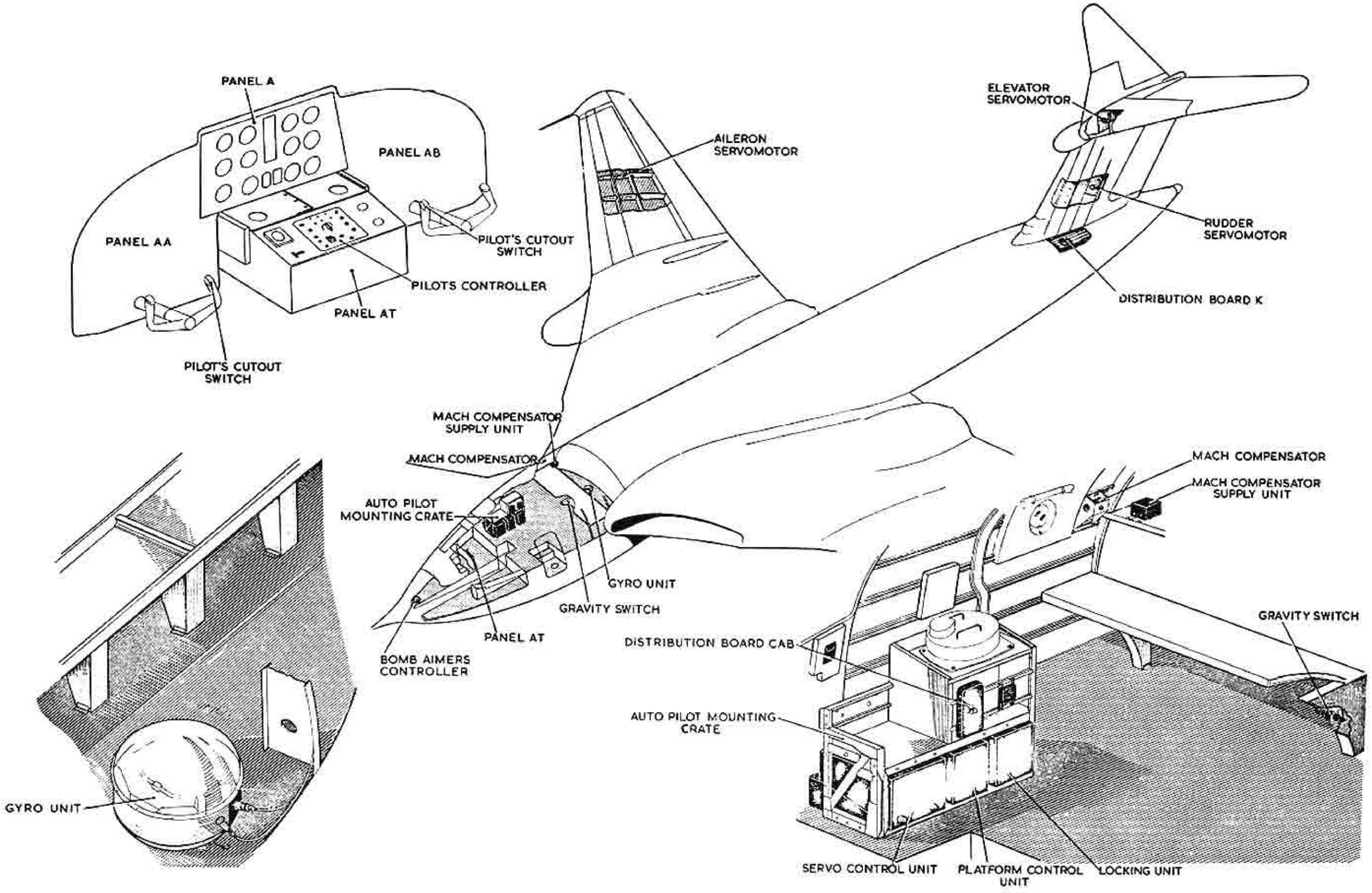

Fig. 2 Auto-pilot components location

(g) Airspeed/altitude lock switch

The IAS/ALT lock switch will control the aircraft to maintain a given airspeed or pressure height, whichever is selected. When the switch is operated, the aircraft will maintain the height or speed at which it is flying at the moment of selection. The height and speed locks can be overriden by operating the fast rate of the pitch control; the slow rate is inoperative when the height lock is in operation. The height/airspeed lock will be disconnected if the GLIDE switch is pulled or if the elevator channel is switched off.

(h) BOMB switch

When the BOMB switch on the controller is pulled out (on), signals from the NBS (blind selected) are fed to the bank platform motor, to maintain the aircraft on the desired bombing track.

Normal Management of the Auto-pilot

4 Full functional checks

After 100 hours flying, or after malfunctioning of the auto-pilot, the following checks should be made:

(a) Engagement

With power supplies on, the yaw dampers at STANDBY and one set of the power controls running, pull out the POWER switch and check that the READY indicator shows white after about 45 seconds. Set the R, A and E switches IN (forward) Check that both beam compasses are synchronised and that the flying controls are centralised and then pull out the ENGAGE switch. Check that the READY indicator shows black and that the IN indicator turns white.

(b) Disengagement

Check in turn the operation of the instinctive cut-out switches on the control columns, noting that the controls become free, the READY indicator shows white and the IN indicator shows black.

(c) Trim indicators and torque limiters

Re-engage the auto-pilot and push the elevator control forward; check that the out of trim indicator shows nose heavy. Increase the push force when the torque limiter should operate and fully dis-engage the auto-pilot. Re-engage and repeat the check in the opposite sense. The rudder control torque limiter will fully dis-engage the auto-pilot (flaps UP) if a strong push force is applied to the rudder controls in either direction.

(d) Roll error cut-out

Re-engage the auto-pilot (flap UP) and after 10 seconds, move the turn control quickly to full travel. The ailerons should move, in the correct sense, to about one quarter of full travel and after a slight delay the auto-pilot should dis-engage fully. Repeat the check in the opposite direction.

(e) Limiters

Re-engage the auto-pilot and select flaps to TAKE-OFF. Check that the roll error cut-out and rudder torque limiter are inhibited by:

(i) Applying a full-scale bank control movement.

(ii) Applying rudder against the auto-pilot.

In both cases the auto-pilot should not disengage. Select flaps UP.

(f) Compass monitoring

Engage the aileron channel only. If the aileron control is moving slowly either way rotate the heading pointer with the synchronising knob in the correct sense to stop this movement. Disengage the auto-pilot, resynchronise the compass and re-engage the auto-pilot. The aileron controls should now be stationary but rotating the heading pointer with the synchronising knob either way will start the aileron control moving in the appropriate sense. Resynchronise the compass and repeat the check with the other pilot's compass selected.

(*g*) *Individual channels*

Check the operation of each channel switch in turn. With any channel switched off, the READY indicator should show white and the appropriate control should be free. Ensure that returning the individual switches to the IN position re-engages the appropriate control. Then select all three channel switches off and check auto-pilot and control disengagement. Return the switches to the IN position and check that the auto-pilot does not re-engage until the ENGAGE switch is pulled out.

(*h*) *Turn control*

Move the turn control slowly from the detent, making sure that the aileron control moves in the correct sense. Set the heading index under the heading pointer and pull TRACK. Check that the turn control is inoperative and leave the turn control fully deflected. Push the TRACK switch in and check that the turn control is inoperative until it has been returned to its detent.

(*j*) *Pitch control*

Engage the auto-pilot and check that forward movement of the pitch control moves the elevator control forwards and that rearward movement moves the control rearwards. Pull ALT and check that the pitch control is inoperative on slow rate but that on selection of fast rate the ALT switch drops in and the control is once more operative. Repeat the check with the ASI switch.

(*k*) *Heading error steering*

With MFS navigational selector central and the heading pointer over the heading index, select TRACK. Check that rotating the heading index to the left moves the aileron control to the left and similarly to the right.

Check that GLIDE cannot be selected. Select LOC on the MFS navigator selector and the TRACK switch will drop in. Reselect TRACK and recheck the heading index operation and that GLIDE cannot be selected. Select LOC & GP on the MFS navigational selector and the TRACK switch should stay out. Recheck the heading index operation. Select GLIDE and check that the ailerons do not respond to movements of the heading index. Select the navigational selector to central when the TRACK and GLIDE switches should drop in.

(*l*) *GLIDE interlocks*

Select LOC & GP on the MFS navigational selector and pull TRACK. Select ALT and then GLIDE. The ALT switch should drop in, the elevator control should move forward and then the torque limiter may operate, disengaging the auto-pilot. Repeat the check with the ASI switch. With GLIDE selected, check that the pitch control is inoperative. The torque limiter may operate when GLIDE is selected.

(*m*) *REMOTE interlock*

With the MFS navigational selector central and TRACK pulled, select REMOTE on the selector and the TRACK switch should drop in. Reselect TRACK and, by moving the heading pointer with the Track Control Unit, check that the ailerons move in the correct sense.

(*n*) Disengage the auto-pilot, switch the channel switches off and push the POWER switch in.

5 Pre-flight checks

The following checks should be made before flight:

(*a*) With power supplies on, the yaw dampers at STANDBY and having started one set of the powered flying controls, set the R, A and E channel switches in, pull out the POWER switch and check that the READY indicator shows white after approximately 45 seconds.

(*b*) Centralise the controls, check the trim indicator is within ± 1 division and pull out the ENGAGE switch. Check that the READY indicator turns black and the IN indicator turns white.

(*c*) Check the operation of the pitch and turn controls. Check the operation of the roll error cut-out (flaps UP) by putting the turn control to maximum deflection.

(*d*) Check the operation of the elevator torque limiter in each direction, by applying a steadily increasing pressure to the control until the auto-pilot disengages. Similarly, check the rudder torque limiter (flaps UP).

(*e*) Switch off the rudder channel and check that the rudder control is free. Switch on again and check that the rudder control is re-engaged. Similarly, check the aileron and elevator channels.

(*f*) Move the elevator control backwards and forwards and check that the trim force indicator moves in the correct sense.

(*g*) Re-engage the auto-pilot and check the operation of each pilot's cut-out switch.

(*h*) Select all three channel switches out and push in the POWER switch.

6 Normal flight control

(*a*) Having checked that the mach trimmer is OFF, the yaw dampers are at STANDBY, the roll damper is ON and that the trim indicator is central, set up and engage the auto-pilot as in para. 5(*a*) but with the controls as required when the aircraft is fully trimmed for the existing condition of flight. The auto-pilot maintains the flight condition existing at the moment of engagement. Whilst the auto-pilot is in use the trim indicator should be kept approximately central by use of the aircraft elevator trimmer.

(*b*) *To turn the aircraft*:

(i) The turn control may be used to select the required angle of bank (up to 45°). As the required heading is approached, the bank must be adjusted accordingly.

(ii) The aircraft may be controlled using the heading index of the beam compass selected, providing TRACK is pulled. With the MFS navigational selector central, no ILS localiser signals are fed into the auto-pilot but, if LOC is selected and TRACK reselected, radio signals are fed in unless the beam compass sense switch is used to suppress the radio signals. When LOC & GP is selected on the navigational selector low speed auto-pilot gearings become operative (see para. 7(*a*)), the aircraft still follows the heading index as long as the radio signals are suppressed and TRACK is pulled.

(iii) It is recommended that method (i) above be used at high altitudes when small angles of bank are required and method (ii) be used for instrument let downs and approaches when up to 25° of bank may be achieved.

(*c*) To climb or descend, move the pitch control forward or back until the required pitch attitude is achieved. Do not use the elevator trimmer to alter the pitch attitude.

(*d*) If the ALT lock is to be engaged, this should be done when the aircraft is in an approximately level attitude. ▶◀

(*e*) At maximum altitudes, if it is desired to carry out a cruise climb, trim the aircraft carefully and then engage the auto-pilot. The aircraft may take several minutes to settle down to a constant mach number. If the speed is not quite right, very small adjustments to the pitch controller correct the speed but the effect is not immediately apparent. Alternatively, a stepped cruise climb can be made, using the speed lock, by disengaging and then re-engaging the lock at the new speed.

(*f*) The auto-pilot must not be used above 0·88M/300 knots if the mach compensator is inoperative or above 0·9M/300 knots when the mach compensator is operative. Outside these limits a pitch oscillation can develop. The auto-pilot must not be used below 0·82M/210 knots except on an ILS approach.

7 Auto-ILS approach

(*a*) To make an auto-ILS approach, set up the MFS as described in Chapter 8, para. 15(*a*). Follow the instructions in para. 15(*b*), suppressing the radio coupling, if required, with the sense switch, then pull TRACK. When the aircraft is in a suitable position downwind, couple onto the localiser by rotating the sense switch and/or by moving the heading index to the QDM of the ILS localiser beam, plus the expected drift at break-off height. When the aircraft is closer than about 15 miles to the airfield and the speed is below 180 knots, LOC & GP should be selected on the navigational selector to introduce low speed auto-pilot gearings, ensuring a smooth intercept of the localiser. Also, when the auto-pilot height lock is in use, if the LOC & GP selection is not made, the height lock performance will be poor.

(*b*) Just before the glide path needle, which is descending, reaches the centre dot of the pitch scale, set flaps, air brakes and throttles as required, select GLIDE on the auto-pilot and APPROACH and DATUM on the MFS selector. Switch the main yaw damper ON. The aircraft will couple onto the glide path. On overshoot, when the pitch scale setting knob is pressed in, the APPROACH setting on the MFS navigational selector is cancelled.

(*c*) The MFS and auto-pilot both have auto-wind-drift facilities, which are brought into use when APPROACH is selected on the MFS navigational selector and GLIDE is selected on the auto-pilot. Consequently the beam bar and azimuth director pointer should be central when on the auto-ILS approach.

(*d*) If a race track pattern is to be followed for subsequent auto-approaches, leave the sense switch pointing upwards but, if the beam QDR is to be flown followed by a procedure turn, the sense switch should be left horizontal.

NOTE: If, for any reason, after GLIDE has been selected, the auto-pilot should be fully disengaged and then re-engaged and GLIDE be reselected, then a further 3° nose down pitch will occur.

8 Asymmetric flight

(*a*) Following engine failure, carry out the following drill:

Physically pre-load the rudder pedals and switch off channel R. Retrim the rudder as required to keep the aircraft straight; then re-engage channel R.

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

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

Malfunctioning of the Auto-pilot

9 Engagement faults

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 POWER switches are pushed in and the channel switches are set off. The auto-pilot must then be regarded as unserviceable.

10 Torque limiters and roll error cut-out

(*a*) (i) The elevator and rudder torque limiters will fully disengage the auto-pilot if too great a load is applied to either of the controls.

(ii) If the auto-pilot should disengage due to operation of the torque limiters and the aircraft was thought to be out of trim, thus causing the disengagement, it may be re-engaged after retrimming the aircraft. If there is no apparent reason for the disengagement, the auto-pilot should be considered unserviceable and switched off.

(*b*) If the auto-pilot should disengage due to the operation of the roll error cut-out it should be considered unserviceable and switched off.

NOTE: See Part II, Chap. 2, para. 6(*b*) for auto-pilot limitations.