PART 1

CHAPTER 7—INSTRUMENTS

Contents

CONTROLS AND INDICATORS

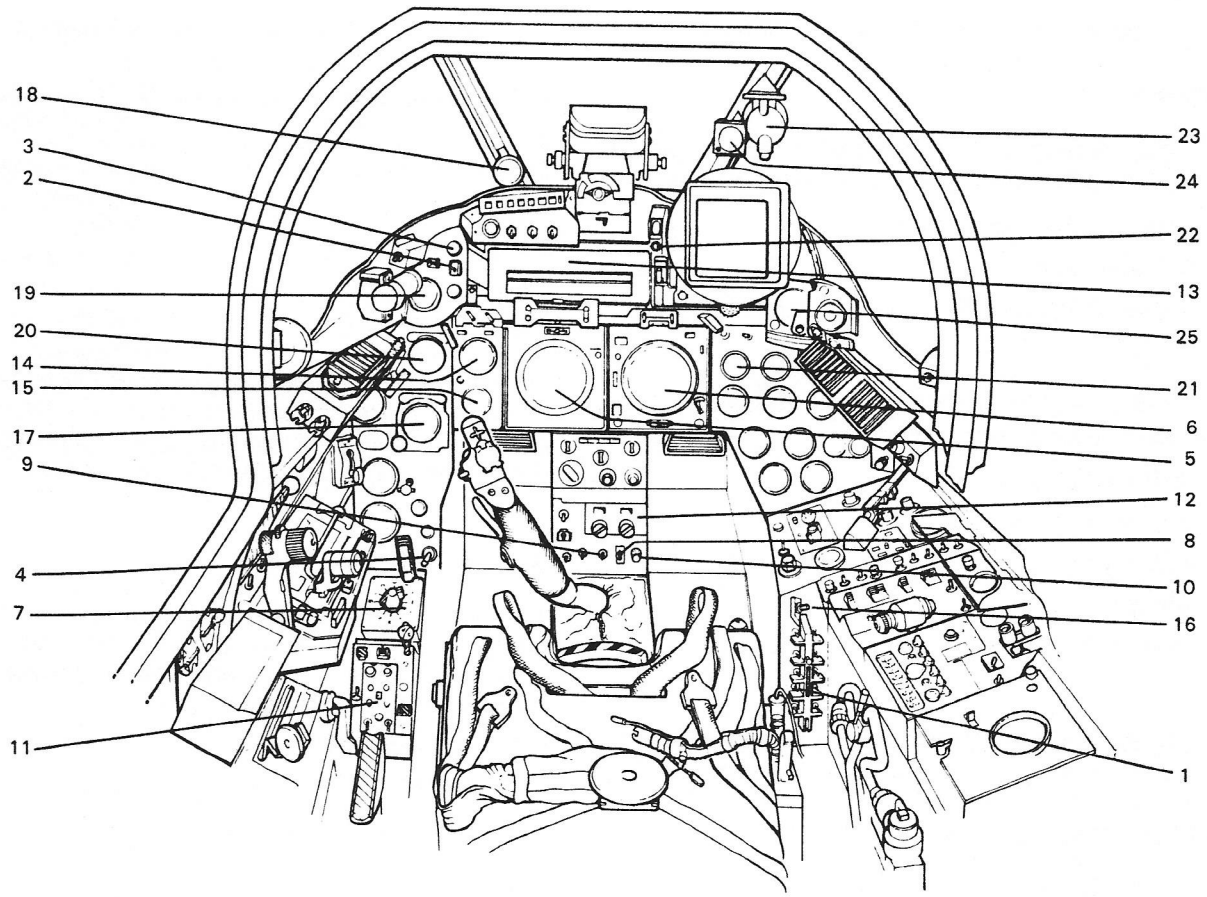
1. The controls and indicators of the integrated flight instrument system (IFIS), the standby flight instruments and the miscellaneous instruments are listed in Table 1 for the F Mk 3 and F Mk 6, and in Table 2 for the T Mk 5. Fig 1 shows the position of items in the F Mk 3 and F Mk 6; Fig 2 shows the positions in the T Mk 5.

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

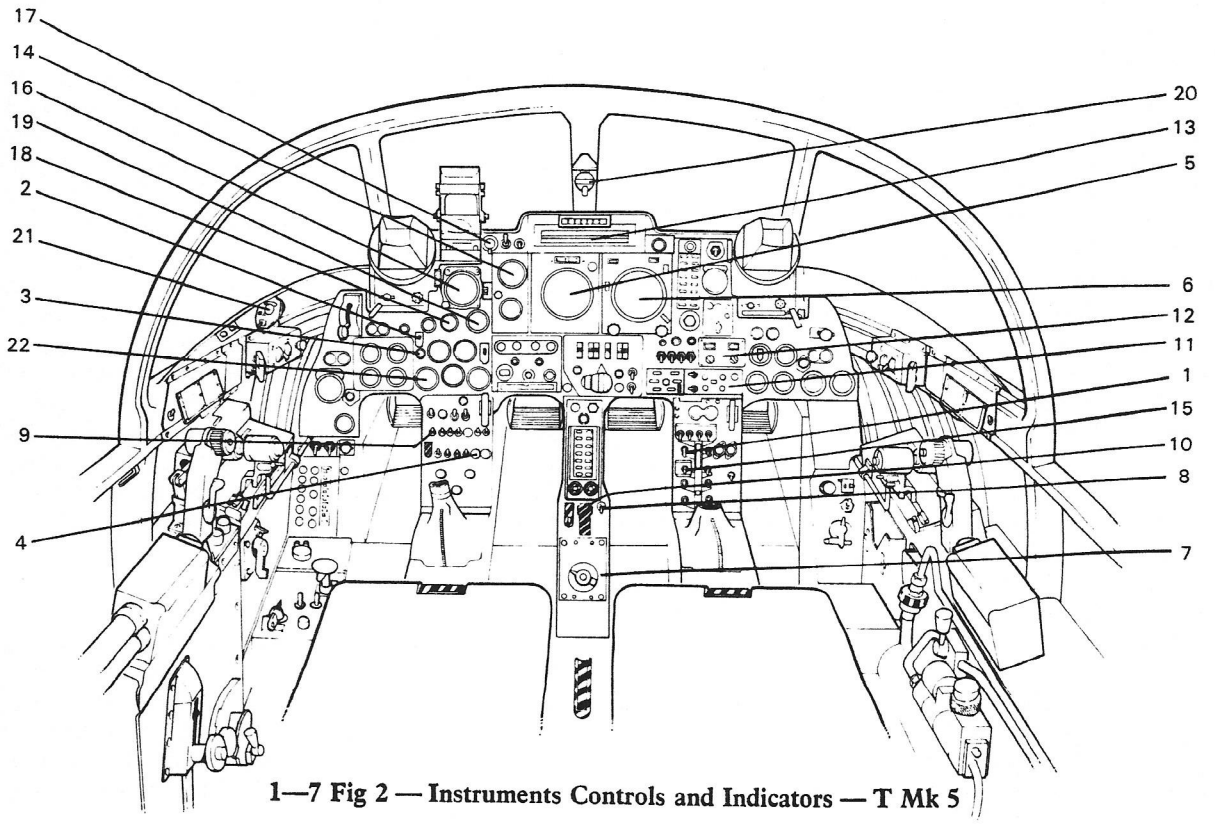
Item No	*Item*	*Markings*	*Remarks*
1	Instrument master switch	INST MASTER	Down for off
2	Standby inverter switch	INVERTER — NORMAL/STANDBY	Guarded to NORMAL
3	Standby inverter MI	Black/ON, white	—
4	Master reference gyro (MRG) switch	MRG — ON	Lock toggle switch; lift and move down to switch off
5	Attitude indicator F4C	—	—
6	Navigation display	See text	—
7	ILS control unit	Channels marked A to L	—
8	ILS master switch	ILS MASTER — ON	—
9	ILS/VP changeover switch	VP/ILS INDR	—
10	ILS volume control	ILS VOLUME	—
11	Tacan control unit	See text	—
12	Tacan offset computer	BEARING/RANGE NM	—
13	Speed display	See text	—
14	Altimeter	See text	—
15	RCDI	See text	—
16	Pitot heaters switch	PITOT HEATER — NORMAL/OFF/ STANDBY	—
17	Standby artificial horizon	—	—
18	Direction indicator (DI)	—	—
19	Standby ASI	—	—
20	Standby altimeter	—	—
21	Radar altimeter (post-mod 4846)	—	—
22	Low height warning light	—	—
23	E2B compass	—	—
24	Accelerometer	—	—
25	Ram air temperature gauge	—	—

Table 2 — Controls and Indicators — T Mk 5

Item No	*Item*	*Markings*	*Remarks*
1	Instrument master switch	INSTRUMENT MASTER — ON	Down for off
2	Standby inverter switch	INV — NORMAL/STANDBY	Guarded to NORMAL
3	Standby inverter MI	Black/ON, white	—
4	Master reference gyro (MRG) switch	MRG — PULL OFF	Integral light
5	Attitude indicator F4C	—	—
6	Navigation display	See text	—
7	ILS control unit	Channels marked A to L	—
8	ILS master switch	ILS MASTER — ON	—
9	ILS/VP changeover switch	ILS/VP INDR	—
10	ILS volume control	ILS VOL	—
11	Tacan control unit	See text	—
12	Tacan offset computer	BEARING/RANGE NM	—
13	Speed display	See text	—
14	Altimeter	See text	—
15	Pitot heaters switch	PITOT — ON/OFF/STANDBY	—
16	Standby artificial horizon	—	—
17	Direction indicator (DI)	—	—
18	Standby ASI	—	—
19	Standby altimeter	—	—
20	E2B compass	—	—
21	Accelerometer	—	—
22	Ram air temperature gauge	—	—



1—7 Fig 1 — Instruments Controls and Indicators — F Mk 3 and F Mk 6



1—7 Fig 2 — Instruments Controls and Indicators — T Mk 5

DESCRIPTION OF THE SYSTEMS

General

2. The integrated flight instrument system (IFIS) derives its information from the following sources:

Dynamic reference system

Air data system

Tacan, ILS and UHF coupling units

3. The derived information is presented in the cockpit on the following instruments:

Attitude indicator

Navigation display unit

Speed display

Altimeter

Rate of climb and descent indicator (RCDI)

4. If the dynamic reference system fails, attitude and heading information is provided by the standby artificial horizon and direction indicator (DI). A pressure-operated ASI and standby altimeter are fitted as standby reference instruments to cater for air data system failure, but there is no standby RCDI.

Electrical Supplies

5. The IFIS requires 28V DC and 115V, 3-phase, 400 Hz AC current. The 28V DC is taken from the main 28V DC busbar. A 115V, 3-phase transformer, fed from the aircraft 200V supply, normally supplies two separate instrument busbars, one of which has an alternative AC power source from a DC-powered Type 100A inverter. The INST MASTER (INSTRUMENT MASTER, T Mk 5) switch controls the selection of AC power to the two instrument busbars and of DC power to the Type 100A inverter. The transformer output is monitored by an undervoltage/phase sequence unit.

6. When a transformer output fault is detected by the undervoltage/phase sequence unit or when AC supply fails, the Type 100A inverter supplies one instrument busbar with AC current but the other instrument busbar is dead. The services lost and the services sustained are listed in Table 3. The inverter comes on line automatically after a fault is detected or when, with the switch to NORMAL, transformer output fails. The inverter may also be started manually by selecting the switch to STANDBY.

Table 3 — Instrument Services Sustained and Lost after AC Failure

Services Sustained	*Services Lost*
MRG and attitude indicator	Air data computer:
Navigation display	Altimeter
Fire detection system	RCDI
Cockpit temp control (auto)	Speed display
Fuel contents gauges	FCS
	AI 23
	JPT control

Note: The standby artificial horizon and DI, which start and normally run on AC power, automatically continue to run on DC if the AC supply fails.

Dynamic Reference System

7. The dynamic reference system uses a master reference gyro (MRG) to provide continuous flight attitude and heading information which is supplied to the following items of equipment:

Attitude indicator

Gyro magnetic compass

Flight control system (FCS)

AI 23

Master Reference Gyro (MRG)

8. The MRG consists of a gyro-stabilised reference platform and an electronics unit mounted in the equipment bay. Its power supplies are controlled by the INST MASTER (INSTRUMENT MASTER, T Mk 5) switch. In the F Mk 3 and F Mk 6, control of the MRG is provided by an MRG toggle switch. In the T Mk 5 the MRG is controlled by an MRG PULL OFF push/pull switch which has an integral lamp which comes on when the switch is pulled out and the INSTRUMENT MASTER switch is on. After AC failure the system takes power from the standby inverter, provided the MRG is already erect. However, the standby inverter may not function normally if it is fed by battery voltage only, thus precipitating MRG failure; this may be noticed after landing when the main AC supplies go off line and generator output is low.

9. To start the MRG, AC power from an external source or from the alternator must be used. An electrical interlock prevents MRG start up from inverter power when NORMAL is selected at the INVERTER (INV, T Mk 5) switch, but when the switch is set to STANDBY the interlock is ineffective

and damage to the inverter occurs if MRG erection is attempted. The correct switching sequence when starting the MRG is therefore important and is as follows:

a. *F Mk 3 and F Mk 6*:

MRG switch	Off (down)
AC power (external or alternator)	On
INVERTER switch ...	NORMAL
INST MASTER switch	ON
Standby inverter MI	Black
MRG switch	ON (up), locked

b. *T Mk 5*:

MRG PULL OFF switch	Out, integral light out
AC power (external or alternator)	On
INV switch	NORMAL
INSTRUMENT MASTER	ON
Standby inverter MI	Black
MRG PULL OFF switch	Light on. Push in, light out

10. When the MRG is switched on, the roller blind on the attitude indicator rotates for about 50 seconds; full erection is complete after approximately two to three minutes and is indicated by the orange disc on the attitude indicator being masked by a black disc. The gyro takes approximately 25 minutes to run down after switching off; during this period the MRG may be switched on again but, if a break of more than 30 seconds has occurred between switching off and on, the erection cycle could take as long as five minutes.

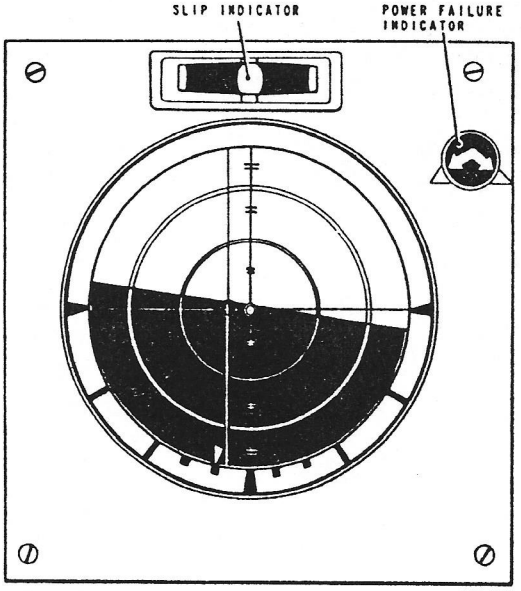
11. Vertical errors in the system, indicated on the attitude indicator, are removed at the rate of approximately 15°/minute by pressing and holding the spring-loaded MRG FAST ERECT button. Fast erection is only to be selected when gross errors are obvious and should only be made in straight and level flight when good external reference exists for levelling the aircraft. The MRG FAST ERECT button is not to be used during the normal erection cycle.

12. The MRG provides gyro-stabilized magnetic heading information on the navigation display in the compass (COMP) mode. Compass monitoring of the indicated heading is cut off when the directional gyro (DG) mode is selected or when flight accelerations and attitudes could cause errors in compass detection. In the COMP mode, no indication of compass monitoring cut-off is given and the annunciator is free to move as the aircraft moves in azimuth; no attempt is to be made, therefore, to use the synchronising control (SYN knob on the navigation display) during accelerating, decelerating, banking or turning flight.

13. If, while operating on standby inverter supplies, the MRG is switched off, no attempt to restart the MRG is to be made unless main AC supplies are available and the inverter switch is to NORMAL.

Attitude Indicator F4C

14. The attitude indicator, which is controlled by signals from the MRG, gives a continuous indication of pitch and roll by roller blind presentation, the lower (black) half indicating nose-down attitude and the upper (white) half, nose up. Aircraft pitch angle is indicated by 20° circles and bisecting 10° marks around the central, zero, datum. Angles of bank are indicated in 10° steps up to 30°, and then in 30° steps up to 90° of bank. A flight director bead for use in conjunction with the flight control system is co-incident with the central datum when not in use. The attitude indicator is shown at Fig 3.



1—7 Fig 3 — Altitude Indicator Type F4C

15. To the right of the instrument face a translucent orange disc, bearing two arrows, indicates power failure to the attitude indicator and the navigation display. The orange disc is normally covered by a black disc which lifts if power is removed. One arrow points to the attitude indicator, and the other to the navigation display for which no separate warning device is fitted.

16. Partial failure of signals from the MRG is shown by the roller blind either changing to all black or rotating continuously at a steady rate, indicating elevation or bank signal failure respectively.

17. A slip indicator, with a slip indicator datum at the top of the attitude indicator face, is fitted above the instrument.

Navigation Display

18. The navigation display combines the function of either a gyro-magnetic compass or a directional gyro together with displays selected by a 4-position mode switch on the instrument, as follows:

COMP — Gyro-magnetic compass or directional gyro

ILS — Instrument landing system display or UHF homing display

TAC — Off-set Tacan display

DL — Direct or air-to-air Tacan (data link is inoperative)

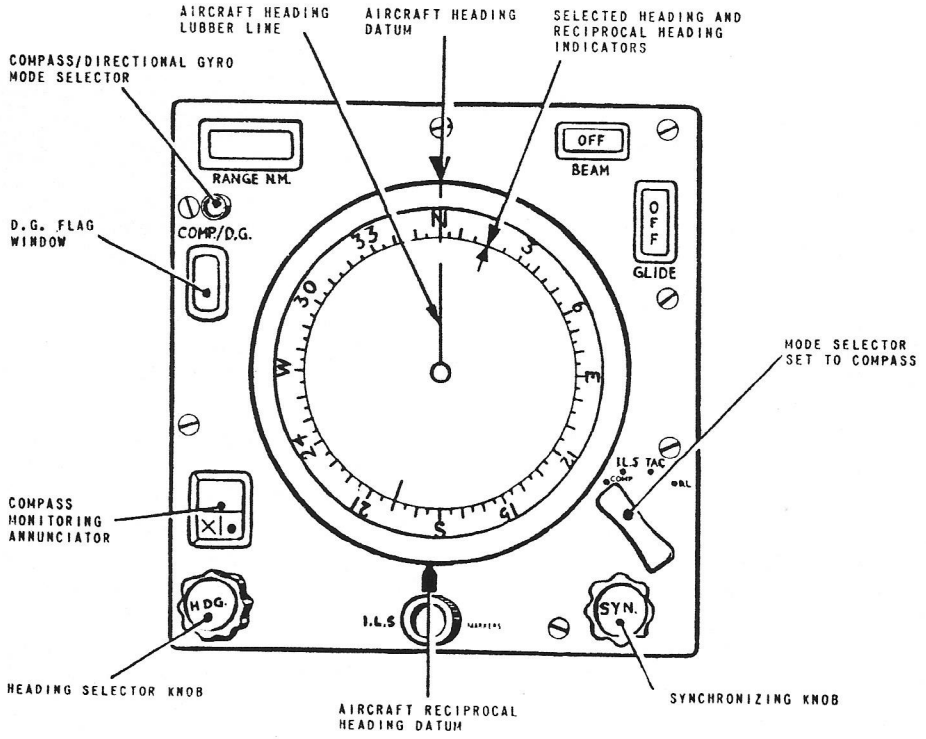
Compass Mode

19. With COMP selected at the mode switch, the display shows only the compass card. It may be used as a magnetic compass or directional gyro as selected on the COMP/DG push on/push off button to the left of the display. If DG is selected, the window beneath the button shows DG; with COMP selected it remains black. See Fig 4.

20. *Compass Synchronisation.* A compass monitoring annunciator window is on the face of the instrument. With magnetic compass selected and synchronised, a dot/cross annunciator slowly oscillates in the window. Fast heading synchronisation is achieved by using the SYN knob at the bottom right of the instrument. To synchronise, the knob is pressed and turned until the annunciator shows an oscillating dot/cross. If resistance to turning is felt, the knob is being turned in the wrong direction. If DG is selected, the annunciator is fixed in the de-energised, central position.

21. *Heading Selection Pointer.* At the bottom left of the instrument is a HDG knob which, when pressed in and turned, moves a heading selection pointer on the instrument. Any divergence between the aircraft heading and the selected heading is transmitted to the flight control computer for use with the flight director or autopilot modes.

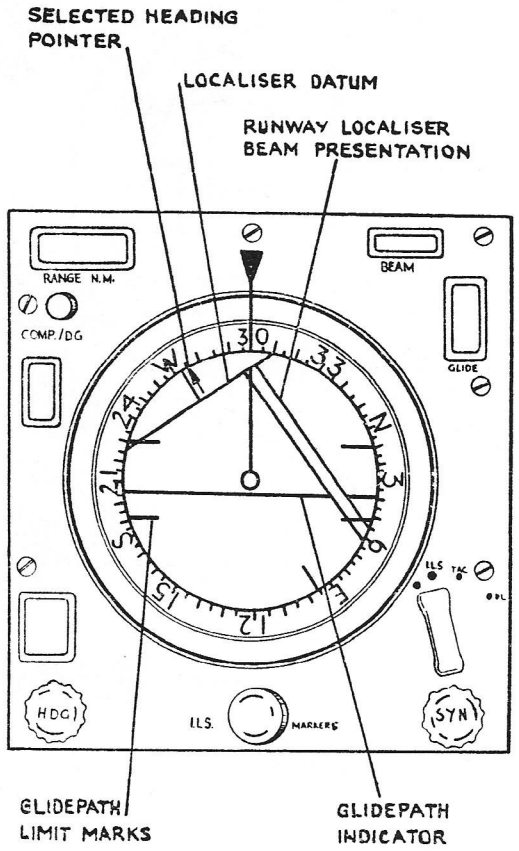
22. *MRG Failure.* With the MRG switch off, the compass card does not rotate to indicate aircraft heading changes. However, provided AC power is available to the navigation display, it is possible to synchronise the compass card by use of the SYN knob to allow for correct ILS or Tacan display orientation. The SYN knob is turned to achieve correct dot/cross annunciation. If resistance to turning is felt, select DG until the indicated heading is approximately the same as the actual aircraft heading and make the final synchronisation with the COMP/DG button selected to COMP.



1—7 Fig 4 — Navigation Display Unit — Compass Mode

ILS Mode

23. To operate in the ILS mode, the mode selector on the navigation display is set to ILS, the ILS control unit is set to the correct channel, the ILS MASTER switch is placed ON, the VP/ILS INDR changeover switch is set to ILS and the ILS VOL control is set as desired. For control positions consult Tables 1 and 2. The ILS display is shown at Fig 5.



1—7 Fig 5 — Navigation Display Unit — ILS Mode

24. Having made the correct selections and provided the signal strength is sufficient for reliability, the BEAM and GLIDE amber lights in the windows at the top right of the display unit are covered by black shutters. The display appears, framed by the compass card, as a pair of parallel lines representing the runway or localiser beam. To orientate the localiser beam presentation a datum marker, which is visible through an aperture in the display and which represents the centre of the beam, is set to the appropriate QDM by pulling *out* and turning the HDG knob and, for auto-ILS approaches, the heading selection pointer is also rotated to the QDM by pressing *in* and turning the HDG knob. The glide path position is indicated by a horizontal bar across the display which moves up and down relative to the fixed central index.

25. A blue flashing ILS MARKERS light (the operation of which is difficult to detect in daylight) is at the bottom of the display. The light has a day/night screen.

26. The ILS VOL control attenuates the volume of the beacon identification signal. It has no effect on the volume of the marker signals which operate in conjunction with the ILS MARKERS light.

Violet Picture

27. The Violet Picture UHF homing system utilises the ILS localiser indicator on the navigation display to indicate relative bearings of received UHF transmissions. To operate the system, set the correct UHF frequency and ADF on the function switch of the V/UHF control panel. Set the VP/ILS INDR switch to VP and the mode selector on the navigation display to ILS. The system operates on UHF frequencies only.

Tacan

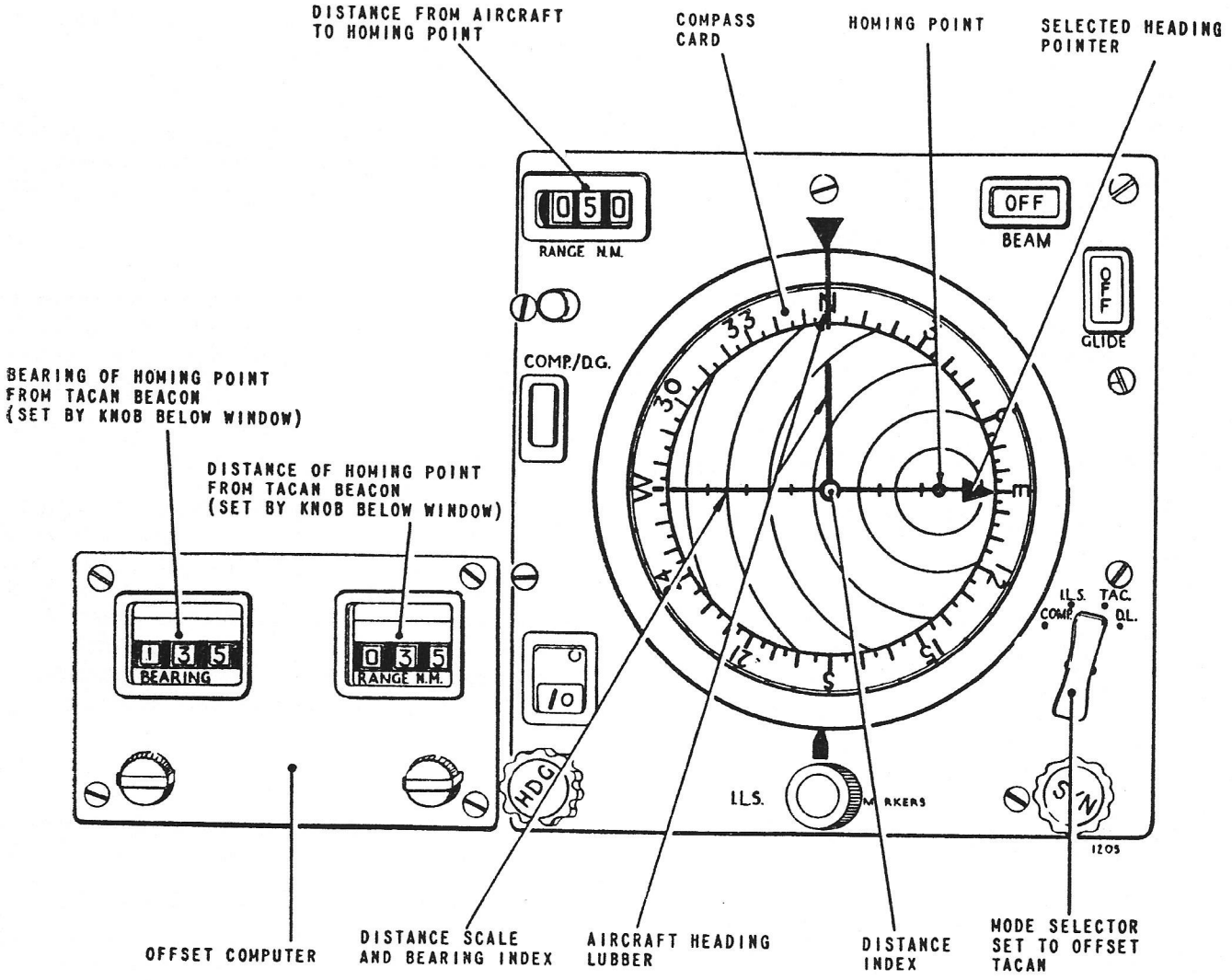
28. The Tacan navigation system gives magnetic bearing and slant distance information at ranges up to 300 NM (depending on aircraft altitude) from a fixed ground beacon. However, the maximum distance from the ground beacon at which reliable signals can be obtained depends on the protected range of the beacon. There is an offset computer fitted to facilitate direct homing to a position other than the fixed ground beacon, provided the offset position is within Tacan range of the beacon at the height flown. The system uses 28V DC and 115V, single-phase AC and is therefore inoperative after AC failure. The Tacan display is shown at Fig 6.

29. The 4-position mode switch on the navigation display utilises the DL position for direct Tacan or air-to-air Tacan; the TAC position is used when offset Tacan information is required. (Offset Tacan becomes direct Tacan when the offset computer range is set to zero.)

30. *Tacan Control Unit.* The Tacan control unit has the following controls:

a. *ON/OFF Switch.* Power on or off.

b. *VOLume Control.* The volume control is used to attenuate the beacon identification signal.



1—7 Fig 6 — Navigation Display Unit — Tacan Mode

c. *A/G—A/A Switch.* The air-to-ground (A/G) position is used when utilising a ground beacon in either direct Tacan or offset Tacan modes, and the air-to-air (A/A) position when working with another aircraft.

d. *Channel Selector Buttons.* Four buttons control channel selection, the two upper buttons increasing and the two lower buttons decreasing the digits shown in the adjacent channel indicator. The right-hand pair of buttons control the 'units' indicated and the left-hand pair, the 'tens'. 126 channels are available.

31. *Offset Computer.* The offset computer has two controls and two veeder counters by which range and bearing of the offset homing point from the Tacan beacon are selected.

32. *Tacan Display.* In the direct or offset Tacan mode the navigation display shows a series of concentric arcs, each representing 20 NM distance from the beacon or offset position. Distance is read off at the centre of the display. A line bisecting the range arcs indicates the magnetic bearing of the beacon or offset position when read against the compass card. With DL selected the display shows direct slant range and magnetic bearing to the Tacan beacon; with TAC selected the display indicates range and magnetic bearing to the offset homing point.

33. *Air-to-Air Tacan.* With DL selected on the navigation display and A/A set on the Tacan control unit, the system is in the air-to-air mode. When working with another aircraft with a similar capability and with channels set 63 apart, slant range information

is displayed in the RANGE NM window. No bearing information is available in the air-to-air mode, and the navigation display roller blind rotates.

Note: When DL is selected on the navigation display, the redundant positions DL and DL/T on the V/UHF controller are not to be selected. Data link is inoperative.

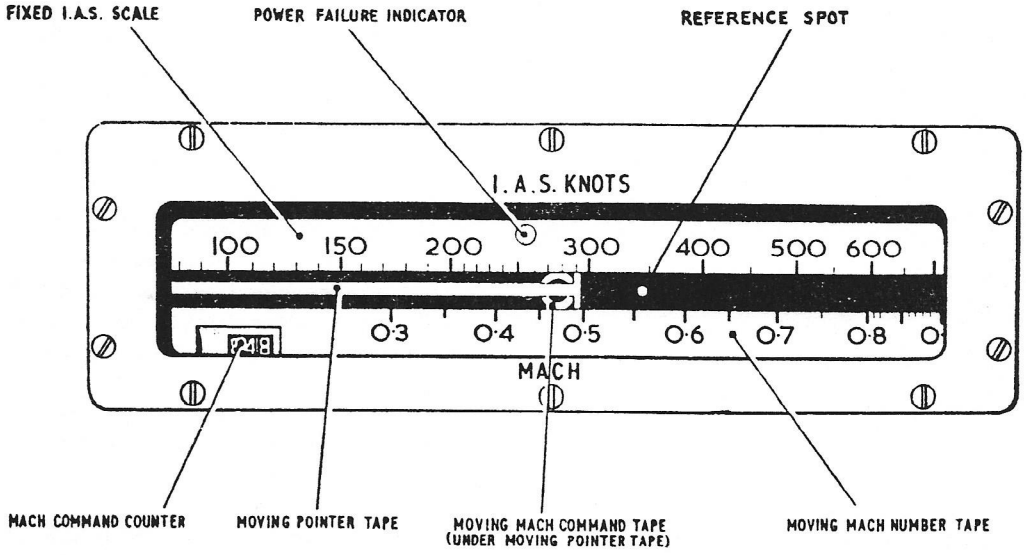
Air Data System

34. The air data system measures pitot and static pressure signals, converts them into electrical signals via transducers and passes the signals to the air data computer. The computer transforms the signals into suitable outputs for the speed display, the altimeter, the vertical speed display (RCDI), the AI 23 radar and the flight control system computer. The system is powered by 115V, 3-phase AC controlled by the INST MASTER (INSTRUMENT MASTER, T Mk 5) switch. There is no standby supply if AC failure occurs.

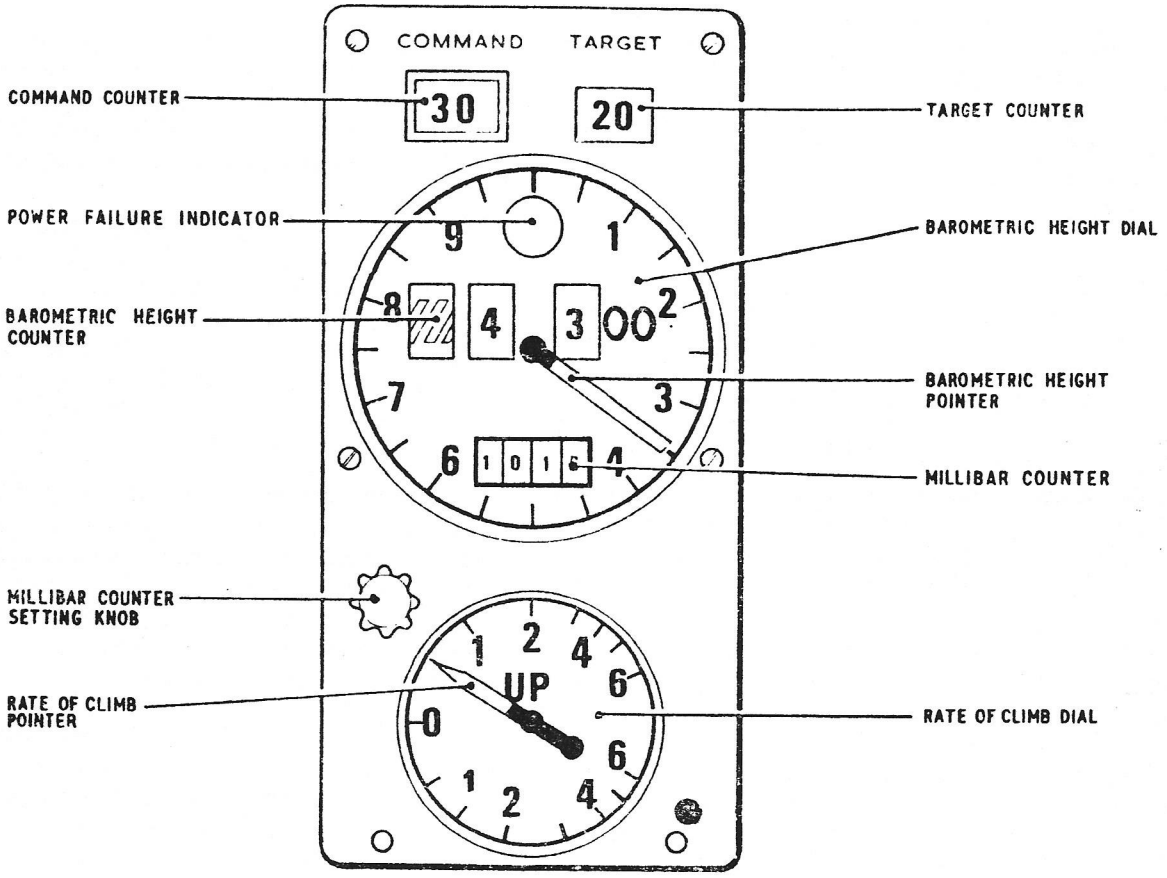
35. *Speed Display.* See Fig 7. The speed display unit presents Mach number and IAS from the outputs of the air data computer. The upper IAS scale is fixed and shows speeds between 80 and 700 knots. The lower Mach number scale moves as necessary so that a white strip, which moves horizontally between the two scales, gives simultaneous indication of IAS and Mach number. The white strip is not visible at speeds below 80 knots, but a white spot ahead of the strip should be located between two white reference bars on the left of the display when the aircraft is at rest with the instrument master switch on. The appearance of an orange disc above the centre of the IAS scale denotes power failure to the display. A transparent tape behind the white strip carries a circular indicator to show data link command Mach number, and this is repeated on a counter at the bottom left of the display. Both the data link Mach number indications are inoperative.

36. *Altimeter.* See Fig 8. The altimeter is electrically operated by signals from the air data computer. The altimeter dial is marked from zero to 1000 feet in 50 feet intervals; it is swept by a single pointer. Three digital counters set into the dial indicate altitude in 100 feet intervals. The 10,000 feet counter is marked with black and white hatching at altitudes below 10,000 feet. A setting knob, at the bottom left of the dial, enables altitude to be displayed relative to the selected barometric pressure which is displayed on a millibar counter near the bottom of the dial. If power to the instrument fails, an orange disc appears at the zero scale mark on the dial. Two windows at the top of the display, labelled COMMAND and TARGET, show data link command altitude and target altitude respectively. Data link is inoperative.

37. *RCDI.* See Fig 8. The RCDI, positioned below the altimeter, is electrically operated by signals from the air data computer and shows the rate of climb or descent in feet per minute. Both halves of the instrument are graduated on a non-linear scale in units of 1000 feet, from zero to 6000 feet, with scale divisions between zero and 1000 feet to indicate 500 feet per minute rate of climb or descent. Power failure to the RCDI is indicated by the orange disc on the altimeter.



1—7 Fig 7 — Speed Display



1—7 Fig 8 — Altimeter and RCDI

Pitot/Static Systems

38. There are two pitot heads. The main pitot head, positioned ahead of the nose intake, supplies pitot and static pressure to the air data system. The secondary pitot head, on the upper radome strut, supplies pitot pressure to the standby ASI, and two fuselage static vents supply the standby ASI, the standby altimeter and the cockpit pressure controller. (The T Mk 5 cockpit pressure controller takes static pressure from the main system.)

39. *Pitot Heating.* A PITOT HEATER—NORMAL /OFF/STANDBY switch (labelled ON/OFF/ STANDBY in the T Mk 5) controls the heating of both pressure heads. When NORMAL (ON) is selected, a 28V single-phase AC supply is used: if the AC supply fails, selecting STANDBY connects a DC supply to the heaters.

Standby Instruments

40. A standby artificial horizon and direction indicator (DI) are fitted. The power supplies are controlled by the INST MASTER (INSTRUMENT MASTER, T Mk 5) switch and the instruments are started and normally run on 115V, 3-phase AC; they are automatically sustained by 28V DC from the DC busbar after AC failure and continue to run on main battery power after AC and double generator failure provided the BATTERY switch is left on. In the T Mk 5 only, after AC failure and power failure of the DC busbar, the emergency battery automatically supplies the standby instruments. In all marks, the standby instruments, although sustained by DC power after AC failure, cannot be started by DC power and no attempt is to be made to test the system on the ground unless power is supplied from an AC source.

41. *Standby Artificial Horizon.* The Mk 6H standby artificial horizon incorporates a fast erection button and an orange and black striped off flag. The off flag disappears approximately 10 seconds after switch-on and the instrument is ready for use after 50 seconds. To correct pitch or bank errors, the FAST ERECTion button on the instrument is pressed until the errors are removed. When airborne, the fast erection button is only to be used in unaccelerated, straight and level flight.

Note: It is possible for the FAST ERECTion button to stick in intermittently against the return spring; ensure it returns out after use.

42. *Direction Indicator (DI).* The DI, which is positioned above the other standby instruments, has a dual purpose synchronisation/fast erection button. When rotated, the button changes the heading indication; when pressed, fast erection of the DI takes place. When the button is pressed a blue indicator light in the centre of the instrument comes on to indicate that fast erection is in progress. If the light goes out when the button is released, the DI is ready for use. If the light stays on, automatic fast erection is proceeding and the light goes out when the instrument is erect.

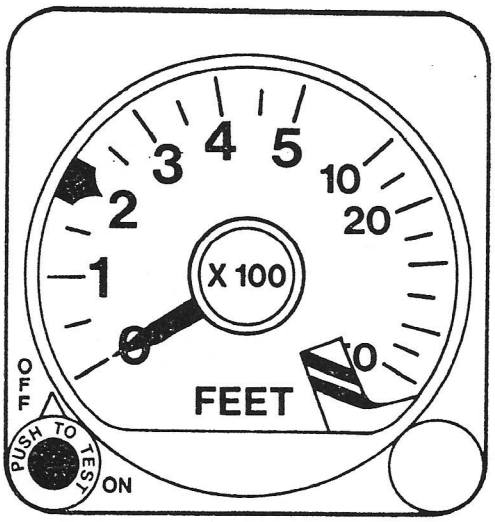
43. *Standby ASI.* A single-pointer Mk 14 ASI is provided to cater for speed display unit failure. The dial is calibrated from 80 to 700 knots. It takes its pitot and static pressures from the secondary pitot/static system.

44. *Standby Altimeter.* A three-pointer Mk 26 standby altimeter is fitted in case of main altimeter failure. The three pointers indicate hundreds, thousands and tens-of-thousands of feet. There is a millibar setting knob which adjusts the millibar scale let into the face of the instrument.

Note: Both the standby ASI and standby altimeter are subject to large errors at supersonic speeds.

Radar Altimeter (F Mk 3 and F Mk 6)

45. Post-mod 4846, a radar altimeter (ARI 23232/8) is fitted to F Mk 3 and F Mk 6 aircraft. It derives aircraft height from leading edge reflection principles. This information is displayed by the radar altimeter indicator which shows height above flight path terrain when below 5000 feet. To obtain a valid display, roll angles must be limited to 60° over good reflective surfaces such as sea, especially when flying close to the upper height limit; for terrain with poorer reflectivity, such as sandy surfaces, lower manoeuvre angles may be necessary to maintain valid signals.



1—7 Fig 9 — Radar Altimeter

46. *System Equipment.* The system consists of a transmitter/receiver in the spine bay, transmitter and receiver aerials flush with the undersides of the aircraft wings, an indicator unit incorporating a low height warning light on the instrument panel, and a repeater low height warning light above the centre instrument panel coaming.

47. *Indicator Unit.* See Fig 9. The indicator unit displays height by a single pointer traversing a non-linear graduated scale of zero to 5000 feet. The scale is expanded between zero and 500 feet to allow easier interpretation at low heights. Controls and indications are as follows:

a. *ON/OFF/Test Switch.* A 2-position ON/OFF rotary switch with a PUSH TO TEST facility and an integral warning light is at the bottom left of the indicator. The PUSH TO TEST facility provides a check of all except the aerial and transmitter circuits. When the switch is pressed with ON selected, the pointer should read 100±15 feet.

b. *Height Index Control.* The height index control knob on the bottom right of the indicator positions the index on the outer edge of the scale to set a datum height.

c. *Integral Warning Light.* An integral red warning light in the ON/OFF rotary switch comes on when the pointer indicates a height less than the datum set by the height index control. Post SEM/LTG/031 a dimmer switch is fitted to the right console to control the intensity of the warning light.

d. *Failure Warning Flag.* A striped failure warning flag appears when the power supply fails, when the pointer reads above 5000 feet, or when no reflected signals are received for over 0·3 second.

48. *Low Height Warning Light.* An amber low height warning light is fitted above the centre instrument panel coaming. The light is wired in parallel with the integral warning light on the indicator unit; its brightness is adjusted by rotating its cap.

49. *Power Supplies.* The ON/OFF switch controls the supply of 115V, single-phase AC current. The system is inoperative after AC failure. The system requires approximately 3 minutes to warm up after switching ON.

50. *Pre-Flight Checks.* Set the control switch to ON and set a height datum of 50 feet. When the system has warmed up and the failure flag has cleared, operate the PUSH TO TEST: check that the pointer indicates

100±15 feet, the warning flag remains retracted and that the warning lights are out. Release the PUSH TO TEST and check that the height display reverts to approximately 10 feet and that the low height warning lights come on. On the ground, especially whilst taxying, the height indication may frequently break lock, bringing the warning flag into view, owing to the widely separated aerial positions. This does not occur in the air.

Miscellaneous Instruments

51. *E2B Compass.* An E2B compass is fitted on the windscreen right frame in the F Mk 3 and F Mk 6; in the T Mk 5 it is on the windscreen centre strut.

52. *Accelerometer.* In the F Mk 3 and F Mk 6, an accelerometer is fitted in a head-up position on the right windscreen strut. In the T Mk 5, the accelerometer is positioned on a quarter panel on the left shroud or on the windscreen centre strut.

53. *Ram Air Temperature Gauge.* The ram air temperature gauge is fitted on the right shroud panel in the F Mk 3 and F Mk 6, and on the left centre of panel A1 in the T Mk 5. Its power is supplied from the DC busbar. The instrument is connected to a thermal sensing probe mounted on the rear spine. The gauge is graduated zero to 150°C. The equipment ram air temperature/time limitations are given in Part 2, Chapter 1.

54. *Monte Carlo Stopwatch (F Mk 3 and F Mk 6 Only).* A Monte Carlo stopwatch is mounted on the left canopy arch.