PART 1

CHAPTER 8—FLIGHT CONTROL SYSTEM

Contents

CONTROLS AND INDICATORS

General

1. The controls and indicators in the flight control system (FCS) for the F Mk 3 and F Mk 6 are listed in Table 1 and illustrated in Fig 1; the controls and indicators for the T Mk 5 are listed in Table 2 and illustrated in Fig 2. Fig 3 shows the detail on the FCS control unit in all marks.

Table 1 — Controls and Indicators — F Mk 3 and F Mk 6

Item No	*Item*	*Markings*	*Remarks*
1	FCS engage switch	FD/OFF/AP	Known as the 'stick switch'
2	FCS control unit	See text	—
3	Heading control knob	HDG	Navigation display
4	Flight director bead	—	Not illustrated. Attitude indicator
5	Autopilot trim indicator	—	—
6	Mode indicator	See text	Repeater from control unit
7	Throttle servo control	THROTTLE SERVO— ENGAGE/DISENGAGE	—

Table 2 — Controls and Indicators — T Mk 5

Item No	*Item*	*Markings*	*Remarks*
1	FCS engage switch	FD/OFF/AP	Not illustrated. One on each control column. Known as 'stick switches'
2	FCS control unit	See text	—
3	Heading control knob	HDG	Navigation display
4	Flight director bead	—	Not illustrated. Attitude indicator
5	Autopilot trim indicator	—	—
6	Throttle servo control	THROTTLE SERVO— ENGAGE/DISENGAGE	Pupil's throttle only
7	Autopilot cutout changeover switch	AUTOPILOT CUTOUT CHANGEOVER SWITCH — POS 1/POS 2	Not illustrated. On bulkhead behind instructor's seat

FCS Control Unit

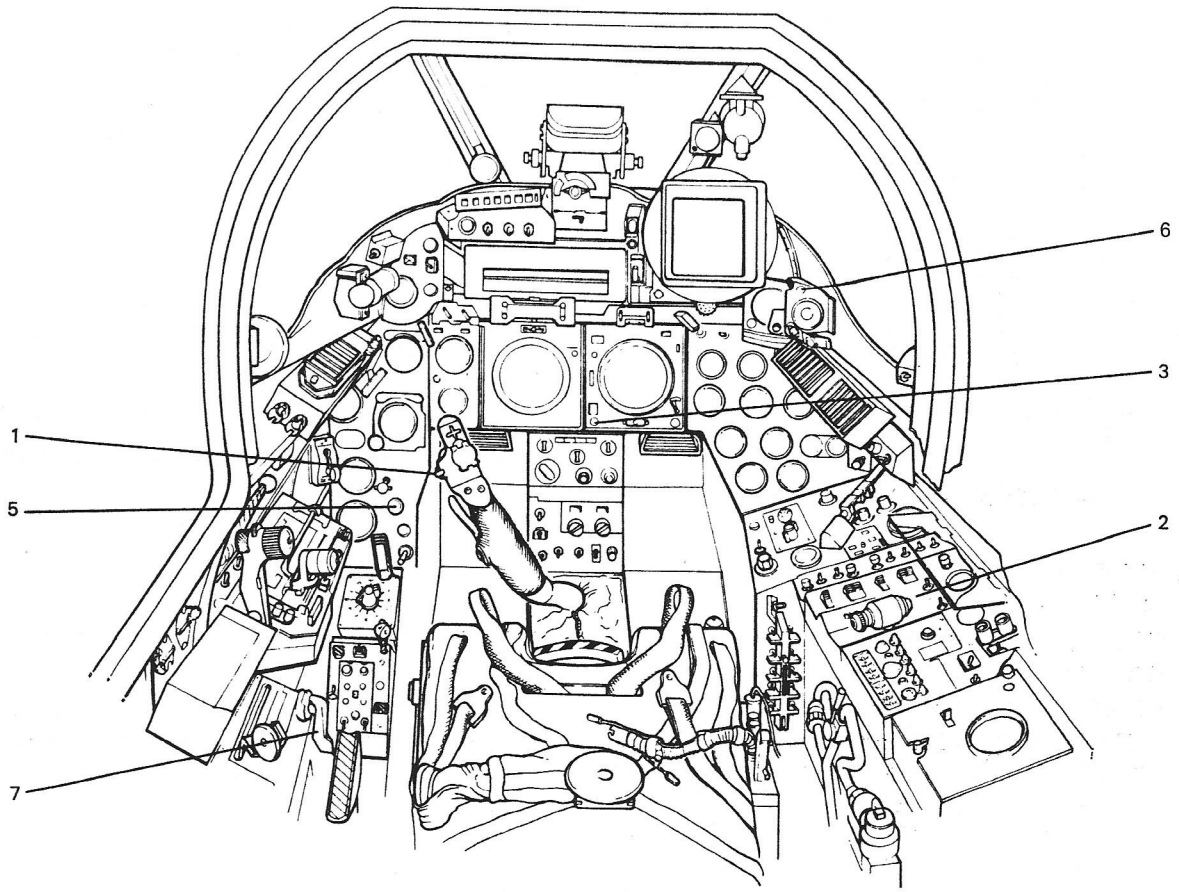
2. The FCS control unit has the following controls and indicators:

a. *MASTER Switch.* When the 2-position MASTER/OFF switch is selected to MASTER, the AC and DC power is connected to the flight control computer (FCC) and to three rate gyros; in addition the pitch autostabiliser actuator is centralised.

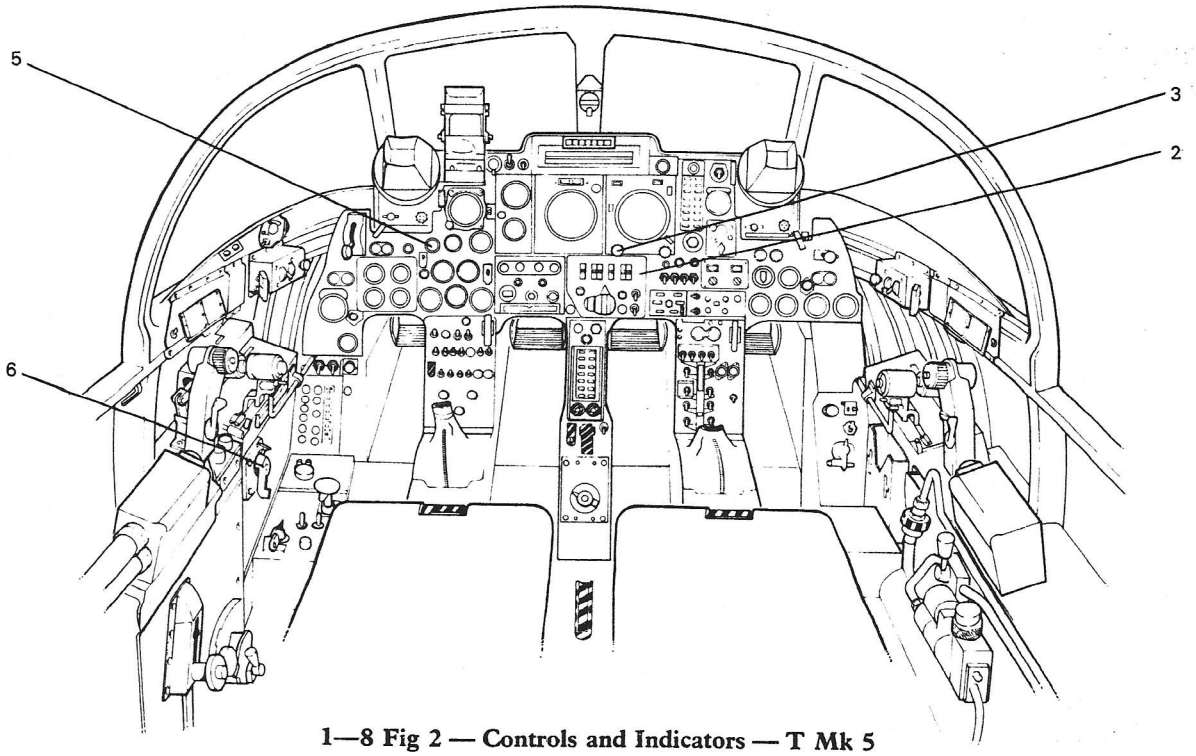
b. *SUPPLIES Indicator.* The SUPPLIES MI shows white/OFF when the MASTER switch is OFF and shows black when DC is available and the instrument master and FCS MASTER switches are on. The MI changes to white/OFF whenever the failure interlocks operate. After AC failure, the MI does not change to white/OFF unless the STAB/OFF switch is selected to STAB.

c. *Mode Indicators.* In the F Mk 3 and F Mk 6 there are two mode indicators, one on the FCS control unit and another above the voltmeter on the right cockpit shroud. The T Mk 5 has one mode indicator on the FCS control unit. When the FCS is in the autopilot or flight director mode the indicator(s) shows AUTO or DIR respectively. The indicator(s) shows white/OFF when no mode is selected on the FCS engage switch or if the CLIMB key is selected and AP engaged. The indicator changes to white/OFF after AC failure, DC failure or g-switch trip.

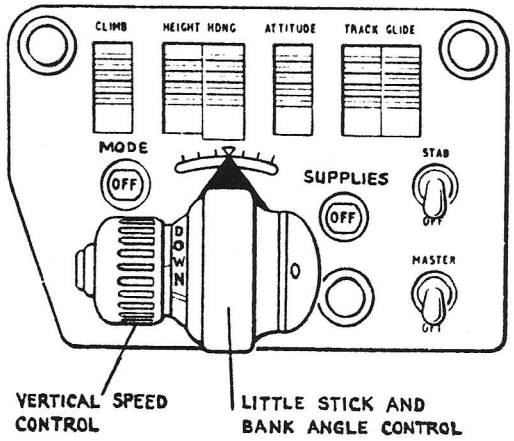
d. *STAB Switch.* Selecting the STAB/OFF switch to STAB with the instrument master and FCS MASTER switches on removes the aileron and rudder stroke restrictors and connects the autostabilisers to the FCC.



1—8 Fig 1 — Controls and Indicators — F Mk 3 and F Mk 6



1—8 Fig 2 — Controls and Indicators — T Mk 5



1—8 Fig 3 — FCS Control Unit

e. *Mode Selector Keys.* The following modes are selected by the mode selector keys:

CLIMB	— Programmed climb
HEIGHT	— Height (attitude) lock
HDNG	— Heading lock
ATTITUDE	— Pitch and bank attitude hold
TRACK	— Combined height and heading lock which can be coupled to the ILS localiser signals
GLIDE	— Couples ILS glidepath signals to the FCS provided TRACK is also selected

f. *Direct Mode Changes.* The direct mode changes which are possible with AP or FD selected on the stick switch are shown in Table 3. For all other mode key selections the FCS engage switch is to be OFF.

Table 3 — Direct Mode Changes

Selected Mode	*Possible Direct Mode Change*
HEIGHT	HEIGHT and HDNG
HEIGHT and HDNG	HEIGHT (by pressing tail of HDNG key)
HEIGHT	TRACK
HEIGHT and HDNG	TRACK
TRACK	TRACK and GLIDE

g. *Little Stick.* The little stick overrides the height and heading hold in certain modes. The vertical speed control (VSC) knob on the top of the little stick must first be centred before a rotation to UP or DOWN is effective. The rate of turn onto a new heading may be varied by use of the bank angle control (BAC) which has three click stops either side of central, corresponding to increasing changes in bank angle. The angular authority of each click stop of the BAC depends upon the mode in use. The little stick operates with AP selected on the control column stick switch in the following modes only:

HEIGHT
HEIGHT and HDNG
ATTITUDE

DESCRIPTION OF THE SYSTEM

General

3. The flight control system (FCS) is a combined autopilot and flight director system. The autopilot provides automatic flight control while the flight director provides information on the attitude indicator during manually-controlled flight. When the autopilot is engaged, the pilot can override the system manually in all three axes. The auto-throttle may also be overridden by using sufficient force on the throttles. The following facilities are provided by the system:

Autostabilisation (in three axes)
Programmed climb (flight director mode only)
Height (attitude) lock
Height and heading lock
Pitch and bank attitude hold
Auto and flight director ILS
Auto-throttle speed control

4. *Limitations.* The limitations on the use of the FCS are given in Part 2, Chapter 1.

System Characteristics

5. The automatic flight control system is essentially a control surface position demand system of limited authority operating through the autostabilisers. Each control surface in the system is operated by its own autostabiliser amplifier and electro-hydraulic actuator.

6. The principal unit of the system is the flight control computer (FCC) which is actuated by the selector keys on the control unit. The control computer's function is to effect data storage, computation and the switching required by the system. The computer receives signals from:

a. Three rate gyros (pitch, roll and yaw)
b. MRG (pitch and bank data)
c. The navigation display (heading error)
d. The air data system (altitude, vertical speed, Mach number, IAS and switching signals for system gearing changes)
e. ILS (displacement from centreline and glidepath)
f. The tailplane trim motor (tailplane trim position)

7. Output demands from the FCC are transmitted either to the flight director diplay on the attitude indicator (with FD selected on the FCS stick switch), or to both the flight director display and the autostabiliser actuators (with AP selected on the FCS stick switch). The FCC also produces outputs for the autothrottle actuator.

8. The autostabiliser actuators move their respective control runs to act on the control valves of the PFCU. Therefore there is no feedback to the flying controls in the autostabilisation mode. However, in ATTITUDE hold or HEIGHT lock modes with AP engaged, an autotrim facility transfers any FCC demand on the tailplane greater than 0·5° to the tailplane trim actuator which moves to ensure that the autostabiliser actuator is kept roughly central. This allows larger changes of tailplane angle than would otherwise be possible with the limited authority of the autostabilisers. In these modes, therefore, the control column follows up any autotrim movement via the feel units.

9. The full control surface authority of the aileron and rudder actuators is ±3°, and of the tailplane actuator 3°18′. However, full authority of the tailplane actuator is only available with TRACK engaged and the undercarriage down. In all other modes the tailplane actuator's authority is limited to ±1°.

Safety Devices

10. To prevent structural damage to the aircraft in the event of an autostabiliser runaway, each control has a solenoid-operated stroke restrictor which must be energised to obtain full authority. The DC current to the solenoid is supplied via an AC relay. Therefore, with the power off, or with failure of AC or DC, or after operation of the g-trip, the actuator stroke is restricted. The aileron and rudder actuators centralise (restricted stroke zero), but the tailplane actuator may drift to either end of its restricted stroke of ±1°.

11. *Hydraulic Failure.* In the event of Services hydraulic failure, the actuators remain in their position at the time of failure. Some out-of-trim rudder force may have to be held, but aileron and tailplane forces can be trimmed out.

12. *Acceleration Cutout.* When AP is engaged, a g-switch automatically trips the autopilot at normal accelerations outside the range of +3g to zero g. In addition to disengaging automatic control, the autostabiliser stroke restrictors centralise.

Note: When the autopilot is disengaged by AC or DC failure, or by a g-switch trip, a series of electrical interlocks prevent the re-engagement of AP unless the correct engaging sequence is followed.

13. *'No Mode' Condition.* Unless a mode is selected on the control unit, autopilot and flight director cannot be engaged. Failure to engage may occur when a mode key is not properly made although the key is apparently selected. Moving the FCS engage switch to OFF and reselecting the mode key more deliberately may cure the 'no mode' condition.

14. *AP Caption.* The AP caption on the SWP is triggered when any one of the following occurs:

Acceleration cutout
AC failure (aircraft or autopilot)
DC failure to autopilot
Incorrect engaging sequence used

Autostabilisation

15. The autostabilisers provide damping in pitch, roll and yaw. A rate gyro in each axis senses changes in angular rates and feeds correcting signals to the appropriate actuator/flying control. To compensate for changes in control effectiveness with changes in altitude, IAS and Mach number, the gearings of the pitch and yaw channels are automatically switched at pre-set values of height and speed, derived from the air data system. Autostabilisation in all three axes is selected by the STAB switch on the FCS control unit, and it must be on before any autopilot mode of the FCS can be engaged.

Programmed Climb

16. The programmed climb mode is a flight director mode only. Selecting the CLIMB mode key and FD on the stick switch provides demands on the attitude indicator's flight director bead for the initial climb, a turn onto a selected heading, and the maintenance of the optimum subsonic climb schedule in maximum cold power. Although satisfactory for reheat take-offs, the mode is not programmed for reheat climbs. The mode is designed to be engaged before take-off; the indicated demands are incorrect if engaged after take-off.

Height or Height and Heading Modes

17. With HEIGHT selected and AP engaged, the aircraft flies at the altitude at which AP was selected, with the wings level. The height datum used by the FCC is the altitude at the moment of engagement, and deviations from this datum result in corrective tailplane demands until the datum altitude is restored. In the transonic region between 0·98M and 1·06M, the

height hold is automatically replaced by pitch attitude hold. When accelerating or decelerating out of this speed band, the height hold re-locks automatically to the pressure altitude at the moment of changeover from pitch attitude hold to height hold.

18. The heading datum used with HEIGHT, HDNG and AP engaged is that indicated by the selected heading marker on the navigation display. Errors from the datum result in corrective turn demands until the aircraft takes up the datum heading. The HDG knob on the navigation display controls the setting of the selected heading marker and therefore the heading maintained by the system. However, with AP engaged and ALIGN selected on the E/F band homer, the heading selector is free to turn without causing a heading change demand through the FCS.

Attitude Hold

19. With ATTITUDE selected and AP engaged, the aircraft is locked to the pitch and bank data signalled by the MRG to the FCC at the time of engagement. Any error from the locked position causes corrective control movements.

ILS Modes

20. The TRACK and GLIDE keys on the control unit are used in conjunction with the ILS localiser and glidepath respectively. The two modes may be used either with FD selected, when the flight director bead of the attitude indicator gives steering dmands, or with AP engaged for automatic ILS. The TRACK mode selects a combined height and heading lock which enables the aircraft to be flown in FD or AP to intercept and hold the ILS localiser centreline. The GLIDE mode, which cannot be selected unless the TRACK key has previously been made, demands or produces a 3° nose-down change of attitude and couples the ILS glidepath to the FCC. The little stick is inoperative in these modes.

Auto-Throttle

21. With any mode selected, the THROTTLE SERVO control can be selected to ENGAGE thus coupling both throttles to the FCC. An actuator, operative in the speed range 166 to 188 knots (162 to 182 knots in GLIDE), moves the throttles to maintain a constant speed. With a mode selected and the FCS engage switch OFF, the actuator moves the throttles in response to airspeed alone; with a mode and AP selected, the actuator responds to both airspeed and attitude changes. The auto-throttle facility is inhibited above 275 knots.

22. If the THROTTLE SERVO is selected to ENGAGE at a speed above the operative speed range, the actuator reduces power until the speed reduces to within the range and then holds a datum speed (eg 175 knots). Adjustments to the datum speed are made by slipping the clutches: with ENGAGE still selected, moving the throttles to a new RPM reprogrammes the datum speed.

23. The THROTTLE SERVO lever is spring-loaded to the DISENGAGE position. When the lever is moved to ENGAGE against the spring, a catch retains the selection. To disengage, downward pressure on the catch releases the lever, which then returns to the DISENGAGE position.

Autopilot Trim Indicator

24. The autopilot trim indicator shows any out-of-trim condition opposed by the tailplane autostabiliser actuator. The model aircraft indication shows how the aircraft will pitch when the FCS engage switch is moved to OFF:

Indication down — nose-down pitch on disengagement; trim nose up

Indication up — nose-up pitch on disengagement; trim nose down

25. If, prior to selecting AP on the FCS engage switch, an out-of-trim indication is given after the selection of any mode except CLIMB, a latent malfunction of the FCC should be suspected and the mode should not be engaged. When CLIMB is selected, the indicator moves down.

26. In the HEIGHT, HDNG and TRACK modes it is normal for an out-of-trim indication to be present in a turn.

27. When only the autostabilisers are in use, the indicator fluctuates about the central position. In the HEIGHT and ATTITUDE modes with AP engaged, the instrument provides an indication of the aircraft's trim condition.

28. When the FCS control unit MASTER is OFF, the indication is off the scale.

FCS Engage Switches — T Mk 5

29. An FCS engage switch is fitted to both control columns in the T Mk 5. Their use to engage autopilot or flight director varies depending upon the position of the AUTOPILOT CUTOUT CHANGEOVER SWITCH.

30. The AUTOPILOT CUTOUT CHANGE-OVER SWITCH is normally wire-locked to position 2. When set at this position the instructor's FCS engage switch becomes an FCS master switch. The switching arrangements are as follows:

Instructor's Stick Switch	*Pupil's Stick Switch*	*Effect*
OFF	OFF or FD or AP	No preselected mode engaged
FD	OFF or FD or AP	Flight director engaged through instructor's switch
AP	OFF	No preselected mode engaged
	FD	Any preselected mode engaged in flight director
	AP	Any selected mode engaged in autopilot

31. When the T Mk 5 is flown solo and the FCS is to be used in other than the STAB mode, the instructor's FCS engage switch is pre-selected to AP and the cutout switch left set and wired to position 2.

32. When the aircraft is flown with the instructor's control column removed, the cutout switch is moved to position 1 to allow the pupil's FCS engage switch to operate.

Flight Director

33. The flight director bead on the attitude indicator is controlled by the FCC when AP or FD is engaged on the FCS engage switch. When in the FD mode, to follow the flight director, 'fly' the centre reference circle of the attitude indicator onto the bead.

34. The bead parks in the 2 o'clock position when the FCS engage switch is to OFF (with the instrument master switch on). If a g-switch trip, an AC failure or a DC failure occurs with FD or AP selected, the bead moves to its parked position.

MANAGEMENT OF THE SYSTEM

Pre-Flight Checks

35. A limited pre-flight check is given in FRC. If a comprehensive pre-flight check is necessary, proceed as given below. The check assumes that the cutout switch in the T Mk 5 is set to position 2.

Preliminary Checks

Throttle servo ...	DISENGAGE
FCS engage switch(es)	OFF
MASTER switch ...	OFF
STAB switch ...	OFF
Mode	ATTITUDE (cancels previous selections)

Switch-On Checks

AC and DC power ...	On line
Instrument master ...	On: FD bead should park
MASTER switch ...	MASTER: SUPPLIES indicator black, autopilot trim indicator 'in trim'
STAB switch ...	STAB: SUPPLIES indicator remains black

CLIMB Checks (F Mk 3 and F Mk 6)

Mode	CLIMB: Check that autopilot trim indicator shows hard nose down
FCS engage switch	AP: MODE indicators remain white/OFF, FD bead remains parked FD: MODE indicators change to DIR, FD bead demands climb (10° approx) OFF: MODE indicators change to white/OFF, FD bead parks

CLIMB Checks (T Mk 5)

Mode	CLIMB: Check that autopilot trim indicator shows hard nose down
Instructor's engage switch	AP: MODE indicator remains white/OFF, FD bead remains parked
Pupil's engage switch	FD: MODE indicator changes to DIR, FD bead demands climb (10° approx) OFF: MODE indicator white/OFF, FD bead parks

Note: In the remaining checks in the T Mk 5, the instructor's engage switch is left at AP and 'FCS engage switch' refers to the pupil's engage switch.

ATTITUDE Checks

Mode	ATTITUDE
FCS engage switch	FD: MODE indicator(s) changes to DIR, FD bead moves to centre, autopilot trim indicator shows 'in trim'. Operate BAC and VSC and check that FD bead moves in sympathy AP: MODE indicator(s) changes to AUTO; check as for FD OFF: MODE indicator(s) changes to OFF, FD bead parks

HEIGHT and HDNG Checks

Modes	HEIGHT and HDNG
Navigation display	Set HDG pointer to aircraft heading
FCS engage switch	FD: Check as for ATTITUDE checks. Move HDG pointer and check FD bead moves in sympathy AP: MODE indicator(s) changes to AUTO; checks as for FD OFF: MODE indicator(s) changes to OFF, FD bead parks

Cancellation Checks

MASTER switch ...	OFF: SUPPLIES indicator changes to white/OFF, trim indicator off scale
STAB switch ...	OFF
Mode	ATTITUDE
Instructor's engage switch (T Mk 5) ...	OFF

Mode Engagement Sequence

36. Interlocks prevent the engagement of the system unless the correct switching sequence is followed. To engage the FCS in flight:

FCS engage switch(es)	OFF
MASTER switch ...	MASTER: SUPPLIES indicator black (see Notes 1 and 2)
STAB switch ...	STAB
VSC	Central
Navigation display	HDG pointer to required heading
Mode	Select required mode
Trim	Straight and level
Autopilot trim indicator	Centre
FCS engage switch(es)	Engage AP or FD (see Note 3)

Note 1: If MASTER is selected in flight, an undemanded pitch increment of $\pm 2 \cdot 8g$ can be experienced under the worst conditions unless corrective action is taken within two seconds.

Note 2: In flight, allow one minute between the selection of MASTER and STAB to allow the rate gyros to spin up.

Note 3: Wait a minimum of six seconds between mode selection and engagement to allow the FCC to collate the new data and compute the new demands.

Autostabilisation

37. The autostabilisers operate when, with AC on line, the instrument master, FCS MASTER and STAB switches are on. Allow one minute between selecting the FCS MASTER switch on and the STAB switch on. The autostabilisation mode is always engaged during flight under normal conditions.

38. *Jury Struts.* When jury struts are fitted in place of autostabiliser actuators, the MASTER switch is to be selected on (to retain full tailplane) but the STAB switch is to be selected OFF.

Programmed Climb

39. Select CLIMB and engage FD before take-off. Set the desired climb-out heading on the navigation display, but this setting must not be greater than 175° from the runway heading to ensure the turn is made in the required direction.

40. Because the initial climb demand is too steep, do not attempt to follow the bead on the attitude indicator until a speed of 300 knots has been attained. Above 275 knots the bead deflects left or right, demanding a turn onto the pre-set heading. Turns are limited to 45° of bank.

41. Transition from the climbing IAS to the climbing Mach number starts at about 0·85M at 9000 feet. It is important to follow the bead very closely during this transition to avoid overshooting the Mach datum of $0 \cdot 89 \pm 0 \cdot 01$M, which is attained at about 14,000 feet and held until 32,000 feet. Above 32,000 feet, Mach number decreases slowly to approximately 0·85M but recovers if the climb is continued above 38,000 feet.

42. When approaching the desired altitude, switch OFF the stick switch and level the aircraft normally. The FCC is not programmed for a reheat climb.

HEIGHT or HEIGHT and HDNG Lock

43. *Use of Mode Keys.* Heading lock cannot be engaged without height lock and the keys are paired so that pressing the HDNG key also selects HEIGHT. HEIGHT may be selected independently, and HDNG can be de-selected separately without disengaging HEIGHT. With HEIGHT selected and AP engaged, a new heading can be pre-selected and the turn initiated when required by operating the HDNG key.

44. *Use of Heading Pointer.* When HEIGHT and HDG are selected and AP is engaged, turning the heading pointer on the navigation display immediately banks the aircraft towards the new heading. Since the aircraft always turns the shorter way to the new heading demanded, the applied bank is reversed if the pointer is turned through the reciprocal of the aircraft's heading. Therefore, heading changes through more than 180° are selected in sectors of 90° approximately. With the BAC on the little stick centred, bank angle is limited to 28° below 400 knots/1·06M and to 50° above those speeds.

45. *Use of the Little Stick.* The bank angle control (BAC) and vertical speed control (VSC) on the little stick are used as follows:

a. *BAC.* The rate of turn onto a new heading may be varied by use of the BAC which, in this mode, increases or decreases the autopilot bank demand by up to 12° in steps of 4°, defined by the three click stops either side of central. Centralise the control manually after use to prevent a standing heading error of up to 2½°. The BAC is spring-loaded to the nearest click stop but automatically centres when the stick switch is moved to OFF, the failure interlocks operate or a g-trip is experienced.

b. *VSC.* The VSC may be used in this mode as a climb rate demand system, having an authority of ±7500 feet per minute. The control must first be centred before a rotation to UP or DOWN is effective. The control remains in any position selected. On both sides of the central detent position there is a small dead band. On centring after use, the system reverts to height lock and the new datum is the altitude at the moment of centring. If the VSC is used at speeds over approximately 375 knots below 25,000 feet, g-switch trips are likely to occur.

46. *Automatic Height Control.* A gearing system which varies automatically with height is incorporated to compensate for changes in control effectiveness with changes in altitude and Mach number. The effect is to decrease the tailplane/height error ratio at high subsonic speeds at low altitude, and to increase the ratio at high altitudes at supersonic speeds. The quality of automatic height control varies with height and speed as follows:

a. *Subsonic Performance.* In subsonic flight, the height control performance varies significantly with IAS and, to a lesser extent, with altitude. The flight conditions which give the most satisfactory control are in the speed band 300 to 350 knots at altitudes between 20,000 and 30,000 feet. At speeds above 350 knots, especially below 20,000 feet, control is oversensitive to such an extent that large or rapid throttle movement may produce pitch disturbances which, if severe, lead to g-switch trip. Conversely, as speed is reduced below 300 knots and/or altitude increased above 30,000 feet, height hold becomes increasingly less precise. During turns at altitudes near the tropopause, up to 500 feet may be lost if speed variation is allowed to occur.

b. *Supersonic Performance.* In supersonic flight, height control varies with altitude but is virtually independent of speed changes. The most satisfactory altitude band is between 20,000 and 40,000 feet. Above 40,000 feet height control deteriorates rapidly, especially in turns. Below 20,000 feet, height control becomes increasingly sensitive. Pitch oscillations may occur with a combination of high altitude (above 36,000 feet) and high bank angle (greater than 50°); this oscillation is alleviated by reducing the bank angle.

c. *Transonic Performance.* When accelerating in the transonic region, the aircraft climbs and, in the worst circumstances, acceleration may cease. During decelerations there is also a tendency to climb, particularly when the deceleration is rapid. Below 25,000 feet, during both acceleration and deceleration, the pitch disturbances induced by the change from height hold to pitch attitude hold and vice versa, may trip the g-switch. For this reason the HEIGHT mode is not to be used during transonic accelerations and decelerations between 15,000 and 25,000 feet.

47. *Tailplane Trim Changes.* Any change in flight conditions requiring large and rapid tailplane trim changes produces temporary height variations. These variations are normally greatest in the climb sense but, during rapid deceleration from high speed at low level, the aircraft tends to descend.

48. *Lateral and Directional Trim.* Lateral and directional trim changes which occur and which are

not corrected manually on the normal trim controls produce heading errors or, in HEIGHT lock alone, bank errors. An out-of-trim condition causes a partial inhibition of autopilot authority in roll, giving a slow roll rate in response to a heading demand.

49. *Asymmetric Loads.* Careful trimming is essential when carrying asymmetric loads (eg single missile or AAR probe).

Attitude Hold Mode

50. Pitch and bank attitude hold is satisfactory in the ATTITUDE mode throughout the flight envelope. However, pitch errors occur if the mode is used in conditions requiring rapid trim changes (eg a high rate of climb). Bank errors also occur if lateral trim changes are required.

51. The little stick may be used in this mode to vary the pitch and bank datum. Its authority in this mode is ±6·6° in pitch and 30° in bank (10° per click stop).

ILS Modes

52. An ILS approach may be flown down to decision height in autopilot with AP selected, or manually in FD, by engaging TRACK and GLIDE at the appropriate positions. The aircraft is landed manually after selecting OFF on the stick switch. Auto-ILS procedure is described in detail in Part 3, Chapter 5.

53. *Bank Angle.* In the ILS modes the bank angle with TRACK selected is limited to 28°. With GLIDE selected, bank angle is limited to 15°.

TRACK Mode

54. In steady cruise conditions the TRACK mode may be used as a height and heading lock. Check that the ILS master switch is off and engage the mode in the normal way. Owing to variations between aircraft and production tolerances on equipment, some aircraft may perform a small pitching oscillation in this mode. Turns are made by rotating the HDG selector on the navigation display, but heading changes in excess of 40° are prohibited because there may be insufficient tailplane authority to maintain height in the turn. Height corrections in turns can be reduced by applying direct control column corrections or by trimming.

Auto-Throttle

55. Auto-throttle may be used on manual and auto-ILS approaches, and on PAR or visual approaches. Its characteristics are described in para 21 to 23.

PAR Approaches

56. The FCS, including auto-throttle, may be used as an aid during PAR approaches. With the ILS MASTER switch off and TRACK selected, engage AP to provide height and heading lock for the initial phase of the PAR approach. Ensure the autopilot trim indicator shows an 'in-trim' situation and start the descent by selecting GLIDE; this pitches the aircraft nose down through 3°, giving a rate of descent of approximately 900 feet per minute at 175 to 180 knots. Adjust the rate of descent manually by re-trimming. Pitch changes take place slowly: make only small trim adjustments and pause between each change.

MALFUNCTIONS OF THE SYSTEM

General

57. The malfunctions possible in the FCS depend on the settings of the MASTER and STAB switches as follows:

a. With the MASTER and STAB switches both OFF there can be no malfunction in any channel, but the tailplane autostabiliser actuator is likely to drift and to remain at one end of its restricted stroke (±1°).

b. With the MASTER switch on and the STAB switch OFF, a malfunction is possible only in the tailplane channel within the restricted stroke of the autostabiliser actuator.

c. With both MASTER and STAB switches on, with or without a mode engaged, hard-over or oscillatory autostabiliser actuator malfunctions are possible in all three axes. In the case of the tailplane, the malfunction is limited to ±1° except when in TRACK with the undercarriage down, when the limit increases to ±3°18′.

58. *Failure Indications.* The attention-getters operate and the AP caption on the SWP comes on after a g-switch trip, after AC or DC failure to the FCS, or when an incorrect selection sequence is made. The MODE and SUPPLIES indicators change to white/OFF and the FD bead parks after a g-switch trip, after AC or DC failure to the FCS, or after an FCS malfunction. If an FCS malfunction occurs which does not bring on the AP caption, it may not be obvious that the system has tripped if the aircraft is in trim, although the MODE and/or SUPPLIES indicators may be showing white/OFF.

Aircraft Response to FCS Malfunctions

59. *Hard-Over Malfunctions.* In the worst cases, without immediate corrective action, the effects of a hard-over (runaway) malfunction are as follows:

a. *Tailplane.* In the autostabilisation mode the maximum normal acceleration increment is $\pm 2 \cdot 8$g, and in the height and heading or attitude hold modes, $\pm 4 \cdot 5$g. At subsonic speeds above 40,000 feet, pre-stall buffet may be experienced after a tailplane hard-over, the buffet increasing in severity with increase in altitude. Except in the autostabilisation mode, the autopilot disengages automatically if less than zero g or more than +3g is experienced. After certain tailplane malfunctions when the hard-over is opposed by the pilot, the push or pull force required progressively increases until the autotrim reaches its limit stop or the FCS MASTER is switched OFF.

b. *Ailerons.* After an aileron hard-over at high subsonic or supersonic speeds, 90° of bank can be applied in two seconds.

c. *Rudder.* After a rudder hard-over, 2° of sideslip and 20° per second peak roll rate can be experienced. Care should be taken during recovery to avoid large sideslip values caused by abrupt rudder correction.

d. *Auto-ILS.* With TRACK and AP engaged and the undercarriage down, the peak hard-over increments are as follows:

Tailplane — $\pm 0 \cdot 85$g
Aileron — 15° of bank in two seconds
Rudder — 1·6° sideslip and 10° per second peak roll rate

60. *Oscillatory Malfunctions.* The aircraft response to oscillatory malfunctions is as follows:

Tailplane — $\pm\frac{1}{2}$g increment at one to two cycles per second
Aileron — Negligible effect
Rudder — Large oscillatory sideslip

Actions Following Malfunctions

61. After an FCS malfunction, take corrective action on the controls, but do not chase an oscillatory malfunction. Then cancel the FCS in the following sequence:

MASTER switch	...	OFF (anticipate a change in tailplane trim)
STAB switch	...	OFF
Stick switch Retrim	...	OFF

62. If the trip indications are not accompanied by an obvious malfunction, make an FD re-engagement. If the indications are satisfactory in FD, AP may be re-engaged with caution. The FCS is not to be re-engaged after an obvious malfunction.

Instrument Power Supply Changeover

63. Whenever the standby inverter MI changes to white/ON, whether accompanied by an aircraft oscillation or not, the FCS is to be cancelled in the correct sequence.

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