TUCANO T Mk 1

AIRCREW MANUAL

Prepared by Handling Squadron

NOTES TO USERS

1. This Manual is complementary to the Tucano T Mk 1 Release to Service (RTS) document, the Tucano T Mk 1 Flight Reference Cards (AP 101B-4901-14 & 5Y) and the Tucano T Mk1 Operating Data Manual (AP101B-4901-16).

2. This Manual is divided by marker cards as follows:

Preliminaries
Part 1 Description and Management
Part 2 Limitations
Part 3 Handling
Part 4 Emergencies and Malfunctions
Part 5 Illustrations

3. Where applicable, each part is divided into chapters as listed on its marker card. Each page is identified by a Part, Chapter and Page reference. Thus, a page bearing the reference 1 - 3 Page 3 is Page 3 of Part 1, Chapter 3.

4. The limitations quoted in Part 2 unless over-ridden by the Release to Service are mandatory. The contents of other parts of the Manual are mainly advisory but instructions containing the words 'is to' and 'are to' are also mandatory.

5. The Manual and its associated Flight Reference Cards aim to provide aircrew with the best operating instructions and advice currently available for normal and abnormal operations. Nothing in these publications removes the requirement to comply with MAA regulatory requirements. The application of sound judgement and good airmanship applies at all times and is paramount. Any deviation from the prescribed procedures or drills will need to be fully justifiable and users are strongly advised to record this justification to aid any subsequent inquiry or investigation.

6. Amendment Lists (ALs) will be issued as necessary, together with an AL instruction sheet which states the main purpose of the amendment and includes a list of changes covered. New or amended matter of importance will be indicated by change bars, positioned in the outside margin alongside the amended text, to show the extent of the amended text. Additionally ►....◄ for insertions and ►◄ for deletions may be used. The number of the amendment list, by which a sheet is issued, appears at the bottom of the right-hand page and any amendment marks, on either side of the sheet, refer to that amendment. However, when a new Chapter is issued or an existing Chapter is completely revised, this fact is indicated within the heading of the Chapter and amendment marks (apart from the AL number) will not appear in that Chapter.

7. The following conventions are observed throughout this Manual:

a. The actual markings on controls are indicated in the text by capital letters.

b. Unless otherwise stated, all airspeeds, heights and temperatures are indicated values.

c. **WARNINGS** Imply the possibility of death or injury.

d. **CAUTIONS** Imply the possibility of damage to the aircraft or its equipment.

e. **Notes** are inserted to clarify the reason for a procedure, or to give information which, while not essential to the understanding of the subject, is useful to the reader.

8. Modification numbers are only referred to in the Manual when it is necessary to differentiate between pre- and post-mod states. For ease of reference, a list of modifications mentioned in the text is included in the preliminary pages of the book, with a cross-reference to the location in the text of the modification details.

IMPORTANT
Proposals for change to this document are to be sent to the Tucano User Authenticator, CFS Standards Flt, RAF Linton-on-Ouse, York, YO30 2AJ for onward transmission to the TGSA and the Publication Organisation (OC Handling Squadron, Boscombe Down, Salisbury, SP4 0JE). Proposals are to be submitted using a photocopy of the MoD Form 765X on the following two pages.

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MOD Form 765X
(Revised Feb 17)

TUCANO AIRCREW PUBLICATIONS AMENDMENT REQUEST

References MAP-01 Chapter 8.2

Originating Unit
Title/Address

Reference

Date

Air Publication / Document*
Publication / Document No.

To Amdt / Issue / Revision Date*

Title

Section / Chapter / Page / Paragraph

Part 1 - Requested Amendment and Suggested Revision
(Use continuation sheet(s) if necessary and firmly attach all diagrams etc.)

Originator's Signature	Rank and Name	Tel No.	Appointment	Date

Part 2 - User Authenticator's Comments			Serial No.	/ /
Proposed Priority:	**Immediate***	**Rapid***	**Routine***	

☐ Other publications affected have been reported at:

User Authenticator's Signature	Rank and Name	Tel No.	Appointment	Date

Send to Project Team:
TGSA
Lancaster Block
RAF Linton-On-Ouse
Yorkshire [redacted]
YO30 2AJ

Copy to:
OC Handling Squadron
Boscombe Down
Salisbury
Wiltshire [redacted]
SP4 OJE [redacted]

plus Copy to Release to Service Authority (RTSA)

* Delete as appropriate

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Part 3 Project Team Action			Serial No.	/ /	
(Please include any report/letter references)	**Approved Priority:**	**Immediate***	**Rapid***	**Routine***	
☐ Other Mks affected and relevant UA notified When complete, send to Publication Organisation					
Signature	Rank/ Grade & Name	Tel No.	Appointment	Date	

Part 4 – Publication Organisation/Handling Squadron*

☐ Requested Amendment incorporated

☐ Requested Amendment rejected (see below)

Incorporation Details:

Copy to be sent to Originator, UA and PT

Incorporated by Publication Organisation*	Name	Tel No.	Date
Handling Sqn PO's Signature*	Rank / Grade & Name	Tel No.	Date

Instructions for Use

1. MOD Form 765X has been introduced to maintain an approval trail of changes to aircrew publications and documents to ensure that both the User Authenticator and Handling Sqn are involved at the earliest opportunity after the form has been raised.

2. MOD Form 765X is to be raised by the individual who observed a deficiency, omission or inaccuracy in the Aircrew Manual, Flight Reference Cards, Operating Data Manual, Mission Operating Procedure cards, Flight Test Schedule or Aircrew Landaway Flight Servicing Schedule. Apart from typographic errors and/or grammatical changes, a separate MOD F765X is normally to be raised for each system deficiency, omission or inaccuracy being reported.

3. When an individual raises a MOD Form 765X (by completing the header detail and Part 1) he is to send the form to the User Authenticator, (RAF: STANEVAL; Army: A Avn Stds, HQAAC; RN: Naval Flying Standards Flight, RNAS Culdrose or RNAS Yeovilton as appropriate).

4. On receipt the User Authenticator is to complete Part 2, enter a serial number consisting of a 3-letter MOB designator, a 3-digit number (starting with 001 from1Jan each year) and 2 digits for the year (eg BZN/016/05), comment as appropriate and pass the form to the Project Team (PT), with a copy to Handling Sqn and a copy to the appropriate Release to Service Authority (RTSA). An electronic version of the Form is available on the Defence Intranet and the Form can be submitted electronically by the UA in the first instance but must be followed up by a signed hard copy.

5. The User Authenticator is to keep a register of all MOD Form 765X arisings.

6. The PT is to complete Part 3 of the MOD Form 765X and forward it to Handling Sqn or the Publication Organisation (copy to Handling Sqn), as appropriate, for action.

7. When the change proposed in the F765X is deemed by the UA or PT to be of an urgent flight safety or operational nature, the PT can authorize HS by e-mail to proceed with the appropriate amendment action in advance of the completion and signature of Part 3 of the F765X. When issue of an ANA closes a F765X, the Publication Organisation is to raise a Tech Pubs task to ensure that the change is incorporated at the next routine amendment.

8. Priorities: Immediate - ANA Action, Rapid - Next AL/AIL, Routine - within a year.

* Delete as appropriate

AMENDMENT RECORD SHEET

ALNo	Amended By	Date

ALNo	Amended By	Date

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AIL RECORD

AIL No	Date of Issue	Location Part/Chap	Signature		Cancelled By	Signature	Date

ANA RECORD

ANA No	DTG	Location Part/Chap	Signature		Cancelled By	Signature	Date

LIST OF EFFECTIVE PAGES

This list shows all the pages which should be present after incorporating Amendment List 1 in this Manual.

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Title page	AL 1
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AIL Record	Initial
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Prelims 9	AL 1
Prelims 11	AL 1
Prelims 13	Initial
Prelims 15	AL 1
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LIST OF ASSOCIATED PUBLICATIONS

Title	*Reference Number*
Tucano T Mk 1 Aircraft Maintenance Manual	AP101B-4901-1 Series
Tucano T Mk 1 Flight Test Schedule	AP101B-4901-5M
Tucano T Mk 1 Flight Test Schedule Guidance Notes	AP101B-4901-5MA
Tucano T Mk 1 Flight Reference Cards (incorporating ALFSS)	AP101B-4901-14 & 5Y
Tucano T Mk 1 Operating Data Manual	AP101B-4901-16
Tucano T Mk 1 Release to Service	RTSA/RTS/Tucano T1
Royal Air Force Manual - Flying	AP3456

Note: A detailed list of associated publications is given in the Aircraft Maintenance Manual.

TUCANO T MK 1 - FLYING TRAINER

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INTRODUCTION

General

1. The Tucano T Mk 1 is an all-metal, low-wing, tandem-seat flying training aircraft.

2. Aerodynamically, the aircraft is of conventional design. The unswept wing has 5° 30' dihedral with trailing edge ailerons and single-slotted flaps. The unswept tailplane has no dihedral or incidence and supports trailing edge elevators, dynamically balanced by weights in the fuselage. The single vertical fin supports a rudder, dynamically balanced by weights in its horn.

3. The centre fuselage houses the aircrew, between the engine in the nose fuselage and the aft fuselage which holds equipment. A ventral airbrake is hinged to the fuselage just aft of the wing. The weighing reference point, on the fuselage side just forward of the left wing, is marked by a metal plate with an etched cross.

4. The aircraft is powered by a Garrett TPE331-12B-701A turboprop engine which drives a Hartzell HC-D4N-5C/D9327K 4-bladed propeller. Fuel is carried in integral wing tanks.

Cockpits

5. A retracting step on the fuselage and a walkway on the left wing give access to the cockpits.

6. A single, sideways-hinged, cockpit canopy is operated manually. It cannot be jettisoned. It embodies two Linear Cutting Cord (LCC) sections and one MDC section. The front LCC is in two sections one of which severs the transparency above the front seat and the other fractures the front of the canopy. The rear MDC fragments the canopy above the rear seat. The LCC and MDC sections above the seats operate independently as part of an ejection sequence but, if required on the ground, all three sections can be operated simultaneously from inside or outside the aircraft. A transparent blast screen on the canopy protects the rear pilot if the front of the canopy is holed.

7. Each cockpit has a fully automatic Type 8LC Mk 1 ejection seat. The seats can be fired individually from each cockpit or in sequence by a command ejection system initiated from the rear cockpit. The command system is preset on or off as required, but can be overridden when selected on.

8. An air conditioning system uses air from the engine compressor and/or ambient ram air to provide a desirable cockpit environment and canopy demisting. The air conditioning system is controlled from the front cockpit.

Cockpit Controls and Equipment

9. The layout of each cockpit is similar. Full control of all systems is from the front cockpit but, for appropriate systems, monitoring or override facilities are in the rear cockpit. The aircraft can be flown solo from the front cockpit after some preparatory checks in the rear cockpit.

10. Controls and equipment in each cockpit are grouped as follows:

   a. Left console - throttle, engine starting and flying control systems.

   b. Main panel - (left to right) landing gear control, avionics, flight instruments, engine and fuel instruments.

   c. Right console - electrics, air conditioning and ice protection.

Electrical Systems

11. An engine-driven 6 kW DC starter/generator supplies a main busbar. An essential services busbar, a battery busbar and a load shedding busbar are supplied from the main busbar. Two batteries supply power for engine starting and, following generator failure, one battery is automatically isolated and the other supplies the main busbar. When required, the isolated battery can be reconnected to the main busbar.

12. A static inverter, supplied from the DC system, provides 115 volts AC electrical power.

13. An external DC power supply can be connected for maintenance purposes and can be used for engine starting.

Central Warning System

14. A central warning system (CWS) gives warnings of failures or events in the aircraft systems which require prompt action. The failures or events are classified and appear as red or amber captions on a central warning panel (CWP) in each cockpit. Attention getters, one on each side of the main instrument panel in both cockpits, flash in association with the illumination of any CWP caption. Pressing any attention getter cancels all four attention getters but they resume flashing if another fault condition is signalled by the CWS. Red warnings are accompanied by an audio tone in the headphones.

Fuel System

15. All fuel is carried internally in integral tanks, one in each wing. Each tank has two cells, outer and inner. Total fuel contents are shown on a single dial in each cockpit. Fuel flows by gravity from outer cell to inner and is then jet pumped into a collector tank in each inner cell. Two booster pumps associated with each tank maintain a steady flow to the engine through a common supply pipe in any approved flight attitude.

16. The tanks are gravity filled through filler caps, one on the upper surface of each wing. Defuelling is by bowser from connections, one on the under surface of each wing.

Engine Systems

17. The Garrett TPE331-12B-701A is a turboprop engine which has a 2-stage centrifugal compressor driven by a 3-stage axial turbine. The compressor and turbine are coupled on a single shaft. In ISA sea level conditions, the engine develops 1100 shaft horse power (SHP) and residual energy in the gas efflux produces a further 51 equivalent SHP.

18. A 4-blade, fully feathering, reverse pitch propeller with aluminium blades rotates clockwise as viewed from the cockpits. The hub houses the pitch change mechanism which uses a spring to move the blades towards feather, and boosted high-pressure engine oil to move the blades through fully fine to reverse pitch.

19. An integral gearbox in the compressor intake casing contains the reduction and accessory drives. The reduction drive connects the engine to the propeller shaft to give a propeller speed of 2000 RPM (100%).

20. On the ground only, the engine is started by the electrically driven starter/generator which cranks the engine through the accessory drives in the gearbox. Relighting in flight is by windmill start.

21. A firewire detects fire in the engine compartment and provides audio and visual warnings in each cockpit. There is no engine fire extinguisher; a fire door in the left cowl allows extinguishant into the engine compartment in case of fire when the aircraft is on the ground.

Hydraulic System

22. An engine-driven pump supplies hydraulic power to the landing gear and airbrake. An emergency accumulator, charged from the main system, provides for emergency lowering of the landing gear.

Flight Controls

23. Flight controls consist of elevators, differential ailerons and rudder which are all mechanically controlled by rod and cable systems. The two control columns are interconnected, as are the rudder bars. Trimming is provided in each axis. The elevators and ailerons can be locked from the front cockpit and, as the rudder bars are linked to the nose landing gear steering, the rudder is effectively locked when the aircraft is parked.

24. Fowler single-slotted flaps on the inboard trailing edge of each wing are electrically operated and mechanically interconnected. They can be selected from either cockpit to any of three positions: up (0°), mid (12°) and down (35°).

25. The hydraulically operated airbrake under the fuselage at the wing trailing edge can be selected from either cockpit and is inhibited during landing gear transit. The switch in the rear cockpit overrides the switch in the front cockpit.

Landing Gear

26. The landing gear consists of two main wheel units and a nosewheel unit. The main units retract inward into the wings and the nose unit retracts rearward into the fuselage. Selectors and indicators are identical in each cockpit.

27. If the normal system fails, the landing gear can be lowered with emergency hydraulic pressure by a Standby Lowering System lever in either cockpit.

28. Brakes on the main wheels are operated by an independent hydraulic system controlled by toe pads on the rudder pedals; differential braking is available. There is no anti-skid facility.

29. The nosewheel is steerable through 20° either side of centre by use of the rudder bar. On the ground, disengagement of a steering link enables full castoring to facilitate unrestricted towing.

Oxygen

30. A high-pressure gaseous system supplies each pilot via a personal equipment connector (PEC) and a seat-mounted demand-type regulator. Individual controls are provided for both main and emergency systems. The emergency system, on each seat, supplies oxygen on ejection or can be initiated manually if the main system malfunctions.

Flight Information Displays and Instruments

31. The primary flight instrument display in each cockpit consists of a combined airspeed indicator/ machmeter (CSI), a main altimeter, a main attitude indicator, a turn-and-slip indicator, a vertical speed indicator (VSI), and a horizontal situation indicator (HSI). Magnetic compass heading or directional gyro heading, or both, are presented on each pilot's HSI. Information on ILS glidepath and localiser, VOR steering and Tacan range, and steering and bearing can be shown on each HSI by selection from either cockpit. Additionally, the aircraft is equipped with a Traffic Alert and Collision Avoidance System (TCAS).

32. Each cockpit also has a standby altimeter, a standby attitude indicator, a standby magnetic compass, an outside air temperature (OAT) indicator, an accelerometer, an angle-of-attack (AOA) indicator and indexer, and a stopwatch. Only the front cockpit has a clock.

Note 1: SEM 016 introduces a second stopwatch into each cockpit.

Note 2: SM 109 introduces the Powerflarm Portable (FLARM) Collision Warning System. Embodiment of SM 109 removes the AOA indexer from both cockpits, the AOA indicator from the front cockpit and the provision for a second stopwatch in the front cockpit.

Avionics

33. An avionics system provides multi-channel U/VHF and 2-channel standby UHF voice communications, Tacan, VOR/ILS/MB (VHF Navigation), dual transponders and TCAS.

34. A communications control system (CCS) provides overall control of the elements of the system. It integrates the U/VHF and standby UHF transmit facilities and their audio signals. It also integrates the audio signals from the VHF Navigation and Tacan receivers and the CWS. The CCS provides intercom between cockpits and between cockpits and a ground intercom point.

Lighting

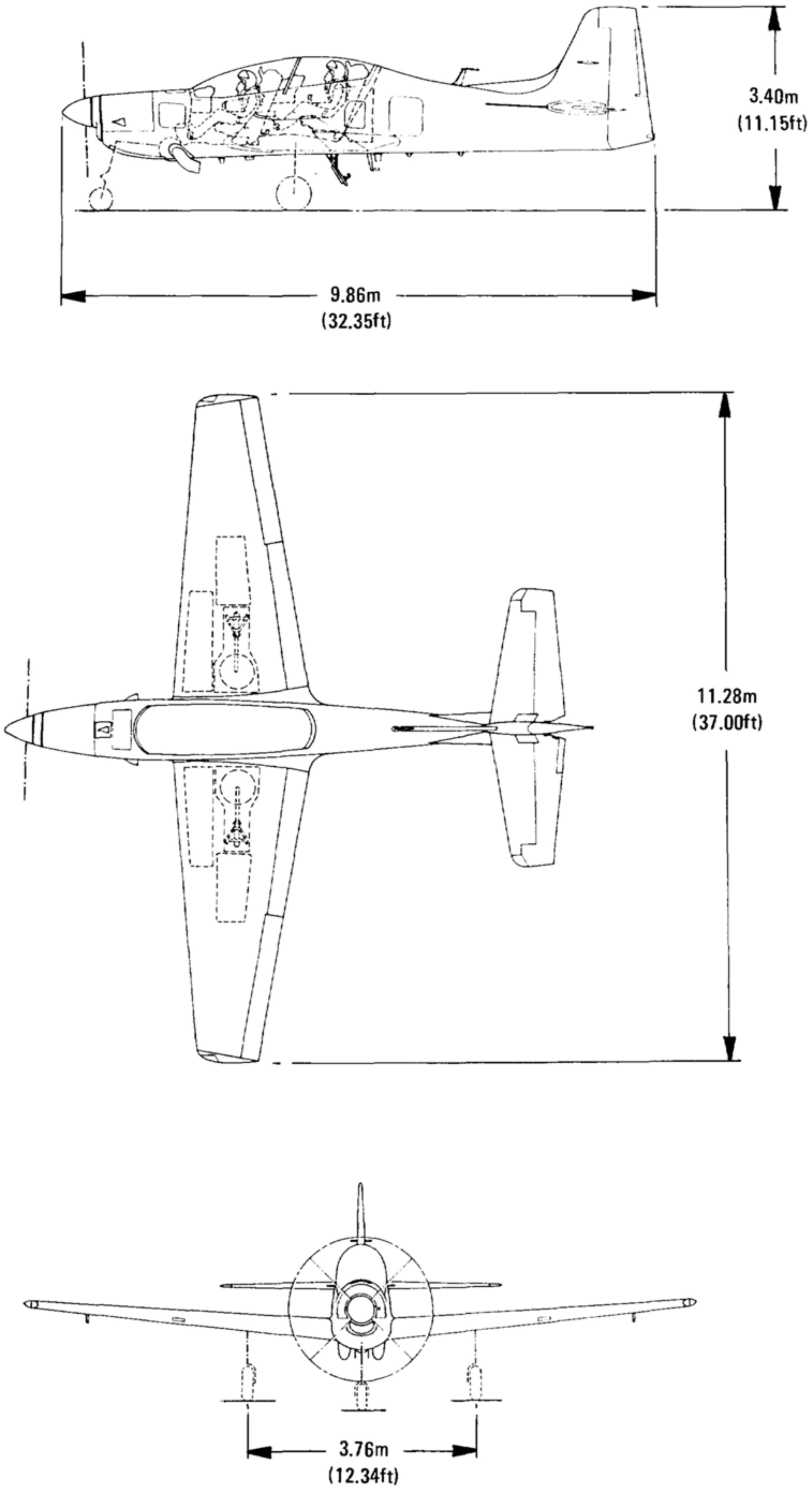
35. The aircraft has normal and emergency cockpit lighting. The external lighting consists of two landing lamps, a taxy lamp, three navigation lights and three anti-collision lights.

Ice and Rain Protection

36. The propeller blades, ice detector, angle-of-attack sensor, stall warning vane, pitot heads and static vents can be heated electrically. The engine intake lip can be heated by engine bleed air. Propeller wash helps rain clearance from the canopy, which is demisted by the air conditioning system.

Accident Data Recorder

37. An accident data recorder (ADR) is interconnected with a data acquisition and processing unit (DAPU) to form an integrated flight data recorder system. The continuous loop tape has four data and three audio tracks and records 18 ADR parameters as well as many discrete events. The duration of the tape is two hours.



Prelims Fig 1 General Arrangement

LEADING PARTICULARS

Name:	Tucano T Mk 1
Type:	Single turboprop, tandem trainer
Crew:	One or two
Duties:	Flying training

Main Dimensions

Wing span:	11·28 m (37 feet)
Wing area (total):	19·40 m^2 (208·8 $feet^2$)
Overall length:	9·86 m (32 feet 4 inches)
Height (level with landing gear down):	3.40 m ·(11 feet 2 inches)
Landing gear track:	3·76 m (12 feet 4 inches)
Wheelbase:	3·16 m (10 feet 4 inches)
Propeller disc diameter:	2·39 m (7 feet 10 inches)
Static propeller clearance:	0·32 m (1 foot 1 inch)
Mass (maximum for take-off):	3000 kg
Mass (maximum normal for landing):	3000 kg

Power Plant

Engine change unit:	Garrett TPE331-12B-701A
Engine Type:	Single shaft, turboprop
Propeller:	Hartzell HC-D4N-5C/D9327K
Propeller type:	4-bladed, aluminium, variable pitch
Performance (ISA sea level):	1151 equivalent shaft horse power

Engine Oil

The following engine oil is cleared for use: OX 27

Oil system capacity:	8·5 litres (15 pints)
Oil tank capacity:	5·9 litres (10 pints)
Usable oil:	1·9 litres (3·3 pints)

Oil consumption (level flight, maximum): 0·13 pints per hour

Fuel

Table 1 - Approved Fuels

NATO Code No		Type
Standard	F-34	Avtur/FSII
	F-40	Avtag/FSII
Alternate	F-35	Avtur

Fuel System

Fuel system capacity (usable fuel): 554 kg (153 gallons)

Electrical Systems

DC generation:	One engine-driven 6 kW generator
Supply:	28 volts
Batteries (two):	24 volts (nominal)
AC supply:	115 volts, 400 Hz, single phase

Hydraulic Systems

Power source:	Engine-driven pump
Services operated:	Landing gear, airbrake

Ejection Seats

Type (front):	Martin-Baker Type 8LC Mk 1 - 1
Type (rear):	Martin-Baker Type 8LC Mk 1 - 2

Oxygen Systems

Regulators (seat-mounted):	1 x Type 500 on each seat
Main system (airframe-mounted):	Gaseous, 1 x 2250-litre cylinder
Emergency systems (seat-mounted):	Gaseous, 1 x 70-litre cylinder on each seat

Air Conditioning

Air Supply:	HP compressor air

Avionics

Communications Control System:	ARI 23245/32
Tacan (Marconi):	ARI 23432
Transponders (Funkwerk):	TRT800A
U/VHF (Plessey):	ARI 23300/59
Standby UHF (Dowty):	ARI 23159
VHF Navigation (Collins):	ARI 23434
Underwater Locating Beacon:	ARI 23438/3
TCAS (Skywatch) (SKY899):	ARI 50045/0

Miscellaneous

Data Acquisition and Processing Unit:	GEC Marconi 612/1/47531/201
Accident Data Recorder:	Penny & Giles D50769

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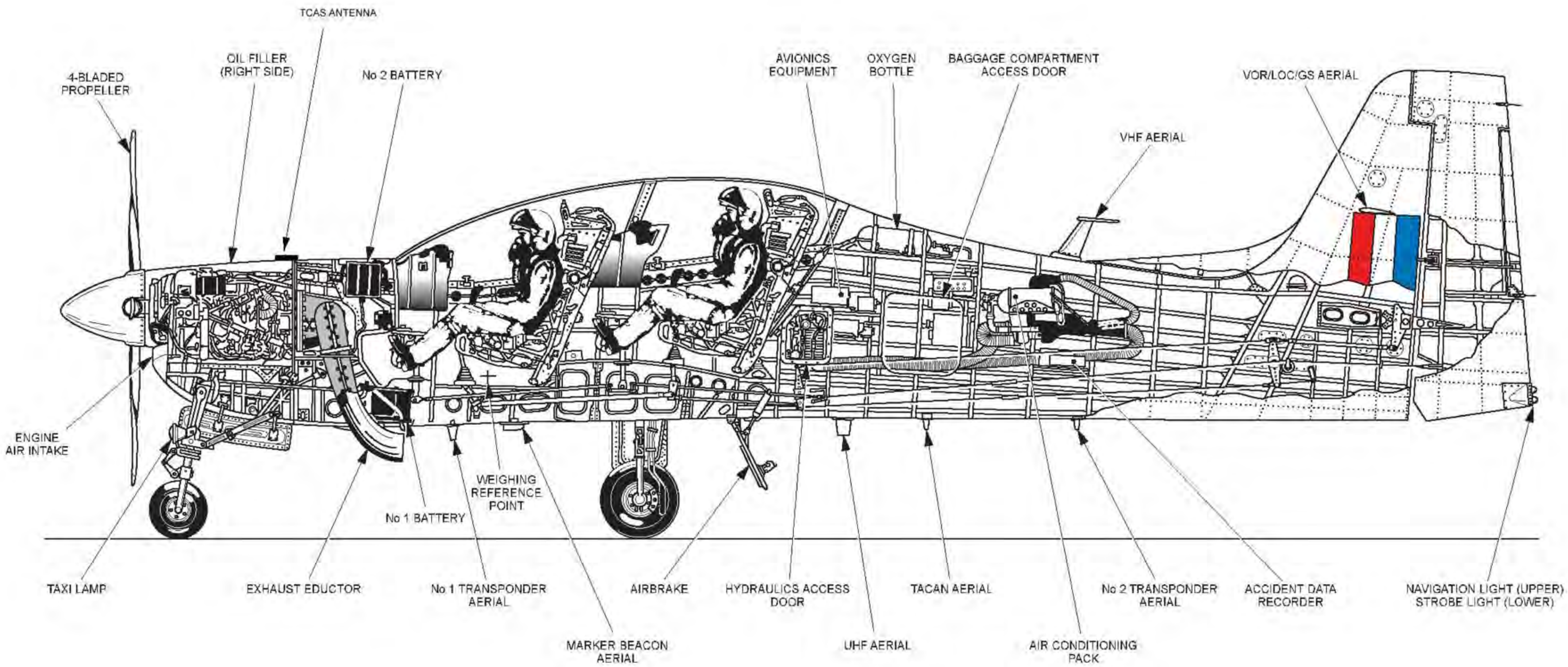

Prelims Fig 2 Tucano T Mk 1 - Side View

ABBREVIATIONS USED IN TEXT

AC Alternating current
ACU Air conditioning unit
ADR Accident data recorder
AGL Above ground level
AIL Advance information leaflet
ANA Advance notification of amendment
ANM Air nautical miles
AOA Angle-of-attack
ASDA Accelerate stop distance available
ATC Air traffic control
AUM All up mass

BIT Built in test
BTRU Barostatic time release unit

C Celsius
CA Controller Aircraft
CAS Corrected airspeed
CAU Cold air unit
CCS Communications control system
CCW Counter-clockwise
CG Centre of gravity
cm Centimetre(s)
CPU Control and protection unit
CSI Combined speed indicator
CW Clockwise
CWP Central warning panel
CWS Central warning system

DAPU Data acquisition and processing unit
DC Direct current
DG Directional gyro
DH Decision height

EAS Equivalent airspeed
EEC Engine electronic control
EGT Exhaust gas temperature
EMBS Emergency maximum braking speed
ESDL Emergency shutdown lever

FCU Fuel control unit
FF Fuel flow
FFFD Fault-free fire detection
FRC Flight Reference Card(s)

GPU Ground power unit
GS Glideslope

HP High pressure
HSI Horizontal situation indicator
Hz Hertz (cycles per second)
HIRTA High Intensity Radio Transmission Area

IAS Indicated airspeed
ILS Instrument landing system
IMN Indicated Mach number
IOAT Indicated outside air temperature
ISA International standard atmosphere

kg Kilogram(s)
kHz Kilohertz
kW Kilowatt(s)
lb Pound(s)
LCG Load classification group
LCN Load classification number
LOC Localiser
LP Low pressure

m Metre(s)
MB Marker beacon
MBEW Maximum basic empty weight
MDC Miniature detonating cord
MDH Minimum descent height
MHz Megahertz
mph Miles per hour
MRM Maximum ramp mass
MSL Mean sea level
MTOM Maximum take-off mass

MZFM	Maximum zero fuel mass
NACA	National Advisory Committee for Aeronautics
NM	Nautical mile(s)
NRV	Non-return valve
NTS	Negative torque sensing
OAT	Outside air temperature
ODM	Operating Data Manual
PEC	Personal equipment connector
	Pressure error correction
PG	Propeller governor
PLB	Personal locator beacon
PPC	Propeller pitch control
PSP	Personal survival pack
PTT	Press-to-transmit
QRF	Quick-release fitting
RFCI	Remote frequency/channel indicator
RL	Reference line
RPM	Revolutions per minute
RVR	Runway visual range
SG	Specific gravity
SHP	Shaft horse power
SOV	Shut-off valve
SR	Specific air range
SRL	Single red line
TAS	True airspeed
TCAS	Traffic Alert and Collision Avoidance System
TCV	Temperature control valve
TORA	Take-off run available
UHF	Ultra high frequency
USG	Underspeed governor
UUPI	Ultrasonic undercarriage position indicator
V	Volt(s)
V_2	Speed at 50-foot screen height
V_{at}	Threshold speed
V_{lof}	Lift off speed
V_r	Rotation speed
V_{stop}	Stop speed
VHF	Very high frequency
VOR	VHF omni-directional radio range
VSI	Vertical speed indicator

MODIFICATION NUMBERS REFERRED TO IN THE TEXT

Mod No.	*Effect of Embodiment*	*Location in the text*		
		Part	*Chap*	*Para*
SEM 016	Addition of second stopwatch in each cockpit	1	11	1, Note 1
SEM 057	Fitment of Camera Equipment to Front and/or Rear Cockpit	2	1	8, Note
SM 109	Addition of FLARM	1	11	1, Note 2

PART 1

DESCRIPTION AND MANAGEMENT

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PART 1

CHAPTER 1 - ELECTRICAL SYSTEMS

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INTRODUCTION

1. The primary power supply in the aircraft is 28 volts DC. DC services are supplied from four busbars (battery, main, essential services and load shedding - see Fig 1) powered by an engine-driven starter/generator, aircraft batteries or an external DC ground supply. A static inverter fed by the DC system supplies a 115 volt AC busbar.

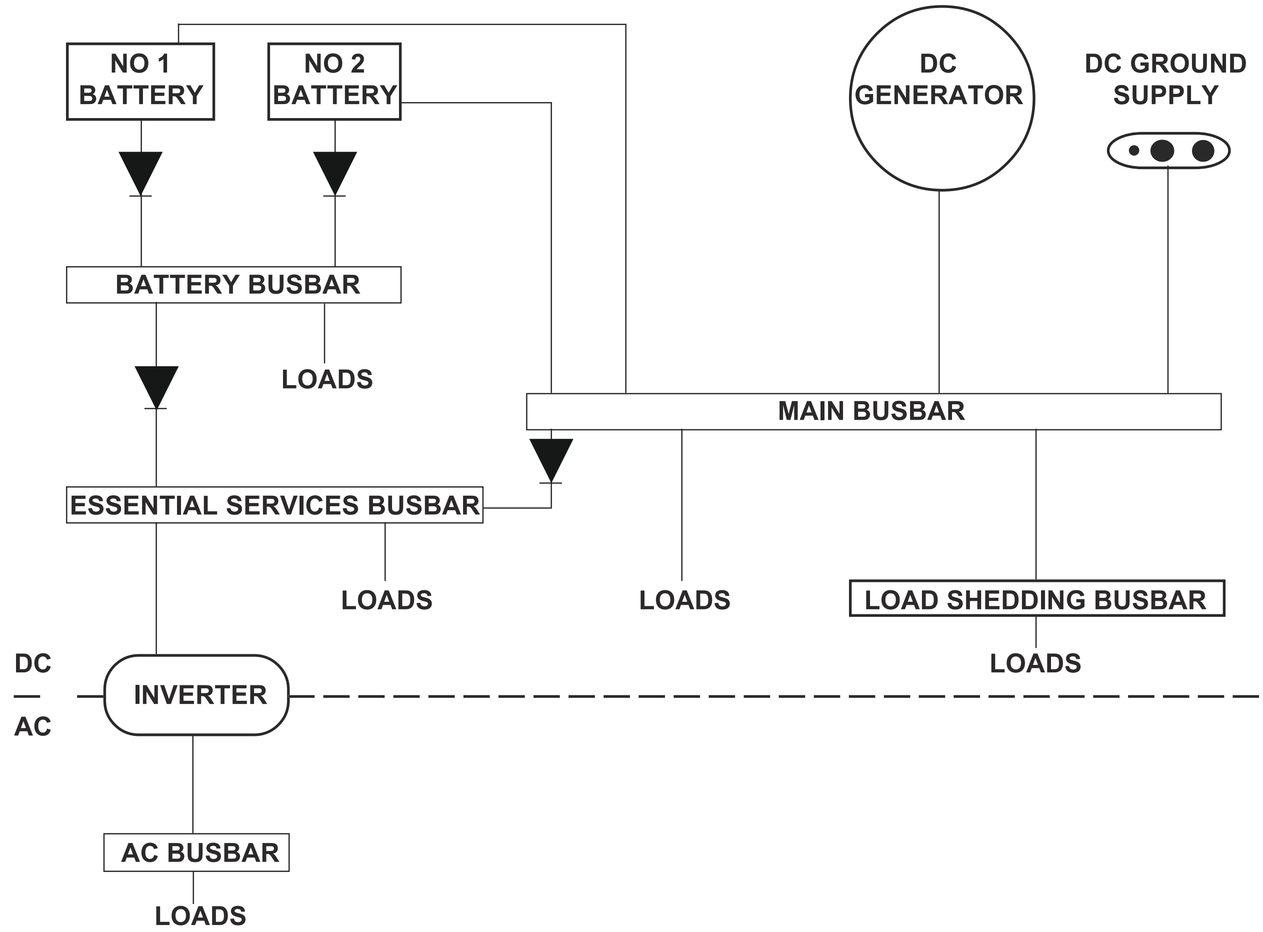
2. The ground supply can be used for engine starting and ground maintenance but not for charging the aircraft batteries.

3. An ELECTRICS panel in each cockpit (Fig 2) controls the electrical system. The switches on the rear cockpit panel override selections made by switches on the front cockpit panel. The front pilot has control of a function when the corresponding gated switch in the rear cockpit is set to FRONT.

4. Each ELECTRICS panel has a 3-scale DC voltammeter which displays generator voltage and current, main busbar voltage and, by use of a switch, the voltage of each battery. Captions on a central warning panel (CWP) in each cockpit indicate generator failure, inverter failure and circuit breaker tripped (see para 24).

5. If the generator fails in the air, the load shedding busbar and No 2 battery are automatically isolated from the main busbar to conserve power and may be restored selectively by switches on the ELECTRICS panels. Those switches which are gated to a selection are of the pull-to-unlock type. Weight switch relays prevent the isolation of No 2 battery and automatic load shedding if the generator fails on the ground. The positive supply to energize the weight switch relays is connected in series through two weight-on-ground switches, one on the right landing gear and one on the left. The switches operate as the oleos extend after take-off.

6. Circuit breakers protect the electrical systems from overload conditions, and are set to trip if the current reaches a preset value.



1 - 1 Fig 1 Electrical Systems - Simplified Schematic

DESCRIPTION

Power Supplies

7. All switches and indicators for the electrical supply are on the ELECTRICS panel on the right console in each cockpit (Table 1). A switch in the front cockpit only controls a function when the corresponding switch in the rear cockpit is selected to FRONT. 28-volt DC and 115 volt AC test sockets are in the avionics bay.

8. **DC Starter/Generator.** 28-volt DC is provided by an engine-driven 6 kW DC starter/generator on the upper left side of the engine; the starter/generator is driven directly from the gearbox. This unit functions as a starter on the ground until RPM reach 60% when the unit changes function and becomes a generator. The starter/generator is controlled by the generator control and protection unit (CPU) and is selected on by selecting the GENerator switch from OFF to ON/RESET (Fig 3). Any attempt to start the engine with the GENerator switch selected OFF may cause the engine to overheat.

9. **Generator Control and Protection.** The generator outputs of voltage and current are controlled by the CPU. While the starter/generator is in starting mode an output from the CPU illuminates the amber GEN caption on each CWP. The engine electronic controller causes the CPU to terminate the start cycle at 60% RPM; closure of the line contactor then connects the generator output to the main busbar (providing the crash switches have not been tripped) and the GEN captions go out. The CPU regulates voltage to 28·5±0·5volts and trips if output exceeds 30 to 31 volts. The generator is disconnected from the main busbar by a reverse current cut-out. On loss of generator output, the CPU de-energizes the line contactor which causes the GEN captions to be illuminated and, in the air, isolates the load shedding busbar.

10. **Batteries.** Two 24-volt nominal, 24 ampere-hour sealed lead acid batteries are provided. No 1 is just forward of the front rudder bar mechanism and No 2 above the engine exhaust, protected by the firewall. The batteries are permanently connected in parallel, via diodes, to the battery busbar. They are connected to the main busbar via contactors and are charged from the main busbar when the generator is on-line and the contactors are closed by selecting the battery switches ON.

a. **Battery Output Voltage.** BATtery 1 or BATtery 2 voltage can be read on the BUS scale of the voltammeter on each of the ELECTRICS panels by selecting the adjacent spring-loaded VOLTS switch to BAT 1 or BAT 2.

b. **Battery Temperature.** The BATT T caption on the CWP and the O/HEAT indicators on the Electrics Panel are inoperative.

11. **Ground Supply.** An external 28-volt DC standard NATO 3-pin supply socket is behind an access panel on the right side of the fuselage aft of the wing. Both battery switches must be selected OFF to enable the ground supply contactor to operate and allow ground power to the aircraft systems. The aircraft batteries cannot be charged in situ by the external ground supply. Ground power is supplied via the ground supply contactor to the main busbar and to all services (including engine start) except those supplied from the battery busbar. The ground supply input is monitored by an overvoltage detector which disconnects the aircraft systems from the ground supply if the input voltage rises above 32 volts. The ground supply is isolated automatically when the generator comes on line. While the ground supply is being used the GEN caption on each CWP and the amber GPU ONLINE indicator on the ELECTRICS panels are illuminated. If the BATTERY switches are selected ON while the ground supply is in use, the batteries are connected to the main busbar automatically when the ground supply is switched off. The GPU ONLINE indicator also goes out as soon as the ground supply contactor opens, which occurs when the ground supply is switched off or when the generator comes on line.

Note: The indicator extinguishing does not indicate that the ground supply source has been disconnected.

12. **Undervoltage Detector.** The undervoltage detector monitors the voltage on the main busbar at all times. On loss of generator output, the resultant undervoltage (below 26 volts) on the main busbar causes the undervolt detector to operate and, in the air, disconnect No 2 battery from the main busbar and provide an alternative positive supply to illuminate the GEN captions.

Note: The alternative supply to the GEN captions ensures that they are illuminated in the event of the line contactor sticking in the energized position on loss of generator output supplies.

Power Distribution

13. Fig 1 is a simplified schematic diagram which shows the layout of the busbars. The services (and the loads they take) supplied by the battery, main, essential services and load shedding busbars are listed in Table 2. Control of power supplies to the various busbars is either automatic or by switch selection from the ELECTRICS panels.

14. **Battery Busbar.** The battery busbar is supplied, via diodes, from the two batteries. It is always live when the batteries are connected to the aircraft. This busbar supplies the control circuits for fuel and hydraulic cut-off during an emergency.

15. **Main Busbar.** The main busbar is supplied from either the batteries or the starter/generator or a ground supply. Distribution from this busbar is to:

a. The essential services busbar via a diode.

b. The load shedding busbar via a contactor.

c. The battery busbar via battery contactors and diodes when the generator output is connected to the main busbar.

16. **Battery Contactors.** A battery contactor connects the relevant battery and the battery busbar to the main busbar and can function provided that:

a. The crash switches have not tripped.

b. There is no external ground power being supplied.

17. **Battery Contactor Operation.** No 1 battery contactor is operated by selecting a pilot's BATTERY 1 switch ON. No 2 battery contactor is similarly operated by selecting a pilot's BATTERY 2 switch ON but only if one or more of the following conditions are met:

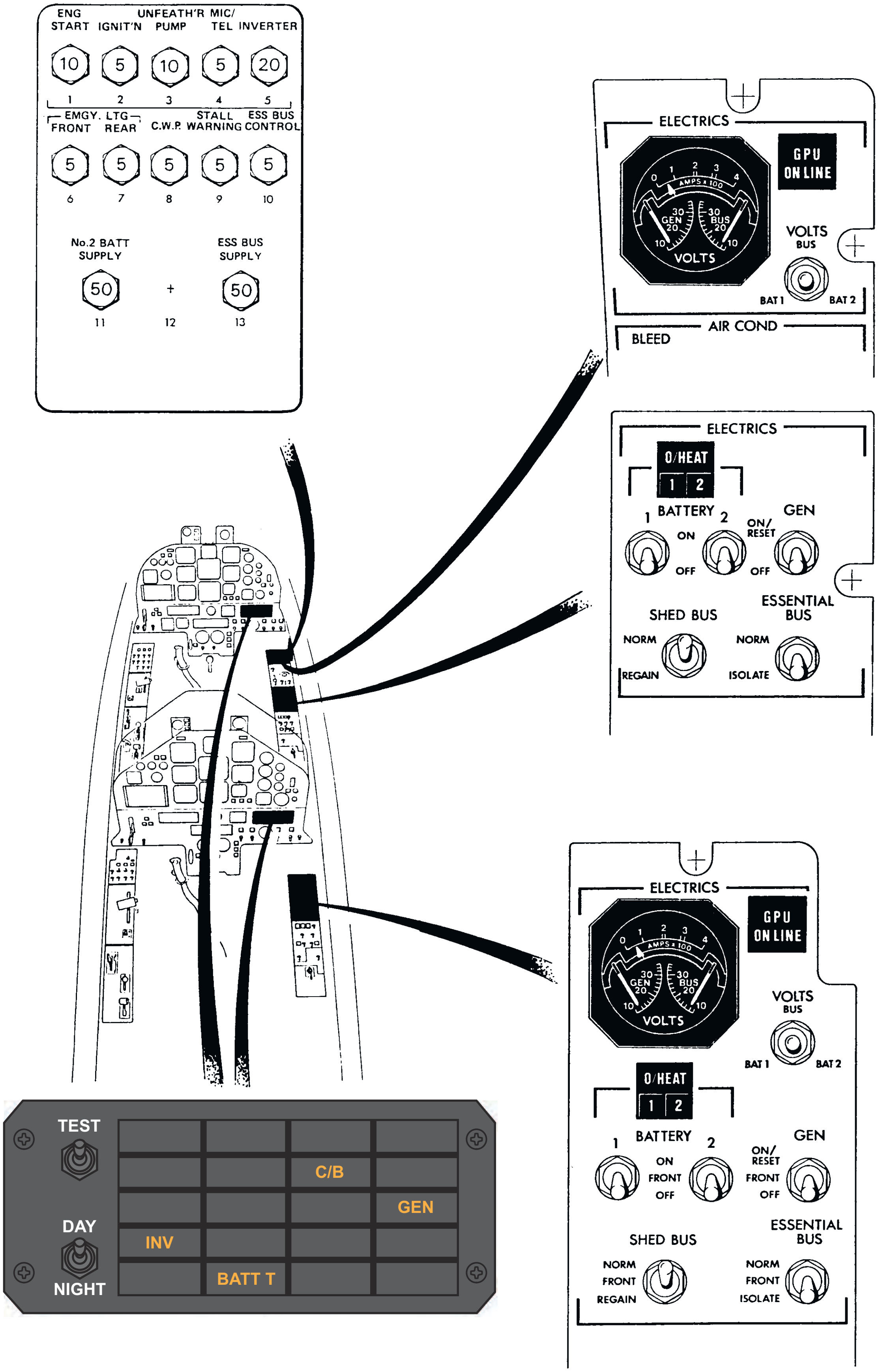
a. The aircraft is on the ground.

b. In the air, no undervoltage has been detected.

c. In the air, a line contactor induced load shedding has been overridden by a pilot's SHED BUS switch being selected to REGAIN.

Table 1 - Electrical System Controls and Indicators

Item	*Marking*	*Function*
On each CWP:		
Inverter warning caption	INV (amber)	Indicates no output from inverter
Battery temperature caption	BATT T (amber)	Inoperative
Generator warning caption	GEN (amber)	Indicates that voltage at main busbar is below 26 volts, or generator not on line
Circuit breaker tripped caption	C/B (amber)	Indicates an open or defective circuit breaker rated up to and including 10 amps
On each ELECTRICS Panel:		
Voltammeter (3-scale):		
Upper scale	AMPS	Reads generator current
Left scale	GEN VOLTS	Reads generator volts
Right scale	BUS VOLTS	Reads main busbar volts or No 1 or No 2 battery volts
Ground power indicator	GPU ON LINE (amber)	Indicates that supply is being taken from ground power source
Voltammeter switch	VOLTS - BAT 1/BUS/BAT 2	Selects voltammeter's right scale to read No 1 battery or No 2 battery voltage. Spring-loaded to centre for main busbar voltage reading
Battery overheat indicator 1/2 (amber)	BATTERY O/HEAT	Inoperative
*Battery switches ON/OFF	BATTERY 1/2	Connect associated battery to main busbar
*Generator control switch	GEN - ON/ RESET/ OFF	Enables generator on line/off line selection
*Load shedding switch	SHEDBUS NORM/REGAIN	Brings load shedding busbar and No 2 battery on line after automatic load shedding. Gated to NORM
*Essential busbar switch	ESSENTIAL BUS NORM/ISOLATE	Isolates the essential services busbar
*These switches on the rear ELECTRICS panel have an additional gated central position marked FRONT. The respective switches on the front ELECTRICS panel function only when the rear panel switches are at FRONT.		
On Front Circuit Breaker Panel:		
Circuit breaker	INVERTER 5	Overload protection
Circuit breaker	ESS BUS CTRL 10	Overload protection
Circuit breaker	No2 BATT SUPPLY 11	Overload protection
Circuit breaker	ESS BUS SUPPLY 13	Overload protection



HS/TUC/1-1-fig2/0016

1 - 1 Fig 2 Cockpit Controls and Indicators

18. **Essential Services Busbar.** The essential services busbar is supplied with power by two routes:

a. Via a diode, from the main busbar.

b. Via a contactor and a diode, from the battery busbar. This contactor is operated by selecting the ESSENTIAL BUS switch to NORM (provided the crash switch has not tripped).

19. **Load Shedding Busbar.** The load shedding busbar is supplied, via a contactor, from the main busbar. The load shedding busbar is disconnected automatically (together with its loads) if main busbar volts reduce to below 26 volts in the air (e.g. if the generator fails); these electrical loads may then be altered by selective switching and the busbar regained by selecting the SHED BUS switch, which is gated to NORM, to REGAIN. This action of the switch also reconnects No 2 battery to the main busbar. On the ground the weight switch relays cause the undervolt detector to be bypassed and a connection between the main busbar and the load shedding busbar is maintained.

20. **AC Busbar.** The 250 volt-ampere static inverter is fed automatically from the essential services busbar, via a circuit breaker labelled INVERTER (5) on the forward circuit breaker panel on the right in the front cockpit (see Fig 2 and Fig 4); this inverter supplies the 115 volt, 400 Hz, single-phase AC busbar. The services supplied by the AC busbar are the normal cockpit instrument lighting and the servo altimeters. If the inverter fails, the amber INV caption on both CWP is illuminated. If the failure is due to an external fault, overload, etc, the inverter resets itself when the fault is removed. The INV captions then go out.

INDICATORS

21. **Voltammeters.** The voltammeters, one on each ELECTRICS panel in each cockpit, give continuous readings on three separate scales of the following:

a. Generator total current load, on the top scale calibrated from 0 to 4 AMPS x 100 (inoperative during start).

b. GENerator voltage output, on the left scale calibrated from 10 to 36 VOLTS.

c. Main BUSbar voltage on the right scale calibrated from 10 to 36 VOLTS. BATtery 1 or BATtery 2 voltages can also be read on this scale when selected by a VOLTS switch adjacent to the meter; the switch is biased to its central (BUS) position.

22. **Ground Power Indicators.** The GPU ON LINE indicators, one on each ELECTRICS panel, are illuminated when external ground power is being supplied.

23. **Battery Overheat Indicators.** The battery O/HEAT - 1/2 indicators, one on each ELECTRICS panel, are inoperative.

Circuit Breakers

24. The circuit breakers are shown in Fig 4. When a circuit breaker (rated up to and including 10 amps) trips, a C/B caption on the CWP is illuminated.

Crash Protection

25. **Inertia Switches.** Each of two inertia switches (below the front cockpit) has a dedicated crash relay. The normally closed contacts of these relays are in the actuation circuits for the line contactor, No 1 battery contactor, No 2 battery contactor and the essential services busbar contactor. In a longitudinal deceleration of 4·5g or more, the inertia switches close and energize the crash relays and the normally closed contacts open. One relay de-energizes the contactor for No 1 battery and the line contactor; the other relay de-energizes the contactors for No 2 battery and the essential services busbar. Thus all power is removed from all busbars, except the battery busbar which remains connected to the batteries.

NORMAL USE

Before Flight

26. Before carrying out the External checks ensure that the aircraft is electrically safe by checking that the rear cockpit BATTERY and ESSENTIAL BUS switches are selected to FRONT, the front cockpit BATTERY switches are OFF and ESSENTIAL BUS switch is at ISOLATE and that the DC ground supply is not connected.

27. **Starting on Internal Batteries.**

a. Check that all the rear cockpit switches are selected to FRONT.

b. With BATTERY 1 & 2 switches OFF check that the GEN switch is to ON/RESET and the SHED BUS switch is to NORM. Select the ESSENTIAL BUS switch to NORM, check that CWP captions are illuminated; then select ISOLATE (captions out). Set BATTERY 1 & 2 switches ON and check that CWP captions are illuminated. Selectively switch first BATTERY 1 OFF then ON and then BATTERY 2 and check that each battery by itself gives a minimum reading of 24 volts. Leave both batteries set ON.

Note: If the battery voltage is above 24 volts the engine may be started using either the internal batteries or a ground supply. If either battery voltage is between 24 and 22 volts a ground supply is to be used for starting. If either battery is below 22 volts a start is not to be attempted.

c. Select the ESSENTIAL BUS switch to NORM. Check that the GEN caption is illuminated and the INV and C/B captions are out.

28. **After Engine Starting on Internal Batteries.**

a. Check that the GEN caption is out. If the GEN caption remains illuminated, set the GEN switch to OFF and back to ON/RESET and check that the caption goes out.

b. Check that GEN VOLTS and BUS VOLTS indicate between 27 and 29 volts.

29. **Before Engine Starting on Ground Supply.**

a. Carry out the procedures at sub paras 27a and 27b but check that each battery gives a minimum reading of 22 volts and select BATTERY 1 & 2 switches OFF.

b. Have the ground supply plugged in and switched on. Check that the GPU ON LINE caption is illuminated and BUS VOLTS reads a minimum of 25 volts. Then switch BATTERY 1 & 2 ON and select the ESSENTIAL BUS switch to NORM.

c. Check the GEN caption is illuminated and that the INV and C/B captions are out.

Note: An engine start may be made with the battery voltage down to 22 volts; when the generator comes on line the batteries are to be allowed to charge for at least 20 minutes before a take-off is attempted.

30. **After Engine Starting on Ground Supply**

a. Check that the GEN and GPU ON LINE captions are out.

b. Have the ground supply switched off and disconnected.

c. Check that the GEN VOLTS and BUS VOLTS indicate between 27 and 29 volts.

d. Check that both batteries are connected to the main busbar by checking that the BUS VOLTS indicates between 27 and 29 volts when the spring-loaded VOLTS switch is selected to BAT 1 and BAT 2 in turn.

e. Before take-off ensure the AMPS indication does not exceed 100 amps (with landing lamp OFF).

In Flight

31. In flight, check that the GEN, INV, and C/B captions remain out, that GEN VOLTS and BUS VOLTS indicate between 27 and 29 volts and that there is no abnormal unexplained AMPS reading (normally about 80 amps with landing lamp ON).

After Flight

32. During the **Shutdown Checks**, switch off all electrical services and then, a minimum of five seconds after RPM have decreased below 10%, switch OFF the BATTERY switches. The ESSENTIAL BUS switch is to be set to ISOLATE and all rear cockpit switches set to FRONT. If the GEN caption remains illuminated after shutdown, select the SHED BUS switch to NORM.

USE IN ABNORMAL CONDITIONS

Ground Supply Contactor Failure

33. If the GPU ON LINE light remains on when the generator is brought on line (GEN caption out), power from the aircraft batteries is not available and the aircraft is not to be flown.

Generator Failure

34. Generator failure is indicated by the GEN caption being illuminated. Set the GEN switch to OFF and back to ON/RESET to bring the generator back on line. If the fault was transient the GEN caption goes out; if it does not, select the GEN switch to OFF. If, in the air, the generator does not reset, No 1 battery only supplies all electrical loads on the main busbar and No 1 and No 2 batteries jointly supply the essential services and battery busbars. Only the services connected to the load shedding busbar are lost.

35. Following the loss of the generator in the air, bus voltage decreases immediately to that of the No 1 battery, i.e. approximately 24 volts, No 2 battery having been automatically disconnected from the main busbar by the undervoltage detector together with the load shedding busbar. Select off or leave off any of the services on the load shedding busbar that are not required. Select the SHED BUS switch to REGAIN; this makes the services on the load shedding busbar available again (see Table 2 for loads) and reconnects No 2 battery to the main busbar. Monitor battery volts. Land as soon as possible because battery operation of the essential loads cannot be guaranteed for more than 30 minutes. Shutdown the engine when clear of the runway.

Inverter Failure

36. Inverter failure is indicated by the INV caption being illuminated. Check the INVERTER circuit breaker (5). If the circuit breaker is tripped, wait ten seconds and then reset; check that the INV caption goes out. If the circuit breaker is made, pull and reset and check that the INV caption goes out. If the caption remains on pull the circuit breaker and do nothing further to regain the inverter. The following services are lost:

a. Normal cockpit instrument lighting.

b. Electroluminescent panels.

c. Servo altimeters.

d. All heading references (except the standby compass).

e. Horizontal situation indicator bearing needles.

f. Traffic Alert and Collision Avoidance System (TCAS).

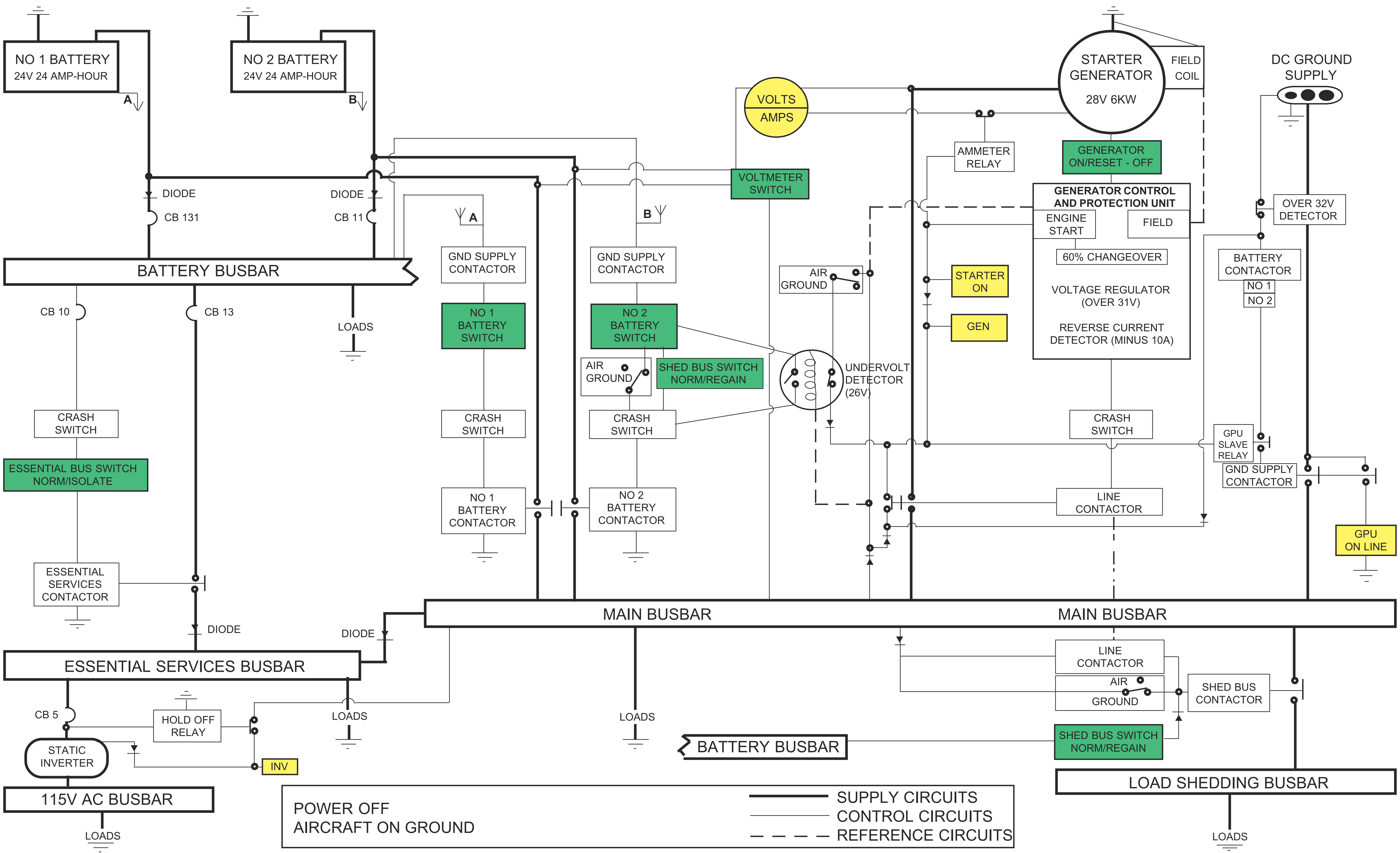
Circuit Breakers

WARNING: If more than one circuit breaker trips this may indicate an electrical fault which may lead to a wiring loom fire or overheat. Do not attempt to reset the circuit breakers. Land as soon as possible. If tripped circuit breakers are accompanied by smells, smoke or fumes carry out the **FRC Smoke or Fumes** drill.

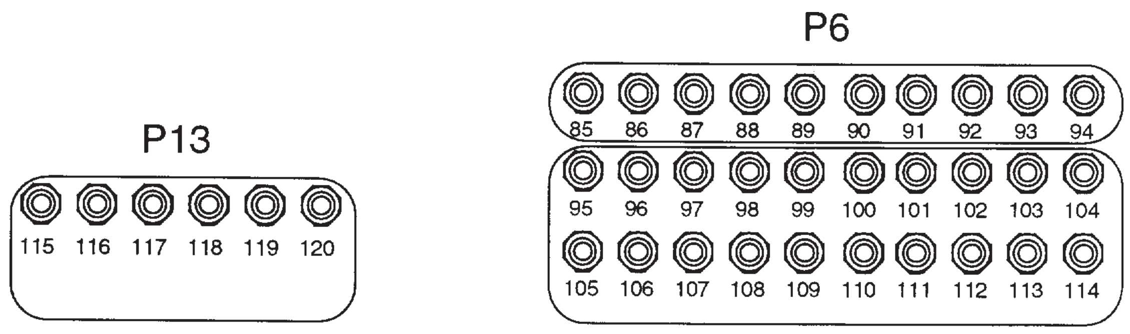
37. It is permissible to reset a circuit breaker in flight after waiting ten seconds; only one attempt is to be made to regain a system. A circuit breaker is not to be reset if it trips a second time. If service lost is critical or caption remains on and cause cannot be positively identified, land as soon as practicable.

Essential Busbar Failure

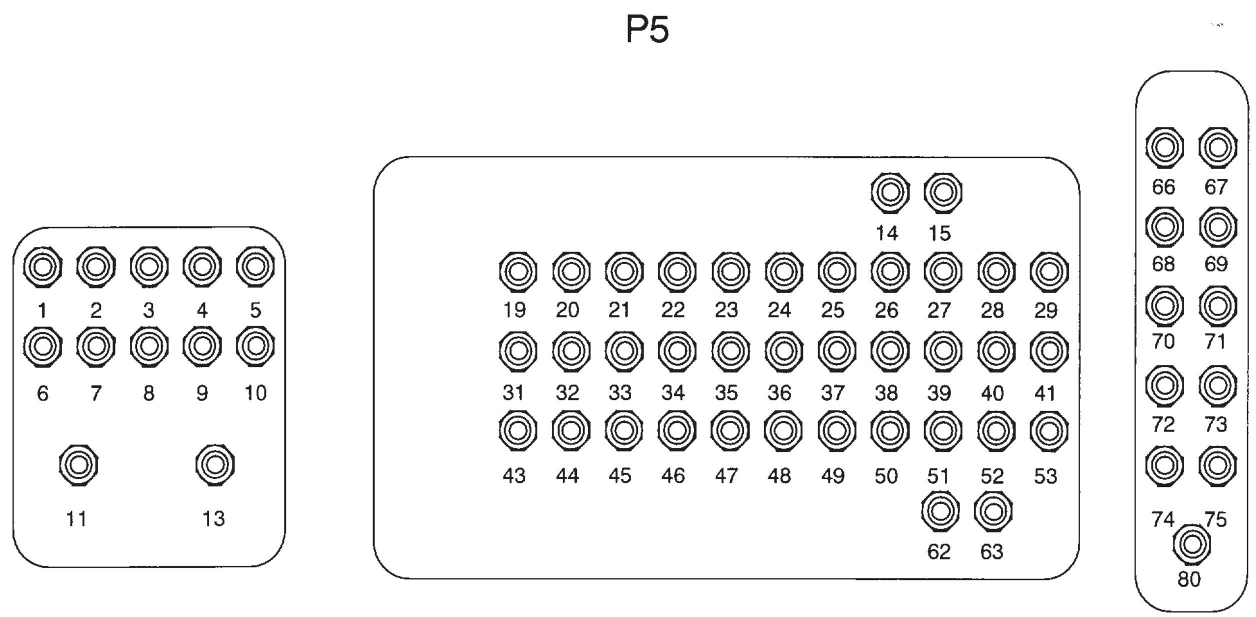
38. The **Pre-Start** electrical panel checks are designed to check the two routes for the power supply to the essential services busbar. If, having followed the checks, both routes are shown to be satisfactory, essential services busbar failure has a low probability. If the essential services busbar does fail (unique indications: torque 100%, RPM zero, turn-and-slip and standby AI flags showing), intercom and radio fail, there is a marked reduction in engine torque, there are no CWP warnings or cockpit lighting and many other services are lost. Check the ESS BUS CONTROL (10) and ESS BUS SUPPLY (13) circuit breakers and reset (once only) if necessary. If the busbar cannot be regained, land as soon as possible using the standby lowering system to lower the landing gear. Note the flap position in order to plan the type of approach. Limit throttle movement as the EGT limit in MANual is 560°C and the EGT gauge is inoperative. Do not use REVerse thrust on landing or on shutdown.



1 - 1 Fig 3 Electrical Power Distribution - Simplified



Rear Cockpit



Front Cockpit

NOTE: For the key to circuit breaker identification numbers, see Table 2.

1 - 1 Fig 4 Circuit Breaker Panels

Table 2 - Busbar Loads

LOAD SHEDDING BUSBAR					
CB	*Load*	*Amps*	*CB*	*Load*	*Amps*
*132	Taxi lamp	16·0	* 72	Air Conditioning	2·0
* 133	Landing lamp (left)	16·0	67	Propeller heater control	1·0
* 134	Landing lamp (right)	16·0	74	Fuel flow indicators	0·7
* 80	Propeller heater	12·0	* 73	Engine intake anti-ice	0·5
* 66	AOA heater	8·0	71	Rear pitot static indicator	0·2
* 68	Rear pitot static heater	4·5	69	AOA heater fail indicator	0·1
* 70	Strobes	4·5	75	Servo altimeter vibrator	0·1
* These items may be isolated/regained by selective switching					

28V DC ESSENTIAL SERVICES BUSBAR					
CB	*Switchable Load*	*Amps*	*CB*	*Switchable Load*	*Amps*
53	Flap motor supply	20·0	62	Rear cockpit background lamps	0·87
47	Fuel pump starboard main	6·5	52	Flap motor control	0·5
48	Fuel pump port auxiliary	6·5	** 4	Microphone and emergency tels amplifiers	0·5
39	Dim/test units	3·0	20	Transponders	0·5
21	U/VHF system	1·0	**6	Front cockpit emergency lamps	0·15
63	Front cockpit background lamps	0·87	**7	Rear cockpit emergency lamps	0·15

CB	*Non-Switchable Load*	*Amps*	*CB*	*Non-Switchable Load*	*Amps*
**1	Engine start control	1·5	31	AOA & stall warning	2·0
**2	Ignition	4·5	32	Beta baulk retraction	2·0
**3	Unfeathering pump	2·0	33	Oxygen indicators	0·1
**5	Inverter	2·7	34	EGT amplifier	0·1
**8	Central warning system	0·2	35	RPM gauges	0·25
**9	Stick Shaker	1·0	36	Fire detection	0·3
14	Circuit breaker tripped caption	0·2	37	Oil pressure indicators	0·1
15	Front CCS station box	0·5	38	Accident data recorder	3·0
19	Rear CCS station box	0·5	40	Landing gear position indicator	0·2
22	Front combined speed indicator	0·1	41	Landing gear control	0·5
23	Rear combined speed indicator	0·1	43	Oil pressure warning indicator	0·1
24	Front turn & slip indicator	0·1	44	Oil temp indicators	0·1
25	Rear turn & slip indicator	0·1	45	Hyd press warning	2·0
26	Front standby altimeter	0·1	46	Fuel press warning indicator	0·2
27	Rear standby altimeter	0·1	49	Low fuel warning	0·2
28	Front standby attitude indicator	0·1	50	Trim tab indicators	0·2
29	Rear standby attitude indicator	0·1	51	Flap position indicator	0·1
**These items are on the front cockpit forward circuit breaker panel					

28V DC MAIN BUSBAR					
CB	*Switchable Load*	*Amps*	*CB*	*Switchable Load*	*Amps*
103	Ice detection system	10·0	94	Airbrake control and indication	3·0
85	Fuel pump left main	6·5			
86	Fuel pump right auxiliary	6·5	107	Navigation lights	3·0
100	Front pitot static heater	4·5	106	Landing/taxi lights control	2·0
95	Elevator trim	4·5	119	Tacan	1·5
96	Aileron trim	4·5	118	VHF navigation receiver	1·2
97	Rudder trim	4·5	104	Pitot static heat auto control	0·6
112	Front seat position motor	4·0	108	Front utility lamp	0·15
113	Rear seat position motor	4·0	109	Rear utility lamp	0·15

CB	*Non-Switchable Load*	*Amps*	*CB*	*Non-Switchable Load*	*Amps*
87	Fuel contents indicators	0·2	102	OAT indicator	0·1
88	Front cockpit HSI	0·1	105	Trim control	0·1
89	Rear cockpit HSI	0·1	111	Canopy unlocked indicators	0·1
90	Front cockpit TCAS	2.0	110	Parking brake indicators	0·5
91	Rear cockpit TCAS	2.0	114	DC power control	0·5
92	Power supply socket	0·2	115	UHF/VHF No1 and No 2	4·0
93	Inverter fail indicator	0·2	116	UHF/VHF, UUPI & tone generator	4·0
98	Front attitude indicator	0·55	117	Directional gyro	2·0
99	Rear attitude indicator	0·55	120	Navigation changeover	0·7
101	Front pitot static indicator	0·2	136	Essential services busbar supply	Bus Load

28V DC BATTERY BUSBAR					
CB	*Switchable Load*	*Amps*	*CB*	*Switchable Load*	*Amps*
**10	Essential services busbar contactor	2·0	129	No 1 battery contactor	2·0
**13	Essential services busbar supply	Bus	130	No 2 battery contactor	2·0
		Load	137	No 1 battery voltameter switch	0·0
127	Fuel/hyd cut off	2·0	138	No 2 battery voltameter switch	0·0
128	Load shedding busbar contactor	2·0	139	CPU control	1·0

CB	*Non-Switchable Load*	*Amps*	*CB*	*Non-Switchable Load*	*Amps*
**11	No 2 battery busbar supply	Bus Load	131	No 1 battery busbar supply	Bus Load
**These items are on the front cockpit forward circuit breaker panel					

PART 1

CHAPTER 2 - CENTRAL WARNING SYSTEM

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INTRODUCTION

General

1. The central warning system (CWS) gives warnings of failures or events in the aircraft systems which require prompt action to ensure the safety of the aircraft. The CWS consists of a central warning panel (CWP) and two attention getters in each cockpit, and an audio warning unit which operates through the headphones.

2. The failures and events appear as red or amber captions on the CWP. The red captions are accompanied by an audio warning; they indicate a more hazardous condition than those signified by amber captions. Each caption is illuminated by two single filament lamps whenever the captions control circuit is activated by the associated aircraft system exceeding a limitation or deviating from normal operating parameters. When appropriate remedial action is taken the CWS resets itself; it is self cancelling if activated by transient failures or events. Power for the CWS is supplied from the essential services busbar. A circuit breaker (labelled CWP) in the power supply line is on the forward circuit breaker panel on the right in the front cockpit.

DESCRIPTION

Central Warning Panel

3. A CWP (Fig 1) is on the right hand side of the lower main instrument panel in each cockpit and the captions and their meanings are listed in Table 1.

4. The layout of the captions on each CWP is identical, and in the event of a hazardous condition or a failure of any of the systems being monitored, identical captions are lit on both panels.

5. **Test Switch.** A TEST switch is on each CWP. The switch is spring-loaded from TEST to the centre (off) position. When selected and held to TEST, a supply from the essential services busbar is fed to the CWP and the filaments of all unlit captions on both CWP illuminate, the attention getters in both cockpits flash and the audio warning sounds in the headsets; the test switch also activates all other unlit warning and

information captions in the cockpits (except the MARKER light). When the switch is released, all captions which were not lit before TEST was selected go out and the attention getters and the audio warning are cancelled. If, while the switch is held at TEST, an attention getter is pressed, the attention getter and the audio warning are cancelled.

6. **Day/Night Switch.** A DAY/NIGHT switch is on each CWP. When selected to NIGHT, the angle-of-attack (AOA) indexer (removed post-SM109 (FLARM)) and all cockpit warning and information captions, with the exception of the red captions (and MARKER light), operate at a reduced intensity. When selected to DAY all captions operate at normal intensity.

Attention Getters

7. The two attention getters in each cockpit are integrally lit, spring-loaded panels which incorporate a cancelling facility. When a CWS control circuit is activated, both attention getters in each cockpit flash and the caption associated with the fault is illuminated on the CWP. Pressing any one of the attention getters cancels all attention getters but the caption associated with the fault remains illuminated. If, after the attention getters have been manually cancelled, the CWS circuits are activated by another fault condition the attention getters resume flashing. If the flashing circuit fails to operate when the CWS control circuits are operated, the attention getter lights remain on steady.

Fire Detection and Warning

8. An integrity-monitoring fault free fire detection (FFFD) and warning system is linked to the CWS. A temperature-sensitive firewire is fitted around the exhaust flange and the engine support frame adjacent to the hot section; the firewire connects with a control unit behind the firewall.

9. Resistance and capacitance in the firewire change with temperature; above a critical temperature they change sufficiently to trigger the control unit. The unit then connects power from the essential services busbar to illuminate the FIRE caption (red) on the CWP.

10. If a system defect occurs which impairs the capability to provide operational warning of a fire or overheat condition, the control unit illuminates the FIRE DET caption (amber) on the CWP.

11. **Test Facility.** A FIRE DETect test switch is on the lower right of the main instrument panel in each cockpit. When held at FIRE TEST and FAULT TEST in turn, full operational warnings for the respective selections confirm serviceability of the system.

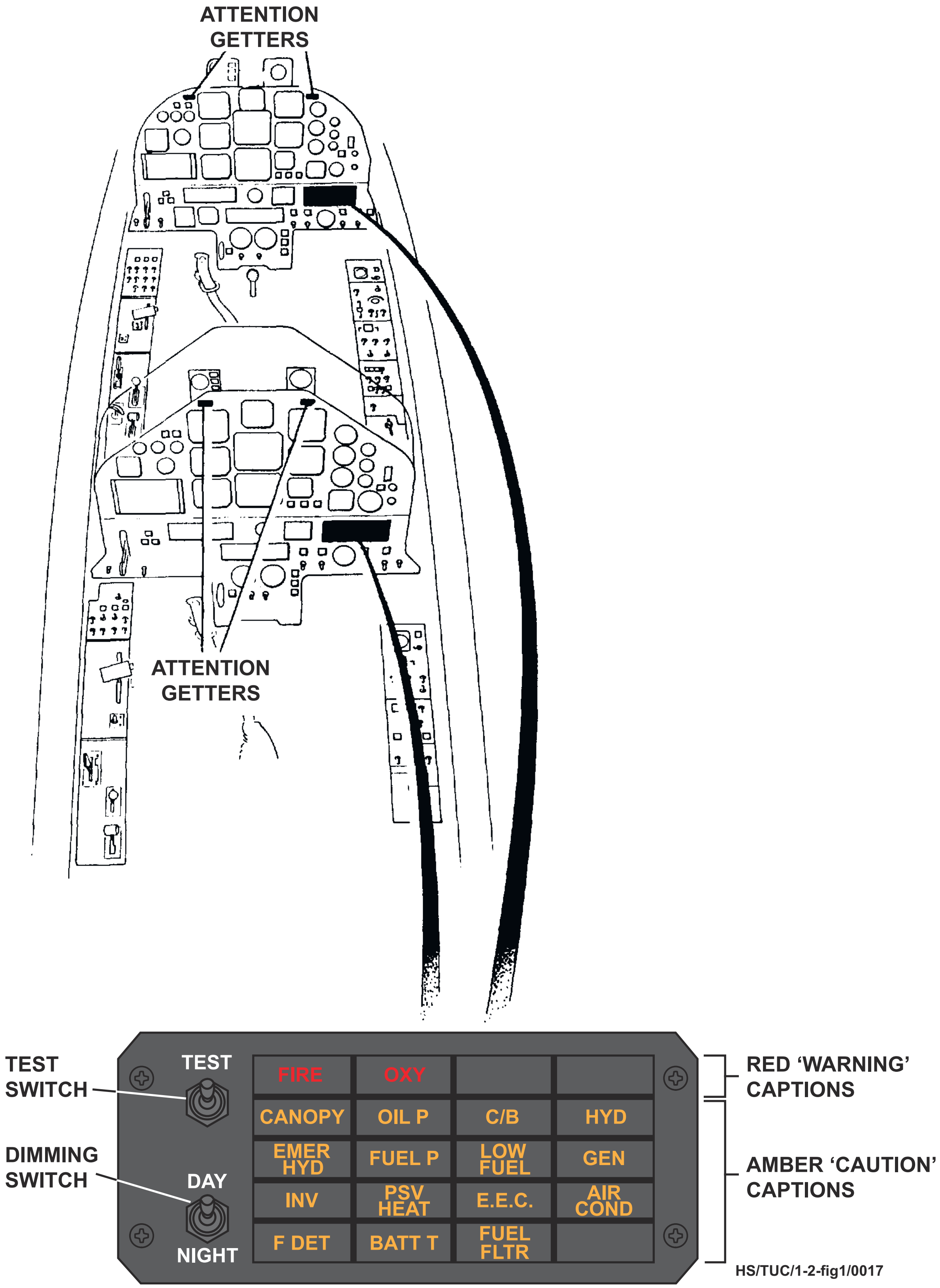
Audio Warning

12. When a failure or an event associated with a red CWP caption activates the CWS control circuits, a tone generator provides an audio warning (swept tone) in the headphones in each cockpit. Pressing any attention getter cancels this audio warning.

Note: A different audio warning (pulsed tone) is activated by other systems not associated with the CWS. These are overspeed, high g and high AOA. This warning is described under Communications Control System in Chapter 13 (see also Stall Warning in Chapter 6). TCAS aural warnings are outlined in Chapter 13.

Table 1 - Central Warning Panel Captions.

RED CAPTIONS	
Caption	*Indicating*
FIRE	Fire in the engine bay
OXY	Low oxygen pressure (below 3·1 bar to 3·45 bar)
AMBER CAPTIONS	
Caption	*Indicating*
CANOPY	Canopy unlocked
OIL P	Low engine oil pressure (below 2·8 bar) (subject to 20-second delay)
C/B	Open or defective circuit breaker*
HYD	Hydraulic oil low pressure (below 158·6 bar) or hydraulic oil high temperature (above 107°C)
EMER HYD	Low emergency hydraulic pressure (below 158·6 bar) or emergency shut-off valve has failed to close after take-off
FUEL P	Low fuel pressure (below 0·41 bar) or individual pump failure
LOW FUEL	Low fuel content (below 35 kg in either tank)
GEN	DC generator off line or failure or output below 26 volts
INV	Inverter failure
PSV HEAT	Pitot, static, stall warning vane or AOA vane heater failure
EEC	Engine electronic control defect (or manual mode selected)
AIR COND	Air conditioning failure (over pressure 7·3 ± 0·3 bar) (over temperature 90 ± 5°C)
F DET	Fire detection failure
BATT T	Inoperative
FUEL FLTR	Pressure drop across fuel filter in excess of 0·0964 bar
* Only circuit breakers rated up to and including 10 amps	



1 - 2 Fig 1 CWP and Attention Getters (Front and Rear Cockpits)

NORMAL USE

Before Flight

13. Before starting the engine, when either the batteries are switched ON or external power is connected and switched on, check that the CANOPY, OIL P, HYD, FUEL P and GEN captions are illuminated. Check that when a CWP test switch is held at TEST, all unlit captions on both CWP are illuminated, the attention getters and audio warning tone are activated and all other warning and information lights in the cockpit (except the MARKER light) are illuminated. Select the FIRE DET switch to FIRE TEST and check that the FIRE caption is illuminated and attention getters and audio warning tone are activated; select to FAULT TEST and check that the F DET caption is illuminated and the attention getters are activated. When the test switches are released, check that all indications revert to the pre-test state, the audio warning ceases and the attention getters extinguish.

Note: If the aircraft hydraulic system has been serviced before flight, the EMERG HYD caption is also illuminated when power is switched on.

14. After starting the engine check that all CWP captions are out.

After Flight

15. After landing select the FIRE DET switch to FAULT TEST and check that the F DET caption is illuminated and then goes out when the switch is released.

USE IN ABNORMAL CONDITIONS

Audio Warning

16. An electrical fault within the CWS can cause an audio warning to sound continuously and in isolation. Radio communication is affected.

17. If, during a flight, a g exceedance activates the audio warning, the warning self cancels as soon as the exceedance ceases; however, the audio warning is subsequently reactivated as soon as engine RPM decrease below 90%. This normally occurs after landing but also occurs if the engine is shut down in flight (e.g. fire or mechanical failure). The audio warning sounds continuously until the DAPU is dumped post flight.

18. A continuous audio stall warning (except speed and g exceedance) may be silenced by pulling circuit breaker 31 (AOA indicator); all AOA information and the audio stall warning are then lost. The stick shaker remains operative in the approach configuration.

19. The audio warning can also be silenced by pulling circuit breaker 4 (MIC/TEL); however, if this is done, the main U/VHF radio is inoperative and the standby UHF radio must be selected. The AOA indicator remains operative. If the CCS station box amplifier selector is at FAIL all communication is lost if c/b 4 is pulled.

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PART 1

CHAPTER 3 - FUEL SYSTEM

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INTRODUCTION

General

1. Fuel is stored in one integral tank in each wing. Each tank has two cells and a collector tank. The tanks are gravity refuelled or defuelled, and have a pressure defuel facility for use in emergency. Booster pumps, associated with each tank, maintain a constant supply of fuel to the engine at low pressure in any approved flight attitude.

DESCRIPTION

Fuel Tanks

2. The inboard cell of each fuel tank extends from the wing root along the wing leading edge. The outboard cell is offset to the rear and occupies the inter-spar area (Fig 1). Each inboard cell has a collector tank containing 9·6 kg, which ensures a fuel supply to the booster pumps during aerobatic manoeuvres. The minimum guaranteed capacity of usable fuel in each tank is 277 kg. The amount of fuel is measured by a capacitance type gauging system.

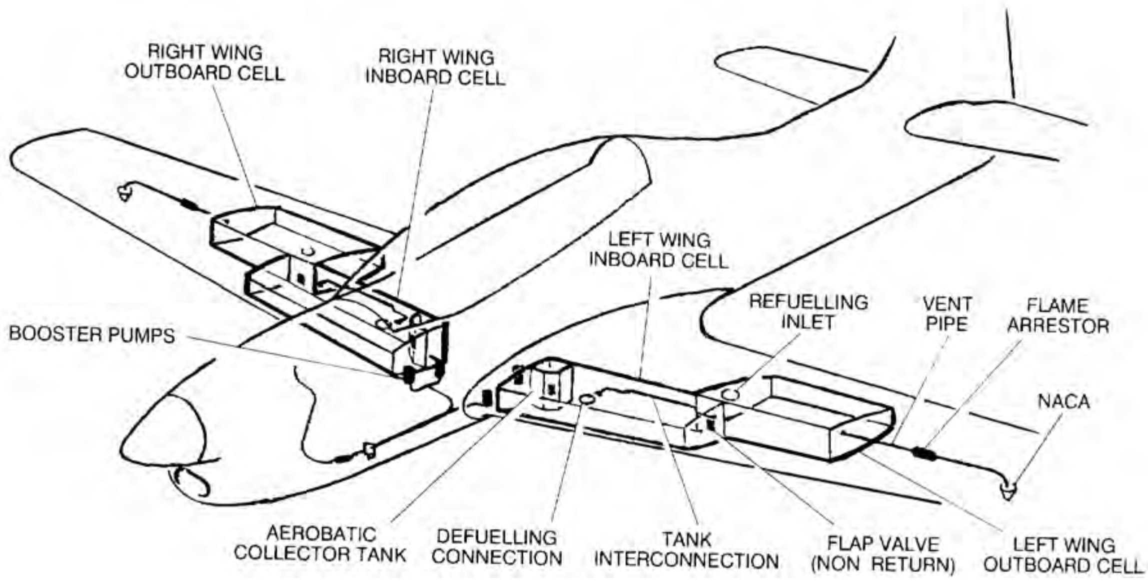
3. **Residual Fuel.** Residual (unusable) fuel, not included in the guaranteed minimum, is 3·63 kg.

Fuel Transfer

4. **Outer Cell to Inner Cell.** Fuel flows by gravity from the outer cell to the inner cell via transfer pipes and a flap-type non-return valve (NRV), which restricts the flow of fuel outboard.

5. **Inner Cell to Collector Tank.** Fuel is sucked into the collector tank from the inner cell by an ejector pump driven by primary fuel pressure.

6. **Collector Tank to Booster Pumps.** A shuttle valve in each collector tank is gravity operated to ensure that, in normal flight, fuel is drawn from the bottom of the tank. In negative g conditions the shuttle valve maintains the fuel supply from the top of the tank.



1 - 3 Fig 1 Fuel System General Layout

Tank Venting

7. Each tank has a vent pipe which runs from the inner end of the inboard cell to the outer end of the outboard cell, and thence to a NACA opening in the wing under-surface. A NRV at each end of the pipe provides ventilation during inverted flight and manoeuvres, and prevents fuel entering the pipe; however, it is not unusual for a small amount of residual fuel to be seen venting after inverted spin recovery. A relief valve in the outer cell discharges tank excess pressure. A flame arrestor, between the outboard vent and the NACA opening, protects the vent pipe from fire due to electrical discharges. Inter-cell venting is provided through transfer pipes.

Fuel Feed

8. Fuel is supplied, from the collector tanks in each inner cell via booster pumps (main or auxiliary), to a common supply pipe and thence to the engine (see Fig 2). The supply pipe incorporates a relief valve, filter, motorized shut-off valve and a pressure switch.

Booster Pumps

9. A main booster pump besides each tank delivers fuel, at low pressure, to the common supply pipe. An auxiliary booster pump is connected in parallel with each main pump.

10. **Power Supplies.** Electrical supplies for the left main pump and right auxiliary pump are taken from the main busbar. Supplies for the right main pump and the left auxiliary pump are taken from the essential services busbar.

11. **Control Switches.** The booster pumps are controlled from the fuel control panel, which is to the right of the main instrument panel in each cockpit (see Fig 3). The switches are labelled PORT PUMPS and STB PUMPS, MAIN and AUX. The switches in the rear cockpit have overriding authority and may be selected ON/FRONT/OFF, rendering the switches in the front cockpit (labelled ON/OFF) operational only when the rear switches are set to FRONT. Any single pump is capable of supplying the engine at any approved power setting and flight attitude. Failure of a booster pump that is selected ON is indicated by flashing attention getter lights (red) on the main instrument panel, the FUEL P caption (amber) on the central warning panel, and the associated warning light (amber) on the fuel control panel.

12. **Bypass Line.** In the event of total booster pump failure, the engine-driven pump sucks fuel directly from the collector tanks; the engine can be run to full power in erect flight without any booster pump running. During normal operation (booster pumps running) each bypass line is shut off by a NRV.

13. **Fuel Pressure Switch.** A fuel pressure switch on the firewall inside the engine bay also activates the FUEL P caption when fuel pressure to the engine falls below 0·414 bar.

LP Shut-Off Valve

14. A guarded FUEL CUT OFF switch is on the main instrument panel in each cockpit. Moving either switch to CLOSE, closes a motorised LP shut-off valve, which is mounted behind the fireshield. Valve closure is indicated by an amber FUEL OFF caption beside each switch. The caption is illuminated when the valve is closed and the switch is at CLOSE. The caption goes out when the switch is selected to OPEN, however the valve does not re-open until the engine start switch is selected to START, or the fuel ignition switch is moved to EM'GY. The switch in the rear cockpit has 3 positions: FRONT passes control to the front cockpit switch; OPEN and CLOSE override the front cockpit switch selections. Selecting the FUEL CUT OFF switch to CLOSE also closes the hydraulic cut-off valve (see Chap 5).

Fuel Low Level Warning

15. Warning of low fuel contents is indicated by illumination of the LOW FUEL caption (amber) on the central warning panel, and the flashing attention getter lights (red) on the main instrument panel. Warning is initiated by closure of a float switch in the inner cell of each tank. In level flight, indication of low fuel contents is given when the usable fuel in either tank falls below approximately 35 kg. When either float switch closes, activation of the LOW FUEL caption is delayed for 60 seconds to minimize pilot distraction during aerobatic manoeuvres.

Controls and Indicators

16. The controls and indicators associated with the fuel system are shown in Fig 3 with identification and function given in Table 1. A knob at the lower right of the flowmeter in the front cockpit is used to set the detotalizer; the indicator in the rear cockpit is a repeater. External controls, i.e. refuelling, defuelling and draining are detailed in para 17 to para 20.

Refuelling

17. The fuel tanks are gravity filled through individual filler caps in the top surface of each wing. The caps are lightning proof and are secured by flush type over-centre latches.

18. The aircraft should be refuelled in a level attitude and may be filled up to filler cap level. Each refuelling inlet is located at the lowest point in the outer cell; this allows sufficient air space to prevent venting during fuel expansion, when the aircraft is filled to maximum level.

Defuelling

19. The tanks can be defuelled in emergency (e.g. following a wheels up landing) by bowser suction, using a standard adapter. The internal pipework from each defuel connection is routed to the lowest point in the inner cell, i.e. adjacent to the collector tank.

Draining

20. The fuel system may be drained by gravity down to undrainable fuel level (0·8kg) by opening drain valves, one at the base of each collector tank. During draining, venting of the tanks is improved by opening the filler caps.

NORMAL USE AND MANAGEMENT

Before Flight

21. Ensure that the rear cockpit FUEL CUT OFF switch is to FRONT during the Cockpit checks and, during the Pre-Start checks, that the front cockpit switch has the cover down. During the Pre-Start checks, check the fuel contents, and test each booster pump, its associated indicator and the FUEL P caption. Confirm the flowmeter reads zero and set the fuel detotalizer.

In Flight

22. Monitor the fuel contents. Fuel asymmetry may arise particularly if the aircraft is flown with sideslip; the asymmetry can be corrected by selective use of the booster pumps. Since the gauge readings are very sensitive to sideslip, trim out sideslip before taking readings. When the indicated fuel contents fall to approximately 35kg on either side, the LOW FUEL caption is illuminated; check the fuel contents gauge and cross check fuel usage against the detotalizer and elapsed flight time. The gauges overread when the aircraft is in a nose-up attitude and underread when nose down.

CAUTION: Fuel gauges should be monitored carefully to safeguard against the effects of preferential flow resulting from mismatched booster pumps.

Note: For take-off and landing select at least one booster pump on each side.

USE IN ABNORMAL CONDITIONS

Fuel Pressure Failure

23. The FUEL P caption comes on when fuel pressure at the entry to the fuel control unit falls below datum, or when any selected booster pump does not provide fuel pressure above its datum. The loss of pressure may also be due to a fuel leak or a partially closed fuel cock.

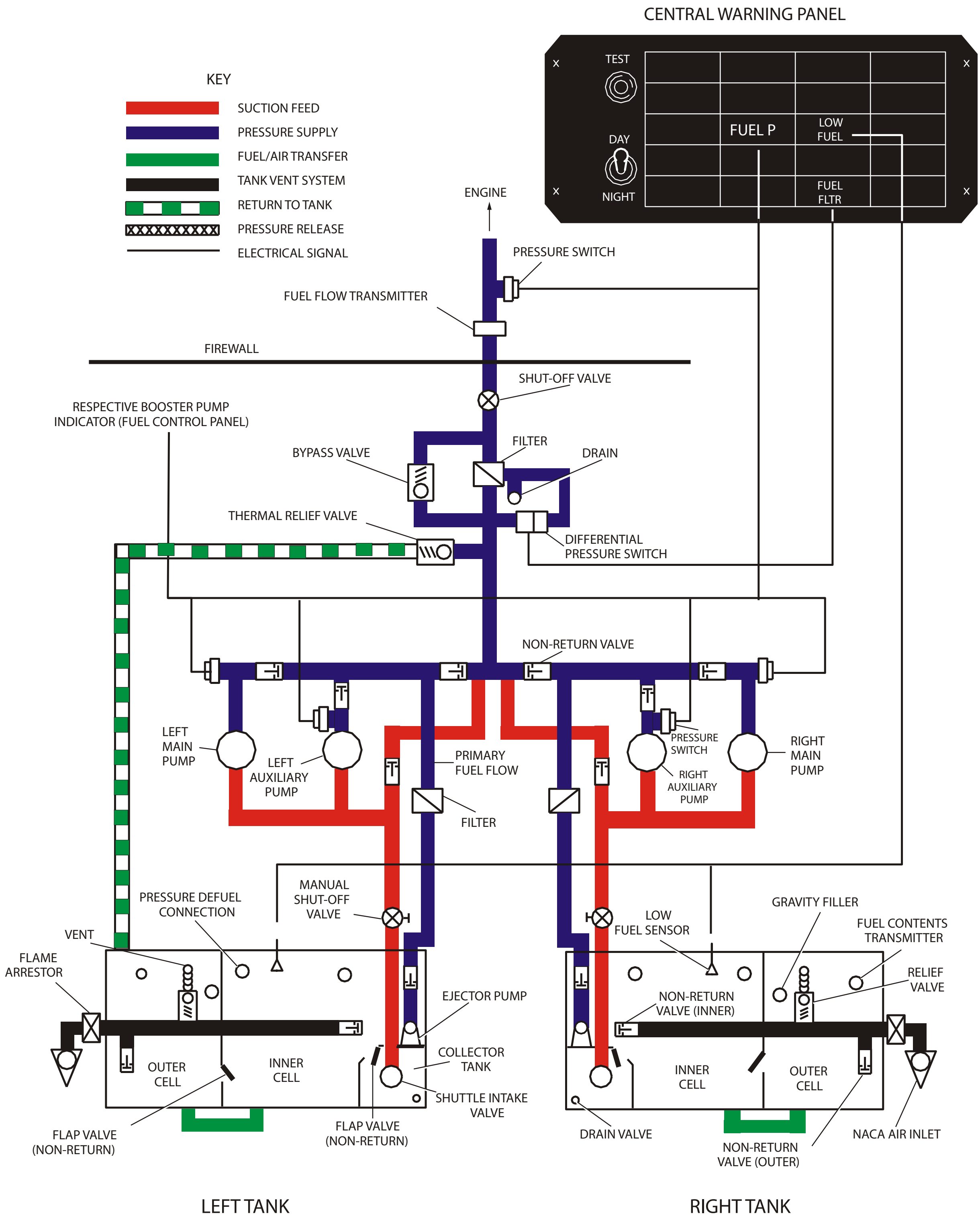
24. Following illumination of the FUEL P caption, check the fuel pump captions. If no fuel pump captions are lit, reduce power to the minimum practicable, select all booster pumps ON (failure indicators out) and check that the fuel contents are normal. Avoid negative g and land as soon as possible. If a fuel pump caption is lit, select the other pump on the failure side and switch OFF the failed pump. If this selection eliminates the warning continue the sortie; if not, maintain power at the minimum practicable, avoid negative g manoeuvres and land as soon as possible. Monitor the apparent rate of fuel consumption.

Fuel Filter Blockage

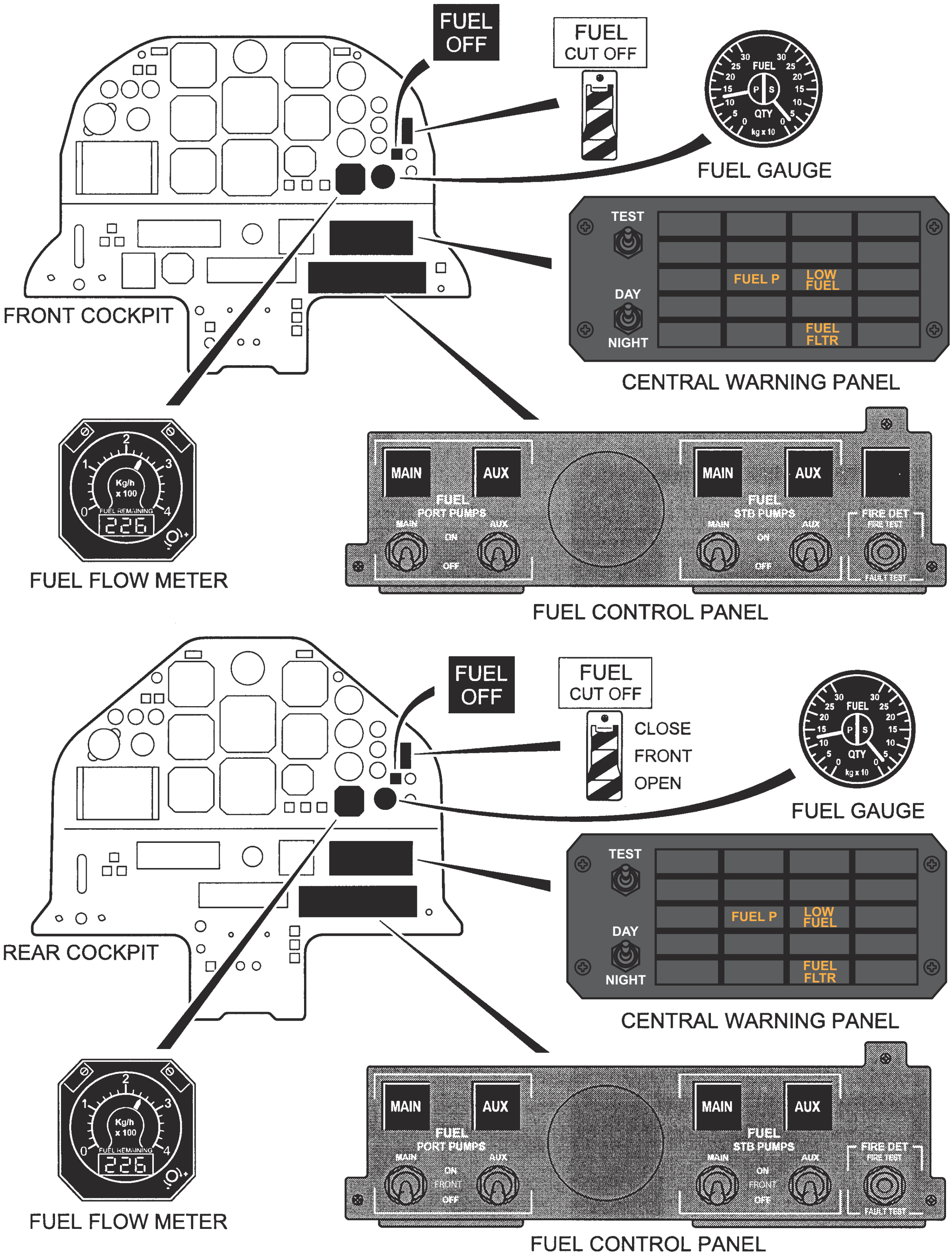
25. Impending bypass of the fuel filter is indicated when the FUEL FLTR caption comes on. When the bypass valve opens unfiltered fuel is routed past the filter to the fuel control unit. If the FUEL FLTR caption comes on reduce the fuel flow by reducing power to the minimum practicable (e.g. if essential for safety, up to full power may be used). Land as soon as practicable.

Low Fuel Level

26. If the LOW FUEL caption comes on, check the fuel contents. If both sides indicate more than 35kg, assume that only 35kg usable remain in each side. If one side indicates 35kg and the other side indicates more, attempt to balance the fuel by selective switching of the booster pumps.



1 - 3 Fig 2 Fuel System Schematic



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1 - 3 Fig 3 Fuel System Controls and Indicators

Table 1 - Fuel System Controls and Indicators

Control/Indicator	*Marking*	*Location*	*Function*
Booster pump switches (four)	PORT PUMPS STB PUMPS - MAIN AUX - ON/OFF ON/FRONT/OFF	Fuel control panel on main instrument panel, front cockpit, rear cockpit	Control power supply to booster pumps
Booster pump failure indicators (four)	MAIN AUX (amber)	Fuel control panel on main instrument panel, both cockpits	Indicate fuel output pressure of respective booster pump below 0·8 bar
Contents gauge	FUEL QTY KG x 10	Fuel control panel on main instrument panel both cockpits	Indicates usable fuel contents
Fuel low level caption	LOW FUEL	CWP, both cockpits	In level flight indicates approximately 35 kg usable fuel remaining in either inboard tank
Fuel low pressure caption	FUEL P	CWP, both cockpits	Indicates fuel pressure at engine below 0·414 bar, or booster pump failure
Fuel flowmeter and detotalizer	KG-H x 100 FUEL REMAINING KG	Main instrument panel, both cockpits	Indicates fuel flow rate and fuel set before flight, less fuel used by engine. Detotalizer is reset by knob on front cockpit instrument; rear instrument is repeater
Fuel filter caption	FUEL FLTR	CWP, both cockpits	Indicates pressure drop across fuel filter in excess of 0·0964 bar
Fuel and hydraulic cut-off switches	FUEL CUT OFF FUEL CUT OFF - CLOSE/FRONT/ OPEN	Main instrument panel, right, front cockpit Main instrument panel, right, rear cockpit	Closes the fuel and hydraulic shut off valves CLOSE - closes the fuel and hydraulic shut-off valves FRONT - transfers control to front cockpit OPEN - overrides the front cockpit selection and selects the valves open when START is selected
Fuel shut-off warning light	FUEL OFF (amber)	Main instrument panel, right, both cockpits	Illuminates when fuel and hydraulic valves have closed and CLOSE is selected

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PART 1

CHAPTER 4 - ENGINE SYSTEMS

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INTRODUCTION

1. The Garrett TPE 331-12B-701A is a turboprop engine which has a 2-stage centrifugal compressor driven by a 3-stage axial turbine (Fig 1). The compressor and turbine are coupled on a single shaft which drives a 4-bladed propeller through a gearbox.

2. In ISA sea level conditions, the engine develops 1100 shaft horse power (SHP); residual energy in the gas efflux produces a further 51 equivalent SHP.

3. **Airflow.** A single intake beneath the propeller spinner passes air directly to the compressor. Some of this air is bled from the compressor for a number of purposes. The larger portion of this air mixes with fuel from the ten fuel burner nozzles in the annular combustion chamber and the resulting gas is ignited; it then flows at increased pressure and velocity, passes through the turbine and discharges at the rear of the engine. The exhaust is directed to atmosphere by a bifurcated duct and two eductors, one each side.

4. **Compressor Bleeds.** Air (P3) is tapped from both left and right sides of the compressor discharge case. The left tappings supply cockpit air conditioning, engine intake anti-icing and a shutdown fuel purge system. The right tappings supply cockpit air conditioning, engine fuel control air and oil pressurization. The bleeds for air conditioning, anti-icing and the fuel purge system are controlled by solenoid valves actuated by the relevant control system.

5. **Gearbox.** The integral gearbox in the compressor intake casing contains reduction and accessory drives. The reduction drive connects the engine to the propeller shaft to give a propeller speed of 2000 RPM (100%) and drives an oil pressure pump and two oil scavenge pumps. The accessory drives provide for:

a. Propeller governor.

b. Tacho-generator.

c. Starter/generator.

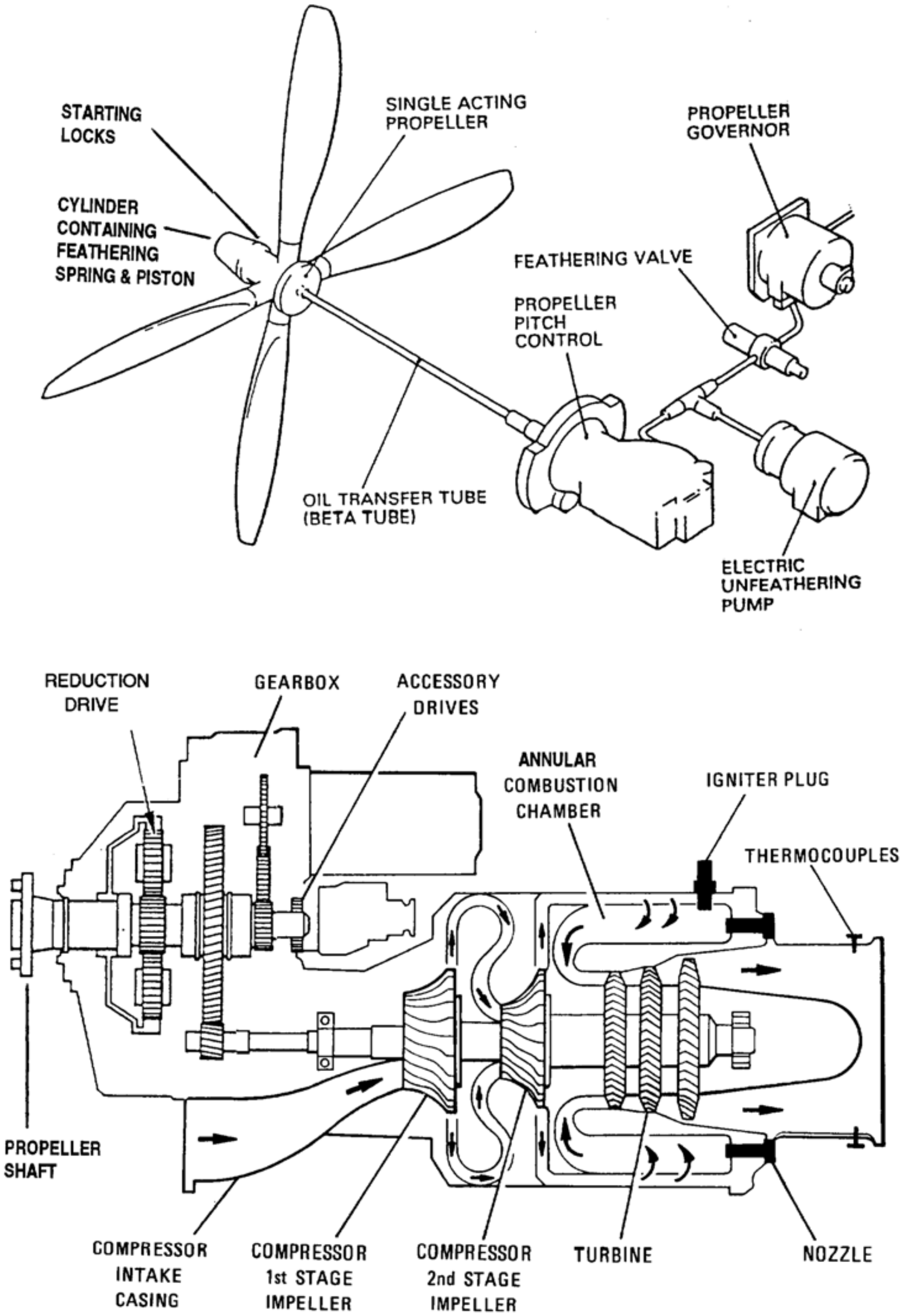
d. Hydraulic pump.

e. Fuel pump with fuel control unit (FCU).

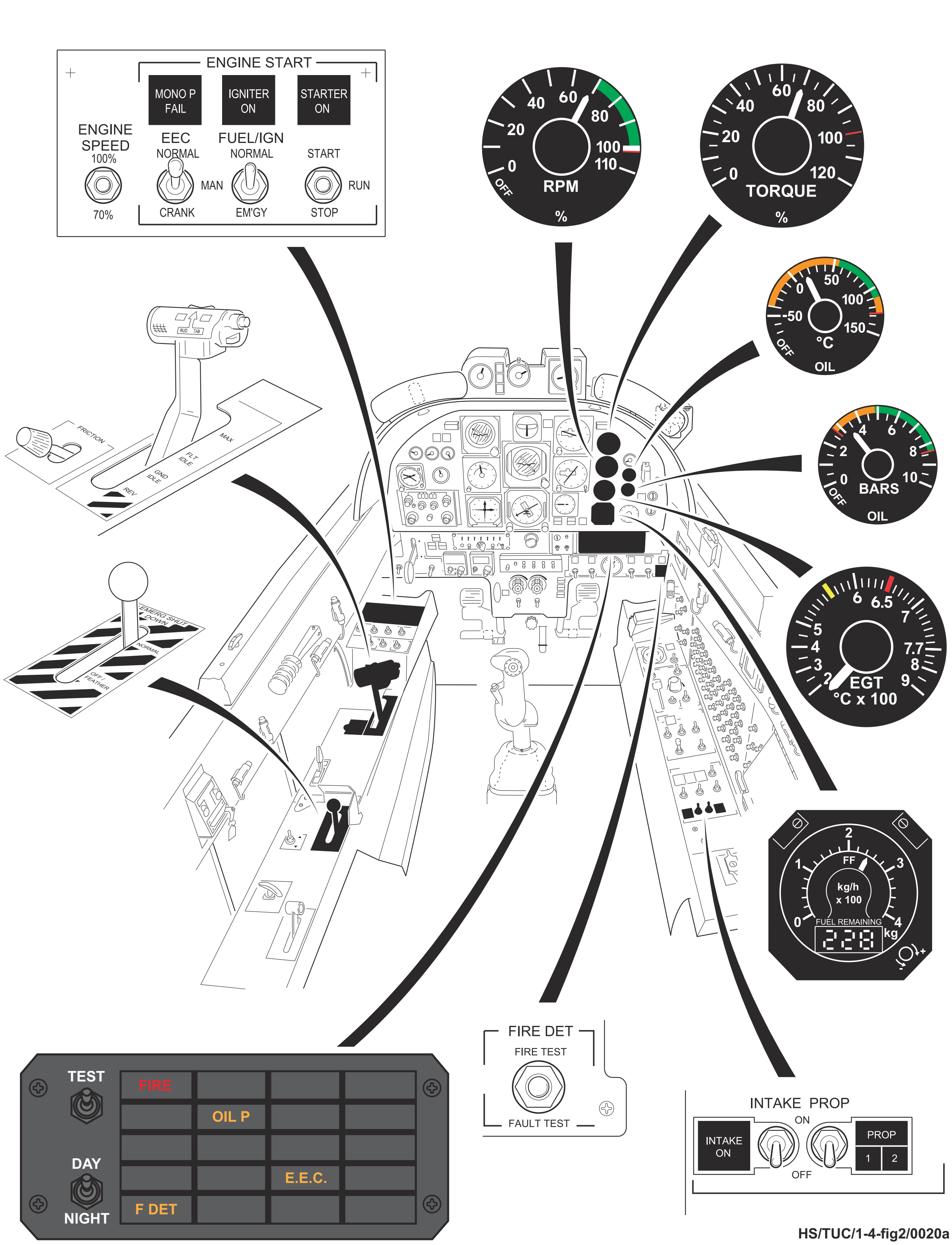
6. **Starting.** The engine is started by an electrically-driven starter/generator which cranks the engine via the accessory drives within the gearbox. Starting is normally controlled by an engine electronic controller (EEC) with a manual backup system. Following in-flight flame-out the engine is relit by a windmill start, actuated either automatically by a negative torque sensing (NTS) system, or manually from the feathered

position using cockpit controls to operate the ignition and unfeathering pump systems. Starting using the starter/generator is inhibited in flight.

7. **Fire Protection.** A single firewire detects fire in the engine compartment and provides audio and visual alarms in the cockpit (see Chapter 2). A fire door in the left side of the engine cowl permits extinguishant to be introduced into the engine compartment. No engine fire extinguisher is fitted.



1 - 4 Fig 1 Principal Features of Engine



1 - 4 Fig 2 Controls and Indicators (Front Cockpit)

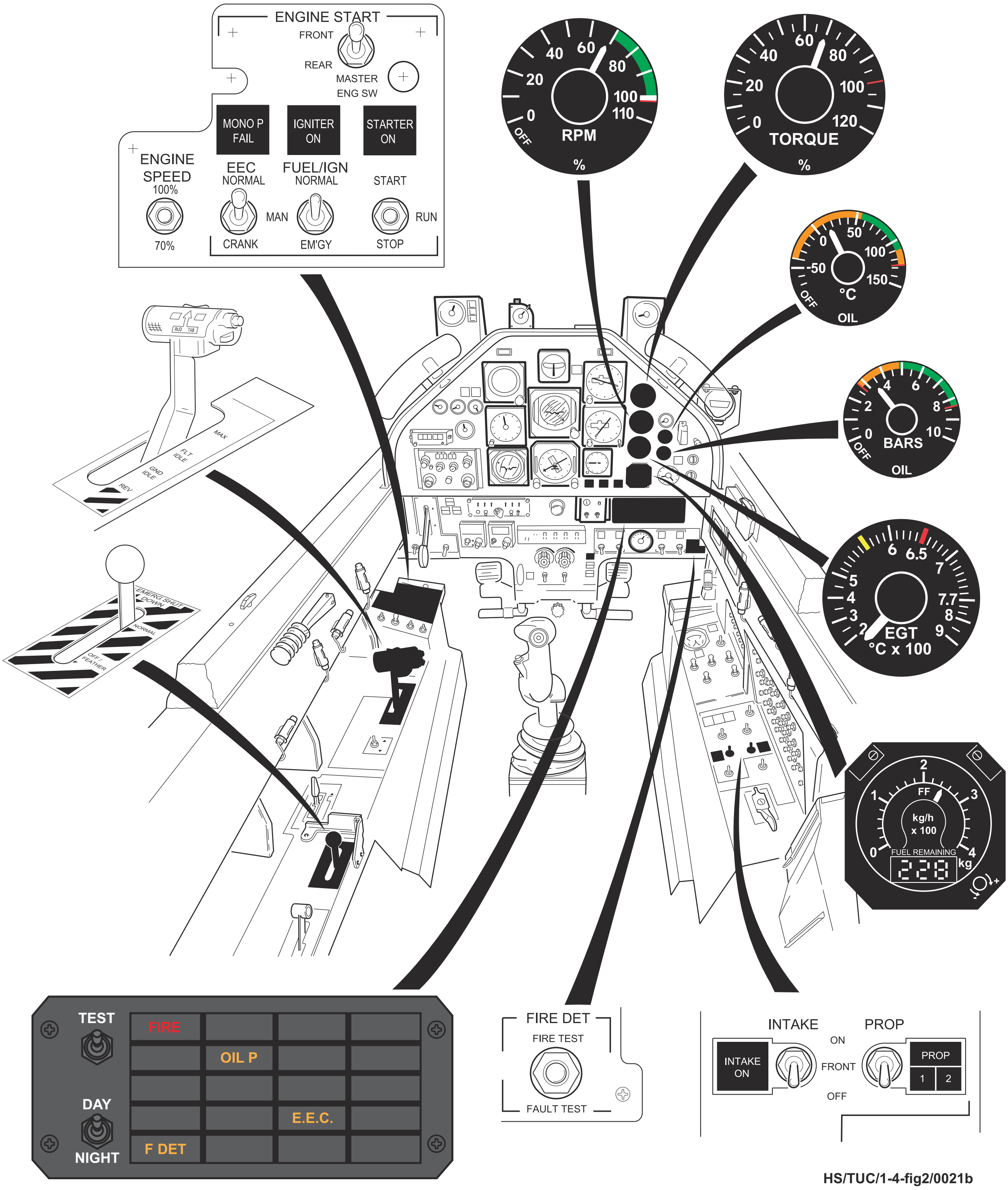
Table 1 - Engine Controls and Indicators (Front Cockpit)

Item	*Marking*	*Remarks/Function*
Emergency shutdown lever	EMERG SHUT DOWN - NORMAL/ OFF/FEATHER	NORMAL - Normal running OFF/FEATHER - Closes FCU fuel shut-off valve, disables NTS, actuates feathering valve and fuel purge system
Throttle Friction knob	FRICTION	Controls ease of movement of throttle. Rotate clockwise to increase friction
Throttle	MAX/FLT IDLE/GND IDLE/ REV REVerse has red/white hatching	Controls engine power demand and propeller pitch. A baulk solenoid prevents movement aft of FLT IDLE in flight
Speed switch	ENGINE SPEED - 100%/ 70%	Spring-loaded to centre. Selects engine speed: 70% - Ground operation 100% - Flight operation
Engine mode switch	EEC - NORMAL/MAN/ CRANK Red cap	Gated in all positions. Selects engine control mode: NORMAL - Control by EEC MAN - Manual control CRANK - Engine cranked without fuel and ignition
Fuel/ignition switch	FUEL IGN - NORMAL/ EM'GY	Spring-loaded to NORMAL. Selects fuel and ignition system control: NORMAL - Control by EEC EM'GY - Manual control
Start switch	START/RUN/STOP	Spring-loaded from START to RUN, gated from RUN to STOP. Controls engine running: START - Mode switch NORMAL: initiates start or relight cycle - Mode switch MAN: runs unfeathering pump - Mode switch CRANK: must be held selected for dry crank RUN - Normal operation STOP - Shuts down engine (may take up to five seconds) and selects fuel purge system
Monopole fail indicator	MONO P FAIL (amber)	Inoperative
Igniter indicator	IGNITER ON (white)	Indicates ignition system on
Start indicator	STARTER ON (amber)	Indicates start system on
RPM gauge	RPM % Red line at 101% Green sector 70 to 101%	Indicates engine speed
Torque gauge	TORQUE % Red line at 100%	Indicates engine torque
Oil temperature gauge	°C OIL Amber sector −40 to +55°C Green sector +55 to 110°C Amber sector +110 to 127°C Red line at 127°C	Indicates engine oil temperature
Oil pressure gauge	BARS OIL Red lines at 2·76 and 8·3 bar Amber sector 2·76 and 4·83 bar Green sector 4·83 to 8·28 bar	Indicates engine oil pressure

(Continued)

Table 1 - continued

Item	*Marking*	*Remarks/Function*
Exhaust gas temperature gauge	EGT °C X 100 Yellow line at 560°C Red line at 650°C	Below 60% RPM indicates raw EGT 60 to 80% RPM indicates compensated EGT Above 80% RPM (EEC normal) indicates single red line computed EGT 560°C mark indicates maximum permitted compensated EGT in EEC MANual
Combined fuel flow indicator with fuel detotalizer	FF KG/H X 100 FUEL REMAINING KG	Indicates fuel flow rate to engine and displays fuel set before flight, less fuel used by engine. Knob resets detotalizer
Fire detector test switch	FIRE DET-FIRE TEST/ off/FAULT TEST	Used to confirm serviceability of fire detection and warning system
CWP captions (engine related)	F DET (amber) FIRE (red) OIL P (amber) EEC (amber)	Illuminated to indicate fire detection system fault Illuminated to indicate engine overheat/fire Illuminated to indicate low oil pressure (below 2·8 bar) Illuminated to indicate engine electronic control failure
Intake heater switch and indicator	INTAKE - ON/OFF INTAKE ON	Manually selects intake heat. INTAKE ON (blue) illuminated when intake anti-ice valve is open
Propeller heater switch and indicator	PROP - ON/OFF PROP 1/2	Manually selects propeller heat. PROP (blue) illuminated continuously when system is on. 1 and 2 (blue) illuminated alternately to confirm correct cycling
On Front Circuit Breaker Panel:		
Circuit breaker	ENG START 1	Overload protection
Circuit breaker	IGNIT'N 2	Overload protection
Circuit breaker	UNFEATH'R PUMP 3	Overload protection



1 - 4 Fig 3 Controls and Indicators (Rear Cockpit)

Table 2 - Engine Controls and Indicators (Rear Cockpit)

Item	*Marking*	*Remark/Functions*
Emergency shutdown lever	EMERG SHUT DOWN - NORMAL OFF/FEATHER	NORMAL - Normal running OFF/FEATHER - Closes FCU fuel shut-valve, disables NTS, actuates feathering valve and fuel purge system
Throttle	MAX/FLT IDLE/GND IDLE/ REV REVerse has red/white hatching	Controls engine power demand and propeller pitch. A baulk solenoid prevents movement aft of FLT IDLE in flight
Speed switch	ENGINE SPEED - 100%/ 70%	Spring-loaded to centre. Selects engine speed: 70% - Ground operation 100% - Flight operation
Engine mode switch	EEC - NORMAL/MAN/ CRANK Red cap	Gated in all positions. Selects engine control mode: NORMAL - Control by EEC MAN - Manual control CRANK - Engine cranked without fuel and ignition
Fuel/ignition switch	FUEL IGN- NORMAL/ EM'GY	Spring-loaded to NORMAL. Selects fuel and ignition system control: NORMAL - Control by EEC EM'GY - Manual control
Start switch	START/RUN/STOP	Spring-loaded from START to RUN, gated from RUN to STOP. Controls engine running: START - Mode switch NORMAL: initiates start or relight cycle - Mode switch MAN: runs unfeathering pump - Mode switch CRANK: must be held selected for dry crank RUN - Normal operation STOP - Shuts down engine (may take up to five seconds) and selects fuel purge system
Monopole fail indicator	MONO P FAIL (amber)	Inoperative
Igniter indicator	IGNITER ON (white)	Indicates ignition system on
Start indicator	STARTER ON (amber)	Indicates start systems on
Master start switch	MASTER ENG SW - FRONT/REAR	Selects front or rear cockpit start authority
RPM gauge	RPM % Red line at 101% Green sector 70 to 100%	Indicates engine speed
Torque gauge	TORQUE % Red line at 100%	Indicates engine torque
Oil temperature gauge	°C OIL Amber sector -40 to +55°C Green sector +55 to 110°C Amber sector +110 to 127°C Red line at 127°C	Indicates engine oil temperature
Oil pressure gauge	BARS OIL Red lines at 2·76 and 8·3 bar Amber sector 2·76 to 4·83 bar Green sector 4·83 to 8·28 bar	Indicates engine oil pressure

(Continued)

Table 2 - continued

Item	*Marking*	*Remark/Functions*
Exhaust gas temperature gauge	EGT °C X 100 Yellow line at 560°C Red line at 650°C	Below 60% RPM indicates raw EGT 60 to 80% RPM indicates compensated EGT Above 80% RPM (EEC normal) indicated single red line computed EGT 560°C mark indicates maximum permitted compensated EGT in EEC MANual
Combined fuel flow indicator with fuel detotalizer	FF KG/H X 100 FUEL REMAINING KG	Indicates fuel flow rate to engine and displays fuel set before flight, less fuel used by engine. Repeater of front cockpit indicator
Fire detector test switch	FIRE DET - FIRE TEST/ off/FAULT TEST	Used to confirm serviceability of fire detection and warning system
CWP captions (engine related)	F DET (amber) FIRE (red) OIL P (amber) EEC (amber)	Illuminated to indicate fire detection system fault Illuminated to indicate engine overheat/fire Illuminated to indicate low oil pressure (below 2·8 bar) Illuminated to indicate engine electronic control failure
Intake heater switch and indicator	INTAKE - ON/FRONT/OFF INTAKE ON	Manually selects intake heat. INTAKE on (blue) illuminated when anti-ice valve is open
Propeller heater switch and indicator	PROP - ON/FRONT/OFF PROP 1/2	Manually selects propeller heat. PROP (blue) illuminated continuously when system is on. 1 and 2 (blue) illuminated alternately to confirm correct cycling

CONTROLS AND INDICATORS

8. The front and rear cockpit controls and indicators for the engine are shown in Fig 2 and Fig 3 and listed in Table 1 and Table 2 respectively.

ENGINE FUEL SYSTEM

General

9. Fuel from the aircraft fuel system (see Chapter 3) is supplied via an engine-driven fuel control assembly, which comprises a boost pump with integral filter, high pressure (HP) pump and the fuel control unit (FCU)(Fig 4). During normal running the HP pump supplies fuel to nozzles in the combustion chamber via the FCU and a flow divider. A separate fuel heater with an anti-icing lockout valve controls fuel heating in low outside air temperatures. A primary flow solenoid valve in parallel with the flow divider controls the fuel flow during starting. During shutdown, after the engine has been run above 95% RPM, a pneumatic purge system removes all residual fuel from the fuel manifolds.

10. The fuel flow from the FCU is determined by a main metering valve controlled by pneumatic bellows. The pneumatic supply for these bellows is P3 air modified by the EEC. Overspeed protection is provided by a mechanical governor in the FCU immediately downstream of the main metering valve. This governor automatically limits the metered fuel when preset overspeed RPM are reached. If the EEC malfunctions, the throttle actuates a manual mode valve in the FCU. This valve then modifies P3 air to drive the pneumatic bellows such that, at most throttle settings, the fuel flow is reduced and the throttle will need to be advanced to restore power (see para 59).

Low Pressure Fuel Supply

11. The fuel control assembly boost pump maintains fuel pressure at the HP pump inlet to prevent cavitation within that pump. A bypass valve is fitted to the filter between the boost and HP pumps and opens if the filter is blocked. The fuel is heated by hot engine scavenge oil in an external heater controlled by a temperature-sensitive anti-icing valve; this begins to open at 10°C and is fully open by 0°C. During engine start a separate solenoid-operated anti-ice lockout valve prevents fuel recirculating back through this external heater, thus ensuring that sufficient fuel reaches the FCU.

HP Fuel Supply

12. The gear type HP pump supplies fuel to the FCU. To protect the FCU against excessive pressure, a pressure relief valve bleeds HP fuel back to the pump inlet.

Fuel Control Unit

13. The FCU does all the fuel metering in both NORMAL and MANual modes of the EEC.

14. **Start Flow.** The main metering valve has a minimum flow stop, which is factory preset to provide the optimum fuel for light-up.

15. **Fuel Enrichment.** As the engine accelerates after light-up the EEC signals the FCU enrichment solenoid valve to open to augment the normal metered flow, in order to increase the rate of acceleration. Operation of the enrichment valve is intermittent (showing as momentary peaking of the exhaust gas temperature (EGT)) since it is shut off whenever 695°C (raw EGT) is approached. Enrichment is available for starting up to 60% RPM and, on a later variant of EEC, between 60 and 90% RPM to aid acceleration.

16. **Acceleration Control.** During engine acceleration the FCU pneumatic bellows sense the increasing modified P3. This controls the main metering valve to maintain the correct air/fuel ratio throughout the acceleration, thus keeping the engine within safe temperature and surge limits.

17. **Underspeed Governing.** The EEC compares the actual engine speed with that selected at the ENGINE SPEED switch. The underspeed governor (USG) in the EEC removes any discrepancy by adjusting P3 at

the FCU pneumatic bellows, to increase or decrease the fuel flow to maintain the minimum of 72% or 94% RPM.

18. **Throttle Control.** With the throttle well aft of FLT IDLE (in the beta range) the USG controls the RPM. However, as the throttle is moved forward towards FLT IDLE, the signal from the throttle position potentiometer at some point exceeds the signal from the USG and takes control of the fuel flow. Therefore, the RPM start to increase (from 94%) until the propeller governor comes on speed (100%); then the engine enters the propeller governing mode.

19. **Torque Limiting.** If the throttle demand tends to exceed 100% torque, the EEC signals the FCU automatically to reduce the fuel flow.

20. **EGT Limiting.** If the throttle demand tends to exceed the calculated single red line (SRL) EGT limit of 650°C, the EEC signals the FCU automatically to reduce the fuel flow.

21. **Overspeed Protection.** A mechanical governor, immediately downstream of the main metering valve, provides overspeed protection; it is set at 104 to 105·5% RPM. This governor also provides the secondary monopole engine speed signal to the EEC.

Flow Divider

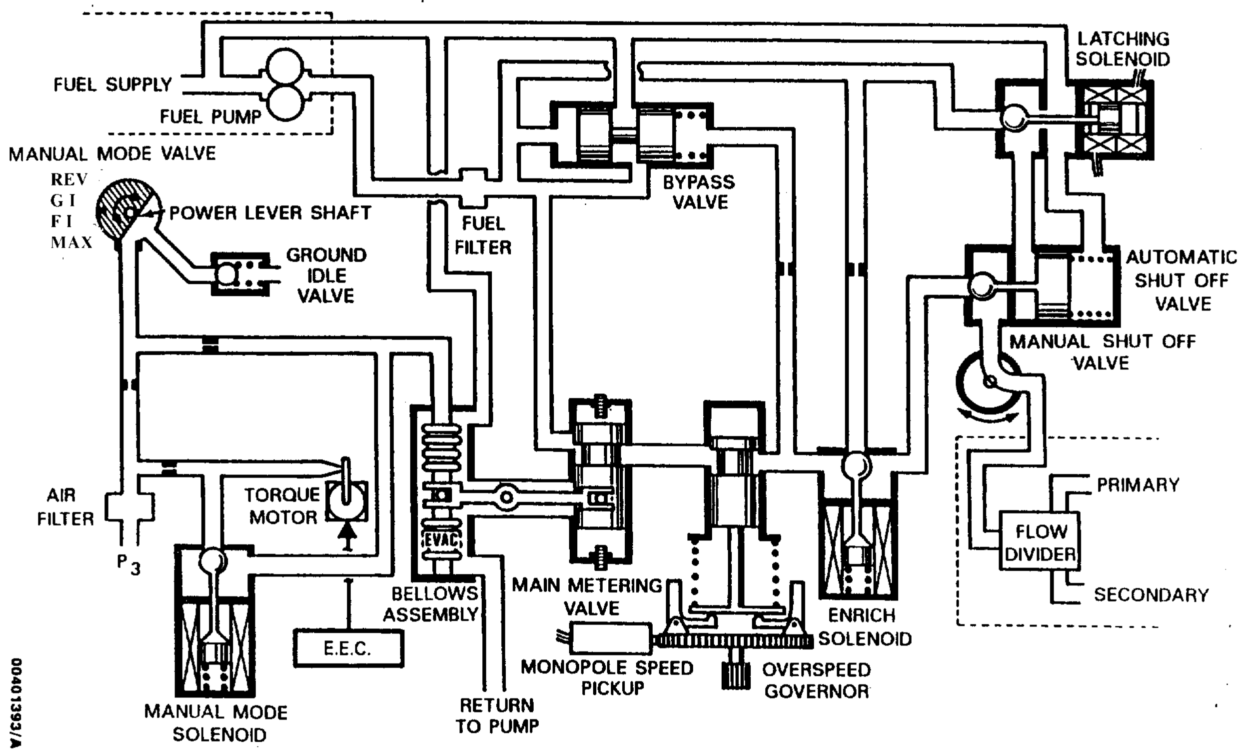
22. The flow divider controls the flow of metered fuel to the nozzles during the start cycle. An external primary flow solenoid valve controls the pressure across the flow divider, to ensure that only primary flow is available up to a nominal 60% RPM, i.e. during light-up and acceleration to idle speed. Above 60% RPM the flow divider also opens to a secondary manifold to further increase flow from the nozzles.

Manifolds and Nozzles

23. The annular combustion chamber contains ten duplex fuel nozzle assemblies, each fed by the separate primary and secondary manifolds.

Fuel Purge System

24. The fuel purge system uses bleed air (P3), stored in a pneumatic accumulator, to burn off residual fuel in the nozzle manifolds during shutdown. As the engine runs down a solenoid valve opens to admit this air, via a filter, to the flow divider. This forces the residual fuel to the combustion chamber where it is burned. There is, therefore, a momentary surge in RPM and EGT when STOP is selected before the engine stops. The system is also operated by a microswitch when an EMERGency shut down lever (ESDL) is selected to OFF/FEATHER. The accumulator starts being charged at 80% RPM, and is fully charged when the engine has run above 95% RPM. If a start is aborted before the RPM have risen enough to charge the accumulator, the purge system is inoperative; fuel may be dumped through the combined drain on the right of the engine during the next start.



1 - 4 Fig 4 Fuel Control - Schematic

IGNITION SYSTEM

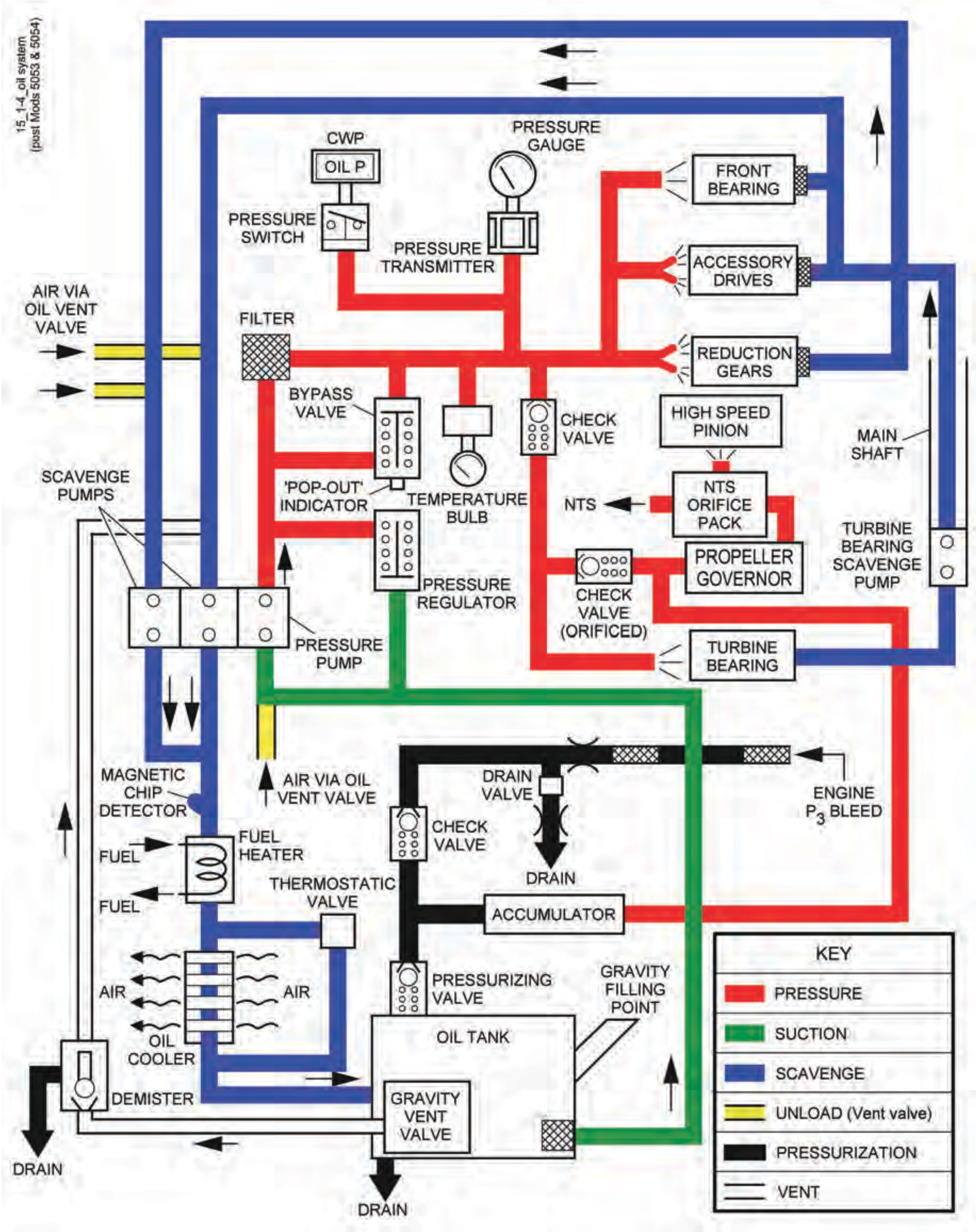
Ignition Unit and Igniter Plugs

25. The ignition system comprises a common capacitor-discharge unit on the engine oil cooler, and two high-energy igniters in the combustion chamber. The power supply is from the essential services busbar. A circuit breaker labelled IGNIT'N is on the forward circuit breaker panel on the right in the front cockpit. The igniters operate automatically between 10% and 60 to 65% RPM during engine starting, and when relighting under EEC (NORMAL) control. If the engine approaches flame out in flight the NTS system trips an auto-ignition switch which switches ignition on. The engine FUEL IGNition switch controls ignition when the EEC is selected to MANual. When selected to EM'GY, the EEC operates the fuel enrichment solenoid and igniters. Additionally, when airborne, it operates the unfeathering pump and signals open the HYD/FUEL shut-off valve.

OIL SYSTEM

Oil Tank

26. The oil system (Fig 5) is self-contained. An oil tank is on the right-hand side of the engine. The tank is gravity filled and the contents are indicated on a dipstick attached to the filler cap, which is behind a hinged flap in the right-hand side of the engine cowl. The oil tank and an accumulator are pressurized using engine bleed air (P3).



1 - 4 Fig 5 Engine Oil System - Schematic

Oil Supply

27. A pressure pump driven by the reduction gearbox draws oil from the tank, and delivers it through a filter to provide engine lubrication and propeller control. A pressure regulator protects the system. A bypass valve allows oil to bypass the filter if clogged; this valve is indicated open, i.e. bypassing, by a pop-out indicator (red) on the right side of the engine gearbox case. A solenoid-operated oil vent valve allows air to enter the system during starting (0% to 60% RPM), to reduce the load on the gearbox scavenge and pressure pumps

and hence the starter. The accumulator provides circulation to the propeller governor (PG) for a limited time during inverted flight.

Inverted Oil Supply

28. An inverted oil supply accumulator provides a supply of oil to maintain propeller governor operation, and for lubrication of the high-speed pinion gear and the rear turbine bearing, for up to 30 seconds during negative g operation. The accumulator is charged by an independent P3 air tapping on the engine casing.

29. When positive g is restored the accumulator is recharged with oil. Expelled air and any oil leakage from the accumulator are fed back to the oil tank via the pressurizing valve. A drain path allows residual oil, which may have leaked past the check valve during transient starting or shutdown conditions, to vent via a pipe within the combined drain. Excessive oil around the drain may be indicative of a leak within the inverted oil system, and should be investigated.

Oil Pressure

30. The cockpit gauge indication of oil pressure is generated by a transmitter mounted on the engine. A separate pressure switch is actuated by oil pressure below 2·8 bar to illuminate (subject to a 20-second delay) an OIL P caption on the CWP.

Oil Scavenge

31. Three engine-driven scavenge pumps (two in the gearbox and one at the turbine bearing) return the oil to the tank through a fuel heater and oil cooler. There is a magnetic chip detector at the fuel heater inlet. Air and gases mixed with the oil are removed at an oil demister and vented by a drains system, the oil being returned into the gearbox casing to be scavenged.

Oil Temperature

32. The cockpit gauge indication of oil temperature is sensed by a temperature bulb on the rear face of the gearbox. As the oil temperature increases towards its normal operating level, oil partially bypasses an air blast cooler until a thermostatic bypass valve closes at 71·1°C, when the full flow of oil passes through the cooler. Low ambient air temperature at altitude combined with low fuel temperature at the fuel heater may cause the in-flight oil temperature to reduce below the minimum of 55°C (see para 95).

PROPELLER SYSTEM

General

33. A 4-blade, fully feathering, reverse pitch propeller with aluminium blades is driven by the engine through a fixed reduction gearbox. The propeller rotates clockwise as viewed from the cockpit. The propeller hub houses the pitch change mechanism, which uses a feathering spring to move the blades towards feather, and boosted high pressure engine oil (0 to 27·07 bar) to move the blades from feathered through fully fine to reverse pitch. The pitch change mechanism includes start locks, to hold the blades in a fine pitch during starting.

34. The engine operates in two distinct control modes:

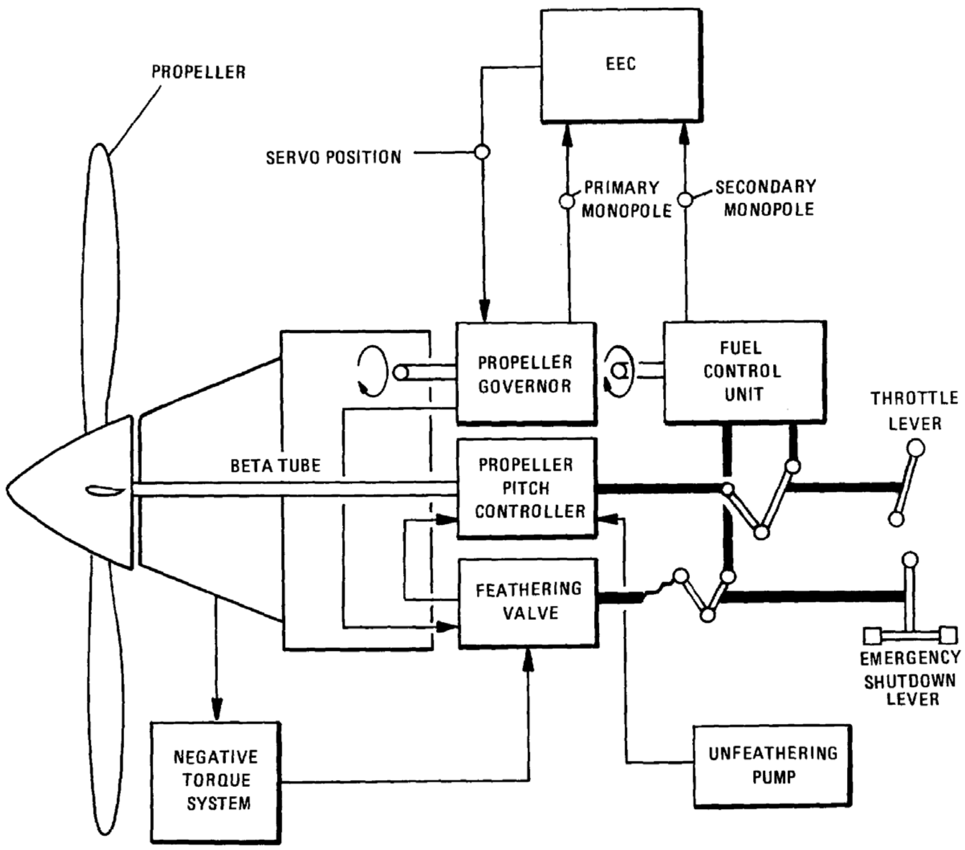
a. **Beta Mode.** During ground operations, with the throttle in the range full REVerse to FLT IDLE, the engine operates in the beta mode. The blade angle is controlled directly by the throttle through the propeller pitch control (PPC), and the RPM are maintained at the selected value by the fuel metering USG (Note that the USG is an electronic function of the EEC; therefore, if the EEC is inoperative there is no USG functioning).

b. **Propeller Governing Mode.** With the throttle in the range FLT IDLE to MAXimum the engine operates in the propeller governing mode. Power is set by the throttle, which controls the fuel flow, and the propeller governor (PG) maintains the RPM by varying the propeller blade angle.

Pitch Control

35. In the propeller governing mode (throttle forward of FLT IDLE), the PG controls the flow of boosted high pressure engine oil to the pitch change mechanism. This adjusts the blade angle, so that the aerodynamic load on the propeller equals the engine torque set by the throttle, when the propeller is running at its selected RPM (100%). In the beta mode (throttle aft of FLT IDLE) the propeller blade angle is set by the throttle through the PPC; the USG adjusts the fuel flow to maintain the selected RPM (72% or 94%). In flight a beta-baulk (removed on the ground by a nosewheel weight-on-ground microswitch) prevents the throttle being moved aft of FLT IDLE.

36. A feathering valve, connected between the PG and the PPC shuts off the flow of boosted high pressure engine oil from the PG, and oil is then vented from the pitch change mechanism; this allows the feathering spring to move the blades towards feather. This valve is operated either automatically, by the NTS system when the engine flames out, or manually, by the ESDL (Fig 6). The NTS systems allows the feathering spring to move the blades towards feather; when the negative torque has been reduced the oil pressure vent from the pitch change mechanism recloses, and further feathering is stopped. The propeller pitch is thus held in a windmilling state (which creates drag) where oil pressure (reduced because of reduced engine RPM) balances the action of the feathering spring. Therefore, to feather the blades fully the ESDL has to be operated. A DC unfeathering oil pump, is used during relighting to unfeather the blades so that the engine windmills. This pump runs when START is selected on the START/RUN/STOP switch on the engine start panel; a circuit breaker labelled UNFEATH'R PUMP is on the forward circuit breaker panel on the right in the front cockpit.



1 - 4 Fig 6 Propeller System

Start Locks

37. On the ground with the engine stopped, the feathering spring attempts to move the propeller blades to the feathered position. Therefore, to minimize aerodynamic loads during starting, start locks hold the propeller in fine pitch. The engine is not to be started with the start locks disengaged. Normally, they are engaged by selecting full REV with the throttle until below 30% RPM during the previous shutdown; the throttle is then set to GND IDLE. However, if the propeller is in the feathered state before the start, the start locks are to be engaged using the unfeathering pump; to do this, ensure the throttle is selected to REV, select

the EEC to MAN and select and hold START until the blades visibly enter a reverse pitch. After start the locks are released by smoothly easing the throttle into REVerse momentarily, thus removing side loads exerted on the locks by the feathering spring and allowing them to move outwards centrifugally.

Negative Torque Sensing System

38. The primary purpose of the NTS system is to limit the amount of torque that the engine absorbs from a windmilling propeller. When negative torque is sensed, the pitch of the propeller is increased towards feather until the negative torque is reduced to an acceptable level (see para 36); the engine igniters are also automatically switched on and may remain on for up to 10 minutes after the engine has been relit due to slow dissipation of the controlling oil pressure.

39. The secondary purpose of the NTS system is to control the rate of propeller unfeathering during propeller-windmilled engine relights so that the engine does not accelerate too rapidly through the relight RPM range.

STARTING SYSTEM

40. On the ground the engine is cranked by a starter/generator powered from the essential services busbar. A circuit breaker labelled ENG START is on the forward circuit breaker panel on the right in the front cockpit. With engine light-up established, the starter reverts to generator-mode to power the aircraft systems. In flight the starter is inhibited by the operation of weight-on-ground switches.

41. The operation of the starter/generator in starter-mode, is initiated by the start switch on the ENGINE START panel. During normal starting, control is via the EEC.

MANAGEMENT AND CONTROL

Engine Control

42. The engine is controlled by varying:

a. **Fuel Flow.** Fuel flow varies power output.

b. **Propeller Pitch.** Propeller pitch (blade angle) varies aerodynamic load on the propeller.

43. At constant engine RPM the torque produced by the engine is equal to the torque absorbed by the propeller. Fuel flow is normally controlled by the EEC, into which throttle position demands are transmitted electronically, and propeller pitch is varied automatically to control propeller (and engine) RPM.

Throttles

44. The throttle in the front cockpit (mechanically linked to a similar throttle in the rear cockpit) controls engine fuel scheduling in both automatic and manual modes. In automatic mode the fuel flow is controlled by the throttle via the EEC, whereas in manual mode the throttle is connected mechanically to the PPC and FCU. A beta-baulk solenoid, controlled by a microswitch on the nose landing gear leg, prevents the throttle being moved aft of FLT IDLE when in flight. Failure of the nose leg microswitch causes the beta-baulk to retract thus allowing the throttle into the beta range in the air. Although the NTS system operates there is a considerable increase in drag followed by drag pulsation as the propeller hunts around an equilibrium position. Recovery is immediate when the throttle is moved forward of FLT IDLE. There is a weak detent on the rear cockpit throttle lever at the GND IDLE position. If the beta-baulk solenoid fails to retract on the ground after flight, the throttle cannot be moved aft of flight idle. As reverse thrust is then unavailable, the landing distance will increase significantly. Consideration should be given to selecting ESDL to Off/Feather if normal braking does not suffice.

45. The front cockpit throttle has an adjustable friction damper. The knob is rotated clockwise to increase friction.

46. Control switches are incorporated in both throttles for rudder trim, airbrake and communications.

Emergency Shutdown Levers

47. The emergency shut down lever (ESDL), labelled NORMAL/ OFF/FEATHER, in the front cockpit, is mechanically linked to a similar lever in the rear cockpit. The ESDL closes the mechanical fuel shut-off valve, disables the NTS system, initiates the fuel purge system and operates the feathering valve to allow the propeller to feather. The ESDL has a striped black/yellow surround and is protected by a raised guard. The operating loads on the ESDL tend to be greater in flight than on the ground. Firm and positive movement of the ESDL is necessary to ensure full travel to the OFF/FEATHER position. The ESDL should only be used to shut down the engine in emergency situations (i.e. as advised in the FRC). If the ESDL is used otherwise when on the ground, the rapid spool down time of 10 to 15 seconds traps residual heat within the engine. Consequently, close tolerances between rotating assemblies and their shrouds are reduced. The assemblies and shrouds may come into contact and this results in excessive internal wear or even significant damage on very hot engines which have no cooling air induced.

WARNING 1: Failure to achieve the full OFF/FEATHER position results in engine rundown without the propeller feathering; this leads to a high rate of descent.

WARNING 2: In the event of an airborne shutdown, failure to operate the ESDL before the FUEL CUT OFF switch results in engine rundown without the propeller feathering; this leads to a high rate of descent.

Note 1: If a start is cancelled below 60% RPM using the ESDL the starter continues to rotate the engine/ propeller at about 15% RPM until STOP is selected.

Note 2: If a start is cancelled below 72% RPM the propeller does not feather since the start locks are still engaged; above 72% RPM the propeller only feathers if the start locks have been disengaged.

Engine Operation

48. On the ground the engine may be run at less than 100% RPM to reduce propeller and engine noise. An ENGINE SPEED switch, spring-loaded to a central (neutral) position, is on the left console in each cockpit. It is marked 70%/100% and can be used to select the lower RPM. A microswitch, operated by the throttle, is provided to override a 70% selection when the throttle is forward of FLT IDLE, thus any attempt to take-off with 70% inadvertently selected should not be possible. Table 3 shows the values of RPM selected by the ENGINE SPEED switch at the USG and the PG.

Table 3 - RPM Control Values

Engine Speed Switch Setting	*Underspeed Governor*	*Propeller Governor*
70%	*72 to 73%	96%
100%	94%	100%
* 80% when air conditioning BOOST selected.		

49. In flight the engine speed is selected to 100%. This selects about 94% on the USG and 100% on the PG. As the throttle is moved the throttle metering valve increases or decreases the fuel flow and the PG increases or decreases the blade angle to maintain 100% RPM. When airspeed is reduced the blade angle reduces to maintain 100% RPM until a blade angle of +8·5° is reached. If airspeed is further reduced the blade angle remains at 8·5° and the RPM begin to decrease. At about 94% RPM the USG begins to increase the fuel flow to maintain RPM.

50. During the landing roll, providing the weight-on-nosewheel microswitch is made, the throttle can be moved aft of FLT IDLE towards GND IDLE and the blade angle reduces under the control of the PPC. As the blade angle reduces to minus 1° (approximately zero thrust with the aircraft stationary) the USG controls the fuel flow to maintain about 94% RPM. Further rearward movement of the throttle moves the blade angle to minus 2° and the USG now increases the fuel flow to maintain about 94% RPM with the engine producing reverse thrust.

51. For ground operations the engine speed is normally selected to 70%. This resets the USG datum to about 72·5% and the PG datum to 96%. The engine operates as in para 50 but with the USG maintaining the engine RPM at 72·5% and not 94%.

Engine Electronic Controller

52. The EEC measures various engine parameters (see para 54) and uses them to control engine fuel flow and propeller blade pitch and thus engine power output. It is powered from the essential services busbar and is remote from the engine. Its functions are:

a. Controlling automatic starting.

b. Scheduling acceleration fuel.

c. Controlling fuel metering.

d. Limiting positive engine torque.

e. Limiting EGT.

f. Correcting single red line (SRL) EGT.

53. There are potentiometers on the EEC to allow maintenance personnel to adjust:

a. Maximum RPM.

b. Idling RPM.

c. Flight idle fuel flow.

d. SRL EGT.

e. Maximum torque.

54. The EEC (selected to NORMAL) provides control signals to the FCU (Fig 7) which are based on:

a. Throttle position.

b. Engine speed (% RPM).

c. Compressor inlet temperature (T2).

d. Turbine outlet temperature (T5).

e. Engine pressure ratio (DP2/P5).

f. Engine torque (%).

55. In propeller governing mode, moving the throttle forward signals a request to the EEC for an increase in power. The EEC signals the FCU to increase fuel flow. The increased fuel flow tries to increase RPM past 100%, but this tentative RPM increase is sensed by the EEC which signals the PG to decrease oil pressure to the PPC. This allows the propeller pitch to coarsen and thus increase the load on the propeller. RPM is thus still limited to 100% and the power output is increased as shown on the torque gauge.

56. The following situations automatically switch the EEC to MANual:

a. Failure of supply voltage to the EEC.

b. Failure of throttle lever signal.

c. Mismatch between the throttle lever signal and the signal at the FCU.

d. Failure of a monopole sensor above 55% RPM.

CAUTION: Should the EEC trip to MANual, especially at high power selections, there is a risk that the manual limit for EGT (560°C) will be rapidly exceeded. Therefore, in the event of an automatic trip to MANual, power demand should be reduced promptly.

57. When the EEC is operating normally, selection of the EEC to MANual mode and reversion to NORMAL mode is permitted as required. Torque is to be at 30% or below when selecting EEC NORMAL to MANual and 20% or below when selecting EEC MANual to NORMAL. After reversion to NORMAL confirm that EGT is at or below 650°C.

CAUTION: The throttle is not to be moved aft of GND IDLE when in MANual mode because fuel metering by the USG is not available. Serious damage to the engine may occur if this limitation is not observed.

Manual Engine Control

58. When the EEC fails and/or is switched to MANual (indicated by the EEC caption being illuminated on the CWP), the fuel flow is controlled by a mechanical linkage between the throttle and the FCU. The following functions are lost:

a. Automatic starting.

b. Acceleration fuel.

c. Torque limiting.

d. SRL EGT limiting.

e. Engine speed selection (reverts to 100%).

f. USG fuel control.

59. For most throttle positions forward of GND IDLE, but short of MAXimum power, the MANual mode gives about 15 to 20% less fuel than the NORMAL mode. Therefore, higher throttle positions are necessary to achieve the required power in MANual mode. However, at or near MAXimum power settings, under certain ambient conditions, fuel flow may be increased in MANual mode, potentially resulting in a temperature exceedance. To reduce the likelihood of an exceedance, an EGT limit of 560°C is imposed in MANual mode. The nominal engine performance in MANual mode is determined by a P3 air signal to the FCU that is influenced by several factors, including:

a. Throttle lever setting.

b. Flight/ambient conditions.

c. Variations in efficiency from engine-to-engine.

d. Variations from FCU-to-FCU due to tolerances.

Note 1: If more engine power should be needed at any stage, a change of AIR COND selection from BOOST to NORMal (or to BLEED air OFF/RESET) will reduce air bleed and hence increase torque.

Note 2: Automatic limiter functions are not available in MANual mode. EGT and torque limiting are controlled by the throttle lever.

Monopole Sensors

60. Two independent monopole sensors (magnetic speed pick-ups) feed engine speed information to the EEC. The primary monopole is in the propeller governor and the secondary monopole is within the FCU. If

either monopole sensor fails, the EEC will automatically switch to MANual mode and the CWP EEC caption will illuminate.

EGT Indications

61. Eight thermocouples measure raw turbine outlet temperature (T5). A compensator corrects the raw temperature for engine manufacturing tolerances and compensated EGT is passed to the EEC. Changes to engine RPM, T2 and the engine pressure ratio change the relationship between T5 and turbine inlet temperature (T4). Using these variables the EEC converts compensated EGT to calculated EGT. Provided the calculated EGT does not exceed 650°C, T4 remains below the permitted maximum. Calculated EGT is commonly referred to as SRL EGT. The type of EGT shown on the EGT gauge varies with RPM and EEC selection:

a. **Raw EGT.** 0 to 60% RPM.

b. **Compensated EGT.**

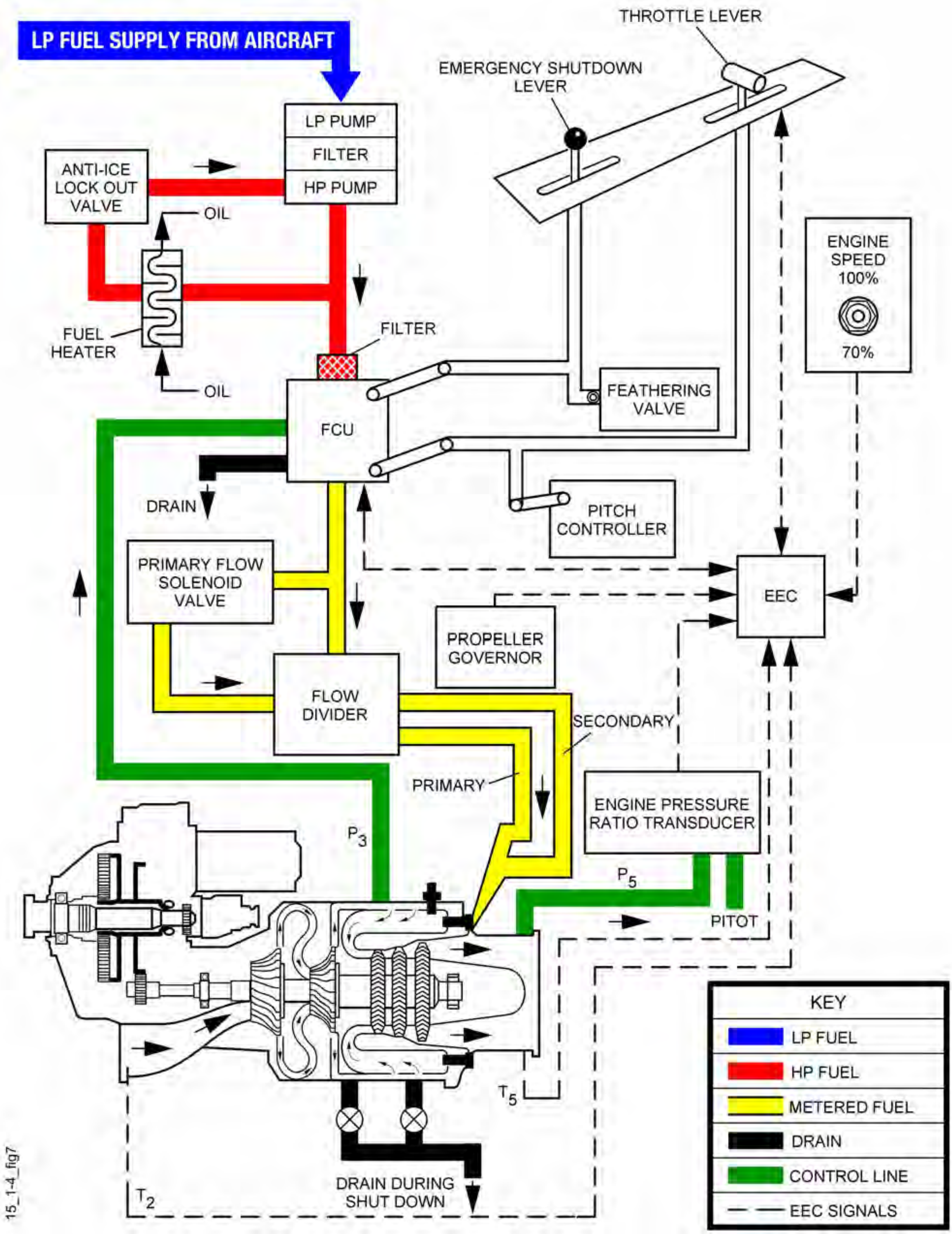
(1) Ground running below 80% RPM.

(2) All conditions with EEC manual and in excess of 80% RPM.

c. **SRL EGT.** All conditions with EEC normal and in excess of 80% RPM.

Torque Indications

62. Engine torque is calculated from a signal derived from a strain gauge bridge in the engine gearbox and displayed on the torque (%) gauge. Positive torque is indicated between zero and 120 and negative torque below zero. Torque information is also fed to the EEC.



1 - 4 Fig 7 Engine Power Management System

NORMAL OPERATION

Engine Starting

63. Turn the propeller through 90° by hand. Select GEN to ON/RESET. Test the batteries and essential busbar; if necessary, connect an external engine-driven ground power unit DC supply or Trolley Battery Electrical Starter (TBES). Set the MASTER ENGine SWitch to FRONT or REAR as required, the ESDL to NORMAL, the EEC switch to NORMAL, and the ENGINE SPEED switch momentarily to 70% (to set the after starting idle speed). Ensure that the propeller start locks are engaged (see para 37), set the start switch at STOP and the throttle at GND IDLE.

Note: If the EGT is higher than 200°C, dry crank the engine (see para 69), observing starter limitations, until the temperature is below 200°C.

64. Initiate the start cycle by selecting the relevant start switch to RUN and holding it against spring pressure to START for 2 seconds. Simultaneously, start the stopwatch and note the illumination of the STARTER ON indicator light. At 10% RPM, the start fuel cycle commences and the igniter plugs are energized as indicated by the IGNITER ON indicator light; light-up occurs within 5 seconds (10 seconds after a cold soak).

65. Monitor the RPM and EGT, check that the oil pressure is rising and observe the EEC and FIRE captions on the CWP. If the light-up is successful, the igniter plugs and starter de-energize at 60 to 65% RPM and the IGNITER ON and STARTER ON indicator lights go out. The engine accelerates to the ground idle speed of approximately 72% (with air conditioning BLEED set to OFF/RESET) under the control of the EEC.

66. Abort the start (see para 68) if any of the following occur:

a. The propeller does not turn when START is selected.

b. There is any unusual noise or vibration.

c. The RPM fail to reach 5% within 10 seconds of START selection.

d. The engine does not light up (EGT rising) within 5 seconds (10 seconds after a cold soak) of the IGNITER ON indicator light illuminating.

e. The EGT rises rapidly through 730°C or is likely to exceed 770°C.

f. The RPM fail to reach 30% within 35 seconds or stagnate during any part of the start cycle.

g. The oil pressure does not rise or the OIL P caption does not go out within 10 seconds of reaching 60% RPM.

h. The STARTER ON and IGNITER ON lights do not extinguish at 60 to 65% RPM or within 60 seconds of selecting START.

i. The CWP EEC or FIRE captions illuminate.

67. **Starter Limitations.** If the starter is inadvertently disengaged, allow the propeller to stop completely before making another attempt. A maximum of 3 start/dry crank cycles may be attempted (each no longer than 60 seconds) at 2-minute intervals. A period of 15 minutes must then elapse before attempting further starts using the same sequence. Only 3 start cycles may be made using internal batteries; before each start cycle the battery voltage must be above the minimum for engine starting.

68. **Aborting the Start.** If it is necessary to abort the start, select the ESDL to OFF/FEATHER and the start switch to STOP. This shuts off the fuel flow and de-energizes the starter and the igniter plugs. If a start is cancelled using only the STOP selection, fuel shut off may take up to 5 seconds. Below 72% RPM the propeller does not feather as the start locks are still engaged; above 72% RPM the propeller only feathers if the start locks have been disengaged.

Note: The fuel purge system is inoperative when a ground start is aborted. The associated accumulator is not recharged unless RPM exceed 95% during an engine running cycle. Fuel may be dumped through the combined drain on the right of the engine during the next start cycle.

69. **Dry Crank.** Following a failed start attempt, carry out a dry crank before a further start to reduce the EGT to below 200°C or to ventilate the engine of unburnt fuel. To dry crank the engine, select the EEC to CRANK then select the start switch to START for the required period (no longer than 30 seconds). The RPM rise to stabilize at 13 to 15%. When the dry crank is complete, select the start switch to STOP, the EEC to NORMAL and the ENGINE SPEED switch momentarily to 70%. Wait 2 minutes for the starter to cool before making a further start attempt.

70. **Start Cycle Cooling.** If the start is cancelled at less than 60% RPM using only the ESDL, the starter will continue to rotate the engine at about 15% RPM until STOP is selected. Use the starter in this way to cool the engine and obviate the requirement for a dry crank. To cool the engine during the start cycle:

a. Abort the start by selecting the ESDL to OFF/FEATHER.

b. Ensure that the EGT stops increasing and fuel flow reduces to zero.

c. Monitor the EGT and the clock. Select STOP when the EGT reduces to less than 200°C or the clock reaches 60 seconds, whichever is the sooner.

d. If the EGT remains above 200°C after 60 seconds, carry out a separate dry crank. Otherwise, attempt a further start, observing the starter limitations (see para 67).

After Starting

71. After starting, with the throttle at GND IDLE, check that RPM are 72 to 73% and EGT is below 560°C. Set both MAIN FUEL PUMPS to ON and check that all CWP captions are out. Smoothly ease the throttle into REVerse momentarily to release the propeller start locks.

Take-Off

72. Before take-off select the ENGINE SPEED switch to 100%. When lined up select 20% torque and ensure that RPM are 100±1%, EGT is increasing, oil temperature and pressure indicate in the green sectors. When full power is selected, torque rises quickly; the maximum permitted torque is 100% with a maximum overswing of 115%. RPM may reach a transient maximum of 101-104% for up to 30 seconds. The EGT, rising more slowly than the torque, may overswing to a maximum of 660°C for 5 seconds, before settling at the red line maximum of 650°C.

Note: Depending on conditions, the EEC will limit the engine output either at 100% torque or at 650°C EGT. The engine is serviceable if either torque or EGT is at its limit.

In Flight

73. Refer to Part 3, Chapter 2 for detailed information on engine handling in flight.

After Flight

74. Do not use REVerse thrust if the EEC is in MANual mode.

75. After decelerating to taxying speed select 70% momentarily. After being at low power for 3 minutes (including approach, landing and taxying) set the throttle to REV (in EEC NORMAL mode only) to engage the start locks then select the start switch to STOP.

CAUTION: Reselecting RUN after an inadvertent STOP selection but before the propeller has stopped rotating may result in damage to the engine.

USE IN ABNORMAL CONDITIONS

Engine Fire

76. If the CWP FIRE caption illuminates, carry out the **FRC Engine Fire** or **Engine Fire on the Ground** drill.

Engine Malfunction Diagnosis

77. Engine power management and control relies on the integrity of the engine and propeller, accessory and ancillary components, as well as their supporting systems and the services provided by the aircraft installation (as illustrated in Fig 4 to Fig 7 inclusive). Engine and engine control malfunctions may arise from the failure of any element within these systems. In conjunction with operating conditions, other indications, sensory cues and cautionary warnings, engine malfunctions may be characterised by whether RPM is stable or reducing. RPM is an essential tool in the diagnosis of engine (and engine control) malfunctions. If there is any abnormal engine control response or indication, with or without an EEC caption, check the RPM.

78. It is important to understand the behaviour of the RPM. 'Reducing' means that the RPM reduce continuously, when the engine should be shut down. 'Stable' means that the RPM either remain at normal (100 ± 1%) or stabilise at a value below normal, having reduced from normal almost instantaneously. Provided that RPM remain stable and the engine continues to provide useful thrust, it need not be shut down. If RPM cannot be maintained above 85% the engine may have to be shutdown.

79. Automatic reversion of the EEC to MANual and failures of the EGT and torque sensing components of the engine control system are relatively common. Automatic reversion to MANual mode can occur at any phase of flight and is a design characteristic response when the EEC cannot fulfil its control or monitoring function (see para 56). In such cases the EEC caption will illuminate, however other control system malfunctions may not illuminate an EEC caption. Symptoms may include a significant loss of thrust or high drag (depending on throttle setting), a change in engine note and no response to throttle movement. Crucially, the RPM remain stable. Although these failures can be alarming, especially at a critical phase of flight, they can usually be remedied by selecting EEC to MANual. Table 4 below summarises known engine faults.

Table 4 - Engine Faults

RPM Stable		*RPM Reducing*	
Engine Control Malfunction	See para 80	Bogdown	See para 85
FCU Failures	See para 81	Flameout	See para 88
Ancillary Component Failure	See para 82	Mechanical Failure	See para 91
Indication Fault	See para 83	Inadvertent ESDL	See para 92
Propeller Malfunctions	See para 84		

RPM Stable

80. **Engine Control Malfunction.** If there is any abnormal response or indication, with or without an EEC caption with RPM stable, set 30% torque if practicable – or throttle to mid-quadrant if the torque does not respond to throttle movement or torque gauge is unreliable – and switch the EEC to MANual mode. Advance the throttle to restore power but do not allow the EGT to exceed 560°C in manual mode – about 2/3 throttle travel if the EGT gauge does not respond to throttle movement. If the abnormal symptoms disappear and power is restored, do not reselect EEC to NORMAL. Refer to Part 3, Chap 2 for information on engine handling in manual mode.

81. **FCU Failures.**

a. **Bellows Failure.** Following on from para 80, if after selecting EEC to MANual, abnormal symptoms persist (torque, EGT and fuel flow decaying with normal RPM) and full throttle fails to restore power, a failure may have occurred within the FCU bellows assembly (see Part 1, Chap 4, Fig 4). Fuel supply to the engine may have decreased, and may continue to decrease, resulting in a progressive reduction in maximum available torque. Once the torque has reduced to zero, a further decrease in fuel supply will result in a reduction in RPM. The timescale over which this process occurs will depend on the severity of the failure but, in the extreme case, is a matter of seconds. The fuel supply to the engine can be augmented by holding the FUEL/IGN switch to EM'GY and using start fuel enrichment to increase available torque by 10 to 20%, depending on altitude. However, this is only effective while there is sufficient fuel flow available; once the fuel flow has decreased beyond a certain point, holding the FUEL/IGN switch to EM'GY will have no effect. When RPM starts to reduce the engine should be shut down using the **FRC Engine Shutdown** drill.

Note: Selecting the FUEL/IGN switch to EM'GY also runs the unfeathering pump. The pump motor is not continuously rated and may fail or catch fire if run continuously; for this reason, pull C/B 3 (UNFEATHR PUM'P) when time permits. Selecting AIR COND BLEED OFF/RESET and INTAKE ice protection OFF will also augment maximum available torque (see Note Chap 4, Page 19).

b. **Torque Motor Failure.** A rare failure within the torque motor flapper valve can cause a sudden fall in P3 air pressure within the bellows assembly (see Chap 4, Fig 4.). This results in a sudden loss of thrust, accompanied by high propeller drag, low EGT (circa 350°C) and reduced but stable RPM. Setting the throttle to mid quadrant and the EEC switch to MANual will quickly restore the engine to 100% RPM.

82. **Ancillary Component Failure.** The maximum output of the engine is controlled by the EEC to either 100% torque or 650°C SRL EGT (see paras 19 and 20). An open circuit in the thermocouple ring or EGT harness or breakdown in the EGT Compensator results in a zero-volts signal giving a full-scale EGT reading of 900°C. Similarly, a failure of the torque signal conditioner may result in a maximum torque indication. The EEC reacts to these false maximum signals by decreasing the fuel flow; power reduces suddenly and cannot be restored even at full throttle. As the EEC itself may not be at fault and none of the four parameters given in para 56 are met, the EEC continues to function (no EEC caption) and the RPM remain normal. To restore power, set 30% torque if practicable – or throttle to mid quadrant if torque does not respond to throttle movement – and switch the EEC to MANual mode.

Note: A genuine EGT of 900°C in the case above would indicate catastrophic damage to the engine. If the engine is still producing thrust with the RPM at normal, it is likely that the 900°C EGT indication is false.

83. **Indication Fault.** An EGT or torque gauge fault may result in a fluctuating indication without any change in engine response. A faulty gauge is likely to fluctuate in isolation, without sympathetic fluctuation of any other gauge. Set 30% torque if practicable – or throttle to mid-quadrant if the torque does not respond to throttle movement – and switch the EEC to MANual mode. Monitor the indication and land as soon as practicable; do not reselect the EEC to NORMAL.

84. **Propeller Malfunctions.** A rare malfunction may cause the propeller to move towards a coarser or finer blade angle than normally scheduled. This will result in a correspondingly lower or higher RPM than the normal 100% ± 1%. If sufficient RPM or power cannot be maintained or the EGT maintained within limits, the engine is to be shut down. Selection of EEC MANual will not resolve the malfunction.

RPM Reducing

85. **Bogdown.** During flight at less than +0.5g, oil is supplied to the propeller pitch change mechanism by the oil accumulator which has a limited capacity. Once this supply is exhausted, propeller pitch control is lost and the propeller blades move towards the feathered position under the action of the feathering spring. This causes a very large increase in rotational drag, a reduction in RPM and a rapid increase in EGT. The condition is colloquially known as bogdown. The symptoms are:

a. A change in engine note.

b. RPM reducing.

c. Torque reducing.

d. High EGT.

86. If bogdown occurs with full power selected, an overtemperature is inevitable. If it occurs at low power settings, prompt action may prevent an overtemperature. If a bogdown is identified, apply positive g as soon

as possible and set the throttle to FLT IDLE. If the EGT limit has been exceeded, land as soon as possible using minimum power (ideally from a precautionary forced landing).

87. The most common causes of bogdown are the cumulative effect of a series of aerobatic manoeuvres involving less than +0.5g or a single, seemingly innocuous manoeuvre such as a prolonged bunt. The symptoms disappear as soon as oil pressure is restored but, if the EGT limit has been exceeded, serious engine damage is likely to have occurred.

Flame Out (and In-Flight Relighting)

88. A flame out is most likely to occur as a result of fuel starvation or a disruption in airflow through the engine intake (icing or bird strike). The NTS provides an automatic and immediate relight capability. If a flame out occurs due to a momentary interruption of fuel or airflow, and the immediate relight is successful, the pilot may have no indication that this has occurred other than the ignition light which may remain on for up to 10 minutes. However, the ignition is also activated if the NTS system operates for reasons other than a flame out. If the engine does not respond and return to normal the symptoms are RPM, Torque and EGT reducing. If RPM falls below 80% after a flame out, shut down the engine. Carry out the **FRC Flame Out/Relight** drills.

In-Flight Relighting

89. The engine starter is inhibited in flight. If the NTS system fails to provide an immediate and automatic relight when a flame out occurs the engine should be shut down. A relight can then only be accomplished by unfeathering the propeller using the unfeathering pump and windmilling the engine. The chance of a successful relight is reduced if the oil temperature is below +4°C. Since the rate of descent at optimum glide speed is only 900 feet per minute, there is usually plenty of time to carry out the drill methodically. However, when START is selected to unfeather the propeller and the engine begins to windmill, there is a significant increase in drag and a consequent reduction in gliding performance. Although the engine relights quickly, it will not produce usable power until the RPM reach 100%.

90. The relights are equally reliable under EEC NORMAL or MANual control. Below 20,000 feet and with the speed at 115 to 200 knots, set the throttle at mid-quadrant, confirm the ESDL is at NORMAL and the FUEL CUT OFF is selected OPEN. Switch at least one fuel pump ON, ensuring that the contents are sufficient for the selected pump(s). Set the GENerator switch to ON/RESET.

a. **EEC NORMAL Relight.** With the EEC switch at NORMAL, select the start switch to STOP and then back to RUN (the EEC caption is illuminated at this stage). Select the start switch to START for 2 seconds; this runs the unfeathering pump and the engine starts to rotate. The propeller unfeathers at a rate controlled by the NTS system such that acceleration is smooth. Relight is automatic under the control of the EEC; at 10% RPM, the start fuel cycle commences and the igniter plugs are energized as indicated by the IGNITER ON light. The EEC caption should extinguish after selecting START; if it does not, or if the propeller fails to rotate, or if the EGT fails to rise within 20 seconds, or if it is likely to exceed 770°C, abort the relight by selecting the ESDL to OFF/FEATHER. Attempt a relight with the EEC in MANual. Operational experience has shown that a normal relight could take up to 2500ft.

b. **EEC MANual Relight.** If an attempt to relight with the EEC in NORMAL is unsuccessful, or if the EEC had previously failed, perform a relight with the EEC switch set to MANual. Ensure that the ESDL is NORMAL and select START to run the unfeathering pump and windmill the propeller. Ignition is not automatic; at 10% RPM hold the FUEL/IGN switch to EMGY for 2 seconds. If the subsequent start is slow or stagnates with a low EGT, select the FUEL/IGN switch to EM'GY for one second at a time to accelerate the start. Abort the relight by selecting the ESDL to OFF/FEATHER if the EGT is likely to exceed 770°C. Do not select the EEC to NORMAL once the engine has relit.

CAUTION: Engine damage will occur if allowed to windmill in the range of 18% to 28% RPM.

Mechanical Failure

91. The symptoms of mechanical failure may include noise, vibration and rapid RPM wind down; if the RPM cannot be maintained above 85% the engine should be shut down using the **FRC Engine Mechanical Failure** drill.

Inadvertent ESDL Operation

92. If the ESDL is operated inadvertently, return the lever to NORMAL immediately, set the throttle to mid-quadrant and select the FUEL/IGN switch to EM'GY for 2 seconds. The engine will relight and accelerate under the control of the NTS system. However, if the lever has been moved fully aft, engine wind down is very rapid (about 4 seconds). If RPM have reduced to below about 30%, the engine may not relight and/or the EGT may increase towards the limit of 770°C. Set the ESDL to OFF/FEATHER and consider a relight, forced landing or ejection.

Note: The FUEL/IGN switch in the rear cockpit is inoperative if the MASTER ENGine SWitch is selected to FRONT.

Abnormal Oil Pressure

93. Abnormal oil pressure is indicated on the oil pressure gauge and ►◄ by illumination of the OIL P caption on the CWP. If, during stable level flight, the oil pressure fluctuates, or rises above or falls below permitted levels (see Part 2, Chap 2, Table 2), reduce power to the minimum required for safe flight, avoid negative g, monitor oil temperature and land as soon as possible. If propeller pitch control is lost, carry out the **FRC Emergency Engine Shutdown** drill.

Abnormal Oil Temperature

94. **High Oil Temperature.** If the oil temperature exceeds 110°C but is less than 127°C (high amber), reduce torque to less than 70% and land as soon as possible. The time with temperature above 110°C must not exceed 5 minutes. If the oil temperature exceeds 127°C (above the high amber), reduce torque to the minimum practicable, monitor the engine instruments and land as soon as possible.

Note: Engine operation at oil temperature above 150°C may result in loss of oil pressure and propeller pitch control. If propeller pitch control is lost, carry out the **FRC Emergency Engine Shutdown** drill.

95. **Low Oil Temperature.** If during flight, the oil temperature decreases to below 55°C (below the green sector), avoid high power settings and land as soon as practicable.

96. **Icing Conditions.** Monitor oil temperature closely during flight in icing conditions. If increases of 3° to 5°C per minute are observed, assume that the engine oil cooler is partially blocked by ice.

In-Flight Shutdown

97. To shut down the engine in flight, select the ESDL to OFF/FEATHER. If time and circumstances permit, and if the engine is unlikely to be relit, carry out the **FRC Emergency Engine Shutdown** drill. The operating loads on the ESDL tend to be higher in flight than on the ground; firm and positive movement is necessary to ensure full travel to the OFF/FEATHER position. Failure to achieve full travel results in engine rundown without the propeller feathering, which causes a high rate of descent. The ESDL must be operated before the FUEL CUT OFF is selected.

Monopole Failure

98. If either monopole sensor fails, the EEC will automatically switch to MANual mode, and the CWP caption will illuminate.

Propeller Blade Separation

WARNING: If pre-flight inspection reveals contamination of the propeller hub or rear of the blades with grease or oil or if, in flight, there is a sudden or abnormal propeller vibration, there is a possibility of imminent failure of a propeller blade or blade retention component. Blade separation in flight will result in loss of the aircraft.

99. If, in flight, there is abnormal propeller vibration, regain straight and level flight as soon as possible and recover to the nearest suitable airfield at low speed and power. Keep manoeuvres gentle and to a minimum and fly with a minimum of sideslip. Do not use propeller reverse braking on landing.

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PART 1

CHAPTER 5 - HYDRAULIC POWER SUPPLIES

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INTRODUCTION

1. The hydraulic power system comprises a reservoir, motorized shut-off valve, engine-driven pump, high pressure relief valve, pressure switches, temperature sensor, pressure and return line filters (see Fig 2). Hydraulic pressure is maintained at 217 to 220·4 bar to operate the landing gear and airbrake. An emergency accumulator (charged from the main system) provides for emergency lowering of the landing gear. A panel to enable opening and closing the landing gear doors for maintenance is at the rear of the baggage compartment.

DESCRIPTION

Reservoir

2. The reservoir is charged with nitrogen and hydraulic fluid at a maintenance panel in the baggage compartment (see Fig 1). The nitrogen pressure gauge is adjacent to the charging connection on the maintenance panel. The fluid contents direct reading gauge is behind the HYDRAULIC RESERVOIR FLUID LEVEL access panel.

Accumulator

3. The landing gear emergency accumulator is charged with nitrogen to 125·69 ± 1·38 bar at 15°C (accumulator empty). The EMERGENCY ACCUMULATOR PRE CHARGE maintenance panel, aft of the baggage door, gives access to a nitrogen charging connection, pressure gauge and a hydraulic pressure release valve.

4. When the aircraft is on the ground (weight switches operated) and main system pressure is above 158·6 bar, the main system pressure switch operates, opening the emergency shut-off valve thus allowing the emergency accumulator to be charged. The shut-off valve closes during take-off (via weight switch control) to retain emergency accumulator pressure. If the shut-off valve fails to close the EMER HYD caption is illuminated through the weight switches.

Hydraulic Pump

5. System pressure is generated by a variable displacement pressure compensated pump on the engine gearbox accessory drive. With no service operating, the pump delivers fluid at a continuously monitored pressure of 217 to 220·4 bar.

Hand Pump

6. A hand pump in the hydraulic bay is permanently connected across the pump suction and high pressure lines for maintenance operations. The pump is operated from the baggage compartment and the handle stowage is adjacent to the pump.

High Pressure Relief Valve

7. If the system pressure reaches 244.8 ± 6·9 bar a high pressure relief valve opens, reducing system pressure to 51·7 ± 3·5 bar. The relief valve does not reset until pressure reduces to 13·8 ± 3·5 bar at engine shutdown.

Filters

8. Delivery fluid from the pump passes through a high pressure line filter before distribution to the services. The filter has a 5-micron element but no bypass facility. Incorporated in the filter is a differential pressure indicator with a tell-tale button. The button pops out when a differential pressure of 3·8 bar is exceeded.

9. A return line low pressure filter (5-micron) has a bypass facility and a differential pressure indicator. A tell-tale button pops out when a differential pressure of 3·8 bar is exceeded and the bypass becomes operational at 4·5 bar.

10. Filter tell-tale button locations are shown in Fig 1.

Pressure Switches

11. Pressure switches in the main and emergency pressure lines illuminate respectively the HYD and EMER HYD captions on the CWP in each cockpit when pressure falls below 158·6 bar. The power supply for the switches is from the essential services busbar. When main hydraulic pressure is above 158·6 bar the pressure switch signals the landing gear emergency accumulator charging shut-off valve to open, however, the valve only opens on the ground.

Temperature Sensor

12. A temperature sensor in the return line also illuminates the HYDraulic warning on the CWP if fluid temperature exceeds 107°C. The sensor resets on decreasing temperature at 96°C. The electrical supply is from the essential services busbar.

Controls and Indications

13. A gated hydraulic shut-off valve switch (HYD - CUT OFF/NORMAL) is in each cockpit. Moving either switch to CUT OFF closes the hydraulic shut-off valve. Moving the switch to NORMAL does not reopen the valve. With the switch at NORMAL, the valve is signalled to open by selecting the fuel ignition switch to EM'GY or by selecting the start switch to START.

14. The hydraulic shut-off valve is also closed when the FUEL CUT OFF switch is selected to CLOSE (see also Chap 3).

15. Hydraulic warning captions HYD and EMER HYD on the central warning panel indicate the following conditions:

a. HYD

(1) Pressure in the main system is below 158·6 bar or,

(2) Fluid temperature is above 107°C.

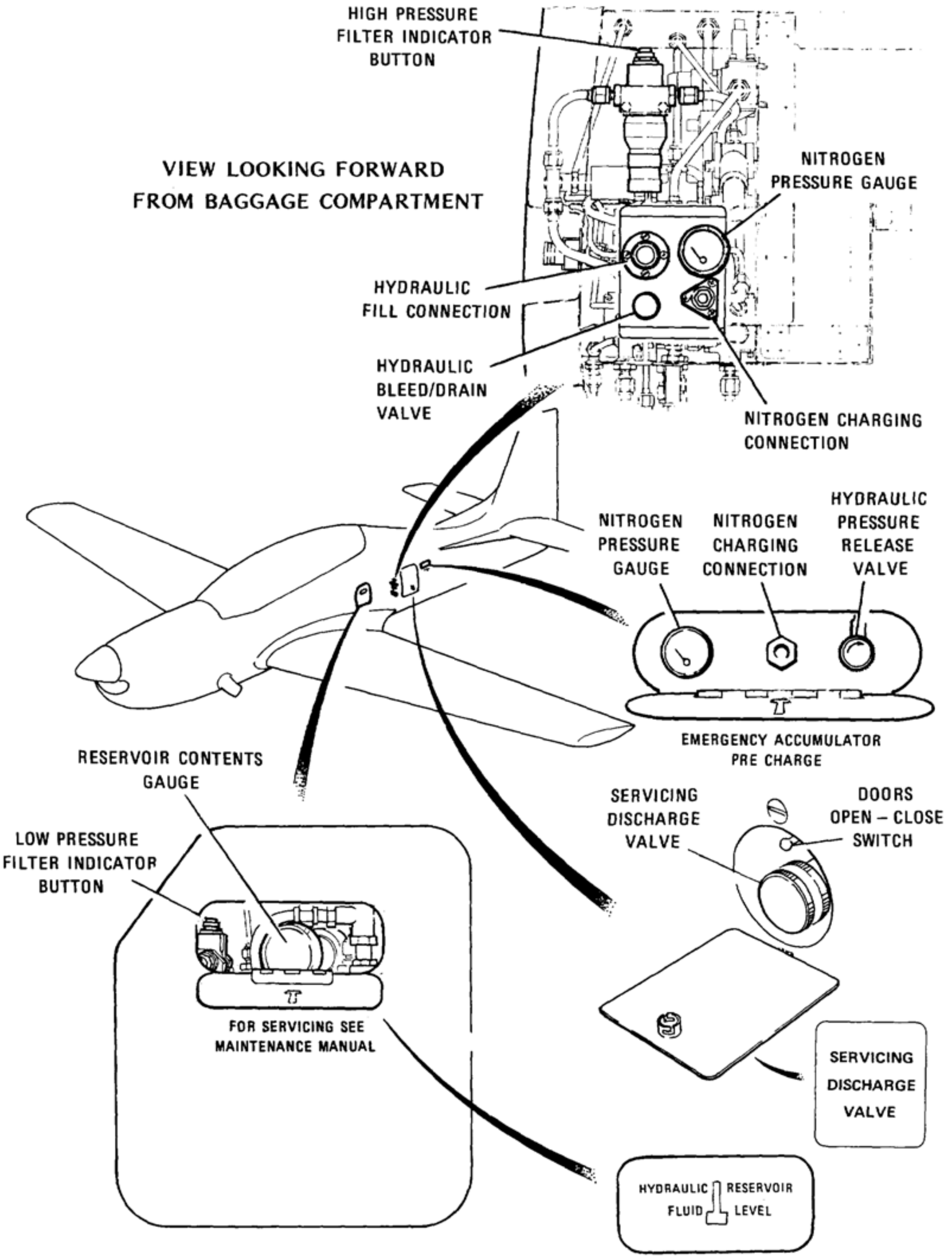
b. EMER HYD

(1) Pressure in the emergency system is below 158·6 bar or,

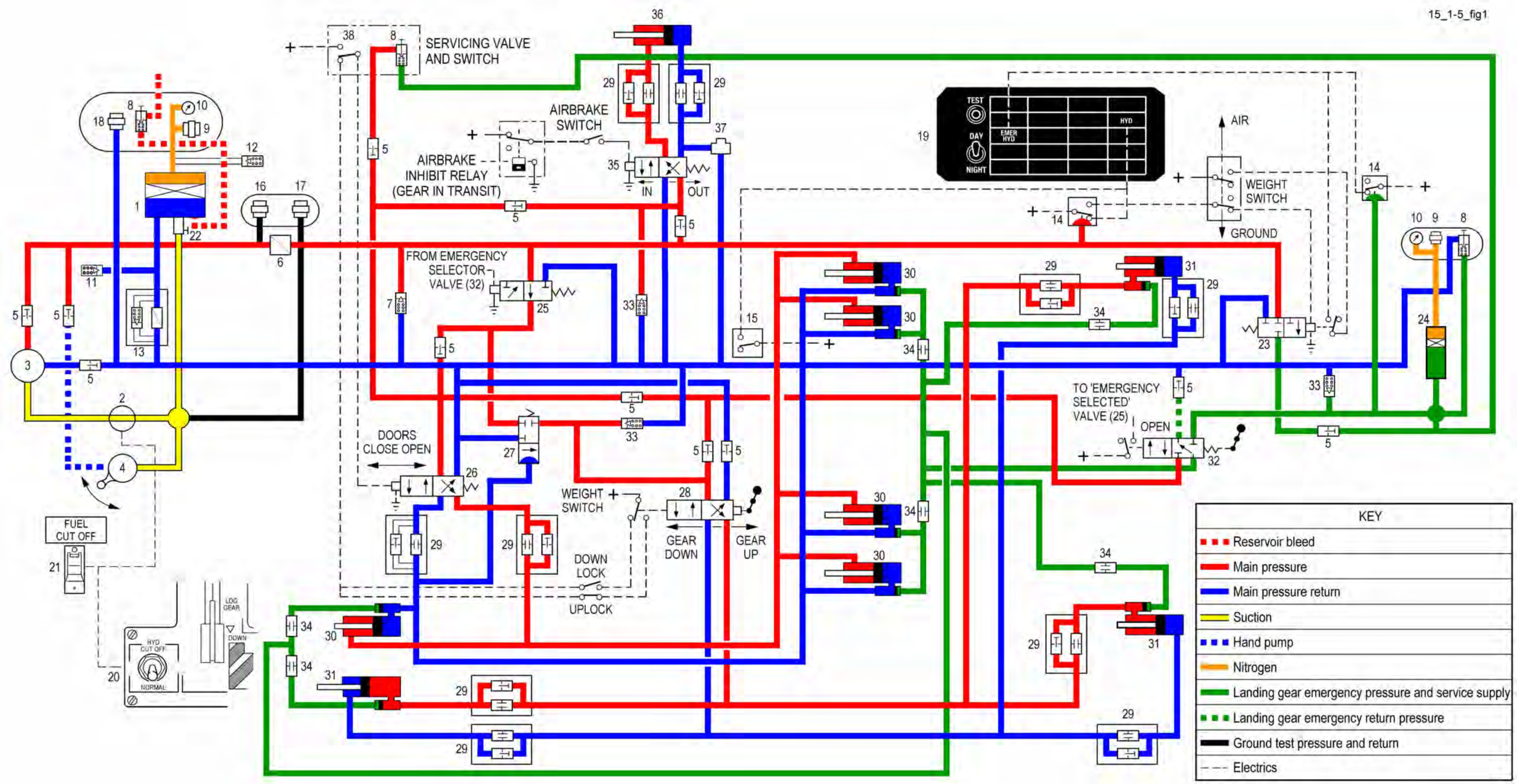
(2) The emergency shut-off valve has failed to close after take-off.

Table 1 - Controls and Indicators

Control/Indicator	*Marking*	*Location*	*Function*
Hydraulic cut-off switch	HYD - CUT OFF/ NORMAL	Main instrument panel, bottom left, both cockpits	Closes the shut-off valve to the engine-driven pump
Fuel and hydraulic cut-off switch	FUEL CUT OFF	Main instrument panel, right, front cockpit	Closes the fuel and hydraulic shut-off valves
Fuel and hydraulic cut-off switch	FUEL CUT OFF - CLOSE/ FRONT/OPEN	Main instrument panel, right, rear cockpit	CLOSE - closes the fuel and hydraulic shut-off valves FRONT - transfers controls to front cockpit OPEN - overrides the front cockpit selection and selects the valves open when START is selected
Hydraulic indication	HYD	CWP, main instrument panel, bottom right, both cockpits	Illuminated when normal hydraulic pressure is below 158·6 bar or fluid temperature is above 107°C
Emergency hydraulic indication	EMER HYD		Illuminated when emergency hydraulic pressure is below 158·6 bar or if the emergency shut-off valve has failed to close after take-off
Warning light (amber)	FUEL OFF	Main instrument panel, right, both cockpits	Illuminates when fuel and hydraulic valves have closed and CLOSE is selected



1 - 5 Fig 1 Equipment Location



Note:-
Circuit drawn - gear down, doors closed and airbrake in

1. Reservoir
2. Motor shut-off valve
3. Engine pump
4. Hand pump
5. Non return valve
6. Filter (pressure line)
7. Relief valve (high pressure)
8. Bleed valve
9. Gas charge connection
10. Pressure gauge
11. Relief valve (L.P. oil)
12. Relief valve (gas)
13. Filter & bypass valve (return line)
14. Pressure switch
15. Temperature sensor
16. Ground connection (pressure)
17. Ground connection (return)
18. Ground connection (system fill)
19. Central warning panel
20. HYD cut off switch
21. FUEL CUT OFF switch
22. Bleed plug
23. Emergency shut-off valve
24. Emergency accumulator
25. Emergency selected valve
26. Selector valve (doors)
27. Sequence valve
28. Control valve (landing gear)
29. Restrictor (one way)
30. Actuator (doors)
31. Actuator (landing gear)
32. Selector valve (emergency)
33. Thermal relief valve
34. Restrictor (two way)
35. Selector valve (airbrake)
36. Actuator (airbrake)
37. Hydraulic lock
38. Servicing switch

1 - 5 Fig 2 Hydraulic Power - Schematic

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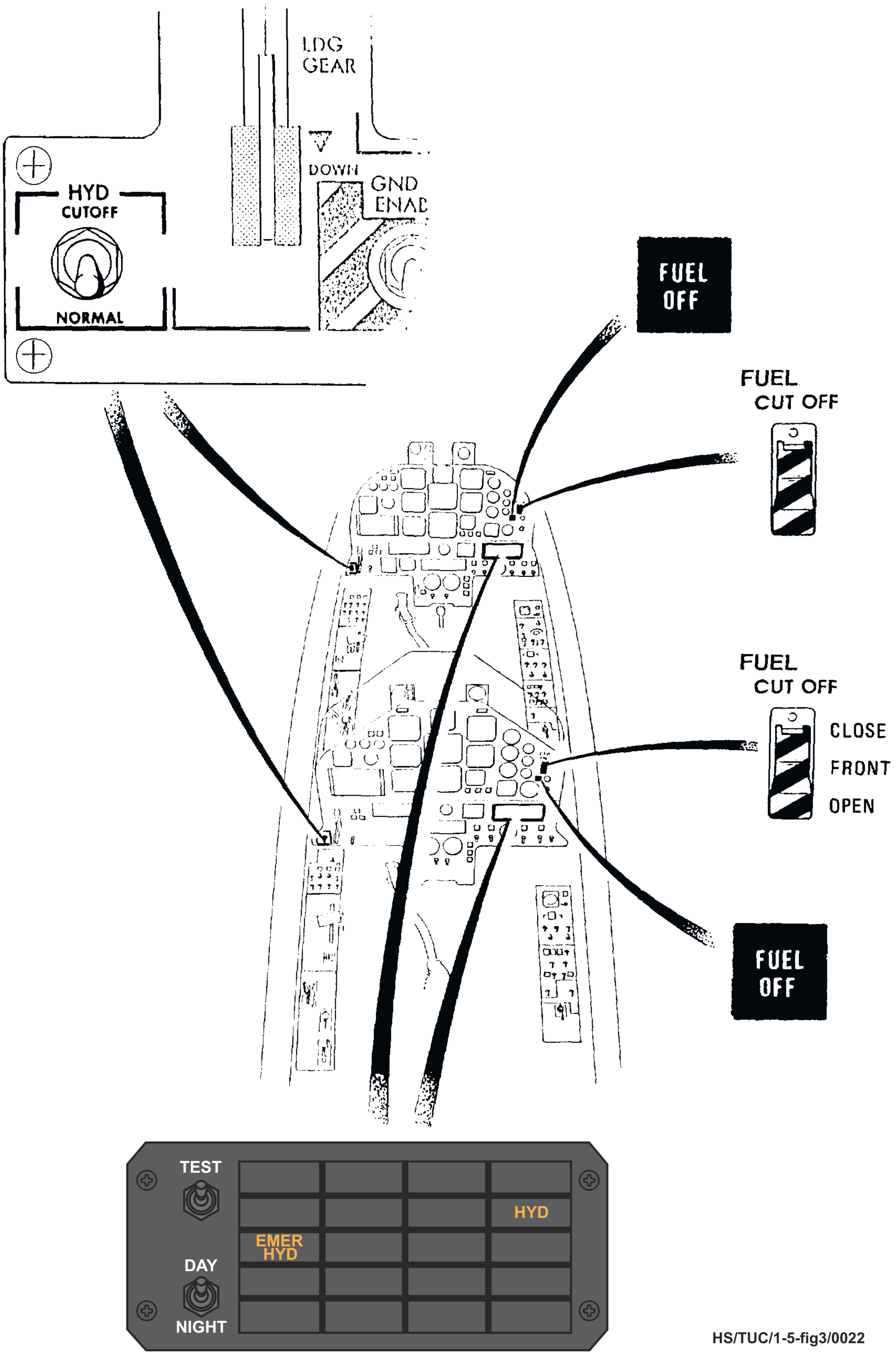

1 - 5 Fig 3 Controls and Indicators

NORMAL USE

Before Flight

16. Ensure the rear cockpit FUEL CUT OFF switch is to FRONT during the **Cockpit** checks and, during the **Pre-Start** checks, that the front cockpit switch has the cover down. During the **Cockpit** and **Pre-Start** checks confirm that the HYD CUT OFF switches in the rear and front cockpits are to NORMAL. After engine start check that the HYD and EMER HYD captions are out.

In Flight

17. The HYD and EMER HYD captions remain out in normal conditions.

After Flight

18. During engine shutdown the HYD caption is illuminated but the EMERG HYD caption remains out.

USE IN ABNORMAL CONDITIONS

General

19. In all cases of hydraulic system failure, land as soon as possible.

Hydraulic Failures

20. If the HYD caption is illuminated when neither the landing gear nor the airbrake is operating, the HYDraulic shut-off valve switch is to be set to CUT OFF. Landing gear is to be extended by means of the LDG GEAR STBY DOWN lever. Following a hydraulic failure the airbrake cannot be retracted completely. When selected IN it moves to a trail position.

21. If the EMERG HYD caption is illuminated, landing gear lowering using the LDG GEAR STBY DOWN lever is not available. As soon as practicable, check that the airbrake is IN and lower the landing gear on the normal system.

PART 1

CHAPTER 6 - FLIGHT CONTROLS

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INTRODUCTION

General

1. The flying controls consist of elevators, differential ailerons and a rudder. A conventional control column in each cockpit manually operates the elevators and ailerons; the two control columns are interconnected. A pair of rudder pedals on a rudder bar in each cockpit mechanically operate the rudder; the rudder bars are interconnected. Trim control is provided in each axis. Fowler single-slotted flaps on the inboard trailing edge of each wing are electrically operated. The airbrake beneath the wing centre section is hydraulically powered. A stall warning vane activates a stick shaker.

DESCRIPTION

Flying Controls - General

2. Flight controls and indicators are detailed in Table 1 and illustrated in Fig 1.

3. The elevators, ailerons and rudder are mechanically actuated by a system of rods and control cables. The three circuits are shown in Fig 2.

Rudder Pedal Adjustment

4. In each cockpit the rudder pedals can be adjusted fore and aft for different leg lengths by turning a handwheel (Fig 1) that is below the centre of the instrument panel. Clockwise rotation of the handwheel moves the pedals closer to the occupant.

Control Locking

5. The elevators and ailerons can be locked from the front cockpit by a spring-loaded strut (Fig 1). The strut engages a fitting on the front of the control column which it holds deflected to the right; it can be used on the ground to cope with control snatching which can be severe when the wind is in excess of approximately 20 knots from the rear quarters. Since the rudder pedals are mechanically linked to the nose landing gear, the rudder is effectively locked when the aircraft is parked. Considerable strain can be placed on the control column gust lock mounting if the elevator is moved up and down by hand; do not try to move the elevators by hand during the **External** checks.

Table 1 - Flight Controls and Indicators

Control/Indicator	*Marking*	*Location*
Both Cockpits		
Trim cut-out switch	TRIM - ISOL/NORM	Left console
Trim indicators (three)	AIL, RUDDER and ELEV	Main instrument panel
Elevator/aileron trim switch	Unmarked	Top of control column
Rudder trim switch	RUD TAB - LH/centre off/RH	Throttle lever handle
Flap selector	FLAPS - UP, MID and DOWN	Left console panel
Airbrake switch	AIRBRAKE - IN/centre off/OUT	Throttle lever handle
Airbrake indicator	AIRBRAKE (when lit) (white)	Main instrument panel
Rudder pedal adjuster	Unmarked	Centrally below main instrument panel
Stall warning audio cut-out switch	STALL WNG - ISOL/NORM	Left console
Front Cockpit Only		
Airbrake emergency up selector	AIRBRAKE STBY UP - PULL & TURN TO LOCK	Left console
Control column gust lock	Red	Right of rudder pedal adjuster
Circuit breaker	STALL WARNING	Right front wall

Trimming

6. The left elevator and the rudder have electrically actuated trim tabs; the rudder tab also acts as a geared tab operated by control surface movement. Each aileron has a geared tab. Aileron trimming is achieved by adjusting a spring centring device in the primary circuit.

7. Trim is adjusted electrically in each circuit using an irreversible electromechanical actuator. The power supply is from the main busbar. For aileron trim, the actuator adjusts the central position of the control centring springs. For elevator trim and rudder trim the actuators are mechanically linked to their respective tab surfaces.

8. Elevator and aileron trimming is controlled by a `coolie-hat' switch on each control column top. The switch is spring-loaded to off (central); holding the switch up (forward) or down (aft) applies nose-down or nose-up trim respectively and holding the switch to one side applies aileron trim in the direction selected.

9. A rudder trim switch is on the forward face of each throttle. It is a 3-position rocker-type switch spring-loaded to off (central). Holding the left side pressed applies left rudder trim and vice versa.

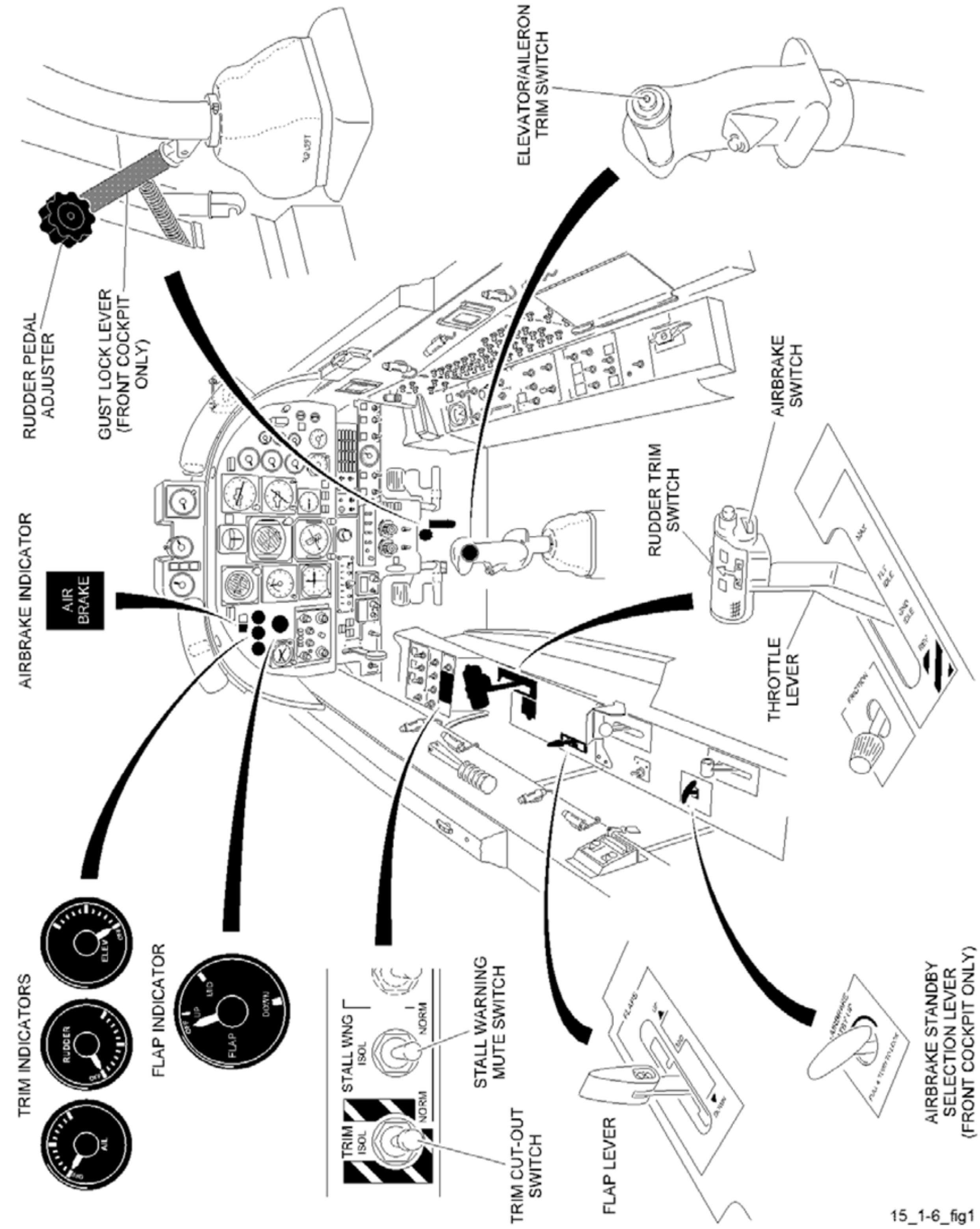
10. In all three trim axes the electrical circuits are arranged so that the rear cockpit trim switches override the front cockpit switches.

11. All trim circuits can be electrically isolated by setting the gated TRIM cut-out switch on the left console of either cockpit to ISOL. The switch has a striped black/yellow surround.

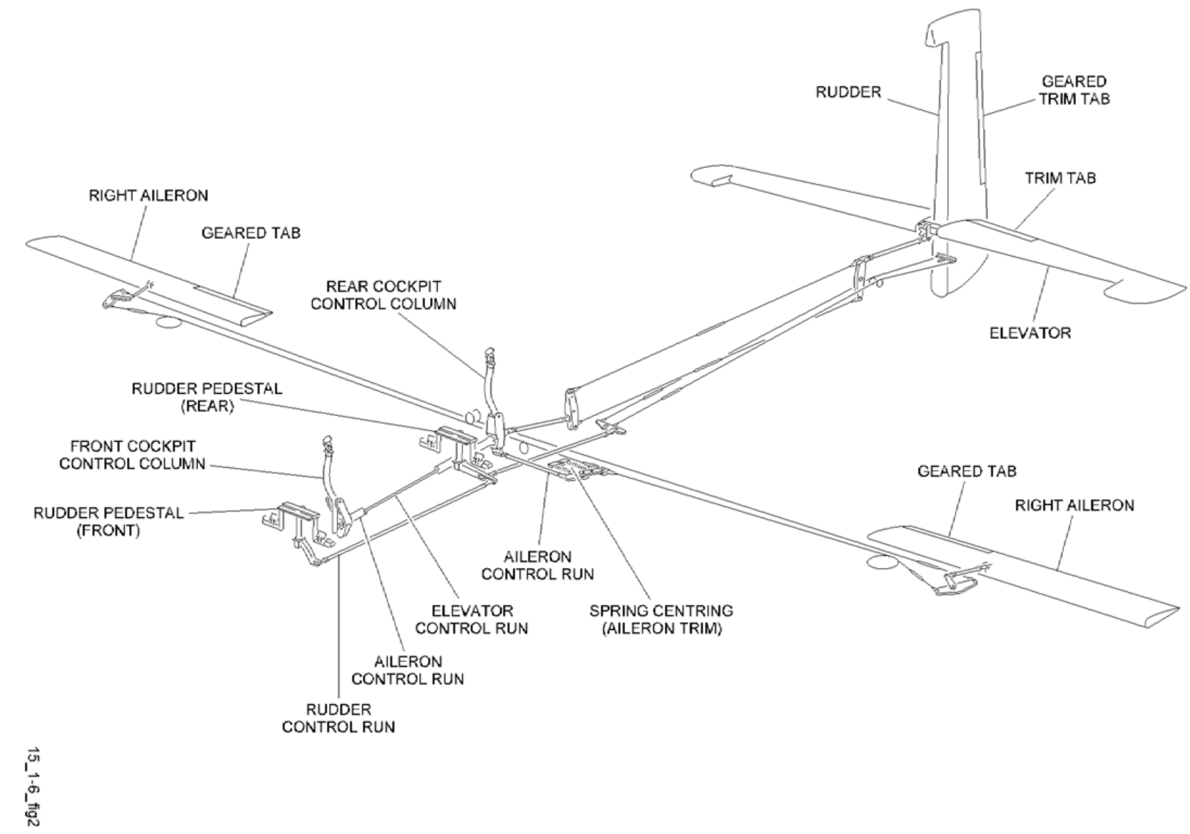
12. A trim position indicator for each circuit is shown in Fig 1. The aileron trim indicator has five divisions either side of neutral, the rudder trim indicator has two divisions left and five divisions right and the elevator trim indicator has five divisions nose-up and three divisions nose-down. Each indicator shows the amount of displacement of its associated actuator.

13. The times taken to trim from stop to stop are approximately:

Elevator	26 seconds.
Aileron	10 seconds.
Rudder	12 seconds.



1 - 6 Fig 1 Flight Controls - Controls and Indicators



1 - 6 Fig 2 Flying Controls and Control Runs

Flaps

14. A Fowler type single-slotted flap is fitted on each inboard wing trailing edge. The flaps are mechanically interconnected. A selector is on the left console in each cockpit (Fig 1); both selectors are mechanically interconnected.

15. Selector setting is signalled mechanically to a control unit which, sensing a disagreement between selector and surface settings, switches an electric motor to drive two linear actuators, one linked to each flap. When the selected flap setting is reached, a feedback signal to the control unit switches off the motor and thus locks the flaps in position. Selector settings and associated flap angles are:

UP	0°
MID	12°
DOWN	35°

16. Under normal aerodynamic loads, flap extension from 0° to 35° takes 12 seconds and retraction from 35° to 0° takes 11 seconds.

17. The flap setting, taken from a transducer on the left flap, is shown on the indicator on each main instrument panel (Fig 1). If a mechanical failure or overload occurs in the flap operating linkage, the electric motor is isolated to minimize flap asymmetry. Limit switches also isolate the motor if the flaps tend to over-deflect beyond the 0° or 35° positions.

18. Power supplies for flap actuation, control and position indication are taken from the essential services busbar.

Airbrake

19. A hydraulically operated airbrake is under the fuselage at the wing centre section. The airbrake is electrically selected IN or OUT by a switch on the throttle in each cockpit (Fig 1) using power from the main busbar; the rear cockpit switch overrides that in the front cockpit. The airbrake is held in the retracted position by a hydro-mechanical lock which is mechanically engaged but hydraulically released.

20. When selected OUT the airbrake extends down and forward 60° into the airstream. Extension or retraction takes 1·5 seconds. An indicator light on each instrument panel is lit to show AIRBRAKE whenever the airbrake is not fully retracted.

21. An AIRBRAKE STBY UP lever (PULL & TURN TO LOCK) is on the front cockpit left console; this is used to retract the airbrake following failure of a normal IN selection.

22. Airbrake operation is inhibited while the landing gear is in transit.

Stall Warning

23. When airborne, if the landing gear is DOWN and/or flaps are extended to MID or DOWN, warning of an approaching stall is given by a stick shaker attached to the control column in the front cockpit. The stick shaker is activated by an electrically de-iced stall warning vane in the outboard leading edge of the right wing. The vane is heated electrically when the aircraft is airborne and the AOA/STALL switch is selected ON or ICE DET is ON. A heater failure is indicated by an amber STALL caption showing on both ICE PROTECTION panels and an amber PSV HEAT caption is illuminated on each CWP. A circuit breaker, labelled STALL WARNING, in the stall warning vane and stick shaker circuits is on the panel of circuit breakers on the right in the front cockpit.

24. The stick shaker can be tested when airborne, if the landing gear is selected DOWN and/or flaps are extended to MID or DOWN, by pressing the AOA STALL indicator switch on the ICE PROTECTION panel in either cockpit.

25. Stall warning occurs approximately five knots above the stall speed for a given aircraft mass and flap configuration (see Part 3, Chapter 2).

26. An increase of angle-of-attack (AOA) above approximately 14 to 16 units in any configuration activates an audio pulsed tone warning. The warning can be cancelled by selecting the STALL WNG - ISOL/NORM switch in either cockpit to ISOL; in the front cockpit, the switch is spring-loaded to NORM. However, the rear cockpit switch is not spring-loaded to NORM. The audio warning is reset when AOA decreases below approximately 14 to 16 units (see Chapter 2 and Chapter 13).

27. The AOA vane is at the outboard leading edge of the left wing. The vane is heated electrically when the AOA/STALL switch is selected ON or ICE DET is ON. A heater failure is indicated by an amber AOA caption showing on both ICE PROTECTION panels and a PSV HEAT caption is illuminated on each CWP. Power to the heater is from the shedding busbar (see Chapter 11, para 40).

28. The audio warning can be tested, on the ground only, by pressing the AOA STALL indicator switch on the ICE PROTECTION panel in either cockpit. While holding the switch pressed, check the audio tone and cancel it by selecting the STALL WNG switch to ISOL, check that the AOA reading rises to about 20 units and check that the AOA indexer cycles to red. Release the AOA STALL indicator switch.

Note: Post-SM 109 (FLARM) the AOA indexers are removed from both cockpits, and the AOA indicator is removed from the FCP.

NORMAL USE

Before Flight

29. Before flight disengage the control column gust lock. Adjust the rudder pedals. Check operation of each trim against the indicators. Confirm the trim cut-out functions on all three trim axes. Check the elevators and ailerons for full and free movement before taxying. Check flap operation and indicator and leave set for take-off. Select airbrake OUT, check indicator lit; select and leave IN, check indicator light out. While taxying check rudder for correct sense within the range imposed by nosewheel steering limits.

After Flight

30. After flight re-engage the gust lock. After landing select the flaps to MID.

USE IN ABNORMAL CONDITIONS

Trim Runaway

31. If trim in any of the three axes runs away, set the TRIM cut-out switch in either cockpit to ISOLate if required. No control authority is lost. If practicable adjust power and/or speed in the appropriate sense to relieve out-of-trim forces.

a. **Aileron.** Full out-of-trim aileron loads are very light and are easily manageable single-handed throughout the speed range.

b. **Rudder.** Full out-of-trim rudder loads are insignificant at threshold speed. Full left trim is easily manageable up to 240 knots but, at this speed, full right trim gives very high footloads that require a speed reduction to about 150 knots to become easily manageable. However, the slow rate of trim application allows ample time to isolate the trims before full deflection is reached.

c. **Elevator.** Full nose-down trim loads are manageable and a safe take-off, circuit and landing can be flown. Full nose-up trim at 240 knots requires a very high push force; reduce power to the minimum practicable and allow the aircraft to pitch up slowly to reduce the load as the speed reduces. Single-handed operation at 130 knots and below at stabilized torque settings presents no difficulties. On take-off or overshoot the push force required by full nose-up trim can be decreased significantly if torque is reduced to 60%. The slow rate of trim allows ample time to isolate the trims before full deflection is reached.

Note: The cut-out switch isolates all three trim circuits.

Flaps Fail to Respond to Selection

32. If the flaps fail to respond to selection, or stop in an intermediate position, place the selector in the detent closest to the indicated position. Check c/b 51, 52 and 53 and, if appropriate, reset. If the fault is because of asymmetric flap, a tendency for the aircraft to roll is apparent; this is easily countered by aileron and can be trimmed out.

Airbrake Fails to Retract

33. If the airbrake indicator remains lit following a normal IN selection, select the AIRBRAKE STBY UP lever (PULL & TURN TO LOCK) on the front cockpit left console. This overrides the system selector valve; the airbrake retracts and the indicator light goes out. If failure was caused by loss of hydraulic pressure, the airbrake blows back to within 10° of fully retracted and the indicator remains lit. A landing can be made successfully with the airbrake fully out.

Airbrake Undemanded Retraction

34. A failure of the electrical supply to the airbrake system causes the solenoid selector valve to return to the airbrake `in' position; the airbrake retracts. Make no further OUT selection.

Airbrake Fails to Respond to Selection

35. If it is suspected that the airbrake has not responded to a selection, refrain from repeated attempts to operate the system. If the airbrake jack ram has sheared and selections are made, the ram will continue to extend and retract with the possibility of damaging the surrounding structure.

PART 1

CHAPTER 7 - LANDING GEAR AND WHEELBRAKES

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INTRODUCTION

General

1. The landing gear comprises three single-wheel units, each with oleo-pneumatic shock struts. The nose gear retracts rearwards into the fuselage, directly below the engine and the main gear retracts inboard into the wings. Hydraulic actuators, which are normally powered by main system pressure, can also be operated from an emergency accumulator thus providing a standby means of lowering the gear.

2. Each leg is mechanically locked when fully extended or retracted and the appropriate indication is given (see para 7) through uplock and downlock microswitches.

3. Each main leg is fitted with a disc brake unit which is independently operated by a non-powered hydraulic system through left and right master cylinders in each cockpit.

4. The forward nose gear doors and the outboard main gear doors are mechanically linked to the gear so that they open and close as the gear extends and retracts. The rear nose bay doors and inboard main gear doors are hydraulically sequenced during landing gear operation and close following normal extension.

DESCRIPTION

Landing Gear

5. **Controls and Indicators.** The controls and indicators for the landing gear system are given in Table 1 and shown in Fig 1.

6. **Position Indication.** The position of the respective gear units and doors is indicated by three dual lens lights on the main instrument panel in both cockpits. They have green lower and red upper segments. The lights confirm through gear and door microswitches when the gear is locked up, down, or in transit. If

airspeed is below 100 knots and the gear is not down and locked, warning is given by a flashing U/C caption on the main instrument panel. Position of the gear is displayed as follows:

Green	Unit locked down (and doors closed on normal selection)
Red	Unit unlocked (gear or doors in transit)
No lights	Unit up and locked and doors closed

Note: Immediately after selecting standby DOWN, the nose gear indicator may illuminate red and/or green momentarily, followed by red. While the gear is travelling the three red lights remain on until the third green light comes on (greens and reds are on together). Provided that three greens are obtained at the end of the lowering cycle, the landing gear is positively locked down.

7. **Position Indication - Taxy Lamp and Ultrasonic Undercarriage Position Indicator (UUPI).** Indication (but not confirmation) of gear down and locked is given by a superimposed tone during UHF transmissions (UUPI), and by the illumination of the taxy lamp when selected to AUTO. If the taxy lamp is selected to TAXI, the taxy lamp will illuminate irrespective of gear position.

8. **Normal Operation.** Normal operation of the landing gear is controlled by the LDG GEAR selector lever. An identical lever is in each cockpit. The lever moves in a slot labelled UP and DOWN and is mechanically linked to a spool in the landing gear selector valve and to the selector lever in the other cockpit. Both hydraulic power and electrical power (via the essential services busbar) are necessary to select down. A solenoid-operated safety lock prevents inadvertent UP selection when the aircraft is on the ground. This solenoid is supplied by the essential services busbar via weight microswitches. As the main oleos extend after take-off, the microswitches close; the solenoid is then energized to withdraw the solenoid lock to permit an UP selection. When UP is selected the doors control valve is electrically energized permitting hydraulic power to open the doors and then operate the landing gear sequencing valve, which permits hydraulic pressure to retract the gear. The uplock switch then allows the doors control valve to redirect hydraulic power to reclose the doors. Selecting DOWN connects electrical power through the downlock switch to the doors control valve. When the doors are open hydraulic pressure is allowed to extend the gear. When the gear is down the downlock switch allows the doors to reclose. On normal selection, the gear retracts within 10 seconds and lowers within 9 seconds.

9. **Standby Lowering System.** The standby lowering system is operated by mechanically linked levers in slots to the rear of the pilots left console in both cockpits. Each lever operates in a slot; the slots are marked LDG GEAR STBY LOWER - NORMAL/DOWN. The levers are spring loaded to return to the NORMAL (forward) position, the lever in the rear cockpit has a latch. Due to the mechanical link, when DOWN is selected on either lever, the latch will hold both levers in the DOWN position. When DOWN is selected, a valve is operated that allows stored emergency hydraulic accumulator pressure to operate the gear and door actuators; a noticeable resistance is felt as the lever operates the actuator valve. Selecting DOWN also automatically opens the electrically operated emergency selected shut-off valve to allow fluid to return from the up side of the actuators to the main hydraulic reservoir. Selection to DOWN should be with a single, firm movement of the lever fully rearward. The landing gear doors remain open, when the gear is lowered on the standby system. A microswitch, fitted to the front lever, inhibits the 3 reds indications that results from the gear doors being open and thus 3 greens will display after the successful operation. Under straight and level flight conditions, below 120 knots, the time taken for the standby system to lower the gear is similar to the normal system. During lowering, as the emergency accumulator becomes depleted, an EMERG HYD caption will illuminate on the CWP. In the extremely unlikely event of an essential services busbar failure, the emergency selected shut-off valve will not open and, as a result, hydraulic fluid will only return slowly from the up side of the actuators to the reservoir. Therefore landing gear may take considerably longer than usual to lower on the standby system with such a failure.

CAUTION: The Standby Lowering System lever is situated to the rear of the ESDL in both cockpits. When selecting either of these levers care should be taken to ensure you have properly identified the correct lever before a selection is made.

10. **Emergency Retraction.** On the ground, the landing gear can be raised in an emergency by selecting the GrouND UP ENABLE switch in either cockpit to ON and selecting a LDG GEAR selector lever to UP. The switch has a black/yellow striped surround. The emergency retraction facility is inoperative if the landing gear

has been lowered by the standby system. The power supply to the GrouND UP ENABLE switch is from the essential services busbar. The switch should not be used in the air.

11. **Nosewheel Steering.** The nosewheel is steerable through 20° either side of the aircraft centreline. Steering control is by the rudder pedals via push-pull rods when the gear is extended. As the gear retracts, after take-off, the nosewheel self-centres and the steering disengages automatically. On the ground, disengagement of the torque steering link allows full castering of the nosewheel, to facilitate unrestricted towing.

CAUTION: It is possible that differential braking may damage the nosewheel assembly particularly with the steering at full scale deflection. If it is essential to use differential braking, then it should not be used with the nosewheel steering fully deflected to one side.

Table 1 - Landing Gear and Wheelbrakes Controls and Indicators

Control/Indicator	*Marking*	*Location*
Extension/retraction lever	LDG GEAR - UP/ DOWN	Main instrument panel - left, both cockpits
Ground up enable switch	GND UP ENABLE - ON/OFF	Main instrument panel - bottom left, both cockpits
U/C caption	U/C (amber)	Main instrument panel - top left, both cockpits
Parking brake handles	PARKING BRAKE	Lower centre instrument panel, both cockpits
Parking brake lights	PARK BRAKE (amber)	Lower centre instrument panel, both cockpits
Gear position indicators (three)	Unmarked	Main instrument panel - left, both cockpits
Standby selector lever	LDG GEAR STBY LOWER - NORMAL /DOWN	Left console, both cockpits
Toe pedals	-	On rudder pedals, both cockpits

12. **Ground Locks.** Three ground locks (each with a warning flag) are provided for nose gear and both main gear units. They are fitted after flight and are to be removed before flight.

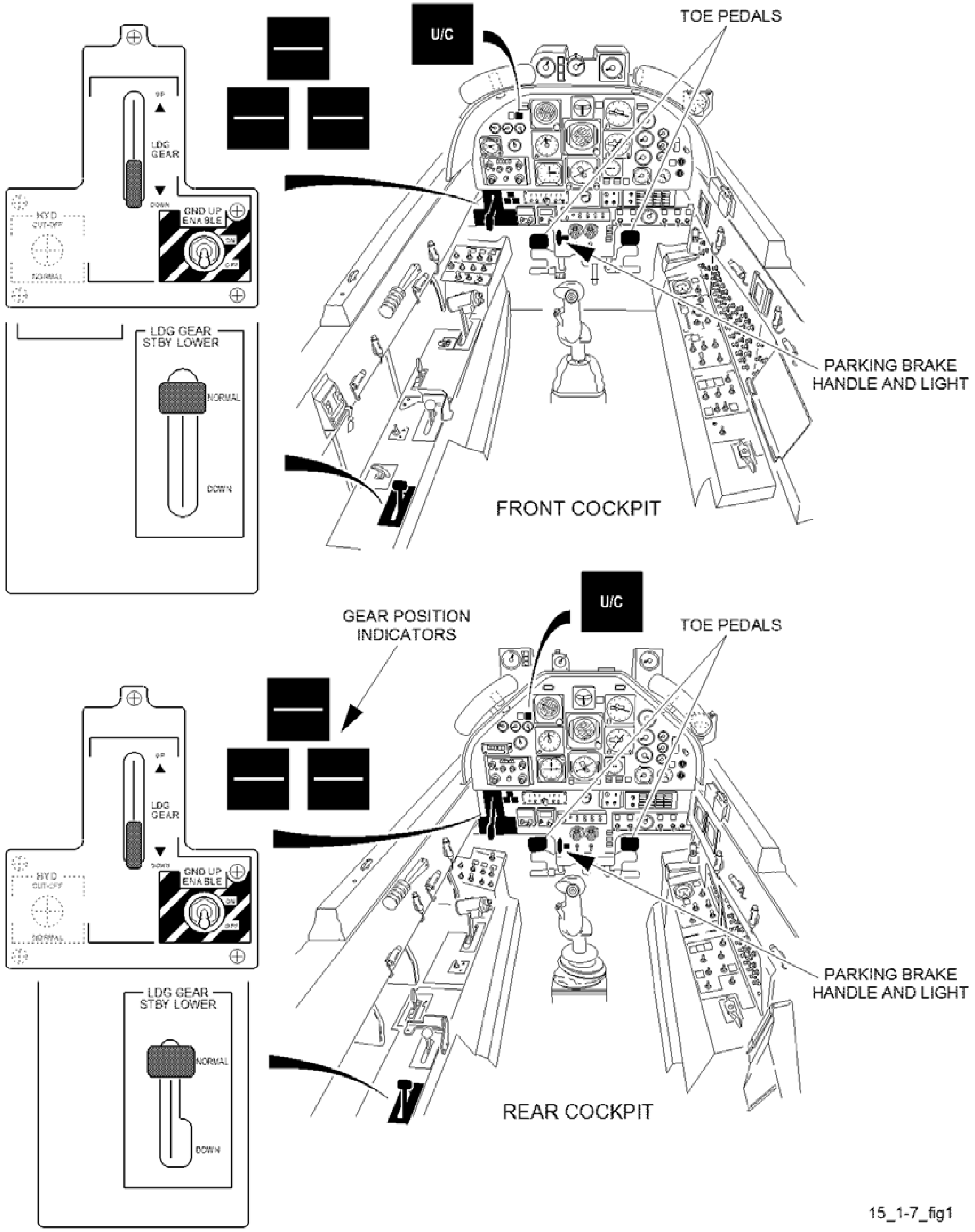
Wheelbrakes

13. The wheelbrakes are operated by a tandem independent hydraulic system (see Fig 2). Each brake system comprises a reservoir, master cylinders, parking valve, shuttle valves and disc brake units. The dual system is interconnected at the shuttle valves.

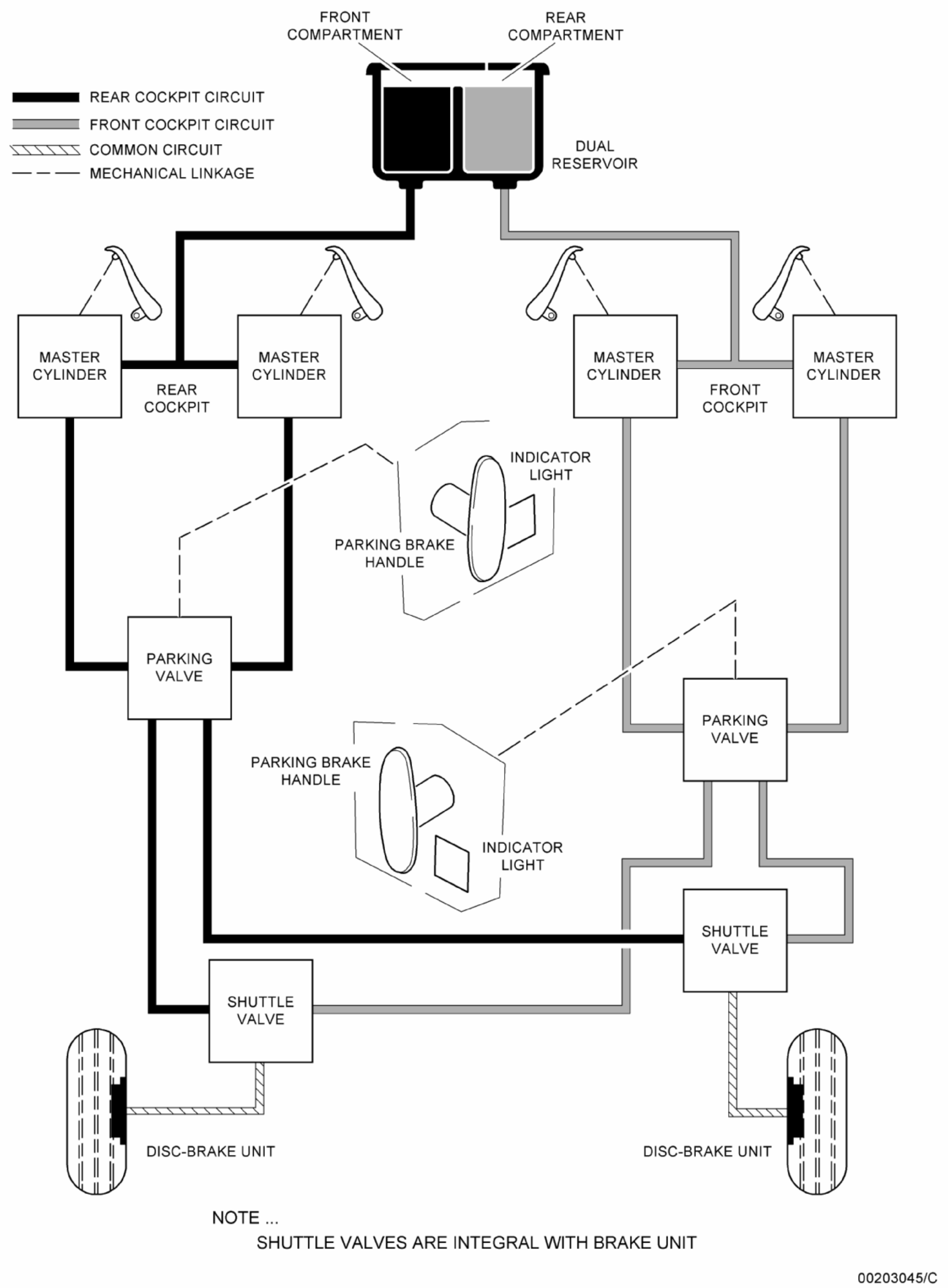
14. The brakes are operated by toe pads on the rudder pedals via the parking valves and shuttle valves on the brake units. The toe pads, operated individually, provide differential braking. However, to avoid damaging the nosewheel steering mechanism, differential braking should not normally be used.

15. The disc brake units have three pistons each incorporating self-adjusting mechanisms which ensure constant fluid displacement and consistent movement of the toe pad throughout the life of the friction pads. The self-adjusters also operate a retraction mechanism (when the toe pad is released) to ensure that the piston and friction pads are clear of the friction disc.

16. **Parking Brake.** A PARKING BRAKE handle, with a PARK BRAKE indicator light beside it, is on the lower centre instrument panel in each cockpit. The parking brake is operated through a push-pull rod assembly and is applied by pressing both toe pads simultaneously and pulling the PARKING BRAKE handle to a detent. The effectiveness of the PARKING BRAKE depends on the pressure applied to the toe pads, not the pull force on the PARKING BRAKE handle. An excessive pull force causes damage to the limit stop and consequent difficulty in releasing the PARKING BRAKE. The parking brake is released by applying brake pressure at the toe pads and moving the handle slightly to the right. Applying a parking brake in one cockpit illuminates the PARK BRAKE warning in the other cockpit.



1 - 7 Fig 1 Landing Gear and Wheelbrakes Controls and Indications



1 - 7 Fig 2 Wheelbrakes - Schematic

NORMAL USE

Before Flight

17. When carrying out **External** checks, check that the ground locks have been removed. Check that there are no fluid leaks from the landing gear or wheelbrake units.

18. During the **Cockpit** checks, check that the landing gear selector is DOWN, the LDG GEAR STBY LOWER lever is NORMAL and that the landing gear GND UP ENABLE switch in both cockpits is OFF. For solo flight ensure that the parking brake in the rear cockpit is selected off.

19. During **Pre-Start** checks apply the parking brake. When the chocks have been removed after engine starting, release the parking brake and move slowly forward by opening the throttle. Close the throttle to GND IDLE and check the operation of the brakes. While taxying, check the operation of the nosewheel steering.

In Flight

20. After take-off, when the landing gear is selected UP, check that the gear position indicators change from green to red and subsequently go out within 10 seconds.

21. When selecting DOWN move the lever down with a positive motion, not slowly. After selecting the landing gear DOWN, check that gear position indicators show red then green and that the parking brake is off and the light is out. On short finals check that the feet are clear of the brake toe pads. During the landing roll apply brakes only as necessary; use the throttle to REVerse as the principal method of braking. The aircraft can be kept straight using the nosewheel steering.

CAUTION: Avoid harsh application of the brakes as there is no anti-skid system.

USE IN ABNORMAL CONDITIONS

Landing Gear Malfunction Indications

22. If the gear fails to retract fully, and green and/or red lights remain, carry out the **Gear Selected Up but Greens/Reds Remain** drill.

23. The only confirmation that all the gear is down and locked is 3 greens, and only 3 greens. The lack of a green light or the presence of a red light either on its own or simultaneously with a green, shows a possible unsafe condition. If an unsafe condition is indicated carry out the **Gear Selected Down but 3 Greens Not Obtained** drill.

Note: If three green lights are not obtained, do not rely on the taxy lamp or UUPI as a positive indication that the gear is locked down.

Nosewheel Steering

24. If the nosewheel steering fails, the aircraft can be directionally controlled by differential braking. This must be done with care as there is no anti-skid system.

Wheelbrakes

25. If the wheelbrakes fail, stop the aircraft by using REVerse throttle. If one brake fails, do not apply further braking unless essential; keep directional control with nosewheel steering and stop with the use of REVerse throttle. After the aircraft has been stopped, do not taxy.

Shimmy

26. If shimmy is experienced whilst taxying, or during the T/O or landing roll, slow the aircraft gently by judicious use of reverse thrust. Nose wheel shimmy is common and generally indicates wear in the bearings or a deflated nose wheel tyre. A more serious failure may have occurred in the torque link bolts securing the

main landing gear. A failure of one of these bolts may result in a loss of directional control as a main wheel will now be free to caster. Keep the aircraft straight using minimal rudder inputs and avoid harsh braking.

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PART 1

CHAPTER 8 - AIR CONDITIONING

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INTRODUCTION

General

1. Conditioned air is supplied by a single system to both cockpits, providing a controlled environment and canopy demisting. The system is operated from a panel on the right console in the front cockpit. Ambient air can also be supplied during flight through a controlled ram air facility. This provides an alternative supply in the absence of conditioned air.

DESCRIPTION

General

2. Pressurized air is taken from the engine compressor and regulated by venturis and shut-off valves (SOV) to supply the system. The air supply temperature is controlled automatically or manually.

Controls and Indicators

3. The system is controlled from a panel on the right console in the front cockpit (see Fig 1 and Table 1). Secondary controls are automatic, through a temperature controller which operates a temperature control valve (TCV) in response to selected requirements. The system is protected by overtemperature and overpressure switches. If either condition occurs, the associated switch closes the SOV (L4) (Fig 2) in the main duct. Indication of a system fault is given by the AIR COND (amber) caption on each central warning panel illuminating. Power supplies for the system are from the load shedding busbar.

Bleed Air

4. Bleed air (P3) is taken from two fixed orifices, one on either side of the engine compressor. The flow at the left orifice is 5% of total engine airflow and is controlled by a SOV (L2). The flow from the right orifice is 4% of the total engine airflow; it is controlled by a venturi passing 1·2% and a venturi passing 2·8% which is controlled by another SOV (L3). The amount of bleed air used for air conditioning depends on engine RPM, throttle position, NORM/BOOST switch and whether the aircraft is flying or on the ground (Table 2).

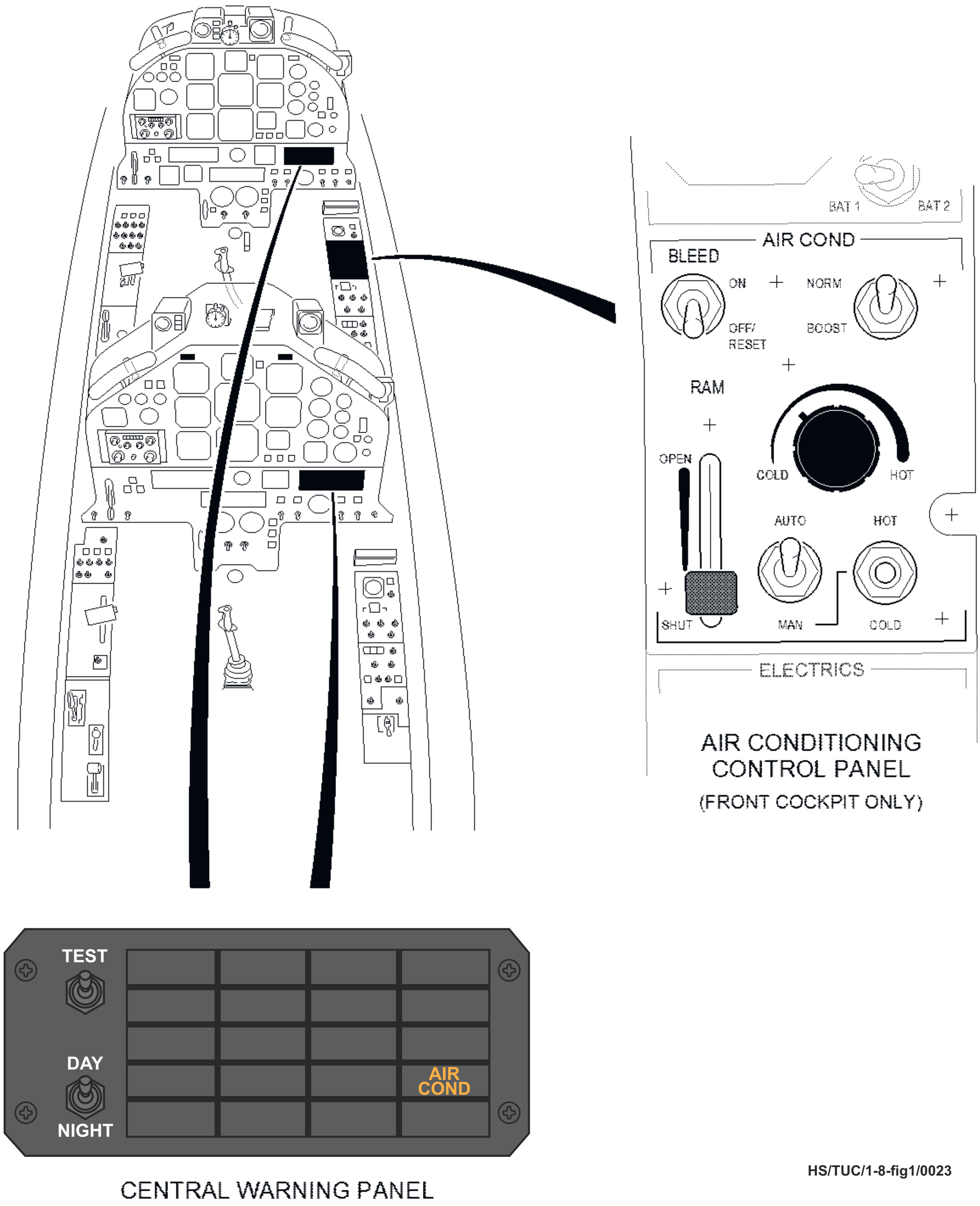
Table 1 - Air Conditioning System Controls and Indicators

Control/Indicator	*Marking*	*Location*	*Function*
Bleed air shut-off valve switch	BLEED - ON/ OFF/RESET	AIR CONDitioning panel on right console (front cockpit only)	ON - opens shut-off valve in main duct OFF/RESET - closes the shut-off valve or resets the valve following an overpressure or overtemperature shutdown, permitting the valve to reopen when an ON selection is made
Bleed air flow control switch	NORM/BOOST	AIR CONDitioning panel on right console (front cockpit only)	NORM - signals the engine electronic control (EEC) to control engine speed and subsequent bleed pressure BOOST (on ground) - increases engine speed to about 80% via the EEC to provide increased bleed pressure BOOST (in flight) - provides 4% bleed
Temperature control switches (2)	AUTO-MAN HOT/off/COLD	AIR CONDitioning panel on right console (front cockpit only)	AUTO - selects automatic temperature control MAN - selects manual temperature control spring-loaded to central, controls the TCV when MANual is selected
Temperature control rotary selector switch	COLD/HOT	AIR CONDitioning panel on right console (front cockpit only)	COLD - HOT - selects the temperature to be maintained when in the AUTOmatic mode
Ram air shut-off lever	RAM - OPEN/SHUT	AIR CONDitioning panel on right console (front cockpit only)	Opens or closes the ram air valve
Air conditioning failure warning	AIR COND (amber)	CWP on both instrument panels	Illuminated in an overtemperature or over-pressure condition

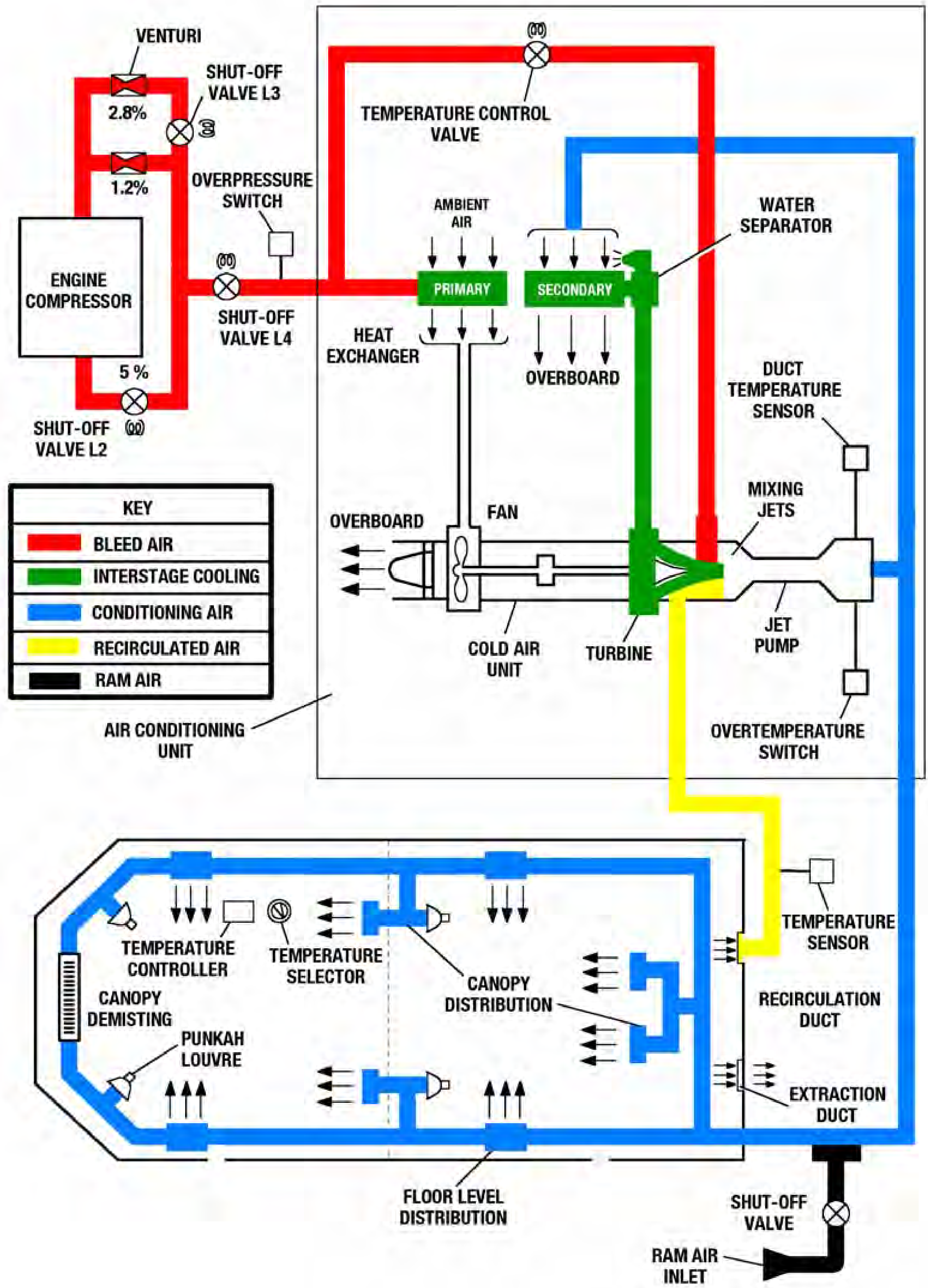
Table 2 - Bleed Air Configurations

Note: When the engine speed switch is set to 70% the actual engine RPM is approximately 72%.

Aircraft	*Throttle Position*	*Engine Speed Switch*	*NORM/BOOST Switch*	*Maximum Bleed %*
On the ground	Away from MAX	70	NORM	6.2
	Away from MAX	70 (actual RPM about 80%)	BOOST	6.2
	Away from MAX	100	NORM or BOOST	6.2
	MAX	100	NORM or BOOST	1.2
In flight	Any	100	NORM BOOST	1.2 4.0



1 - 8 Fig 1 Air Conditioning Controls and Indicators



1 - 8 Fig 2 Air Conditioning Schematic

5. Both bleed lines join to form a main duct where the air is controlled by a SOV (L4). All three SOVs open and close pneumatically through solenoid valves. The main duct SOV is closed manually by selecting the BLEED switch on the AIR CONDitioning panel (Fig 1) to OFF/RESET, or automatically by overpressure or overtemperature switches. If automatic closure occurs, the main duct SOV can only be reopened by selecting the BLEED switch to OFF/RESET and then to ON.

6. The main duct separates into two lines, one bypassing the primary and secondary coolers to provide the hot air supply, the other passing through the refrigeration stage of the air conditioning unit (ACU) to provide the cold air supply and the power to drive the turbine.

7. **On Ground.** During ground running at 72% RPM, bleed airflow is increased by selecting the flow control switch from NORM to BOOST. This signals the engine electronic control to increase engine RPM to approximately 80%, with the associated increase in bleed pressure.

8. **In Flight.** During flight, the bleed airflows are 1·2% when the NORM/BOOST switch is set to NORM and 4% when set to BOOST.

Note: On take-off, with BLEED ON/BOOST selected, a slight drop in torque is normal at lift-off due to the air conditioning valve scheduling in conjunction with the WOW microswitch.

Air Conditioning Unit

9. The ACU is aft of the baggage compartment and comprises a heat exchanger (incorporating a water separator), cold air unit (CAU), jet pump, TCV, overtemperature switch and a duct temperature sensor.

10. Bleed air enters the primary section of the heat exchanger where it is cooled by ambient air, which is induced by the CAU fan through a louvred inlet on the fuselage right side. On entering the secondary section the air is further cooled by already conditioned air (regenerative) routed from the jet pump outlet. A water separator in the secondary section removes water droplets from the air; the second stage cooling is enhanced by spray injecting this water into the regenerative air. Spent ambient and regenerative air is vented overboard.

11. The air is expanded across the turbine of the CAU to cool it below 0°C. Power generated during this process drives the ambient air fan. Turbine outlet air passes through the jet pump to induce an airflow from the cockpit and from the hot air bypass line (depending on the TCV setting). These flows then mix and pass to the cockpit to provide conditioned air.

12. The AUTO/MAN switch controls the TCV. When the switch is set to AUTO and the temperature requirement is set on the rotary selector switch (COLD - HOT), an input is provided to the temperature controller under the front pilot's floor; the controller also responds to inputs from the cockpit temperature sensor (in the cockpit recirculation duct) and the duct sensor in the jet pump. The controller compares the inputs and opens or closes the TCV to maintain the selected cockpit temperature. The temperature controller and rotary selector switch are designed to control the temperature within the range of 10°C to 25°C. When the AUTO/MAN switch is set to MAN the rotary switch is inoperative and temperature changes are obtained by selecting the HOT/COLD toggle switch briefly to HOT or COLD until the desired temperature is obtained. Make allowance for a delay in obtaining the desired temperature after a temperature change selection when using MAN.

Cockpit Ventilation

13. The mixed (conditioned) air in the jet pump is passed through a single duct to the cockpits, where it branches to outlets at floor and canopy level. The floor level outlets are on both sides of each cockpit providing conditioned air at foot and lower body regions, whilst twin outlets at the rear of each cockpit (at canopy level) circulate a large volume of air throughout the cockpits. Upper body and facial coverage is supplied through punkah louvres on either side of each main instrument panel.

Note: Due to leakages from the ducting within the right console in both cockpits, equipment in this area may be adversely affected particularly by moist air at low temperature.

14. The canopy is demisted by conditioned air from a louvred distribution outlet above the front main instrument panel, assisted by the canopy level outlets.

15. Spent conditioned air is extracted through two ducts in the rear bulkhead; one recirculates the air to the jet pump, the other vents overboard through the oxygen compartment.

Ram Air

16. A ram air facility provides an alternative supply at ambient temperature in the absence of conditioned air. Ram air is introduced through a scoop on the right side of the fuselage directly behind the engine bay combined drain port, and is selected by a mechanical linkage and a valve shut off lever labelled RAM - OPEN/ SHUT. The valve can be set to any position between the extremes; it may be used if the air conditioning system fails.

NORMAL USE

Before Flight

17. Before starting the engine, check that the BLEED switch is selected to OFF/RESET, the flow control switch is set to NORM, the RAM air lever is SHUT and the AUTO/MANual control is set to AUTO.

18. After starting the engine the air conditioning BLEED is to be selected ON. Select BOOST and set the rotary control to a mid position. Above 20°C OAT ground running should be limited to 20 minutes pre- and post-flight for crew comfort and engine oil cooling reasons.

Note: If selected to MANual COLD when selected ON, there is a risk of icing at the CAU outlet also the cockpit fills rapidly with water vapour mist.

19. For ground operations, the following selections are recommended:

a. OAT minus 10 to +5°C. Select BOOST and the ENGINE SPEED switch to 100%.

b. OAT +5 to +20°C. Select BOOST (idle RPM automatically increase to 80%).

c. OAT +20 to +30°C. Select BOOST and the ENGINE SPEED switch to 100%.

In Flight

20. For all flight conditions select BOOST to maintain acceptable cockpit temperatures. Only select MANual if the temperature control system fails on AUTO.

21. **Canopy Demisting.** The performance of the canopy demist system may be marginal in conditions which promote significant canopy misting, e.g. high rates of descent into humid air following long periods at 15,000 to 25,000 feet. Select AUTO BOOST HOT for three minutes before descent. If mist forms on the canopy after descent, select AUTO BOOST COLD until clear. If satisfactory clearance is not obtained in under two minutes, reselect AUTO BOOST HOT until the canopy is clear, then reselect the temperature control for comfort.

22. **Ram Air Valve.** Oil fumes are continually dumped overboard via the engine bay combined drain port and opening the ram air valve during flight may introduce engine fumes into the cockpit. Opening the valve either on the ground or in flight with the air conditioning system operating is not recommended as it results in an outflow of conditioned air thus degrading the effectiveness of the system.

Note: If more engine power should be needed at any stage, a change of AIR COND selection from BOOST to NORMAL (or to bleed air off) will reduce air bleed and hence increase torque.

USE IN ABNORMAL CONDITIONS

Smoke or Fumes

23. If smoke or fumes contaminate the cockpit, select 100% oxygen and set the mask toggle down. If defective equipment can be identified, switch it off. Select the air conditioning as required. Land as soon as possible. If smoke and fumes remain and present a significant danger, eject.

Air Conditioning Failure

24. If the AIR COND caption on the CWP comes on, select BLEED air OFF/RESET, then ON. If the system then operates normally and the caption goes out, continue with normal operation; if not, select OFF/RESET.

25. If there is no response to AUTO selection, no caption indication is given.

Temperature Control Failure

26. If the temperature control fails on AUTO, select MANual. Select the spring-loaded toggle switch to COLD for 10 seconds to ensure that the temperature control valve closes; water vapour mist may enter the cockpit from the air conditioning outlets. Then, without undue delay, select the toggle switch to HOT for four seconds to stop the temperature control valve at mid-position. Allow three to five minutes for the cockpit air delivery temperature to stabilize. Further temperature adjustments may then be made; allow similar intervals after each selection. Adequate temperature control is difficult to achieve and adjustments should only be by momentary selection of either HOT or COLD.

CAUTION 1: Prolonged running with MANual fully COLD selected could result in icing within the air conditioning pack and possible CAU failure.

CAUTION 2: When selecting MANual, the initial temperature selection should always be to COLD, since MANual HOT selection supplies very hot air to the cockpit and temperature control is difficult. Repeated overheat shutdown of the system is very likely; this is accompanied by an AIR COND warning. If this occurs, select the spring-loaded toggle switch to COLD for four seconds and then select the BLEED switch to OFF/RESET and then back to ON. Prolonged operation with MANual HOT selected could lead to failure of the front SSR transponder.

Hot Air Leak

27. A particular failure of the air conditioning system may allow hot air to leak from air conditioning lines, causing cockpit panelling to become hot. Selection of the BLEED switch to OFF/RESET may alleviate this problem by removing the source of hot air. If required, selecting the RAM air lever to OPEN will provide an alternative air supply at ambient temperature.

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PART 1

CHAPTER 9 - CANOPY AND EJECTION SEATS

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INTRODUCTION

WARNING: Death or serious injury is likely to occur to anyone near the cockpit if an ejection gun, drogue gun, linear cutting cord (LCC) or miniature detonating cord (MDC) is accidentally fired. Accidental operation of an ejection gun results in the seat exploding from the aircraft.

General

1. This chapter covers the canopy and the ejection seats, normal entry to and exit from the cockpits, emergency egress and rescue facilities and procedures.

Escape System

2. In the primary mode the escape system gives the facility for ejection through the front and rear overhead transparencies which are automatically cut or shattered by MDC systems. Each seat can be fired individually, or both seats can be fired by a command ejection facility. Canopy breakers are fitted to the ejection seat headboxes to assist penetration of the overhead transparency if the MDC fails. The MDC systems above the front and rear seats operate independently during normal separate seat ejections; both these systems, together with a system at the front of the canopy, operate simultaneously if manually selected.

3. Static on-ground escape is by normal opening of the canopy, from either inside or outside. If damage prevents normal opening, the transparency can be broken using the MDC, initiated from either crew station or by an external lanyard.

Escape Envelope

4. The best possible chance of safe escape by ejection is given within the following envelope in Table 1 (see also Part 4, Chapter 2):

Table 1 - Safe Ejection Envelope

Altitude	Ground Level to 35,000 feet
Minimum level speed	70 knots at ground level
Maximum level speed	280 knots at ground level
Maximum dive speed	330 knots

DESCRIPTION

Canopy

5. The canopy is hinged on the right side, latched on the left side and covers both pilots. The front transparency is thicker than the rear, the two being joined by a metal hoop. A transparent blast screen on the canopy between the cockpits protects the rear pilot if the front of the canopy is holed. A clearance between the blast screen and the canopy allows full demisting of the canopy. The whole is balanced to reduce opening or closing loads. A fabric loop is attached to the front grab handle to facilitate closing the canopy when the pilot is strapped in. When open on the ground, wind speeds up to 40 knots can be withstood. A ground locking pip pin is provided to lock a support strut in the open position. The locking pin has a stowage at the left rear of the front cockpit. Experience of operating in high wind speeds shows that it is difficult, when strapped in, to control canopy opening/closing and impossible to insert the locking pip pin; therefore, in crosswind components of greater than 15 knots from the right or 20 knots from the left obtain groundcrew assistance. When the canopy is unlocked an amber caption is illuminated on the CWP.

6. Both pilot positions have LCC/MDC systems. The front LCC is in two sections one of which severs the forward transparency above the seat and the other fractures the front of the canopy to facilitate ground egress. The rear MDC fragments the rear transparency. The two LCC/MDC sections above the seats operate independently as part of an ejection sequence. If required, all three LCC/MDC sections can be operated simultaneously from inside or outside the aircraft. Should the LCC/MDC fail in an ejection sequence, the canopy is penetrated by the breaker knives on the headbox of the front seat, and the breaker horns on the headbox of the rear seat, to provide exit paths.

Canopy Fracture Handles

7. **Internal.** A CANOPY FRACTURE - PULL TO ARM/PUSH TO FIRE handle, striped black/yellow, is on the right side in each cockpit (Fig 1). The handle is used to assist escape if any ground incident prevents normal opening of the canopy. To operate the handle, remove the safety pin, pull the rear portion inwards and then push it firmly forwards; this actuates all three cockpit LCC/MDC systems. The canopy fracture handles are not cleared for airborne use.

8. **External.** Ground rescue of incapacitated crew is aided by either of two external canopy fracture handles, one each side of the canopy rear frame. Each handle is housed within a hinged access panel which has a quick-release latch. A handle is connected to 5 m (17 feet) of cable. The operator should grasp a handle and, facing away from the aircraft, take up the cable slack and then sharply tug the cable. When the taut cable is tugged all three sections of LCC/MDC are exploded, irrespective of whether or not the internal canopy fracture handles are secured by their safety pins.

Ejection Seats

9. Each cockpit has a Type 8LC Mk 1 ejection seat. The front seat, designated Mk 1-1, and the rear seat, Mk 1-2, are similar in operation but have individual features to cater for their particular cockpit and command ejection system. References to one seat apply to both unless stated otherwise. Each seat has a combined seat and parachute harness. The parachute and drogue are contained at the seat top.

10. After ejection, separation of the harness and occupant from the seat and deployment of the parachute occur automatically. A manual separation facility can be used if any of the automatic functions fail or if man/seat separation is required prematurely. The seats can be fired individually or by command ejection which is an automatic sequence (rear seat first) initiated by the firing of the rear seat.

11. Each seat has three main parts:

   a. **Ejection Gun.** The ejection gun initiates the ejection and is fixed to, and stays in, the aircraft.

   b. **Main Beams.** Two main beams ride on guide rails attached to the ejection gun. The beams carry the parachute container and most of the seat operating devices.

   c. **Seat Pan.** The adjustable seat pan rides on tubes on the main beams and has an upright backrest and a well to hold a personal survival pack (PSP).

Safety Pins

12. All safety pins are listed in Table 2. The ejection seat safety pins are shown in Fig 2. A stowage for the SEAT FIRING pin is on the left canopy frame in each cockpit. A 3-place stowage for the other pins is at the rear of the front cockpit on the upper left side and visible to the front pilot only (Fig 1).

Safety Apron

13. A safety apron secures the PSP, the harness and the appendages of the rear seat when the aircraft is flown solo. When not used the apron is stowed in a bag in the baggage compartment.

Table 2 - Canopy and Ejection Seat Pins

Unit	*Pin Marking*	*Type*	*Responsibility*
Seat firing handle (2)	SEAT FIRING (red)	T-bar	Aircrew (2)
Internal canopy fracture handle (2)	INTL CAN FRACTURE (black/yellow)	T-bar	Aircrew (2)
Note: Fitting of the above 4 pins makes the aircraft **Safe for Parking**.			
Manual override handle (2)	MOR SEAR (red)	Ring	Groundcrew
Note: Fitting these 2 MOR SEAR pins, as well as the 4 **Safe for Parking** pins, makes the aircraft **Safe for Maintenance**.			
Canopy strut	CANOPY STRUT (blue)	Pip pin	Air/Groundcrew

Seat Pan Height Adjustment

14. Seat pan height is adjusted by an electrical actuator controlled by a SEAT ADJust - UP/DOWN (forward/aft selection respectively) switch on the left console. Limit switches cut off the electrical supply (main busbar) when the seat pan reaches the end of its 15 cm (6-inch) travel. To avoid overheating the actuator, the facility should not be used continuously for more than one minute in any 8-minute period.

Personal Survival Pack

15. The PSP, which has a seat cushion attached to the top of its case, is housed in the well of the seat pan. The PSP is secured to the parachute harness by a strap which passes through two rings on the pack, one at each side; the end fittings on the strap are connected to two quick release side connectors on the harness. During a parachute descent the PSP can be lowered and allowed to hang on a lowering line by disconnecting either of the side connectors.

16. The 4·4 m (14·5 feet) lowering line connects the PSP to the occupant. The line emerges from the front left side of the pack and terminates at an end fitting retained by a sticker clip on the left inner side of the seat pan. During strapping-in, a quick-release connector on an attachment strap at the left side of the life preserver is secured to the end fitting. On man/seat separation after ejection, the life preserver attachment strap automatically initiates operation of a personal locator beacon (PLB) in the life preserver.

Note: The lowering line is not to be disconnected unless the PSP is to be jettisoned.

Harness

17. The harness secures the occupant to the parachute by lift webs integral with the harness, and to the seat by harness locks on the seat. Two sticker straps (stickers) from the rear of the harness are retained by spring clips on the seat pan. The harness is secured on the occupant by a quick-release fitting (QRF) on the negative-g strap, which in turn is locked to the seat pan. The QRF has a rotatable face marked TURN TO UNLOCK and PRESS TO RELEASE. Its two upper slots accept and lock the shoulder straps. The locks are secure when a yellow notch on the face is uppermost. To engage the shoulder strap lugs, the QRF should be checked at the `locked' setting. After routing through the leg loop, the first shoulder strap lug is then

inserted and, with a firm push, locked. Repeat the process for the second shoulder strap. When the face of the QRF is rotated clockwise through 90°, a red line on the edge of the face is uppermost and the locks are prepared for release. Firm pressure on the face of the QRF then allows the shoulder straps to pull free.

WARNING: Because the QRF secures the occupant to both seat and parachute, the QRF is to be pressed only when separation from the parachute is intended.

Negative-g Restraint

18. Negative-g restraint is provided by a strap secured to a harness lock at the front of the seat pan; the upper end of the strap is permanently attached to the QRF. Restraint is enhanced by a `V'-strap connected between the negative-g lug at the bottom and the harness leg loops at the top.

Leg-Restraint System

19. An automatic leg-restraint system holds the occupant's legs against the seat pan during ejection. From shear pins on the cockpit floor, two lines are routed through one-way snubbers on the seat pan and rings on the occupant's leg garters to taper plugs in locks on the sides of the seat pan. The snubbers allow the lines to be tightened as the seat rises and the shear pins break when the legs are restrained. The snubbers maintain their grip until man/seat separation. The taper plug locks are released to free the legs when the man portion of the personal equipment connector (PEC) (para 42) is released either manually (normal, after flight) or automatically (after ejection). Two snubber release controls in the frontal recess of the seat allow the lines to be lengthened for strapping in.

Shoulder Harness Power Retraction Unit

20. The seat shoulder harness is connected by roller fittings to two looped retraction straps above the seat pan. The retraction straps are attached at one end to individual harness locks and at the other to a cartridge-operated power retraction unit. The retraction unit has two spring-loaded spools around which the straps are wound, and a ratchet mechanism which can lock the spools to prevent extension of the straps.

21. The ratchet is normally controlled by a 2-position go-forward control lever on the left side of the seat pan. The lever has to be lifted before its position can be changed. When the lever is forward (unlocked), the occupant can lean forward against spring pressure to a maximum of 30 cm (12 inches). When the lever is aft (locked) the spools take up any slack in the retraction straps to prevent forward movement. If, with the lever forward, the retraction straps are extended at an excessive rate (e.g. during rapid deceleration), the ratchet automatically and immediately engages to prevent any further forward movement of the occupant. After the load on the straps has been relaxed, forward movement is again possible.

WARNING: If there is insufficient deceleration to engage the ratchet and the go-forward lever is forward, the seat occupant may be thrown forward and/or downward resulting in his head striking the coaming or the top of the control column. This situation may be met during a heavy landing, turbulence at low level or a barrier engagement. Therefore, the go-forward lever is always to be selected to the rear for take-off, flight in severe turbulence and landing.

22. When ejection is initiated, a retraction unit cartridge fires; the resultant gas pressure powers the retraction unit which winds in the retraction straps, pulling the occupant's shoulders back into the seat.

Harness Lock Release

23. The lock release system frees all of the man/seat connections automatically after ejection or when the manual separation handle is pulled. The locks are in two groups:

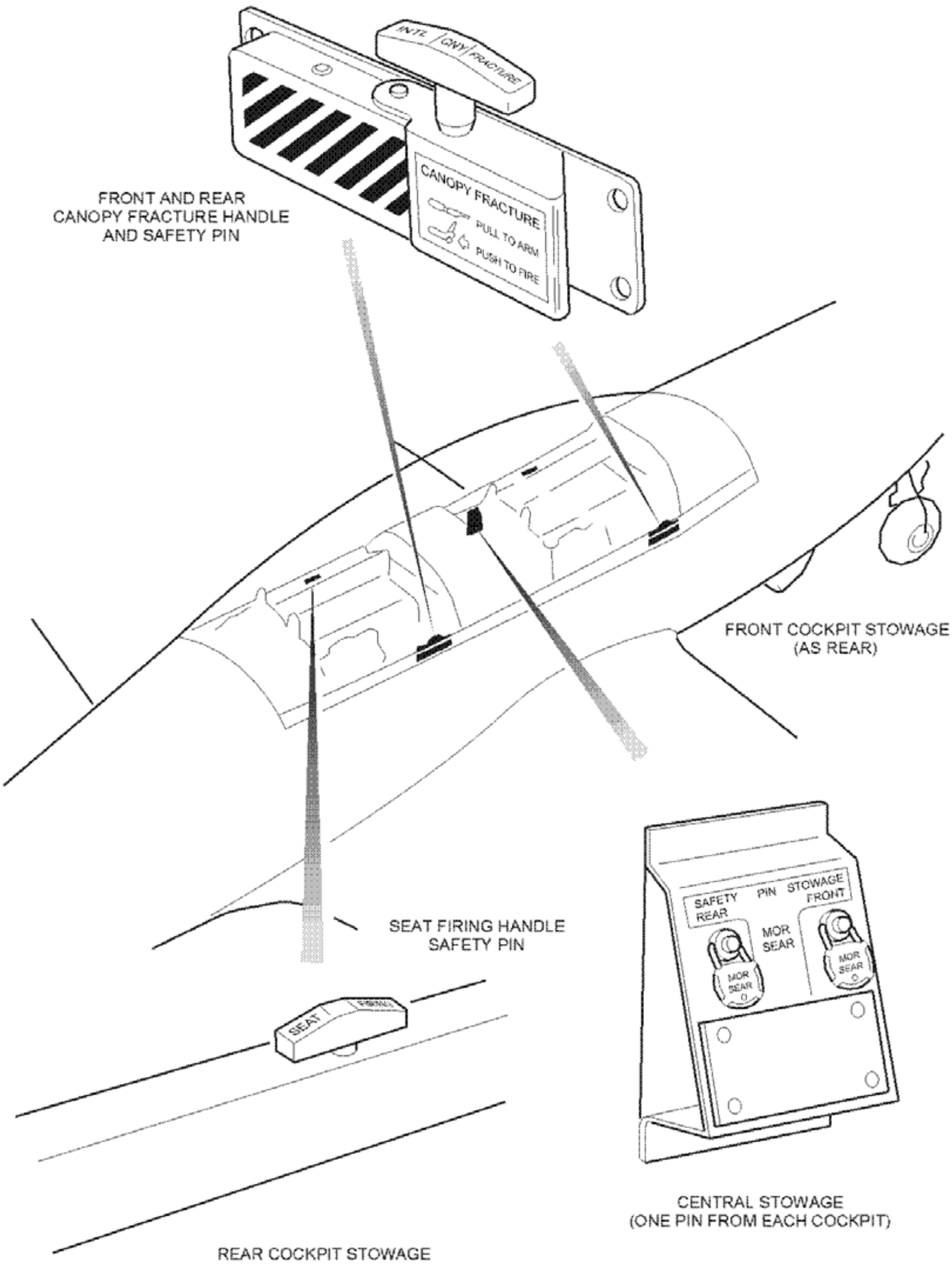
a. **Top Locks.** Two top locks secure the retraction straps and thus the shoulder harness.

b. **Bottom Locks.** The bottom locks secure the harness lap straps (two), the negative-g strap (one), and the man portion of the PEC (one) which is interconnected with the leg-restraint taper plugs (two).

Seat Firing Handle

24. The seat firing handle is a black and yellow flexible loop at the front of the seat pan. The handle has a red SEAT FIRING safety pin which is to be removed and stowed after strapping in. When the handle is pulled sharply upwards (20 to 70 lb pull force) it moves approximately 4 cm (1·5 inches) to fire a cartridge, before being restrained. Gases from the cartridge operate the harness power retraction unit, the MDC initiator and fire the seat ejection gun. On the rear seat, the gases also fire a command ejection cartridge.

25. The firing handle also controls a mechanical safety lock, which prevents operation of the manual separation handle until the seat firing handle has been pulled fully upwards.



1 - 9 Fig 1 Ejection Seat Safety Pin Stowage, Canopy Fracture Handle and Canopy Strut Safety Pin Stowage

Command Ejection System

26. The command ejection system interconnects the firing systems of the seats, and allows the sequenced ejection of both seats to be initiated from the rear cockpit. A COMMAND FIRING - ON/OFF lever is in the rear cockpit on the aft bulkhead at the lower left side. When the lever is at ON (up) the command system is operative. At OFF (down), the command system is inoperative.

27. A cartridge at the selector valve fires when the rear seat firing handle is pulled; the sequence then depends on the setting of the firing lever:

a. With the lever ON, the cartridge gases are passed to the front seat and immediately operate the front seat power retraction unit. After a delay of 1·4 seconds, the gases fire a breech unit cartridge in the front cockpit to initiate the firing of the front seat ejection gun.

b. With the lever OFF, the cartridge gases exhaust into the rear cockpit with no effect.

28. The command firing lever is lift-guarded at both settings and has a rotatable knurled knob, used to lock the lever at the selected setting. The lever setting is altered by rotating the knob counter-clockwise, lifting the lever against spring pressure and moving it to the new setting (up for ON, down for OFF), where it can be correctly located when released. The lever may then be locked at the new setting by rotating the knob fully clockwise. To avoid difficulties in releasing the lever for subsequent sorties, the lever should not be tightened hard against the stop.

WARNING: The front seat firing handle remains effective (for front seat independent ejection) irrespective of the setting of the command firing lever.

Ejection Gun

29. Seat ejection is initiated by the telescopic ejection gun, powered by a primary and two secondary cartridges which fire in sequence. The gun barrel is fixed to the aircraft and the seat is attached to the inner of two sliding tubes, which are locked within the barrel by a top latch mechanism. During ejection the sliding tubes extend. The outer tube forms an extension of the gun barrel and remains with the aircraft. The inner tube is ejected with the seat.

30. The gun is fired when the seat firing handle is pulled (or, on the front seat only, when the command ejection system operates). Gas pressure from the firing unit cartridge (or the command breech unit cartridge) fires the primary cartridge. Gas from the primary cartridge initiates upward movement of the tubes. As the tubes rise, ports are opened which allow the primary cartridge gas to ignite the secondary cartridges in turn. When the tubes are fully extended, separation of the inner and outer tubes occur. The seat is then free of the aircraft.

Drogue and Parachute

31. A drogue is packed with an aeroconical personal parachute in the container at the top of the seat. The drogue is deployed automatically to stabilize and retard the seat, before deployment of the parachute to which it is attached. The top of the parachute container is covered by fabric closure flaps and secured by a closure pin, which is withdrawn automatically during the ejection sequence.

32. The drogue is deployed by a withdrawal line attached to a drogue gun piston, and in turn is attached to a parachute withdrawal line. The parachute withdrawal line is secured by a gas operated piston at the top of the seat beams, and is further restrained within the parachute container. Operation of a barostatic time release unit releases both the container restraint and the drogue shackle, allowing the drogue to deploy the parachute.

33. The aeroconical parachute is designed to travel horizontally (as well as vertically) after deployment, with the occupant facing the direction of horizontal movement. The horizontal component, although small, results in improved stability and a relatively low rate of descent. The parachute is steerable via two lines routed down the front lift webs, one line on each web. With the parachute canopy inflated, pulling down a hand-loop at the end of the appropriate line, turns the parachute in that direction (i.e. pull the left line to turn left, and vice

versa); the loop should be pulled down to shoulder level for maximum steering response. To stop the turn, gradually relax the pull on the line and allow the line to rise to its original position.

Drogue Gun

34. The drogue gun, on the top left side of the seat, is fired automatically by a trip rod. The drogue gun ejects a piston, which (via an attached line) removes a pin securing closure flaps on top of the parachute container, and then deploys the drogue. The gun has two separate cartridges, one mechanically fired by the trip rod 0·6 second after the trip operates during ejection, the other gas fired by the action of the barostatic time release unit, or by the operation of the manual separation handle. A shear pin is fitted through the top of the drogue gun barrel to retain the piston until the gun fires.

Barostatic Time Release Unit

35. The barostatic time release unit (BTRU) on the top right side of the seat provides for the automatic release of the drogue shackle, deployment of the personal parachute, and separation of the occupant from the seat after ejection. The deployment/separation sequence occurs when a cartridge in the BTRU is fired. Two devices in the BTRU (a time delay mechanism and a main barostat) delay the firing of the cartridge, depending on the ejection conditions:

a. **Time Delay.** The mechanical time delay is triggered by a static trip rod when the ejection seat starts to rise during the ejection sequence. If the delay mechanism is unobstructed (see sub para b. below), it allows the BTRU cartridge to fire 1·5 seconds after seat ejection.

b. **Main Barostat.** After ejection at altitude, the main barostat prevents operation of the time delay until the man/seat have descended to an altitude where tolerable oxygen/temperature conditions exist. The barostat has a normal setting of 10,000 feet (pressure altitude). After ejection, the drogue-stabilized seat descends rapidly with the occupant still strapped in. At 10,000 feet the barostat removes its restraint on the time delay, which is then free to operate.

36. When the BTRU cartridge fires, the resultant gas simultaneously:

a. Operates a release mechanism to free the restraint on the parachute withdrawal line within the parachute container.

b. Operates a piston which releases the drogue shackle and releases the top locks of the harness. The release of the drogue shackle frees the drogue from the seat, thereby initiating deployment of the personal parachute.

c. Releases the harness bottom locks, allowing the occupant to be pulled from the seat as the parachute develops.

d. Fires the second cartridge of the drogue gun. This overcomes any failure of the mechanical firing of the gun and is normally a redundant action.

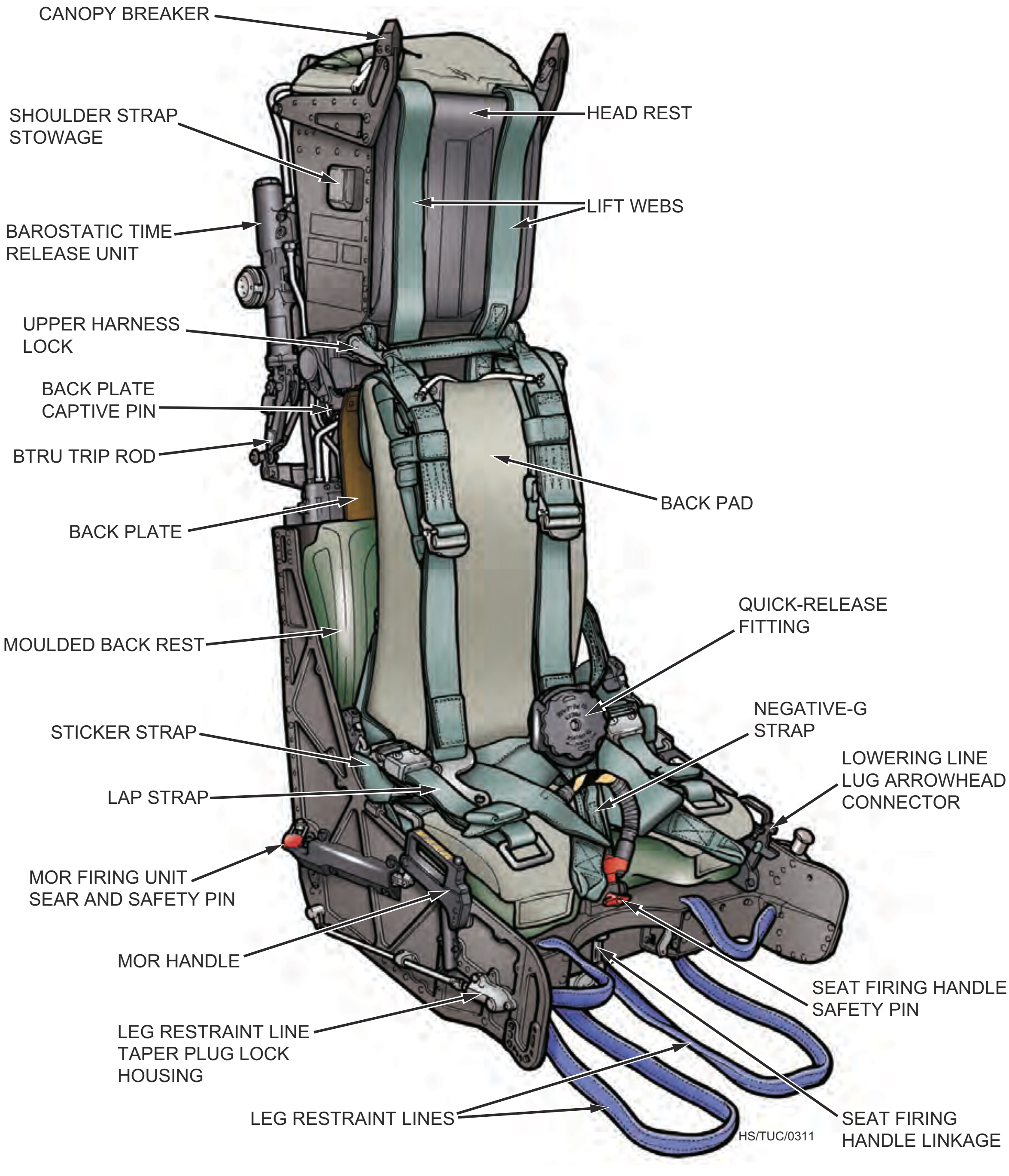
Manual Separation

37. The manual separation facility provides an alternative method for firing the drogue gun and BTRU, thus catering for the failure of either or both, allowing the occupant to deploy the parachute and separate from the seat if the automatic sequence of actions fails, or if it is desired to achieve separation prematurely.

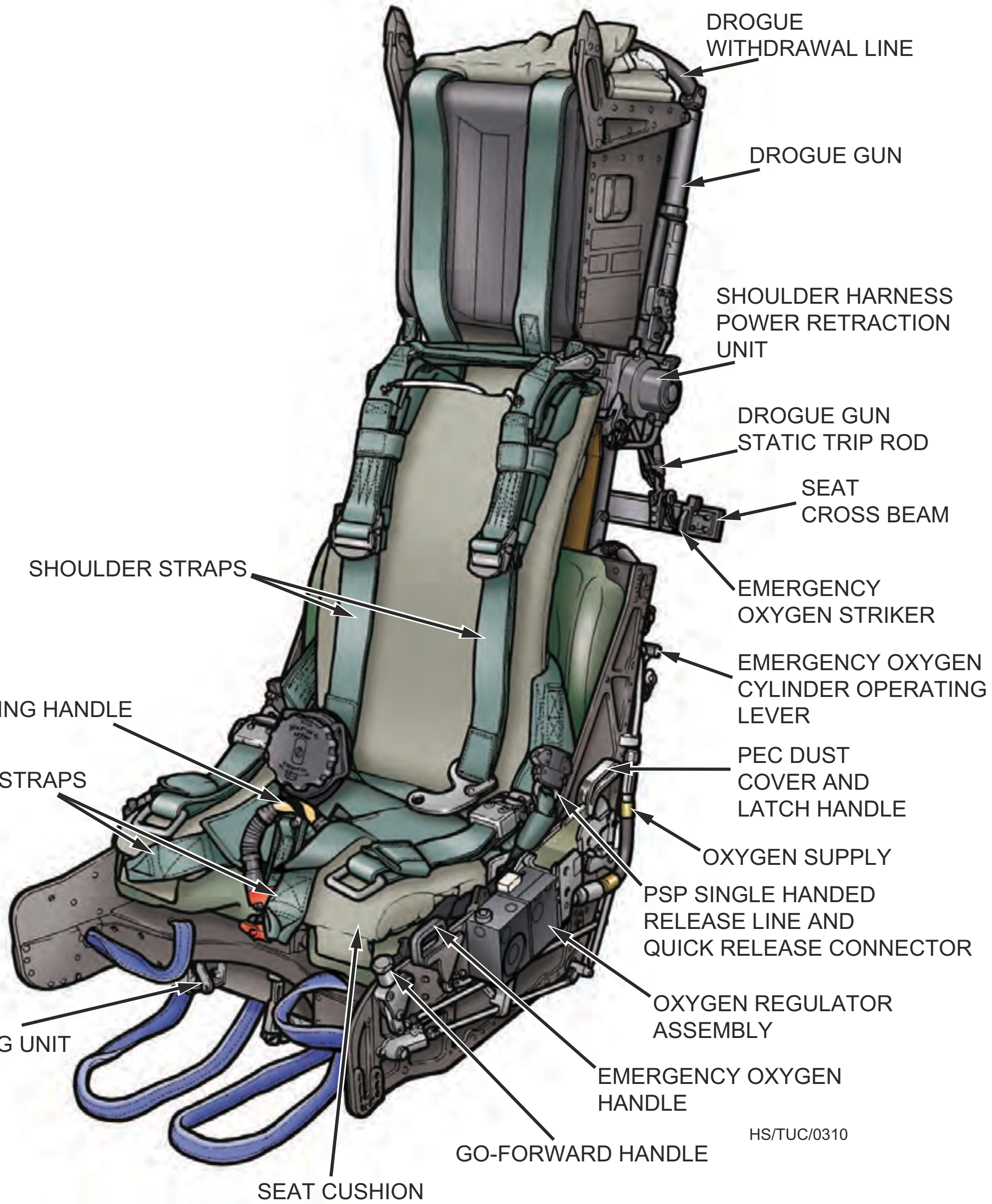
38. The facility is operated by a black and yellow striped Manual Over-Ride (MOR) handle on the right side of the seat pan (see Fig 2); a thumb button on top of the handle must be held pressed to release a mechanical lock before the handle can be pulled. When the MOR handle is pulled a cartridge in a firing unit aft of the handle is detonated, and produces gases which operate the mechanisms normally operated by the BTRU. A safety lock prevents operation of the MOR handle until the seat firing handle has been pulled fully upwards.

WARNING: If the front seat is ejected via the command ejection system, and the occupant subsequently has cause to use the manual separation facility, he must first pull his seat firing handle.

39. The MOR firing unit sear, on the right side of the seat, has a safety pin marked MOR SEAR which is to be checked as having been removed from the sear and stowed before strapping-in. Ensure that there are no foreign objects between the seat and the right console.



1 - 9 Fig 2 Ejection Seat - Right Side



1 - 9 Fig 3 Ejection Seat - Left Side

Seat/LCC/MDC Interconnection

40. Gas pressure from the firing unit cartridge causes the canopy fragmentation initiators to fire, detonating the LCC/MDC firing unit on the canopy frame. The LCC/MDC severs/fractures the associated section of canopy before contact with the seat. If the LCC/MDC fails the seat ejects through the canopy.

41. The canopy breaker knives (front seat) and horns (rear seat) are designed to cut and weaken the intact transparency before the remainder of the seat structure and occupant contact it.

Note: The seat/LCC/MDC interconnection operates to sever/fracture only that section of the canopy above the seat from which the ejection is made, whereas operation of either of the internal CANOPY FRACTURE handles causes severing/fracturing of the entire canopy (i.e. front section and both sections above the seats).

Personal Equipment Connector

42. A PEC, on the left side of the seat pan (Fig 3), provides single action connection of the occupant's mic/tel and oxygen supplies before flight; it also provides disconnection after flight and automatically during the ejection sequence. The PEC comprises seat and man portions:

a. **Seat Portion.** The seat portion provides for connection of the man portion on its top face. It is locked to the seat pan and is coupled to the oxygen regulator. A catch at the aft end of the seat portion enables the whole unit to be removed for maintenance. A metal dust cover, provided to protect the seat portion when the seat is not occupied, is stowed on the cockpit aft bulkhead. The time when the seat portion is not covered by either the dust cover or the PEC man portion (para 42b) is to be kept to a minimum.

b. **Man Portion.** The man portion is part of the flying clothing and has an oxygen tube and mic/tel lead which are to be connected to the occupant's oxygen mask hose and helmet mic/tel lead respectively. The man portion is connected by aligning it over the seat portion, locating its front end and pressing down firmly on its aft end until it locks into place. It is released manually by pulling up its latch handle after pressing a thumb catch on the handle. It is released automatically after ejection by a linkage from the harness lock release mechanism. Both release methods also disconnect the leg-restraint lines.

Note 1: During the strapping-in procedure, to prevent the possibility of surplus oxygen tube and mic/tel lead fouling the pilot's elbow, pull them forward through the restraint flap on the life preserver to minimize the length between the flap and the PEC.

Note 2: The man portion is not to be connected to the seat portion until after the main oxygen supply has been selected ON; it is to be disconnected and the dust cover fitted before the oxygen supply is selected OFF after flight.

Oxygen System on the Seat

43. The main oxygen system is connected to the seat at an automatic pull-off bayonet connector behind the right side of the seat pan, and thence by pipe and flexible tube to the regulator/PEC.

44. An emergency oxygen cylinder on the rear left of the seat feeds into the main supply line and has a supply release mechanism which is tripped automatically by a striker during ejection, or can be operated manually at any time by pulling sharply upwards and backwards on a control handle on the left side of the seat pan.

Independent Ejection Sequence

45. To ensure safe separation between seats a minimum interval of 1·4 seconds between the rear seat and front seat ejections is desirable when the rear seat independently ejects first. When independent ejection is initiated, i.e. the command firing lever is at OFF or, with the lever at ON, the front seat firing handle is pulled before the rear seat handle, the following sequence occurs:

a. The seat firing unit cartridge fires immediately and movement of the seat handle releases a lock, which enables the manual separation handle.

b. Gases from the firing unit are distributed to:

(1) **Harness Power Retraction Unit.** The harness power retraction unit cartridge fires to pull the occupant's shoulders back into the seat and lock the retraction straps.

(2) **Seat Ejection Gun.** Fires the primary cartridge of the ejection gun.

(3) **Canopy Fragmentation System.** The canopy detonator(s) are initiated.

(4) **Command Eject Selector Valve.** Fires the command ejection cartridge and, with the command firing lever selected OFF, the gases are vented into the rear cockpit.

Note: If the command firing lever is selected ON and the front seat handle is pulled first, the gases from the Command Ejection Selector Valve pass to the front cockpit but have no effect since the front seat has already ejected.

c. Gases from the ejection gun primary cartridge initiate upward movement of the seat, releasing the locking plunger from the top latch and thus unlocking the seat from the gun barrel.

d. As the seat accelerates up the guide rails, the following events occur automatically:

(1) The ejection gun secondary cartridges fire in turn.

(2) The static trip rods withdraw the sears from the drogue gun and the BTRU, and static cables disconnect the command ejection system, the main oxygen supply and the mic/tel supply.

(3) The emergency oxygen supply is initiated and the regulator is set to 100%.

(4) The leg restraint lines are pulled downwards through the snubbing units and restrain the occupant's legs. The units maintain the restraint after the shear pins break to free the lines from the floor.

e. The drogue gun fires, ejecting its piston which withdraws the pin from the closure flaps on the parachute container and deploys the drogue. The drogue is fully developed approximately one second after initiation of ejection.

f. The remainder of the sequence is controlled by the BTRU:

(1) **Above Main Barostat Altitude.** If the ejection is made above main barostat altitude, the seat descends to that altitude band and the main barostat then allows the 1·5 second time delay mechanism to operate and fire the BTRU cartridge.

(2) **Below Main Barostat Altitude.** If the ejection is made below the main barostat altitude the time delay then operates and fires the BTRU cartridge.

g. When the BTRU cartridge fires, its gases cause the drogue shackle and the harness top locks to be released; the gases also release the harness bottom locks and pass to the drogue gun to fire its second cartridge (normally a redundant action).

h. The release of the harness locks frees, but does not separate, the occupant from the seat. The release of the drogue shackle transfers the drag of the drogue to the personal parachute which is then pulled from its container.

i. The occupant is then held in the seat only by the restraint of the seat pan stickers. As the parachute develops it lifts the occupant and the PSP from the seat, pulling the seat pan stickers and PSP lowering line connector from their clips (the latter initiating PLB operation). The occupant must release his grip on the seat firing handle at or before this stage. The seat then falls away cleanly and the leg restraint lines run out freely through the rings on the leg garters. A normal parachute descent should then follow.

Command Ejection Sequence

46. The following ejection sequence occurs when the command firing lever is at ON and the ejection of both seats is initiated by pulling the rear seat firing handle. When the rear seat firing unit cartridge fires, gases are fed to the command ejection selector valve firing its cartridge. The ejection of the rear seat continues as in the independent sequence.

47. From the selector valve cartridge gases are passed to the command breech unit in the front cockpit, and also (via a bypass) to the front harness power retraction unit which immediately pulls the occupant's shoulders back into the seat. After a 1·4-second delay the command breech cartridge fires which in turn fires the front ejection gun, thus initiating seat ejection; the sequence then continues as in the independent ejection sequence.

WARNING: If the command ejection system is operative (i.e. selected ON), removal of the rear seat firing handle safety pin renders the front seat live, whether or not the front seat firing handle safety pin is fitted.

NORMAL USE

Cockpit Access

48. **General.** Avoid handling the transparencies. When entering or leaving the cockpit, do not use the glare shield as a handhold. Take care that the PEC shoe does not swing freely and damage cockpit installations.

49. **Canopy Opening from Outside.** Pull out the release handle on the left side of the fuselage at the rear cockpit and turn it fully clockwise. This disengages the locking mechanism and enables the canopy to be lifted open using the external handle at the rear cockpit position.

50. **Canopy Operation from Inside**

a. **Closing.** In either cockpit use the grab handle to pull the canopy down to the closed position against the counterbalancing mechanism; in the front cockpit it may be necessary to use the fabric loop. Ensure the fabric loop is not trapped between the canopy and cockpit sill. While holding the canopy down take hold of the handle on the front left wall and, turning the handle through 90° to form a crank, rotate the lever clockwise until a positive locking click is felt or heard; considerable force may be required to obtain a lock. Ensure that the canopy caption on the CWP extinguishes.

b. **Opening.** In either cockpit the lever on the front left wall releases the locking mechanism. Pull the handle away from the lever axis and turn it through 90° to form a crank. Rotate the lever counter-clockwise. Raise the canopy using the internal handle at the front cockpit position.

Before Flight Checks

51. On donning the life preserver, check that the PEC oxygen tube and mic/tel lead are routed through the flap on the life preserver. Check that the oxygen and mic/tel connections are properly made at the PEC man portion and secure the PEC oxygen tube to the front of the life preserver by the dog-lead clip.

52. Before dual or solo flight check that the aircraft is Safe for Parking and that both MOR pins have been removed and stowed. Check both cockpits for loose articles, particularly for foreign objects lodged between the ejection seat and the right hand console.

WARNING: The front ejection seat canopy breaker knives are very sharp. Take care to avoid injury when carrying out Ejection Seat checks and entering the cockpit.

53. The SEAT FIRING pins are to remain in the seat until after strapping in, the canopy has been closed and the engine started. When stowed, the pins are visible from outside to enable the groundcrew to check that the aircrew have removed and stowed the seat pins in both cockpits (dual sortie) or the front cockpit seat pin (solo sortie), before flight.

Note: The INTL CAN FRACTURE pins remain in the canopy handles at all times during normal operation.

54. In the rear cockpit, confirm the command ejection selector OFF, checking that the lever is correctly located. Turn the rear cockpit oxygen supply ON if dual, OFF if solo.

55. Before solo flight check:

a. The rear seat firing handle and ejection seat firing handle safety pins are both visible.

b. The rear seat safety apron is securely fitted and tightened over the locked and tightened harness. The top of the apron is secured by two pip-pins which locate with two press studs secured to the yoke strap.

c. The rear cockpit leg-restraint and PSP lowering lines are secure.

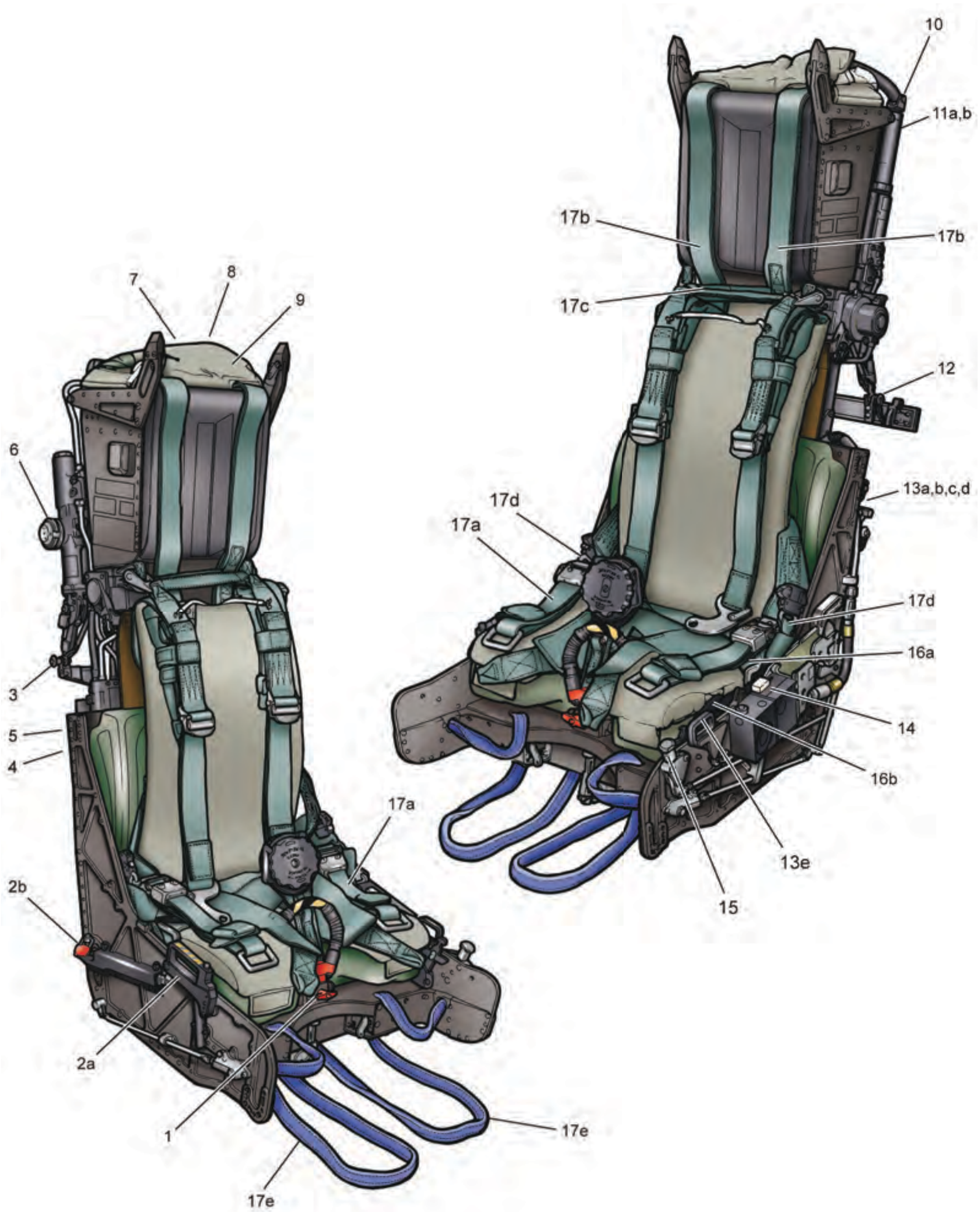
d. The skirt of the apron is tucked around the seat cushion and PSP.

56. Turn the front cockpit oxygen supply ON.

Ejection Seat Checks

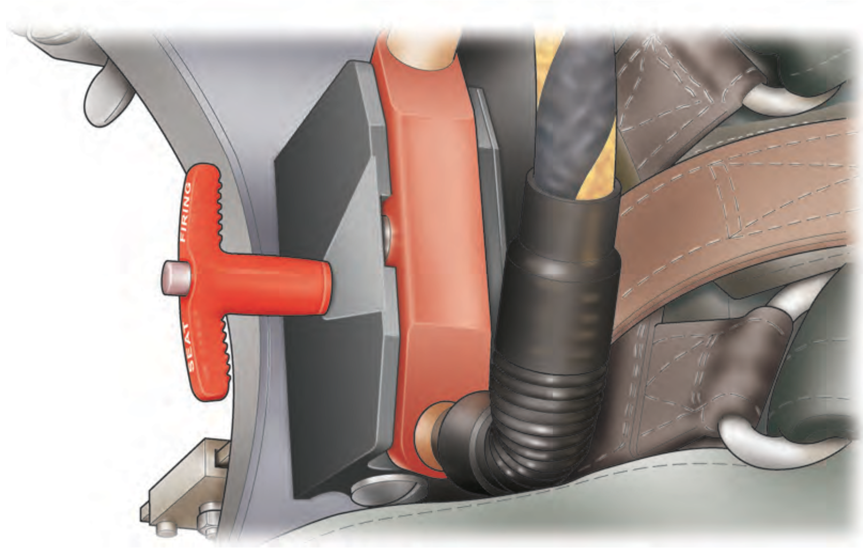
57. To avoid the risk of inadvertently disconnecting seat components, only those items which are normally handled during strapping-in should be subjected to a physical check. The remainder of the seat should be checked visually.

a. Carry out the Ejection Seat checks given in the Flight Reference Cards (itemised within Fig 4) which are amplified below:



1 - 9 Fig 4 Sequence of Checks

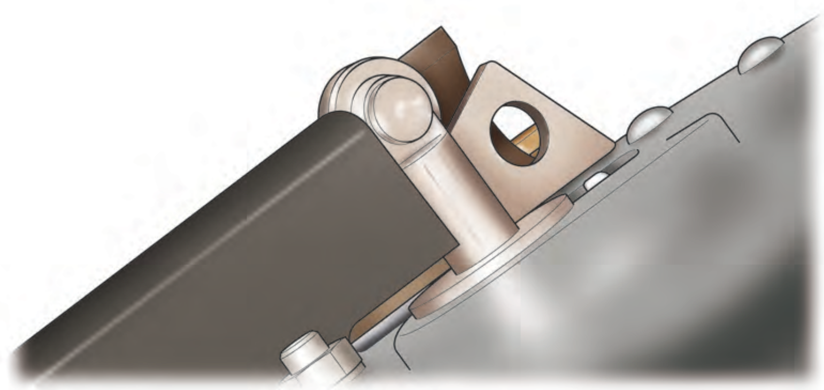
(1) Confirm that the seat firing handle is fully engaged onto the seat firing handle housing. Check that the seat firing handle safety pin is fitted through both the seat firing handle and the seat firing handle housing. (Fig 5).



1 - 9 Fig 5 Seat Firing Handle Safety Pin

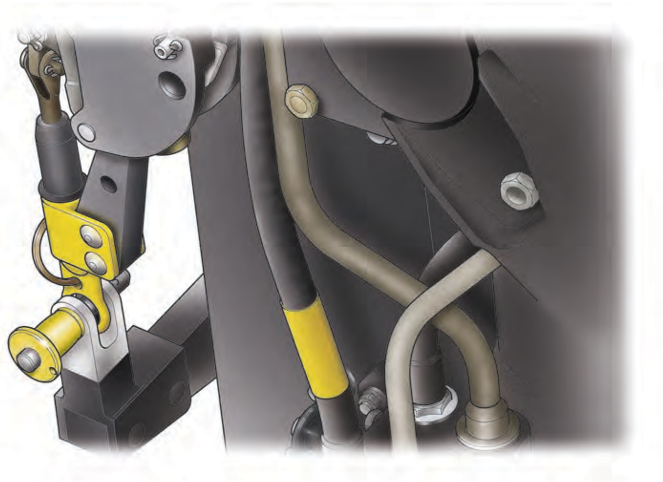
(2) Ensure that the MOR handle is locked down with the thumb button fully out (Fig 6) and the firing unit safety pin has been removed and stowed (Fig 7).

1 - 9 Fig 6 MOR Handle



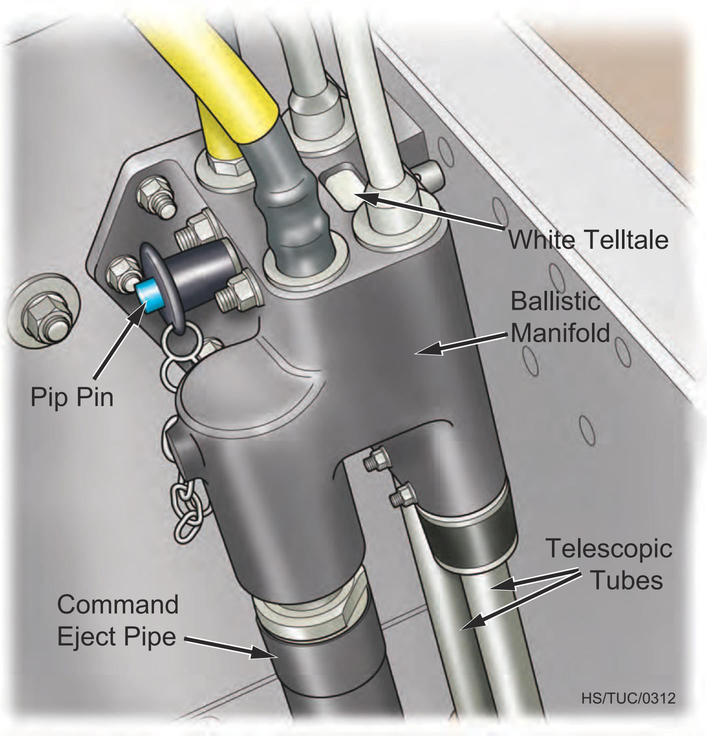
1 - 9 Fig 7 MOR Firing Unit Sear

(3) Ensure the BTRU static trip rod is secured to the cross beam with a pip pin (yellow-white-yellow-white) (Fig 8).



1 - 9 Fig 8 BTRU Static Trip Rod

(4) Visually confirm that the command ejection pipe(s) (two on front seat/one on rear seat) are not disconnected from the ballistic manifold (Fig 9).



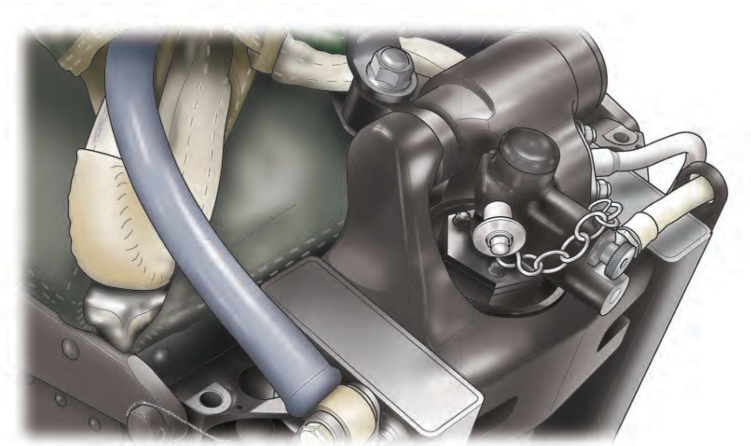
1 - 9 Fig 9 Command Eject Pipes

(5) Ensure that the command (seat firing (fwd inboard)) and BTRU (manual separation (fwd outboard)) telescopic tubes are securely attached with a pip pin to the ballistic manifold and the white telltale is flush (Fig 9).

(6) Check the BTRU capsule has the correct operating altitude (Fig 10).

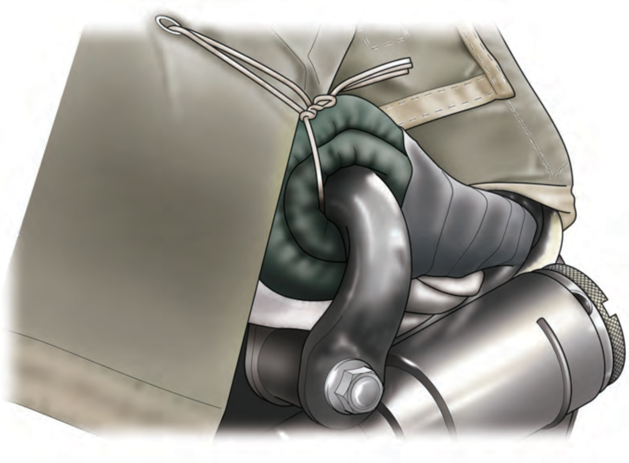
1 - 9 Fig 10 BTRU Capsule

(7) Ensure that the ejection gun firing unit latch plunger is engaged and the quick-release pip pin fitted. The latch plunger should be flush with the housing, but due to manufacturing tolerances a small gap may be present (Fig 11).



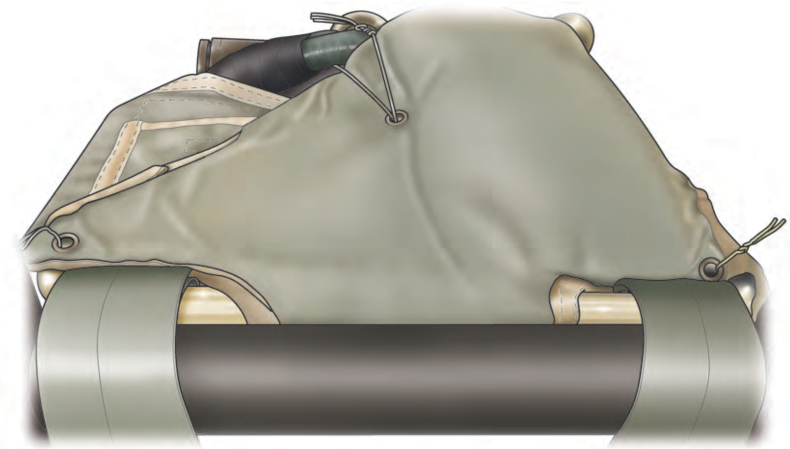
1 - 9 Fig 11 Ejection Gun Firing Unit

(8) Check the drogue shackle is secured to the drogue link shackle and the tie is intact. Check the drogue link shackle is secure in the piston housing (Fig 12).



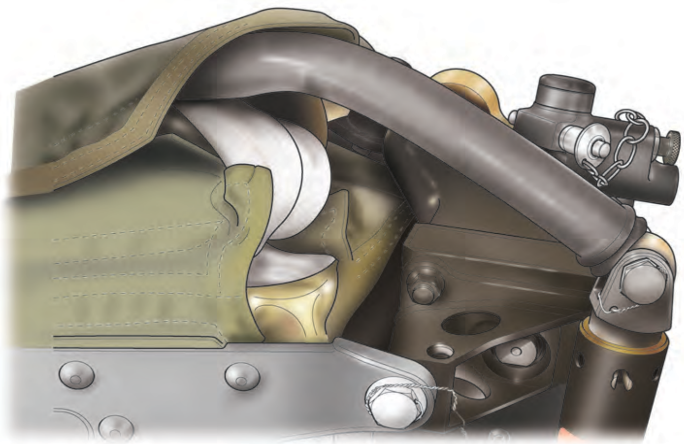
1 - 9 Fig 12 Drogue Link Shackle

(9) Ensure that the parachute container closure flaps are closed and secured over the drogue withdrawal line and that the two ties are intact (Fig 13).



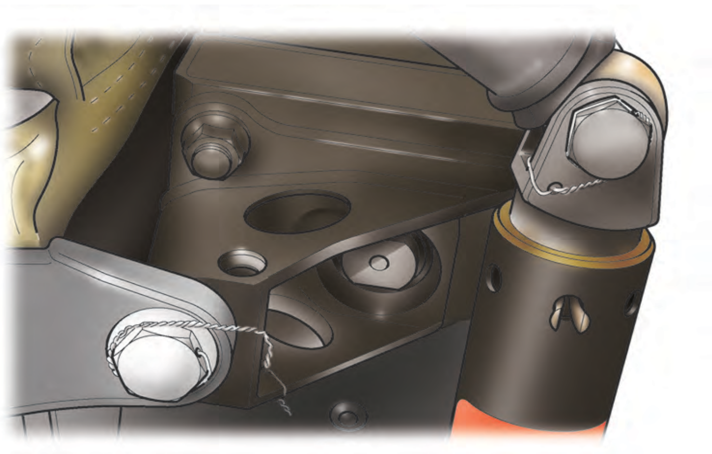
1 - 9 Fig 13 Parachute Container

(10) Ensure the drogue withdrawal line is attached to the drogue gun piston (Fig 14) and that the shear pin is fitted.



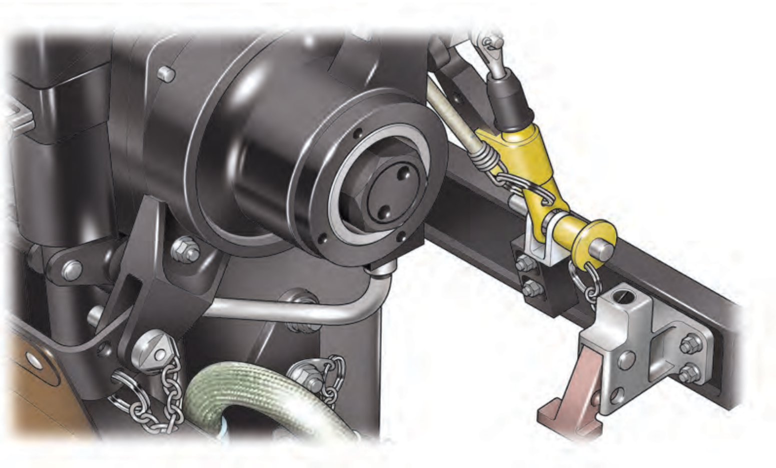
1 - 9 Fig 14 Drogue Gun Piston

(11) Ensure that the seat is correctly locked to the ejection gun by checking that the top latch indicator spigot (inner plunger) is flush with or slightly protrudes from the end of the latch plunger and that the top latch plunger is flush with or slightly recessed in the end of the housing face (Fig 15).



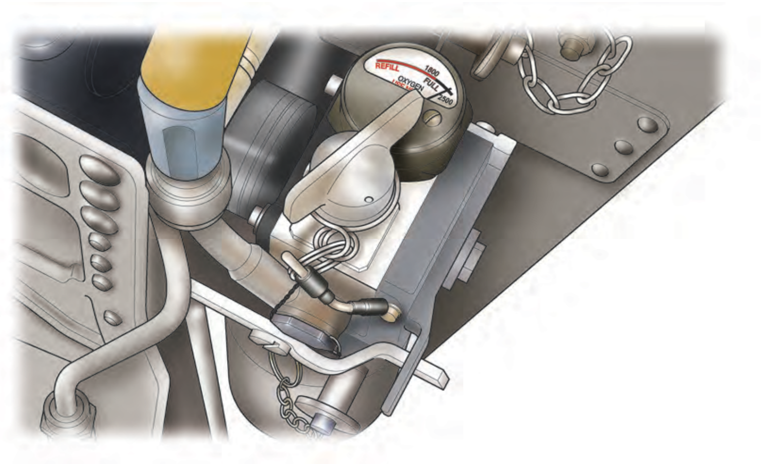
1 - 9 Fig 15 Indicator Spigot & Plunger

(12) Check the drogue gun static trip rod is secured to the cross beam with a pip pin (yellow-white-yellow-white), see (Fig 16).



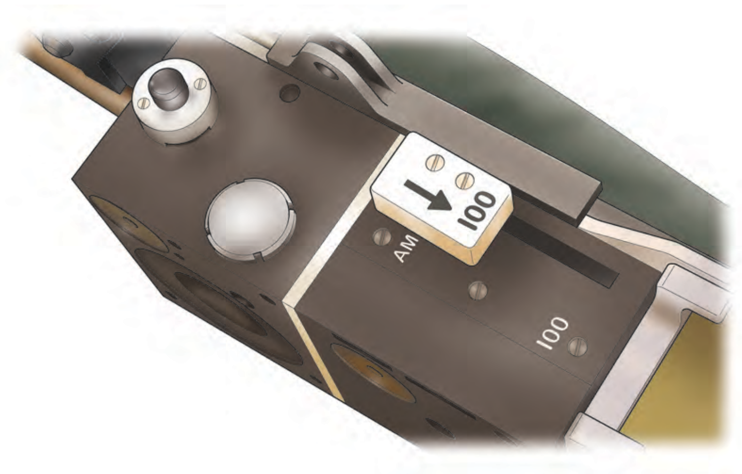
1 - 9 Fig 16 Drogue Gun Static Trip Rod

(13) Ensure the emergency oxygen contents gauge indicates full (green mark) and the pip pin is fitted. Ensure the manual control handle is fully down and the trip lever has not been operated. Ensure that the emergency oxygen striker is in the extended position (Fig 17).



1 - 9 Fig 17 Emergency Oxygen

(14) Set the oxygen regulator to AM (forward), see (Fig 18).



1 - 9 Fig 18 Oxygen Regulator

(15) With the go-forward lever in the locked position (fully back), pull on the shoulder straps to ensure that they are locked. Check that the straps are free to move with the lever forward (Fig 19), and ensure that they are released under control to prevent the harness power retraction unit mechanism from locking. Ensure that the harness back-plate is secured to the harness power retraction unit.

1 - 9 Fig 19 Go Forward Lever

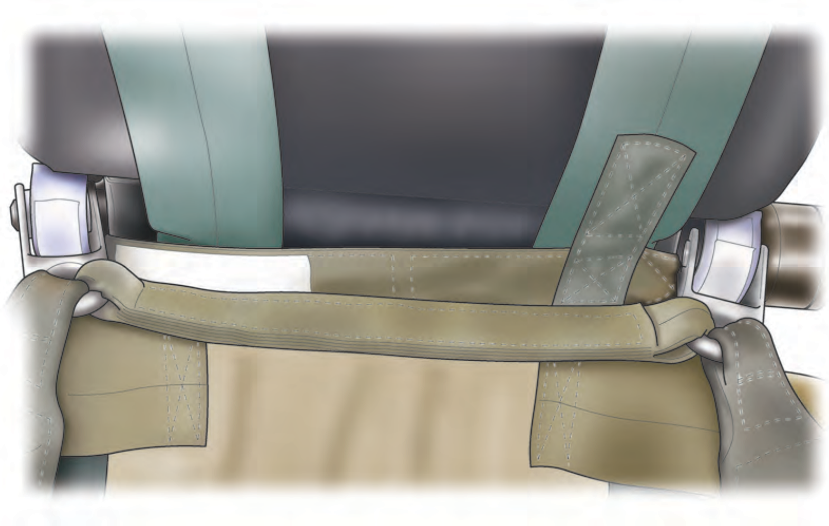
WARNING: If the go-forward is inoperative when checked before flight, do not fly the aircraft.

(16) Ensure that the PSP suspension strap is routed under the parachute harness seat pad, through both lugs on the PSP and inside the sticker straps but outside the lap straps (Fig 20). Check that the arrowhead connectors at each end of the strap are attached to the associated side connectors on the harness. Ensure the PSP lowering line connector is secure in the seat pan spring clip.

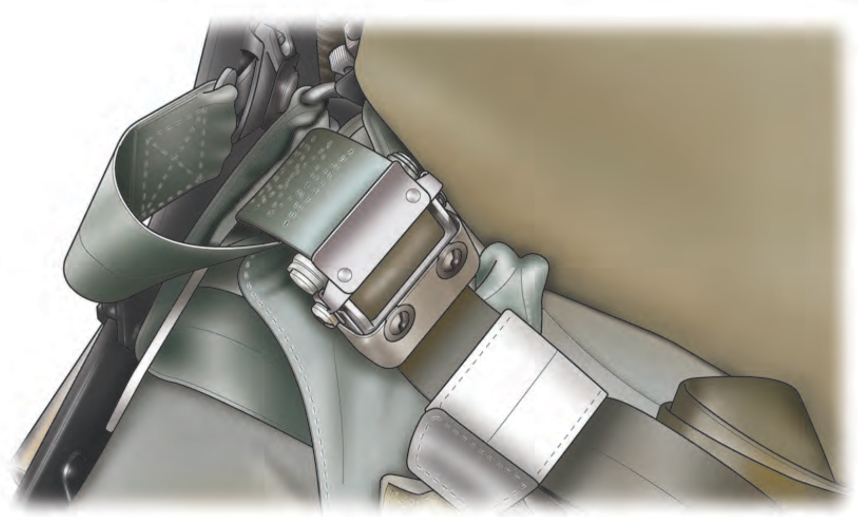
1 - 9 Fig 20 PSP Suspension Strap

WARNING: The PSP connectors are susceptible to inadvertent release by groundcrew and aircrew entering the cockpit.

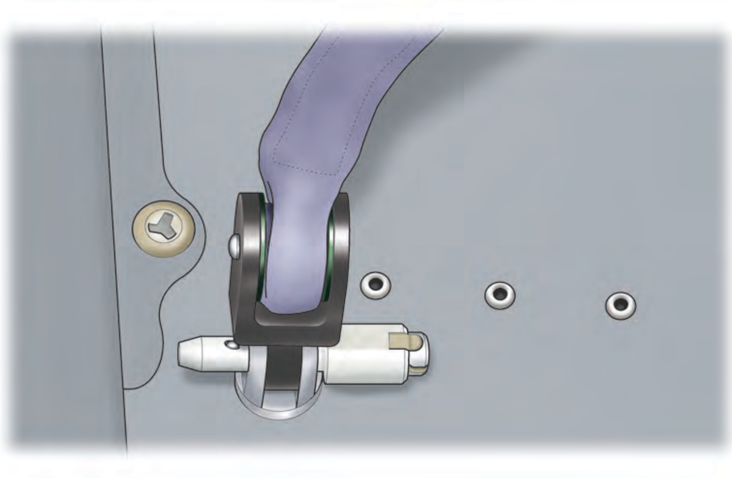
(17) On the combined harness, check that the shoulder straps, lap straps and lower negative-g strap are secured in the harness locks, by pulling each in turn. Confirm that the crotch loops are through the V-Straps and the V-Strap lower ring is secured to the negative-g strap lug. Check that the parachute lift webs are routed inboard of the retention straps (Fig 21) and that the retraction straps are in front of the lift webs and secure in the harness top locks. Lift the shoulder harness clear and stow it on the clips on the parachute container. Ensure the sticker straps (Fig 22) are routed outside the lap and PSP straps and connected to the spring clips on the seat pan. Ensure the leg-restraint lines are connected to their floor attachment points (Fig 23) and are correctly routed through the snubbing units. Ensure that the harness is prepared for strapping-in: crotch loops forward over the cushion and through the loops on the underside of the lower apron, lap straps laid clear of the cushion, shoulder straps in the stowed position and the negative-g strap not through the seat firing handle.



1 - 9 Fig 21 Combined Harness



1 - 9 Fig 22 Sticker Straps



1 - 9 Fig 23 Leg Restraint Attachment Points

Strapping In

WARNING 1: To prevent the leg-restraint line taper plugs snagging during pull through on an emergency ground egress, it is important that the leg garters are worn with their quick-release connectors on the inside of the leg. The free end of the garter adjustment strap should be at least 25 mm away from the outer D-ring.

WARNING 2: Ensure that all loose objects are safely stowed before operating the SEAT RAISE/LOWER switch. Ejection seat components may be damaged, and ejection sequences inadvertently initiated, if the seat is raised or lowered with objects under the seat or between the seat and side consoles.

WARNING 3: When strapping in ensure that there is no possibility of the AEA fouling seat mechanisms during subsequent ground operations and flight.

WARNING 4: Because a command ejection system is fitted, do not move any safety pins until both occupants are correctly strapped in and the canopy is closed.

58. Lay the lap straps clear and occupy the seat, taking care not to stand on the seat firing handle. Adjust the rudder pedals and set the go-forward lever to its locked (aft) position. Move the back pad fully up before leaning back into the seat.

59. Connect the quick-release connector on the left side of the life preserver to the PSP lowering line, routeing the strap outside the left thigh. Re-check that the lowering line end fitting is secure in the seat pan sticker clip and that the line is below all hoses and the lap strap.

60. Lay the left lap strap on the left thigh. Connect the PEC by offering the man portion to the seat portion at an angle in excess of 45° and pushing the man portion forward into the guide slot as far as possible before pressing down into position, ensuring its security.

61. Pass the left leg-restraint line from the snubbing unit through the garter rings on the front of the left leg, passing the line from inboard to outboard, and insert the taper plug in the lock on the left side of the seat pan. Similarly pass the right leg-restraint line through the rings on the right garter and secure its taper plug on the right of the seat pan. Ensure that the lines are not crossed and are not snagging the lower negative-g strap.

Note: If necessary the taper plug locks can be checked for release at this stage by pulling up the PEC latch handle to release the man portion. The taper plugs should eject from their locks. The PEC is to be reconnected and the taper plugs again inserted in their locks, care being taken to ensure that the connections are secure.

62. Adjust the leg-restraint lines so that there is just sufficient line above the snubbing units to allow enough leg movement for the application of full rudder in both directions. Pull any excess leg-restraint line down through the snubbing units. If the lines prevent the application of full rudder in both directions, operate the snubbing release controls in turn and pull up the required amount of line.

63. Bring the negative-g strap and attached QRF up between the legs, ensuring it is aft of, and not through, the seat firing handle. Check that the QRF is locked, i.e. yellow notch on the face uppermost.

64. Bring the left leg loop up inside the left thigh, ensuring it is aft of, and not through, the seat firing handle and pass it through the left lap strap D-ring from below. Fold the leg loop through 90° using a forward twist, bring down the left shoulder strap and pass its lug through the left leg loop, push the lug down into the QRF left slot until the lug is securely locked. Repeat the process for the right side of the harness.

WARNING: Positively check that the shoulder strap lugs are locked in the QRF before tightening the lap straps. Tightening the lap straps causes the lugs to geometrically lock in the QRF slots; this may disguise an insecure lug.

65. Check that the PEC supplies are outside of the left lap strap, and the life preserver attachment strap is under the left lap strap; check that the oxygen tube is under the left shoulder strap. Pull the oxygen tube and the mic/tel lead forward through the restraint flap on the life preserver to reduce to a minimum the surplus between the flap and the PEC.

66. Fully tighten the lap straps, positioning the QRF centrally.

67. Fully tighten the shoulder straps ensuring that the QRF remains in a central position. Have any slack pulled rearwards through the shoulder D-rings and tucked away behind the shoulders. At this stage the tension in the shoulder straps should be slightly overtight. It is this degree of overtension which extracts the correct amount of harness power retraction unit blue strap when the go-forward lever is unlocked.

68. Check that the shoulder straps are clear of the lobes and inflation handle of the life preserver.

69. With power applied, adjust seat pan height so that the head is approximately centred on the headrest of the seat.

WARNING: Adjusting the seat too high can result in backache, head and spinal injuries during ejection and fouling of the control column by the knee or thigh. Once strapped in the occupant may adjust the seat height to improve visibility for taxying and manoeuvring, but the seat should be returned to the normal in-flight position before take-off.

70. Set the go-forward lever to its forward (unlocked) setting and lean forward to extend the shoulder straps. Set the go-forward lever aft (locked) and slowly sit firmly back into the seat while checking for correct locking of the power retraction unit. Re-tighten the shoulder straps firmly. At this stage ensure that approximately 2 to 3 inches of the inertia reel blue webbing strap is horizontal and clear of the inertia reel fairing blocks (groundcrew assistance is an advantage) and that the shoulder strap adjustment buckles lie comfortably forward on the shoulder (below the collar bone).

Note: If a shoulder strap becomes twisted when leaning forward, the strap may jam during retraction. To untwist, pull the strap directly forward manually and allow it to retract slowly into its housing.

WARNING: To avoid an increased likelihood of serious back injury, do not tighten the shoulder harness straps with the go-forward lever in the forward position.

71. Finally, check that there are no straps or lines routed through the ejection seat firing handle.

Unstrapping and Normal Exit

72. Make the aircraft Safe for Parking and then, with oxygen mask donned and visors down, open the canopy.

73. Release the oxygen mask. Disconnect the PEC man portion.

74. Ensure the PSP lowering line is disconnected. Pull the leg-restraint lines free of the leg garter rings. Release the harness by rotating and then pressing the QRF face; free the shoulder straps from the QRF and return the face of the fitting to the locked setting. Slip the leg loops from the lap strap D-rings and lay the straps clear.

75. Fit the dust cover to the PEC seat portion. Stand up and stow the shoulder straps on the parachute container. Fit the canopy strut pin if required. Vacate the cockpit.

Note: If the harness shoulder straps are incorrectly stowed they may cause jamming of the seat, when its height is adjusted, and lead to the release of the harness top locks. It is essential therefore, to ensure that the shoulder straps are correctly stowed.

EMERGENCY USE

Abandoning in Flight

76. To carry out a normal ejection, complete as much of the Abandoning drills as time and conditions permit. If the command firing lever has been selected OFF the front crew member should delay 1·4 seconds after the rear crew member has ejected to ensure adequate separation.

77. At low altitude the aircraft should be in substantially level flight to provide the optimum ejection conditions. Allow additional terrain clearance if the aircraft is descending or in an extreme attitude.

78. At altitude the aircraft attitude is not important but, in controlled ejection conditions, adjust speed and height before ejection. Ideally, position the aircraft over an unpopulated area. Set aileron trim at one-half maximum in either direction and set the throttle to FLT IDLE before ejection; subsequently the aircraft should impact within a short radius of the ejection point.

WARNING: If a parachute descent is being made into water it is important to lower the PSP before splashdown, since the side connectors may be difficult to operate in the water.

Emergency Ground Egress

79. Do not use the ejection seats on the ground with less than 70 knots indicated. When stationary, if it is impossible to open the canopy normally, leave the aircraft using the procedure given in Part 4, Chapter 2.

USE IN ABNORMAL CONDITIONS

Ejection Seat Fails to Fire

80. If the seat fails to fire, immediately check that the seat firing handle safety pin is removed and pull the seat firing handle sharply again. If, with the command ejection system operative, the front seat fails to eject in sequence, the front occupant must immediately pull his own seat firing handle.

Failure of Automatic Sequence After Ejection

81. **Drogue Gun Failure.** If the drogue gun does not deploy the drogue during an ejection sequence one of the following situations applies:

a. **Failure Above Main Barostat Altitude.** The seat is not stabilized and descends in this condition until the BTRU operates at main barostat altitude. Without the drogue, the seat may descend in a stable condition and the occupant can wait for BTRU operation. If, however, the seat gyrates in a manner which causes severe discomfort and may result in the occupant losing consciousness, separate from the seat manually (see para 82). Delay manual separation, if possible, until the seat has descended to an altitude where tolerable oxygen and temperature conditions exist.

b. **Failure Below Main Barostat Altitude.** Assume BTRU failure and immediately separate from the seat manually (see para 82).

82. **BTRU Failure.** If the BTRU fails to operate at or below barostat altitude, the seat continues its descent without automatic man/seat separation. Immediately pull seat firing handle fully up. Then locate and grasp the MOR handle, press the thumb button on top of the handle and pull the handle upwards; this fires the BTRU cartridge to initiate separation. The parachute deploys and man/seat separation takes place almost immediately.

WARNING: If automatic separation failure occurs following command ejection, the front seat occupant has to first pull his seat firing handle before he can operate the MOR handle.

83. **Canopy Unlocked in Flight.** If the canopy is suspected of becoming unlocked in flight (caption illuminates), then immediately reduce airspeed to the minimum safely practicable. Check that the locking

handle is fully forward, but do not attempt to unlock then relock the canopy. Land as soon as practicable. If the canopy is lost then a safe landing can be made. Carry out a low speed handling check.

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PART 1

CHAPTER 10 - OXYGEN SYSTEM

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INTRODUCTION

General

1. A high-pressure gaseous oxygen system supplies both crew members. An emergency system, on each ejection seat, supplies oxygen when a crew member is ejected or can be initiated manually if the main system malfunctions. Individual cockpit controls are provided for both main and emergency systems.

DESCRIPTION

Oxygen System - General

2. The main oxygen system (Fig 1) provides both occupants with a common supply from one 2250-litre cylinder behind the rear cockpit bulkhead. A 70-litre cylinder on each seat provides a gaseous emergency supply for each occupant; it is selected automatically during ejection or can be selected manually. Once activated it cannot be turned off.

3. A charging point for the main cylinder is on the right side of the fuselage just aft of the cockpit; a shut-off control, a gauge and a captive cover are provided; there is also an overboard vent indicator to alert groundcrew to main oxygen cylinder overpressure. A main system contents gauge is on the right of each main instrument panel. Each emergency cylinder has an individual in situ charging point with a contents gauge alongside.

4. The main supply is routed through a combined pressure reducing valve (outlet pressure 4·8 to 5·8 bar) and relief valve before dividing to provide a separate supply to each cockpit. There is a shut-off valve and a flow indicator transmitter for each crew position. A low pressure warning switch is in the common medium-pressure line. At the seat, the supply flows via a quick-disconnect connector, a coupled demand regulator and a personal equipment connector (PEC) and tube to the mask.

5. The main oxygen supply endurance at sea level, when fully charged, with the regulator set to air mixture, is approximately 4 hours when dual and 6 hours when solo; with the regulator set to 100%, the endurance is approximately 1 hour when dual and 1·75 hours when solo. However, endurance, when using 100%, is greater at high altitude than at low altitude.

6. The supply from each emergency cylinder flows through a pressure reducing valve (outlet pressure 3·45 bar) to the demand regulator via the main system supply line, which it joins before reaching the regulator. A non-return valve at the quick disconnect connector (para 4) prevents feedback of the emergency supply into the main system.

7. The emergency system provides the crew with 100% oxygen during the descent of the drogue-stabilized seat(s) after ejection. The system can also be selected manually. It has an endurance of approximately 3·5 minutes at low altitude and approximately 11·5 minutes at high altitude.

Note: An oxygen cylinder contains a fixed mass of oxygen. A constant volume is used for each breathing cycle. The pressure of the inspired oxygen (and thus the mass flow) reduces with increasing altitude. Hence the endurance of the system is greater at high altitude than at low altitude.

Controls and Indicators

8. The oxygen system controls and indicators, of both cockpits, are listed in Table 1 and illustrated in Fig 2.

Main Supply Selectors

9. The main supply selectors, one on the right rear console in each cockpit, control the main oxygen supply to the seats. Each selector is ON when pointing forward and OFF when pointing athwartships.

Contents Gauges - Main Supply

10. The main supply contents gauges, one on the right on the main instrument panel in each cockpit, indicate the main oxygen cylinder pressure contents. The gauge scale is graduated in eighth intervals to full (F) and marked in fractions at quarterly intervals. When the gauge registers in the red sector (between zero and one eighth) the oxygen main supply is to be considered empty.

Flow Indicators - Main Supply

11. The oxygen flow magnetic indicators are electrically operated by flow transmitters in the main supply line in each cockpit. Indicators are de-energized and show black when no oxygen is flowing or there is no electrical supply; they are energized to show white vertical bars when oxygen flows. When the main oxygen system is in use the indicators should show alternating black and white indications in time with the user's breathing. Two flow indicators are on the right on each cockpit instrument panel, one for each crew member, the forward station being uppermost. At high altitude, when breathing may be shallow, the flow of oxygen may not be sufficient to operate the flow transmitter and the indicator may stay black. The crew member should then breathe more deeply to check the integrity of the indicator.

Low Pressure Warning Switch - Main Supply

12. The main supply low pressure warnings are controlled by the low pressure warning switch, which causes the red OXY caption to be illuminated in both cockpits when pressure is below 3·1 to 3·45 bar. This also activates the attention getters and audio warning.

WARNING: The OXY caption gives warning of imminent failure of the main oxygen supply and does not give a particular minimum further endurance.

Demand Regulator

13. The Type 500 demand regulator is two miniature regulators in one unit which is coupled to the seat portion of the PEC. The unit provides a controlled air oxygen mixture or 100% oxygen breathing supply to the mask at all altitudes up to 35,000 feet, and includes the following components:

a. Air/oxygen mixture section.

b. 100% oxygen section.

c. Changeover selector.

d. Press-to-test button.

14. **Air/Oxygen Mixture.** When the air mixture section is in use, an air/oxygen mixture is supplied to the mask. The proportions of the mixture are progressively adjusted by an aneroid up to 30,000 feet; above this altitude 100% oxygen is delivered. The mask hose delivery pressure is adjusted by the regulator according to the altitude, below 15,000 feet delivering a supply to the mask at ambient pressure only when the user inhales. Above approximately 15,000 feet the mask hose delivery pressure is in excess of cockpit pressure, thus providing a safety pressure. The regulator air intake is at a low level in the cockpit and is prone to collect any fumes that gather at floor level.

15. **100% Oxygen.** When the 100% oxygen section is in use, undiluted oxygen is supplied to the face mask irrespective of the aircraft altitude, and safety pressure is provided from sea level.

16. **Changeover Selector.** The changeover selector is used to select the required section of the regulator. The air mixture section is operative at the forward setting (AM) and the 100% section at the aft setting (100). The selector is to be set positively to its full extent of travel. When the emergency oxygen is selected on, the selector automatically changes to 100%.

17. **Test Button.** The test button is operative only when AM is selected. It allows the occupant to check his face mask for correct fit and to test the system and connections for leaks. Pressing the button increases the flow, and pressure at the mask confirms correct operation of the system.

Face Mask and Mask Hose

18. The oxygen face mask is connected to the helmet by a toggle chain. A bayonet connector joins the mask hose to the PEC oxygen tube which is secured to the front of the life preserver by a dog-lead clip. The PEC tube is restrained at the left side of the life preserver by a flap, allowing the crew member to position the tube to prevent elbow obstructions, and prevents flailing of the tube and PEC man-portion after man/seat separation following an ejection.

Emergency System

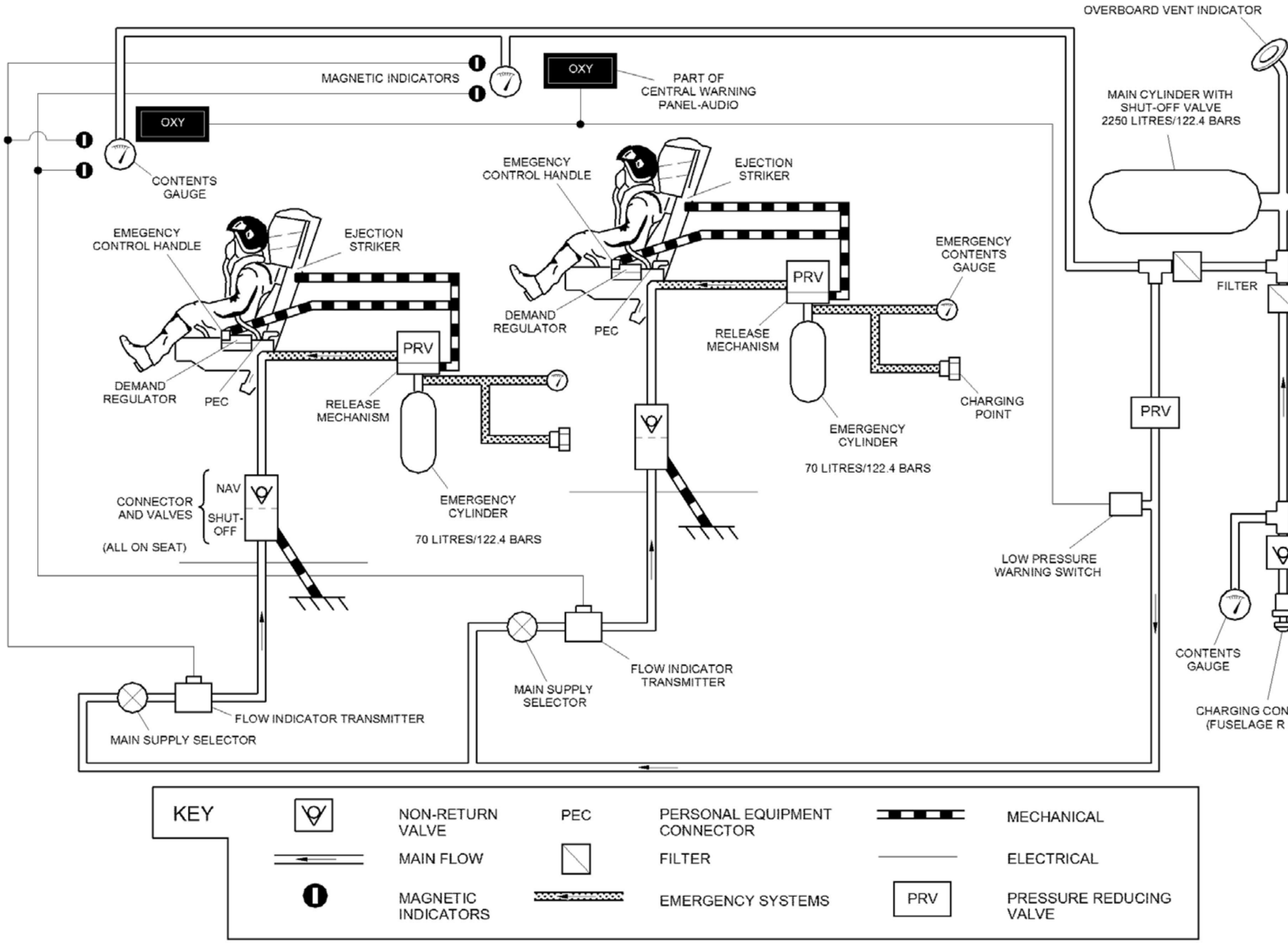
19. An emergency oxygen cylinder, on the rear left side of each seat pan, has a charging point (via which the cylinder can be charged in situ), a contents gauge and an operating lever which is connected to manual and automatic release mechanisms on the seat. A transit safety pin can be fitted to the head of the emergency cylinder operating mechanism to prevent inadvertent operation. The pin is fitted near the head of the cylinder and its removal is to be confirmed before strapping in.

20. The emergency cylinder is manually selected on by pulling the seat-mounted control handle sharply upwards and backwards. It may be necessary to ease the left thigh away from the control handle to prevent obstruction when it is being pulled. The control handle requires a pull force of between 20 and 30 lb. Once an emergency supply has been selected on it cannot be turned off. There is no flow indication when emergency oxygen is being used.

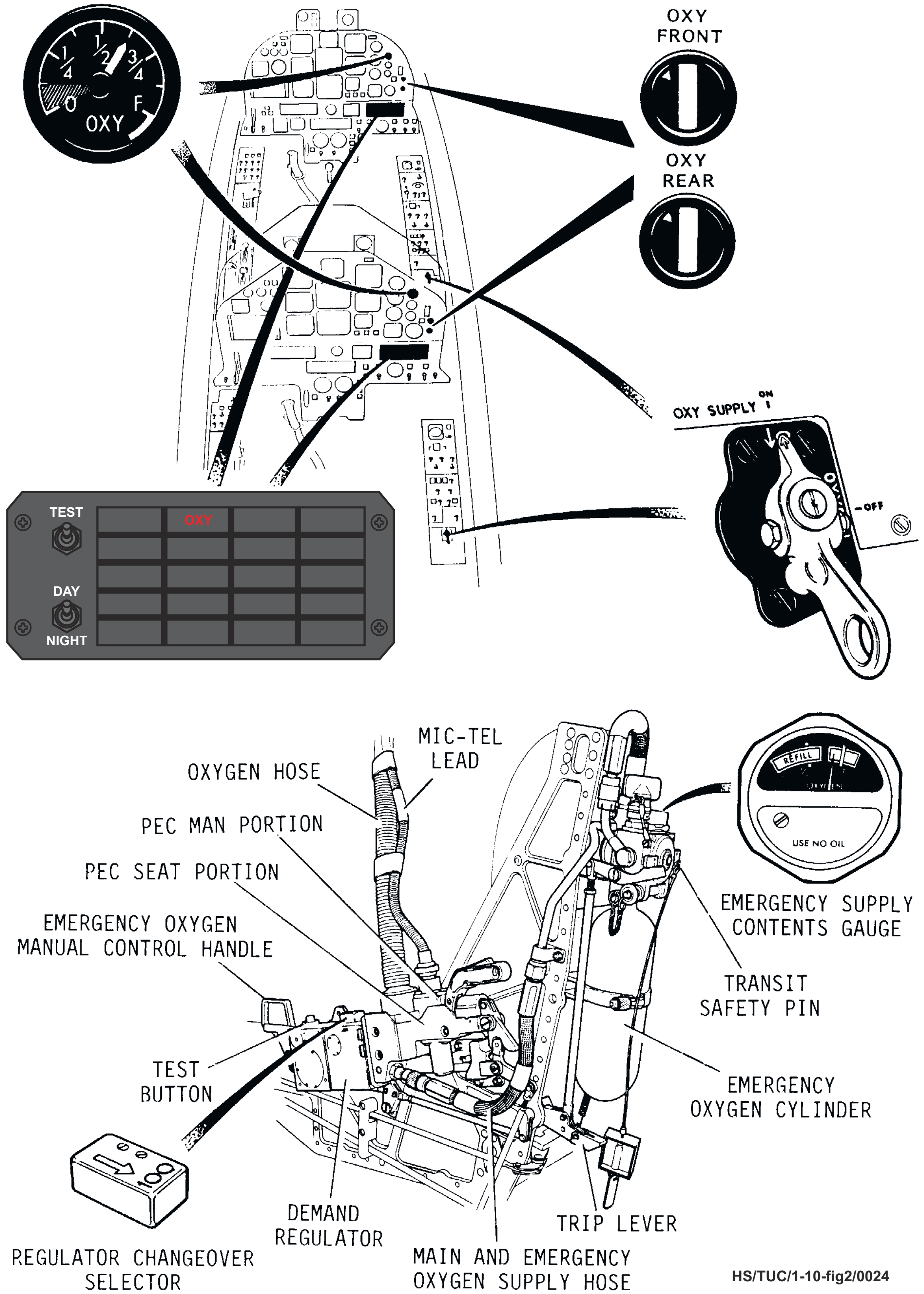
21. Since the outlet pressure at the emergency system valve is lower than the outlet pressure at the main system reducing valve, emergency oxygen cannot flow if the main system pressure is dominant. If the emergency supply is required in these conditions, e.g. contaminated main supply, the main supply selector is to be set to OFF.

Emergency System - Ejection

22. The emergency system is automatically selected on during the seat ejection sequence when an aircraft-mounted striker engages the cylinder operating lever. Since the emergency system is seat-mounted, the supply is lost when man/seat separation occurs.



1 - 10 Fig 1 Oxygen System - Schematic



1 - 10 Fig 2 Controls and Indicators

Table 1 - Oxygen System Controls and Indicators

Controls/Indicators	*Marking*	*Location*
Main supply selector (2-position rotary control)	OXY SUPPLY - ON/OFF	Right console
Main supply contents gauge	OXY	Right side of main instrument panel
Flow magnetic indicators (two) (Main system only)	OXY FRONT OXY REAR	Right side of main instrument panel
Regulator changeover selector (2-position slide control)	AM/100 - 100 ⇐ (arrow points rearward)	On regulator (left of seat)
Test button	-	On regulator
Emergency supply control handle	EO ⇒ Black and yellow handle	Left side of seat pan
Emergency supply contents gauge	Two coloured segments: Green (full), Orange marked REFILL	On top of emergency supply cylinder
Oxygen supply low pressure caption (Main system only) (red)	OXY	Central warning panel (CWP)

NORMAL USE

Before Flight

23. Check the system before flight in accordance with the drills in the Flight Reference Cards (FRC). The emergency system contents gauge cannot be seen by the seated occupant, therefore, check the gauge during the **Ejection Seat** checks. The main oxygen system is not to be less than half full.

Note: Back pressures, created at the regulator by flexing of the oxygen tube or by breathing into the face mask before the oxygen supply has been selected ON, can damage valves in the regulator. Therefore, the PEC man-portion is not to be connected to the PEC seat-portion until the oxygen supply has been selected ON.

24. **Testing the System.** After strapping in, make the following checks independently at each crew station:

a. **With Air Mixture Selected.** Check that the OXY flow indicator shows white bar when breathing in and black when breathing out, or when holding the breath. Press the test button, check that oxygen pressure is felt at the face mask and that the flow indicator shows black/white indications during three consecutive breathing cycles. Release the test button. Select 100% (aft setting).

b. **With 100% Selected.** Check that the flow indicator responds correctly in time with crew breathing (para 24, sub-para a). Lift the mask from the face and check that the flow indicator shows a steady white bar.

In Flight

25. The regulator may be set to AM when a positive air conditioning flow has been established after selecting BOOST following engine start. It may be selected to 100% if the air mixture regulator is suspect, faulty or when an emergency calls for selection of 100% oxygen (see FRC). Make periodic checks of the main oxygen contents and the operation of the flow indicators.

26. The emergency oxygen supply is of limited duration and, once activated, cannot be turned off. Restrict its use to emergency situations only.

After Flight

27. After disconnecting the PEC and before leaving the aircraft, fit the PEC seat-portion dust covers, turn OFF the oxygen in both cockpits and then select 100% on each regulator.

USE IN ABNORMAL CONDITIONS

General

28. Indication of main oxygen system malfunction is given by one or more of the following:

  a. Illumination of the OXY caption.

  b. Flow magnetic indicator.

  c. Signs of abnormal consumption.

  d. Physical senses.

29. The flow indicator may continue to show normal oxygen flow even when the system pressure is below the minimum required by the crew. Therefore, the illuminated OXY caption is to be accepted as a true indication unless, by a process of cross-checking, it is proved to be spurious.

30. Indications of a system malfunction may not appear simultaneously in both cockpits. Therefore, any indication of system failure in one cockpit should, where possible, be cross-checked with the other. A failure downstream of a main supply selector affects the associated cockpit only.

31. Malfunction of a regulator in either cockpit may occur in the air mixture or the 100% section, but is unlikely to occur in both sections at the same time. Therefore, in the event of a suspect regulator, set the changeover selector to the alternative setting and check the system for clearance of the failure symptoms.

32. If a system malfunction (other than a red OXY caption) is indicated, check the following:

  a. OXYgen SUPPLY ON.

  b. PEC tube and mask hose correctly connected.

  c. Contents sufficient.

  d. Mask seal.

  e. Alternative regulator selected.

33. If emergency oxygen is selected, descend immediately below 10,000 feet, since the duration of the emergency supply is limited and there are no means of monitoring the system contents or operation. If the main system pressure fails, the OXY caption is illuminated.

OXY Caption Illuminated

34. If the OXY caption is illuminated, select emergency oxygen and descend below 10,000 feet.

Flow Indications

35. **Steady Black.** If the flow indicator shows steady black (no flow) confirm that the main system is selected ON, check connections, contents and mask seal and select 100%. If breathing is then not restricted, the air mixture section is at fault and flight may be continued using 100% oxygen subject to frequent satisfactory checks of the contents gauge and the flow indicator. If breathing is restricted after selecting 100%, select emergency oxygen and descend below 10,000 feet.

36. **Steady White Bar.** If the flow indicator shows a steady white bar (continuous flow) confirm that the main system is selected ON, check connections, contents and mask seal and select 100%. If breathing is not restricted the flight may be continued using 100% oxygen subject to frequent satisfactory checks of the contents gauge and the flow indicator. If breathing is restricted after selecting 100%, select emergency oxygen and descend below 10,000 feet.

Breathing Difficulties

37. **Resistance to Breathing In.** If resistance to breathing in cannot be overcome by the initial checks (para 32) select emergency oxygen and descend below 10,000 feet.

38. **Resistance to Breathing Out.** If resistance to breathing out persists, lift the edge of the face mask from the face to breathe out and descend below 10,000 feet.

Excessive Oxygen Consumption

39. If the contents gauge indicates that oxygen consumption is higher than expected, check the mask and system connections for leaks, and descend below 10,000 feet, while oxygen endurance remains. Selecting 100% may isolate a leak in the air mixture regulator. Other leaks, downstream of the main supply selector, may be isolated by setting the selector to OFF (after first selecting emergency oxygen in the associated cockpit); this action may preserve the main supply for use in the other cockpit (when appropriate). Remember that the location of the leak may permit the escape of emergency oxygen after it has been selected on.

Symptoms of Hypoxia

40. If symptoms of hypoxia are experienced, check the PEC and mask hose connections are made and that the mask is making a correct seal on the face. If the oxygen flow is not restored, select emergency oxygen and descend rapidly to below 10,000 feet. Where two crew members are present and one observes symptoms of hypoxia in the other, he is to initiate descent and encourage the other to check his oxygen system and/or select emergency oxygen.

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PART 1

CHAPTER 11 - FLIGHT INFORMATION DISPLAYS AND INSTRUMENTS

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INTRODUCTION

General

1. A primary flight instrument display, on the upper instrument panel of each cockpit, comprises a combined airspeed indicator/machmeter (CSI), a main altimeter, a main attitude indicator, a turn-and-slip indicator, a vertical speed indicator (VSI), and a horizontal situation indicator (HSI). Each cockpit also has a standby altimeter, a standby attitude indicator, a standby magnetic compass, an outside air temperature (OAT) indicator, an accelerometer, an angle-of-attack (AOA) indicator and indexer, a clock and a stopwatch (see Fig 1 and Fig 2).

Note 1: SEM 016 introduces a second stopwatch into each cockpit.

Note 2: SM 109 introduces the Powerflarm Portable (FLARM) Collision Warning System. Embodiment of SM 109 removes the AOA indexer from both cockpits, the AOA indicator from the front cockpit and the provision for a second stopwatch in the front cockpit.

2. Magnetic compass heading or directional gyro heading or a combination of both is presented on the HSI in each cockpit and is also fed to the Tacan. Information on ILS glidepath and localiser, VOR steering and Tacan range, steering and bearing can be shown on each HSI by selection at a navigation mode selector, marked VOR ILS/TACAN, in each cockpit. A HSI selector in each cockpit allows the selected track to be controlled by either the front or rear HSI track select knob. See Chapter 13 for information on the VOR ILS/TACAN and HSI selectors. Power is from the main busbar. If this supply fails, a display of attitude is provided by the standby attitude indicator and the standby magnetic compass gives direction information. For instrument lighting refer to Chapter 12, or to the relevant paragraph in this chapter.

PRESSURE - OPERATED INSTRUMENTS

Pitot-Static System

3. Pitot and static air pressures are fed to pressure instruments in the front and rear cockpits (see Fig 3).

4. The pitot tube under the left wing and two static ports supply the front cockpit instruments. The pitot tube under the right wing and two other static ports supply the rear cockpit instruments. One static port of each system is on the horizontal centreline on each side of the fuselage between the avionics bay and the tailplane. This compensates for sideslip, giving an average of the pressures sensed by the static ports.

5. For ice protection see Chapter 14.

6. The pitot-static system supplies the main altimeters (repeater in rear cockpit), standby altimeters, VSI and CSI.

7. Tappings from the pitot and static lines provide inputs to height and speed transducers in the accident data recorder. A further tapping from the pitot line provides an input to an airspeed and ambient static transducer for the engine (see Chapter 4).

Main Altimeters

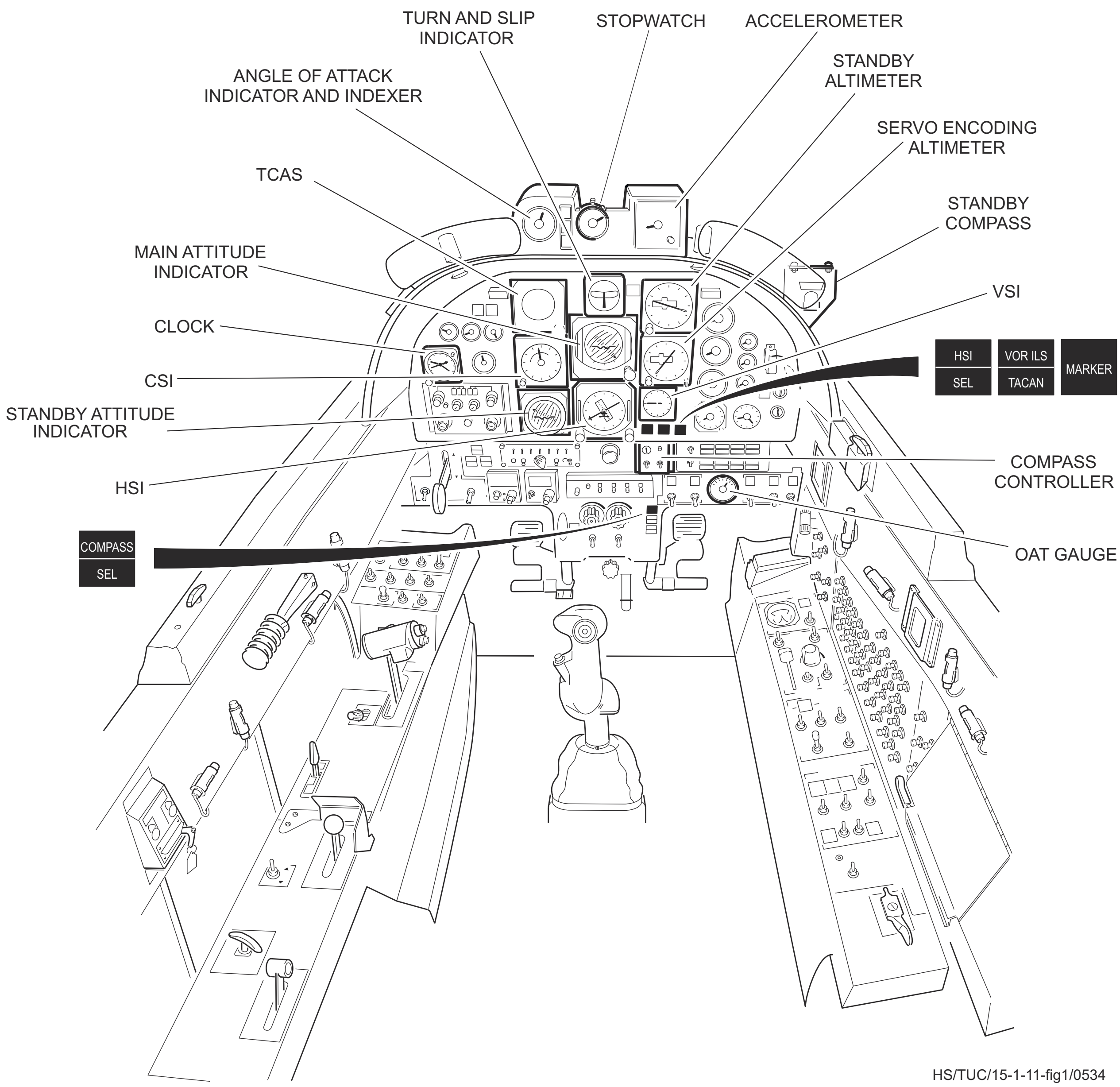
8. A Mk 30C servo encoding altimeter (Fig 4) in the front cockpit gives indications of altitude on a counter and by a single pointer. The altimeter, which uses static pressure, has a calibrated range of minus 1000 to + 35,000 feet and provides an encoded altitude, for altitude reporting, and a synchro signal to drive a pressure reversion repeater altimeter Mk 29C (Fig 4) in the rear cockpit. When not being servo driven the Mk 29C operates as a sensitive altimeter. On both altimeters the pointer makes one full rotation for each thousand feet of altitude. Each altimeter has a 3-drum 5-digit counter which indicates altitude in increments of 100 feet. The window displaying hundreds of feet is elongated to display three digits simultaneously to avoid misinterpretation. Between zero and 9900 feet, the tens of thousands of feet digit (left-hand drum) is obscured by a black and white striped flag; below zero feet, the digit is obscured by a red-and-white striped flag. Altitude below zero feet is calculated by adding the indicated height to minus 10,000 feet, e.g. a true

pressure altitude of minus 200 feet is indicated when the red and white flag obscures the tens of thousands of feet digit and the altimeter display reads 9800 feet (minus 10,000 feet + 9800 feet).

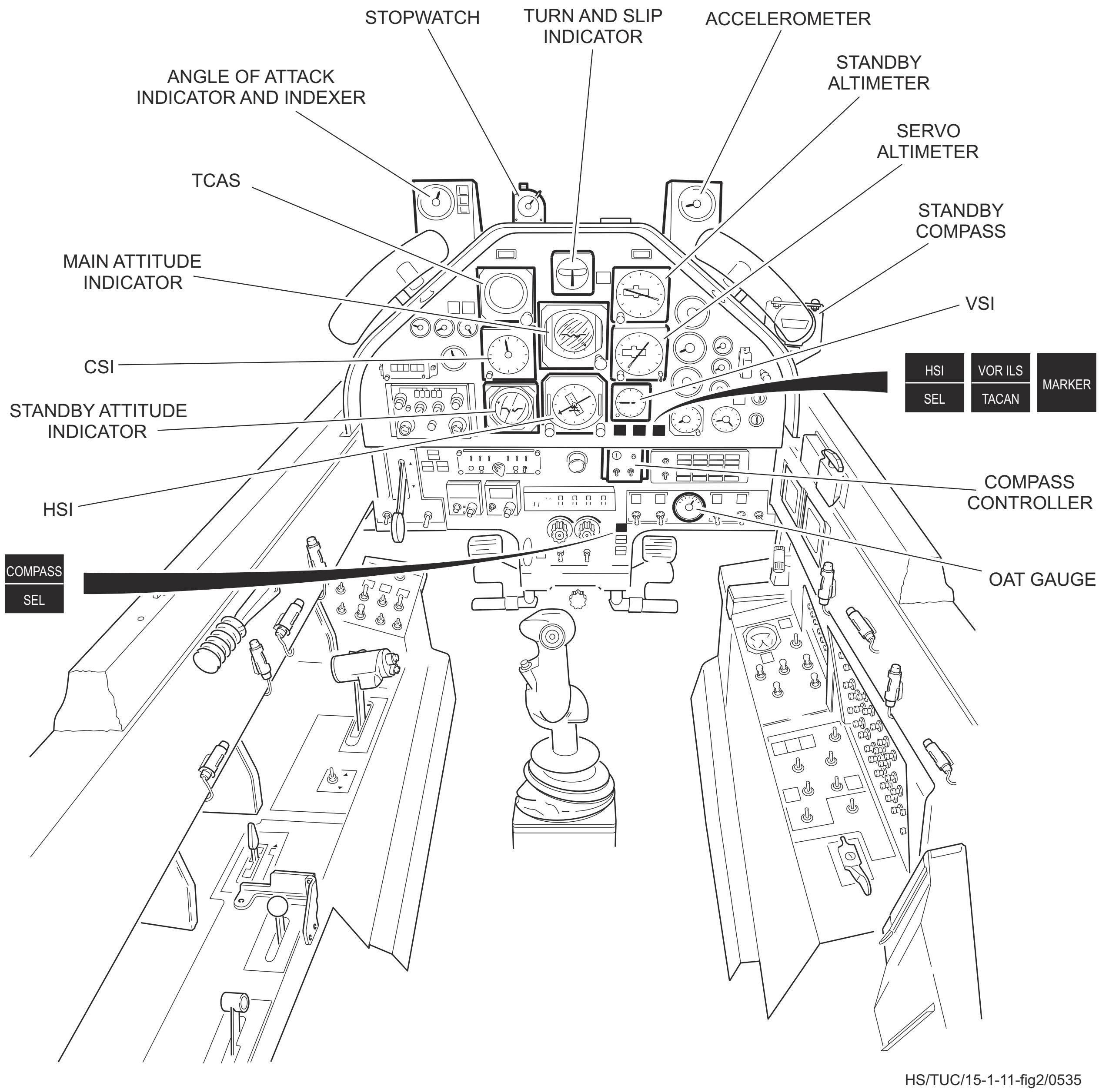
9. **Altimeter Pressure Datum.** Both the Mk 30C and Mk 29C altimeters have a pressure datum setting control, at the lower left hand corner, for adjusting the hectopascal sub-scale in the face of the instrument. The controls on the front and rear cockpit altimeters are not interconnected.

10. **Altimeter Coded Output.** The front cockpit altimeter gives a digitized coded output of altitude to the transponder. The coded output is related to 1013·25 mb and is not affected by changing the setting of the hectopascal sub-scale.

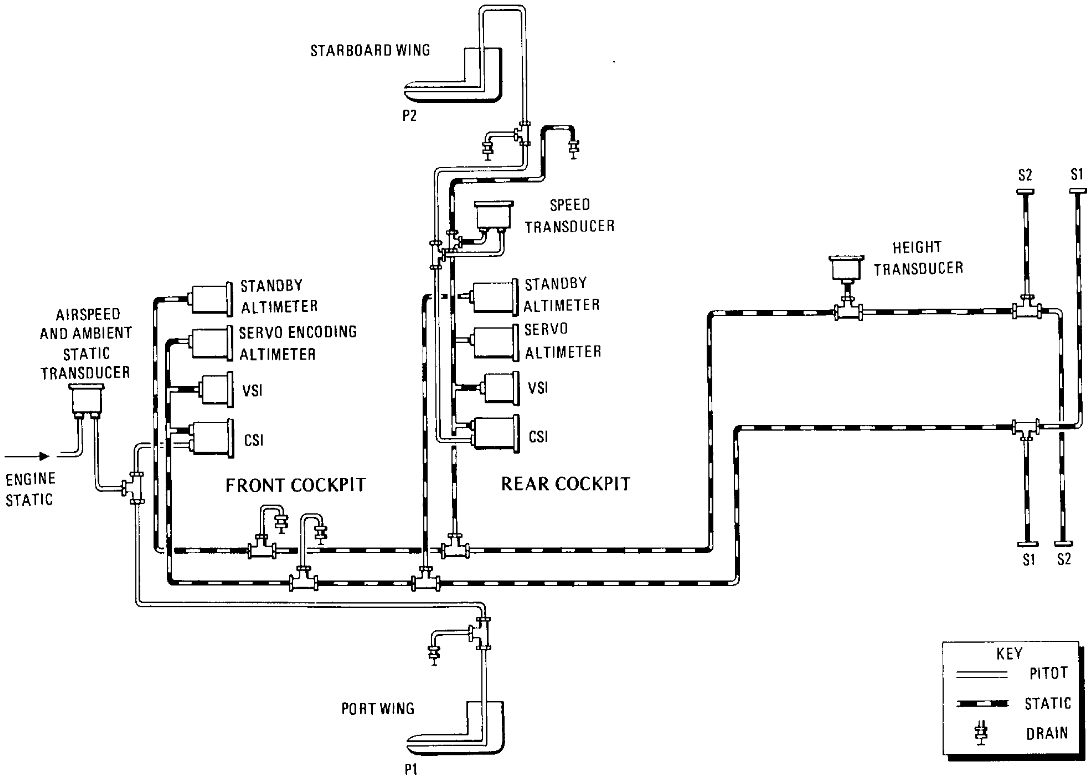
11. **Altimeter Dial Presentation.** The dial is calibrated in steps of 100 feet with subdivisions at 50 feet intervals. The Mk 29C altimeter has a flag, marked STBY, that indicates when the altimeter is not acting as a repeater of the Mk 30C altimeter.



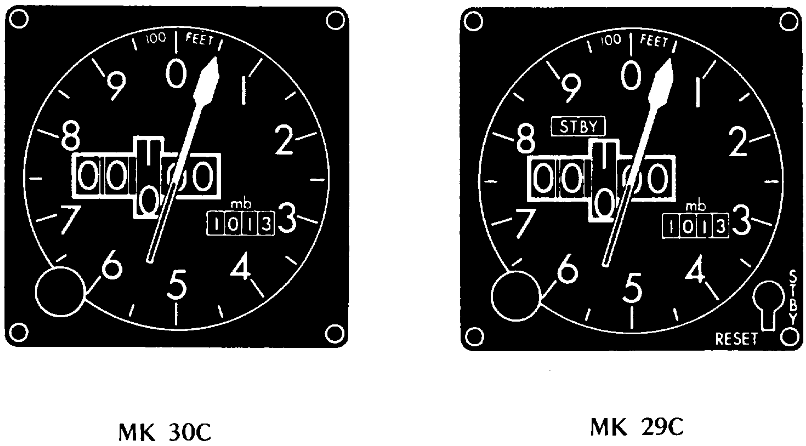
1 - 11 Fig 1 Flight Information Instruments and Controls (Front Cockpit)



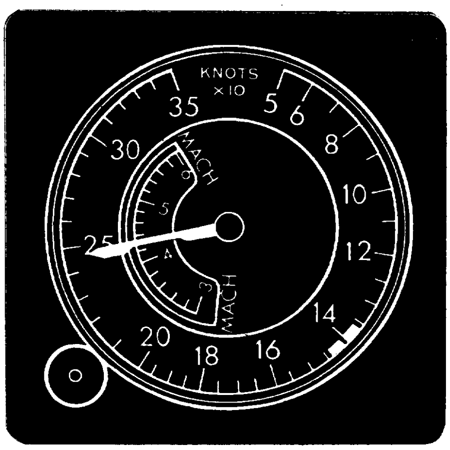
1 - 11 Fig 2 Flight Information Instruments and Controls (Rear Cockpit)



1 - 11 Fig 3 Pitot-Static System



1 - 11 Fig 4 Main Altimeters



1 - 11 Fig 5 Combined Speed Indicator

12. **Mk 29C Altimeter Standby/Reset.** A centrally biased selection switch, marked STBY/RESET, is on the bottom right hand corner of the Mk 29C altimeter and operates as follows:

a. **Standby Mode.** If the altimeter is tripped into the standby mode either manually, or automatically by a fail-safe detection circuit, the STBY flag drops into view on the dial face. At the same time an integral vibrator is energized to overcome friction and minimize error. Reversion to servo operation is by manual reselection of RESET provided that the cause of the failure is no longer present. When RESET is selected the STBY flag disappears and the vibrator is de-energized. The detection circuit automatically reverts the altimeter to the mechanical standby mode in the event of any of the following faults:

(1) Primary power failure.

(2) Servo amplifier failure.

(3) Servo motor failure.

(4) Failure within any part of the detection circuit.

(5) Servo failure of the Mk 30C altimeter.

(6) Differences (at MSL) of greater than 4000 feet between the standby and servo indicated altitude.

b. **Servo Mode.** The altimeter is engaged in the servo mode by selecting RESET. The altimeter now acts as a repeater of the Mk 30C altimeter.

13. **Altimeter Power Supplies.** Both altimeters are supplied from the 115V AC busbar. The Mk 29C vibrator is supplied from the load shedding busbar. If the AC power fails, or the servo malfunctions, the altitude counter of the Mk 30C is obscured by a red-and-black striped bar and the Mk 29C automatically operates in the STBY mode.

Standby Altimeter

14. A Mk 28E standby altimeter in each cockpit gives indications of altitude on a 2-drum 4-digit counter and by a pointer. The pointer makes one revolution for each 1000 feet change of altitude and the 4-digit counter registers the whole number of thousands and tens of thousands of feet. To ensure a smooth pointer movement throughout the range an internal vibrator, supplied from the essential services busbar, is incorporated. A hectopascal setting control is at the lower left corner of the instrument.

15. **Dial Presentation.** The dial presentation comprises a pointer and a 4-digit counter displaying altitude, a barometric sub-scale and a flag, marked VIB, to indicate the vibrator condition. The VIB flag goes out of view when power is applied to the standby altimeter. The dial is calibrated in steps of 100 feet with subdivisions at 50 feet intervals.

Vertical Speed Indicator

16. A VSI in each cockpit is calibrated in thousands of feet per minute and registers rate of climb and descent to a maximum of 6000 feet per minute.

Combined Speed Indicator

17. A CSI (Fig 5) in each cockpit shows airspeed and Mach number derived from pitot and static pressure. Airspeed is indicated by a pointer against a scale graduated from 50 to 350 knots in 10 knots increments. Mach number is shown in a window and read against the airspeed pointer; the scale is calibrated from 0·3 to 0·7M in increments of 0·02M. The Mach number scale moves independently of the airspeed pointer to maintain the correct relationship between airspeed and Mach number.

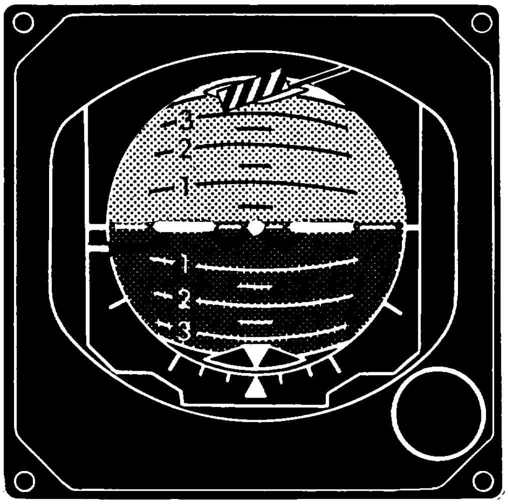
18. An adjustable fluorescent orange airspeed lubber mark, with 360 degrees of rotation, is set by a knob at the lower left of the instrument.

19. The instrument has two airspeed switches set at 290 knots and 100 knots to activate overspeed and U/C warnings respectively.

ELECTRICALLY - OPERATED INSTRUMENTS

Main Attitude Indicator

20. The main attitude indicator (Fig 6) in each cockpit is of the moving ball type, and has an integral vertical gyro assembly powered by an integral static inverter. The gyro assembly provides the pitch and roll signal for the indications on the moving ball. The moving ball has a blue top half with white pitch attitude markings, representing the area above the horizon, and a brown bottom half with white pitch attitude markings representing the area below the horizon; a white line between the two halves represents the horizon. Pitch attitude is indicated by division lines marked at 5° intervals on both halves of the ball parallel to the horizon line, and read against a fixed black/fluorescent orange aircraft symbol. The division lines are numbered 1 to 8 from the horizon line to show 10° to 80° of climb or dive. Roll attitude in each direction is measured by movement of an index against a fixed semicircular scale which has 30° divisions up to 90° and 10° subdivisions to show bank angles up to 30°; the fixed scale, marked in white, is at the bottom of the indicator display. A fast erection knob is at the bottom right of the instrument. A red-and-black striped warning flag at the top of the display indicates a power supply failure, when the gyro is running below 18,000 RPM or the fast erection knob is pulled.



1 - 11 Fig 6 Main Attitude Indicator

21. **Fast Erection Knob.** Pulling the fast erection knob brings the integral gyro assembly near the vertical; when the knob is released the gyro is free to move and aligns itself precisely with the true vertical. To ensure that the gyro has attained a sufficiently high rotation speed before fast erection is initiated, wait for a minimum of 30 seconds after application of power before pulling the fast erection knob. Thereafter only use the knob in straight, level and balanced flight.

Note: Unrestrained release of the fast erection knob may damage the instrument internally; therefore, manually restrain the return spring action when releasing the knob.

22. **Power Supplies.** The main attitude indicator has an integral static inverter, which provides AC to drive an integral gyro assembly. The inverter is powered from the main busbar. If the power supply fails a red and black striped flag is displayed centrally at the top of the instrument face. After applying power the gyro requires three minutes to spin up to its operating speed; the instrument should not be used within this period.

Standby Attitude Indicator

23. A standby attitude indicator in each cockpit is smaller than the main attitude indicator. It is similar in appearance (except that the red-and-black striped warning flag appears slightly to the right at the top of the

instrument face) and presents information in the same way as the main attitude indicator. Fast erection procedure is also similar to that for the main attitude indicator.

24. **Power Supplies.** The standby attitude indicator has an integral static inverter, which provides AC to drive an integral gyro assembly. The inverter is powered from the essential services busbar.

Turn-and-Slip Indicator

25. A turn-and-slip indicator in each cockpit has a pointer, which indicates direction and rate of turn, and a ball which indicates slip or skid. The rate scale is graduated, left and right of a centre-mark, with marks to indicate rate 1 and rate 2 turns. An orange-and-black striped warning flag appears when the DC supply is interrupted or the integral gyro RPM drop to a level where accuracy is impaired.

26. **Power Supplies.** An integral static inverter provides AC to the integral gyro assembly, and is powered from the essential services busbar.

FLIGHT NAVIGATION INSTRUMENTS

Gyro-Magnetic Compass System

27. The DG710A gyro-magnetic compass system consists of a gyro unit (with a compensation module attached) in the avionics equipment bay, a compass controller on the lower instrument panel in each cockpit and a flux detector unit in the tail fin. Magnetic compass information or directional gyro information or a combination of both from the gyro-magnetic compass system is presented on the HSI in each cockpit, and is also fed to the Tacan. A selector, marked COMPASS/SEL, on the lower instrument panel of each cockpit, allows control of the compass system from either cockpit.

28. **Gyro Unit.** The gyro unit contains a directional gyro which provides a stable reference. On initial switch-on the gyro executes a self test sequence, which can be monitored by reference to the HSI. The accuracy of the displayed heading is within ±1·5° and is valid within two minutes of system switch-on; the heading flags of each HSI then clear. A normal erection/slaving system levels the gyro at 5 ± 2° per minute and slaves it to the detector unit heading at 2·25 ± 0·5° per minute. The gyro unit can be fast erected and/or fast slaved to the detector unit heading, using the FAST ERECT button on the compass control panel. The fast erection rate is not less than 300° per minute, and the fast slaving rate is 8° per second for 0 to 3 seconds and thereafter 30° per second. An automatic erection/slaving cut-out circuit operates when the rate of turn exceeds 30° per minute.

29. **Compensation Module.** The compensation module interfaces with the gyro unit and contains Electrically Erasable Programmable Read Only Memory (EPROM). This memory contains the data necessary to eliminate index error, single cycle error and instrument error.

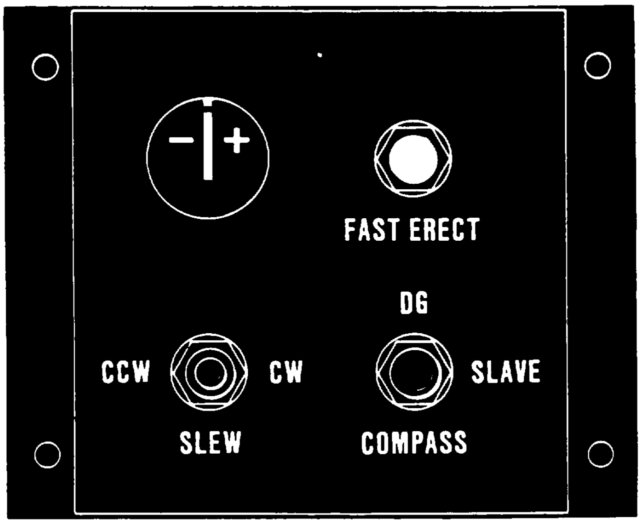
30. **Compass Controller.** The compass controller (Fig 7) has the following features:

a. **Mode Selector.** The mode selector is a 3-position gated switch which is used to select gyro operating mode. It is necessary to lift the switch out of SLAVE mode to either DG or COMPASS mode. The gyro operating modes are as follows:

(1) **SLAVE Mode.** Heading output derived from flux detector unit with gyro stabilization.

(2) **DG Mode.** Heading output derived from gyro motion only.

(3) **COMPASS Mode.** Heading output derived from flux detector unit only.



1 - 11 Fig 7 Compass Controller

b. **SLEW Control.** The SLEW control is a 3-position, centre off, spring-loaded switch. When the mode selector is at DG the switch applies the appropriate signal to the gyro unit which in turn drives the heading output in a clockwise (CW) or counter-clockwise (CCW) direction.

c. **FAST ERECT Button.** The FAST ERECT button is used to synchronize the gyro and level the inner gimbal axis rapidly to the case horizontal.

d. **Slaving Annunciator.** The slaving annunciator has a centre zero movement with a pointer which moves left (-) or right (+) of centre to indicate the direction in which the gyro is desynchronized; a full scale deflection indicates an error of 10° or more. If the pointer is deflected, resynchronize the compass by pressing and releasing FAST ERECT.

31. **Flux Detector Unit.** The flux detector unit provides long-term heading information by sensing the horizontal component of the earth's magnetic field.

32. **Power Supplies.** Power is from the main busbar. The compass controllers have 5V AC integral lighting, which is controlled by the INSTRUMENTS dimmer in the respective cockpit.

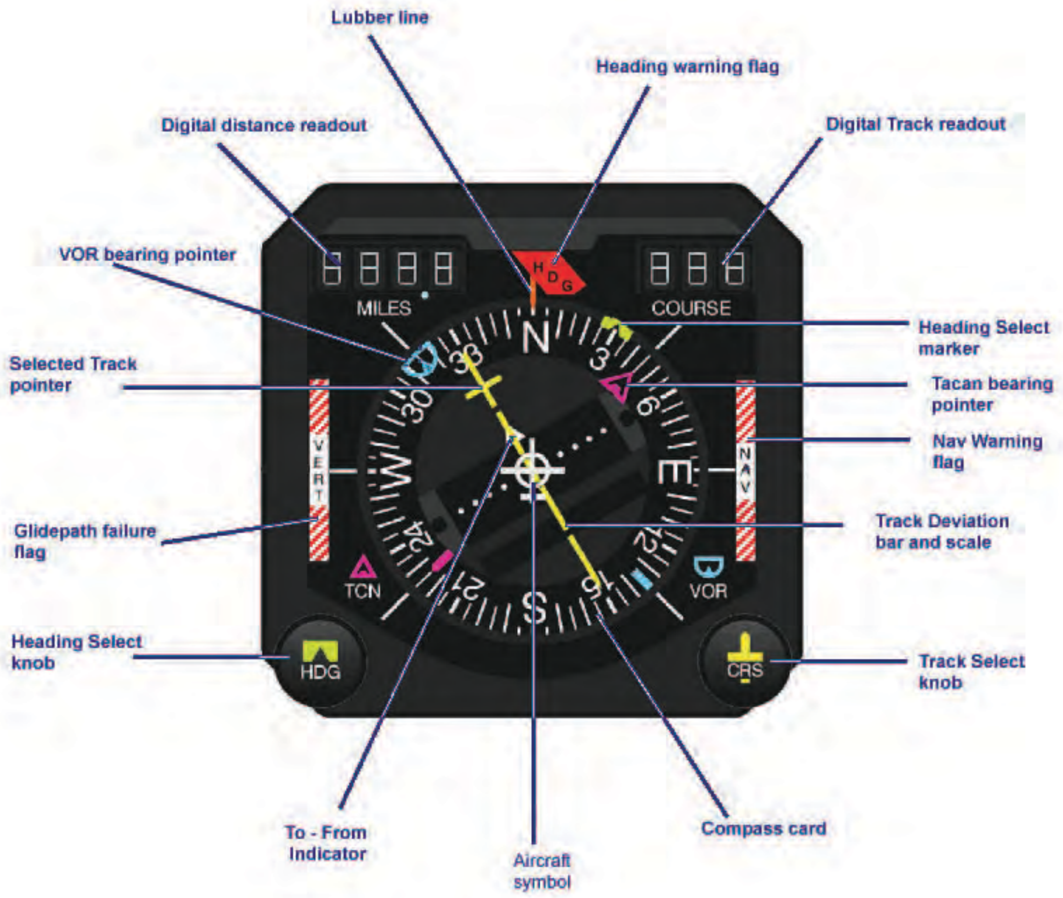
Horizontal Situation Indicator

33. An Horizontal Situation Indicator (HSI) (Fig 8) on the upper instrument panel of each cockpit combines the compass system, the VOR/ILS and the Tacan displays. A selector, marked HSI/SEL, on the upper instrument panel of each cockpit allows the selected track to be determined either by the front cockpit HSI or by the rear cockpit HSI, when the respective selector indicates SEL. The HSI displays the following:

a. **Heading.** Heading is indicated by a fixed orange lubber line above a rotating compass card. The card is graduated at 5° intervals and is marked alpha numerically at 30° intervals.

b. **Heading Select Marker.** A green heading select marker registers against the outside edge of, and rotates with, the compass card. The marker can be manually set relative to the compass card by a heading select knob, annotated HDG and marked with a symbol representing the heading select marker, at the lower left of the instrument.

c. **Selected Track Pointer and Digital Track Read-out.** A yellow selected track pointer registers against, and rotates with, the compass card. The pointer can be manually set relative to the compass card by a track select knob, annotated CRS and marked with a symbol representing the selected track pointer, at the lower right of the instrument. The reciprocal of the track set is indicated by a selected track pointer tail which registers against, and rotates with, the compass card. A 3-digit display of the selection is given on a digital track read-out (COURSE) at the top right.



1 - 11 Fig 8 Horizontal Situation Indicator

d. **Track Deviation Bar.** A yellow track deviation bar, and a fixed scale of four white dots either side of a centre index, are in the centre display assembly. The outer edge of the centre index represents the first dot of the scale. The bar moves left or right of the index to indicate deviation (2° per dot) from the selected track when a Tacan or VOR is selected, or 0·5° per dot from an ILS localiser when ILS is selected.

e. **Bearing Pointer.** The magnetic bearing to a Tacan ground beacon, is indicated by a magenta pointer head when read against the compass card; VOR bearing is indicated by a pale blue pointer head. The reciprocal bearings (or radials) are indicated by the tail of the appropriate pointer. Provided that the Tacan and VOR remain locked to a ground beacon, their respective bearings are displayed continuously irrespective of navigation mode selection.

f. **To/From Indicator.** The to/from indicator is a white triangle, and appears underneath the track deviation bar on the centre display assembly. With the navigation mode selector set to TACAN, a Tacan radial set on the selected track pointer, and the Tacan locked onto a Tacan beacon, the white triangle is displayed either `to' or `from'. Whenever the bearing from the Tacan beacon is less than 90° from the selected Tacan radial, a `to' indication is displayed. Conversely, whenever the bearing from the Tacan beacon is more than 90° from the selected Tacan radial, a `from' indication is displayed. Similar indications are displayed when the navigation mode selector is set to VOR ILS and a VOR selection is made.

g. **Digital Distance Read-out.** Slant range to a Tacan ground beacon, in nautical miles, is shown on a 4-digit read-out, marked MILES, at the upper left corner of the instrument. When range information is invalid the read-out indicates four dashes. Provided Tacan is locked to a ground beacon, range is displayed irrespective of navigation mode selection.

h. **Glidepath Pointer.** A yellow wedge pointer, to the left of the compass card, read against a fixed vertical scale of white dots indicates deviation from the glidepath. The pointer represents glidepath position and the centre dot the aircraft, e.g. the aircraft is on the glidepath when the wedge covers the white dot in the centre of the scale, or the aircraft is below the glidepath when the pointer is above the centre dot. The pointer is only driven against the scale when ILS is selected on the VHF Nav controller.

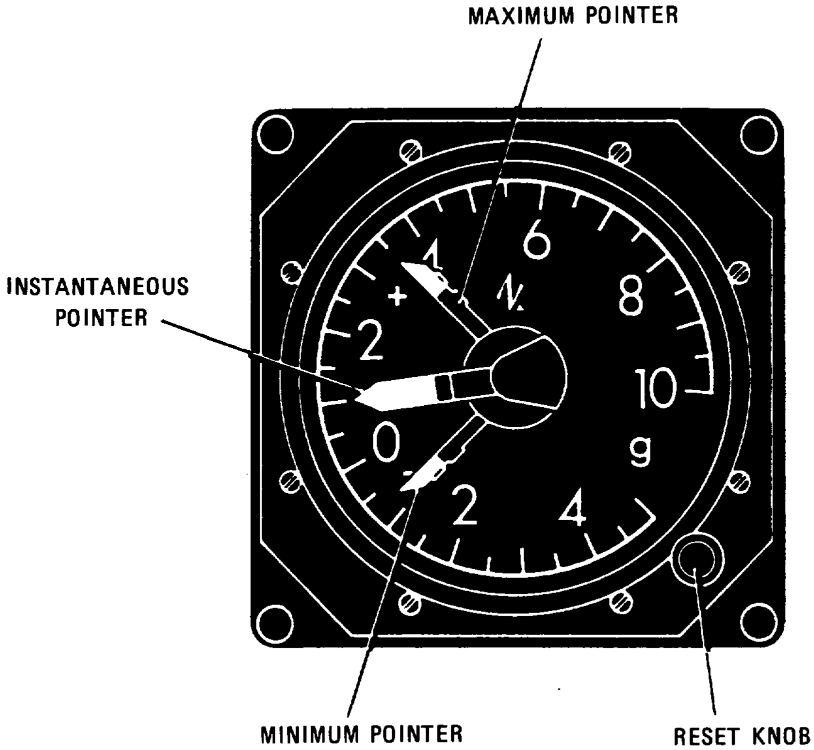
i. **Glidepath Warning.** A white-and-red striped flag with VERT in black, covers the vertical deviation scale when the glidepath information is invalid, or when Tacan or VOR information is presented to the HSI.

j. **Navigation Warning.** A white-and-red striped flag with NAV in black, appears to the right of the compass card, when Tacan bearing or VOR bearing or ILS localiser information is invalid. Under these conditions, track information is unusable, however all heading information remains valid.

k. **Heading Warning.** A red flag with HDG in black, appears at the top of the compass card when the compass system fails. Heading information is then unusable, but all track information remains valid. The flag also appears if a power supply to the HSI fails.

34. **Power Supplies.** The power supplies for each HSI are from the main busbar.

MISCELLANEOUS INSTRUMENTS



1 - 11 Fig 9 Accelerometer

Accelerometer

35. An accelerometer (Fig 9) on the top right coaming in each cockpit indicates normal acceleration, by an instantaneous pointer moving around a circular dial graduated from minus 5 to +10g. Maximum and minimum pointers show the acceleration extremes encountered during flight; these pointers can be reset by pressing a knob at the lower right of the instrument. The instrument has 5V AC integral lighting; controlled by the INSTRUMENTS dimmer in the respective cockpit.

Standby Compass

36. A standby compass on the right coaming, behind the mirror in each cockpit, is a self-contained magnetic unit that provides a constant indication of aircraft heading. The compass has integral lighting controlled by the INSTRUMENTS dimmer switch, and is supplied from the essential services busbar; intensity is not variable.

Outside Air Temperature Indicator

37. A master OAT indicator in the front cockpit, and a slave OAT indicator in the rear cockpit, provide a continuous reading of outside air temperature. The scale of the indicator is calibrated over the range minus 65° to +85°C. The indicated temperature reading is only accurate when stationary. When airborne the accuracy is affected by altitude and speed. Correction figures for all heights and speeds can be obtained from the IOAT/OAT conversion graph in AP101B-4901-16, the Tucano T Mk1 Operating Data Manual. The instrument has 5V AC integral lighting controlled by the INSTRUMENTS dimmer in the respective cockpit.

Note: Calibration tolerances of ±3°C can cause a difference of up to 6°C between the readings in the two cockpits. Also the system tends to overread by up to 3°C. Due to gauge tolerances and incremental markings the instrument does not indicate temperature sufficiently precisely to judge the onset of icing.

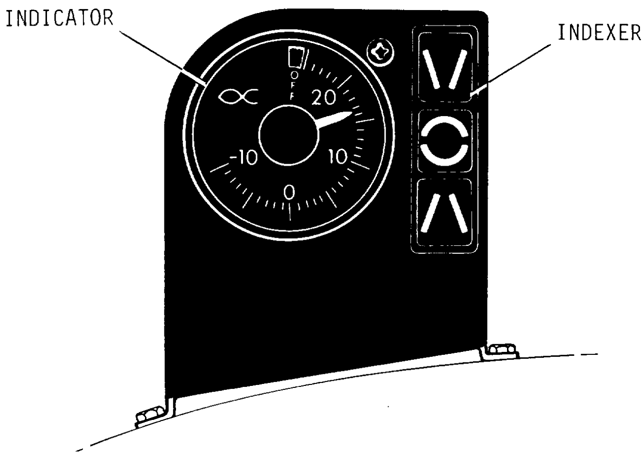
Clock

38. A clock on the left instrument panel in the front cockpit displays actual time in hours and minutes. Two additional hands controlled by a reset knob display elapsed minutes and seconds on the same face. A rotatable bezel, marked in minutes, is controlled by a small knob.

Stopwatch

39. Each cockpit has a stopwatch mounted on the glareshield. If SEM 016 is embodied, a second stopwatch is mounted adjacent to the first in each cockpit. However, with SM 109 (FLARM) embodied, SEM 016 adds a stopwatch to the rear cockpit only.

Angle-of-Attack Indicator and Indexer



1 - 11 Fig 10 Angle-of-Attack Indicator and Indexer

Note: Embodiment of SM 109 (FLARM) removes the AOA indexer from both cockpits, the AOA indicator from the front cockpit and the provision for a second stopwatch in the front cockpit.

40. The AOA indicator and indexer (Fig 10) are adjacent to each other on the top left coaming in each cockpit. The AOA indicator displays AOA from minus 10 to +25 units and the calibrated pointer movement is clockwise from a red-coloured OFF position to minus 10 units. The integrally heated AOA sensor on the leading edge of the left wing provides signals via the AOA electronics unit to the AOA indicator. The AOA electronics unit is powered from the essential services busbar. The indicator has 5V AC integral lighting

controlled by the INSTRUMENTS dimmer in the respective cockpit. For further information see under Stall Warning in Chapter 6.

Note: With the ICE DET selected ON, the AOA vane heater thermostat may operate either on the ground or in flight, and give a PSV HEAT warning suggesting heater failure. If this happens carry out the PSV HEAT drill.

41. The AOA indexer provides a head up display of AOA information. An upper chevron, a middle circle and a lower chevron (colour coded red, green and yellow) are illuminated to show, from top to bottom, a slow, on speed or fast AOA. The indexer illumination intensity depends on the DAY/NIGHT selection on the central warning panel in the particular cockpit. The power supply for the indexer lights is from the essential services busbar; they are isolated when the gear is retracted as the power supply is routed through nose wheel down lock relay.

ICE DETECTOR SYSTEM

42. For information on the ice detector see Chapter 14.

NORMAL USE

Before Flight

43. **Turn-and-Slip Indicator.**

    a. Check that the warning flag clears within three minutes after power is switched on.

    b. Whilst taxying, check the instrument for correct indications.

44. **Accelerometer.** Reset the accelerometer.

45. **Main Altimeters.**

Note: Do not attempt to adjust the hectopascal sub-scale until power is on line.

    a. Check that the warning bar clears from the altitude counter when power is applied.

    b. In the front cockpit set QFE on the hectopascal sub-scale and check that the altimeter indicates zero ±35 feet.

    c. In the rear cockpit check that the STBY flag clears when RESET is selected. Check that it reads within ±20 feet of the front cockpit main altimeter reading.

    d. Check operation in the standby mode by setting QFE and observing that the altimeter indicates zero ±50 feet.

46. **Standby Altimeters.**

    a. Check that the VIB warning flag clears when power is applied.

    b. Set QFE on the hectopascal sub-scale and check that the altimeter pointer indicates zero ±50 feet.

47. **Attitude Indicators.**

a. If necessary operate the fast erect system but not within 30 seconds of switch on.

b. Check that the warning flags clear.

48. **Gyro-Magnetic Compass and HSI.**

a. Set the compass mode selector to SLAVE.

b. Check that the HDG warning flag clears from the HSI.

c. Check the HSI compass heading against the standby compass.

d. Using the heading select knob (HDG) on the HSI, check that the heading select marker moves freely relative to the compass card.

e. Set HDG as required.

f. Select control of the HSI.

g. Using the track select knob (CRS) on the HSI, check that the selected track pointer moves freely relative to the compass card and that the digital track (COURSE) counters indicate correctly.

h. Set track as required.

49. **AOA and Ice Detector Ground Tests.** Test the AOA indicator and indexer and the ice detector system. See Chapter 6 and Chapter 14 respectively.

Note: Embodiment of SM 109 (FLARM) removes the AOA indexer from both cockpits and the AOA indicator from the front cockpit.

In Flight

50. **Attitude Indicators.** After aerobatics or spinning the attitude indicators may need to be re-erected:

a. Establish straight level and balanced flight.

b. Pull the fast erect knobs until the attitude is correctly indicated.

c. Release the fast erect knobs.

51. **Gyro-Magnetic Compass.** Gimbal error, in turns with more than 45° bank, may cause difficulty and result in roll-out heading errors in excess of 10°. Periodically check that the gyro-magnetic compass remains synchronized. In particular it is recommended that the compass be fast-erected and resynchronized after any aerobatics whether or not it appears to indicate that it is synchronized. If synchronization is necessary:

a. Establish straight level balanced flight.

b. Press and release the compass system FAST ERECT button.

c. When the HDG warning flag clears check the HSI compass heading against the standby compass.

52. **Angle-of-Attack Indicator and Indexer.** A cross-check of the AOA system can be made against the CSI at an AUM of 2650 ± 50 kg with 20% torque:

a. At 120 ± 4 knots with landing gear and flaps up the AOA should be minus 7 units.

b. At 90 ± 3 knots with landing gear and flaps down the AOA should be zero.

c. The AOA indexer indicates a fast chevron (yellow) whenever the landing gear is down unless the IAS is below 90 ± 3 knots.

d. With landing gear and flaps down the AOA indexer indicates an on speed circle (green) at 10 units AOA at 77 ± 3 knots and a slow chevron (red) at 14 units AOA at 69 ± 2 knots.

Note 1: The above values are only true for an AUM of 2650 ± 50 kg.

Note 2: Embodiment of SM 109 (FLARM) removes the AOA indexer from both cockpits and the AOA indicator from the front cockpit.

USE IN ABNORMAL CONDITIONS

Power Supply Failures

53. **Main Altimeters.** If the power supply to the main altimeter in the front cockpit fails, the warning bar obscures the altitude counter, and the main altimeter in the rear cockpit reverts to its standby mode. The height encoding to the transponder also fails.

54. **Standby Altimeters.** If the power supply to a standby altimeter fails the red VIB flag appears; the altimeter indications are then prone to lag and stiction but may still be used.

55. **Attitude Indicators.** If the power supply to the main attitude indicator fails, use the standby attitude indicator. If the main attitude indicator information is unreliable (cross-checked against the standby attitude indicator and performance instruments) and the main attitude indicator warning flag is not displayed, achieve straight level balanced flight, and then pull and hold the fast erect knob until the display is erected. Release the fast erect knob and monitor the performance of the main attitude indicator against the standby attitude indicator and performance instruments.

56. **HSI.** If the HDG flag appears on the HSI the heading information cannot be used. Heading information may be regained by selecting one of the reversionary modes:

a. **Compass Mode.** Select the mode selector on the compass control panel to COMPASS. The displayed heading is subject to normal unstabilized magnetic compass errors, but in straight unaccelerated flight, a reasonably accurate heading is shown.

b. **DG Mode.** Select the mode selector on the compass control panel to DG and, using the SLEW control, slew the gyro unit heading to a heading obtained from either the HSI with the mode selector to COMPASS, or from the standby compass. If these headings differ by more than 15° when in straight level balanced flight, use the standby compass heading. If, with DG selected, the heading wanders, the gyro unit is unserviceable; use the COMPASS mode.

57. **Turn-and-Slip Indicator.** If the warning flag is displayed on the turn indicator the turn indications are unreliable and are not to be used; the slip ball indications are unaffected.

Pitot Static Supply Failure

58. **Combined Speed Indicators.** If either or both CSI malfunction a cross-check may be made against the AOA information. If the airspeed indication fails, a circuit can be flown lowering the landing gear and flaps to MID downwind at minus 7 units AOA and then flying a final approach at zero units AOA, which gives approximately 90 ± 3 knots (see para 52 and Part 4, Chapter 2, para 19.)

59. **Altimeters.** If one pitot static supply fails, one main and one standby altimeter malfunction in opposite cockpits. Use the standby altimeter in the cockpit that has the main altimeter failure.

Instrument Covers

60. Cloth covers for both main and standby attitude indicators are attached to the underside of the glare shields in both cockpits by velcro fasteners. If any of these instruments fail, the covers may be used to

remove false, distracting indications from view by attaching the covers to the velcro fastenings around the instruments.

PART 1

CHAPTER 12 - GENERAL EQUIPMENT

Contents

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INTRODUCTION

General

1. This chapter covers aircraft lighting, the accident data recorder and details of equipment stowages for loose items. Aircraft picketing points are also identified.

DESCRIPTION

Interior Lighting

2. **General.** The aircraft interior lighting (Fig 1) is independently controlled for each cockpit. The facilities provided are panel and instrument lighting, background lighting, map reading lights, emergency cockpit lighting and a utility lamp. The baggage compartment has a remotely controlled lamp.

3. **Panel and Instrument Lighting.** Instruments and control units on the main instrument panel are integrally lit. A pillar lamp on the right upper side of the panel illuminates the oxygen flow indicators. The side consoles and lower instrument panels have electro-luminescent panels. Selection is made using the NORMAL - ON/OFF switch on the INTERIOR LIGHTS section (see Table 1) of the related main instrument panel. Lighting intensity is controlled by two dimmers (PANELS and INSTRUMENTS); these are above the control switch. Background lighting, the map reading lights, the standby compass and the U/VHF control unit are illuminated from the essential services busbar when the INSTRUMENTS dimmer switch is selected on; the intensity is not variable. All other panel and instrument lighting is powered from the AC busbar.

4. **Background Lighting.** Each cockpit has four red background lamps, two above each side console. They are controlled by switching on the INSTRUMENTS dimmer switch on the INTERIOR LIGHTS section (see Table 1) of the main instrument panel; the intensity is not variable. Power is from the essential services busbar via circuit breakers 62 and 63. The forward left light may be rotated into the cockpit to serve as a light for the left knee pad.

5. **Map Reading Lights.** Each cockpit has two map reading lights, located on the left and right underside of the coaming. They are controlled by switching on the INSTRUMENTS dimmer switch on the INTERIOR LIGHTS section (see Table 1) of the main instrument panel; the intensity is not variable. Power is from the essential services busbar via circuit breakers 62 and 63. Integral switches allow the lights to be operated independently on/off by pulling/pushing the lens cap.

6. **Emergency Cockpit Lamps.** Each cockpit has four floodlights, two above each side console. It is important to ensure before every flight that they are set up correctly and pointing at the instrument panel. They are controlled by a 3-position switch EMERG - OFF/DIM/BRT on the INTERIOR LIGHTS section (see Table 1) of the main instrument panel; above the switch is a beta strip to aid identification in the dark. Power is from the essential services busbar; two circuit breakers labelled EMGY LTG - FRONT, REAR are on the forward panel of circuit breakers on the right in the front cockpit.

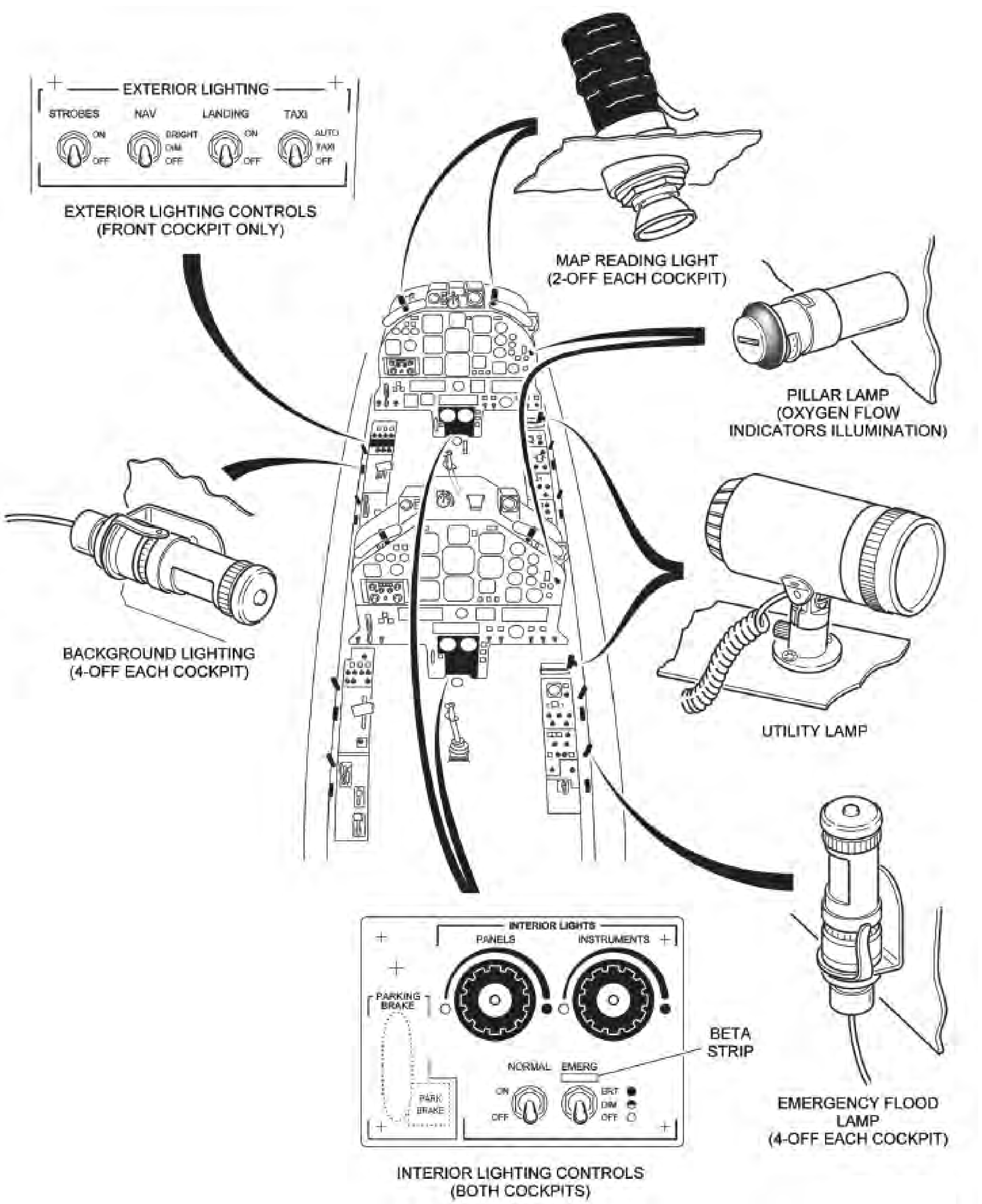
Table 1 - Interior and Exterior Lighting Controls

Control	*Marking*	*Function*
Interior Lights (Both Cockpits)		
Instruments/Panel light switch	NORM - ON-OFF	Controls supply from AC busbar dimmer controls for instrument and panel lighting
Rotary dimmer	PANELS	Controls intensity of electro-luminescent panel lighting
Rotary dimmer	INSTRUMENTS	Controls intensity of integral lighting. Selects standby compass and U/VHF panel lighting, background lighting and map reading lights respectively; the intensity of these is not variable
Emergency cockpit lamps switch	EMERG - OFF/DIM/BRT Beta strip above the switch	Controls supply from essential services busbar to four floodlights, two each side of the cockpit
Utility lamp (integrally controlled)	Unmarked	Provides an additional map reading or instrument illumination facility. Power is from the main busbar
Exterior Lights (Front Cockpit only)		
Navigation lights switch	NAV - OFF/DIM/BRIGHT	Controls supply from main busbar to navigation lights
Anti-collision lights switch	STROBES - ON-OFF	Controls supply from load shedding busbar to strobe lights
Landing lamps switch	LANDING - ON/OFF	Energizes a contactor using power from the main busbar to connect operating power from the load shedding busbar to two landing lamps
Taxy lamp switch	TAXI - OFF/TAXI/AUTO	Selects the lamp on the nose gear leg using operating power from the load shedding busbar when: (a) Switch is set to TAXI for ground use. Controlling power is taken from the main busbar (b) Switch is set to AUTO in flight. Taxy lamp illuminates when landing gear is down. Controlling power is taken from the essential services busbar

7. **Utility Lamps.** A utility lamp is provided in each cockpit. The lamps are at the forward end of the right console in both cockpits. Integral controls allow selection of white or red floodlighting in narrow or wide beam widths. The lamps are removable for map reading and are powered from the main busbar via circuit breakers 108 and 109. In the stowed position, and at a reasonably low intensity, the lamps can be pointed at the fuel gauge area to enhance the readability of the gauge or the visibility of the fuel pump switches.

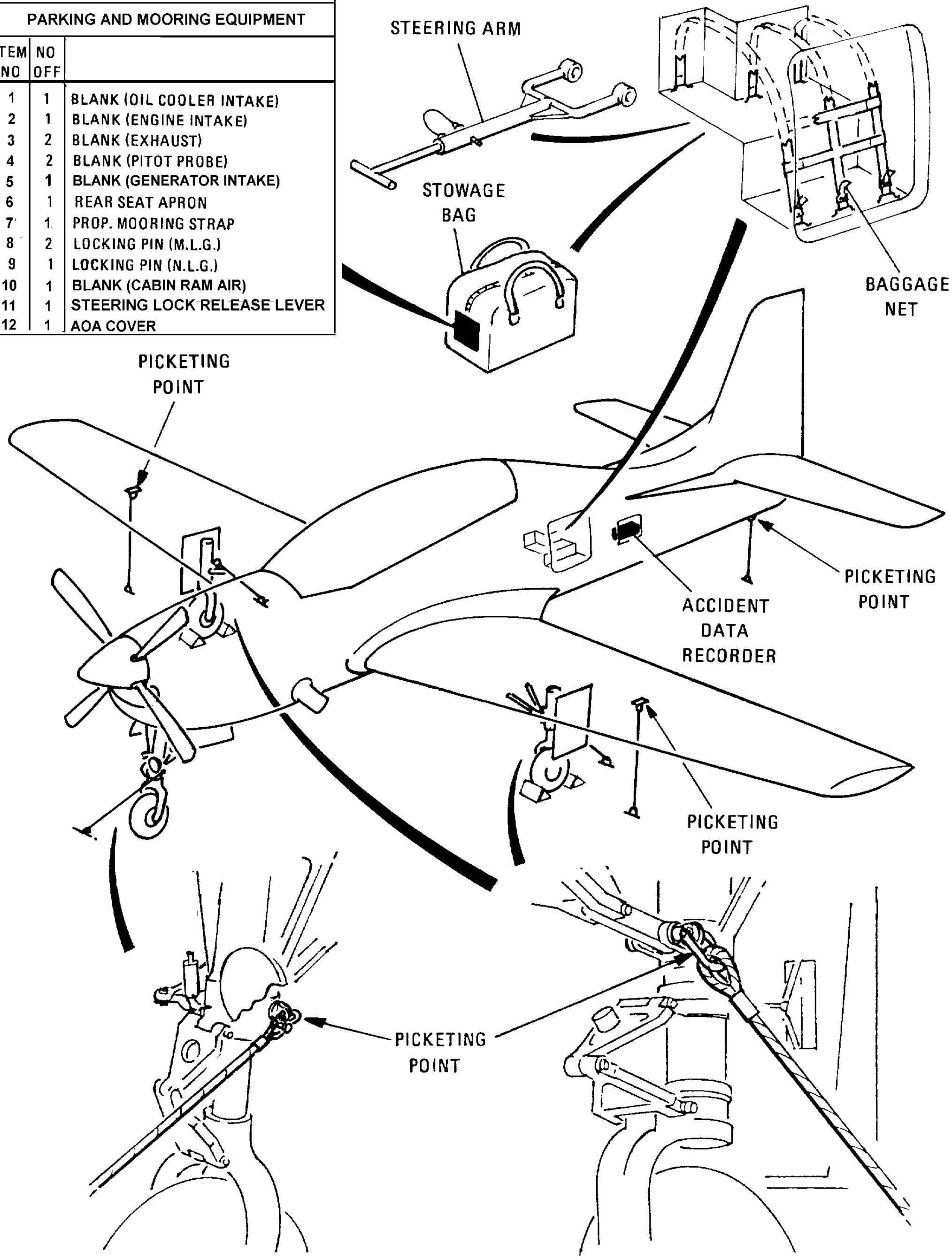
8. **Baggage Compartment Lamp.** The baggage compartment has a single lamp and associated ON/OFF switch on the roof of the compartment. The lamp is powered from the main busbar via circuit breaker 109.

9. **Reflections.** The main instrument panel and console and background lighting together give strong reflections on the inside of the canopy thus compromising night vision adaptation and the ability to lookout. There is a heightened risk of disorientation caused by apparent movement of these reflections as the pilot's head is moved.



1 - 12 Fig 1 Interior Lighting Controls

PARTS CHECK LIST		
PARKING AND MOORING EQUIPMENT		
ITEM NO	NO OFF	
1	1	BLANK (OIL COOLER INTAKE)
2	1	BLANK (ENGINE INTAKE)
3	2	BLANK (EXHAUST)
4	2	BLANK (PITOT PROBE)
5	1	BLANK (GENERATOR INTAKE)
6	1	REAR SEAT APRON
7	1	PROP. MOORING STRAP
8	2	LOCKING PIN (M.L.G.)
9	1	LOCKING PIN (N.L.G.)
10	1	BLANK (CABIN RAM AIR)
11	1	STEERING LOCK RELEASE LEVER
12	1	AOA COVER



1 - 12 Fig 2 Miscellaneous Equipment Stowage and Location

Exterior Lighting

10. **General.** The aircraft exterior lighting consists of two landing lamps, a taxy lamp, three navigation lights and three anti-collision lights. All exterior lighting is controlled from the front cockpit only.

11. **Navigation Lights.** Navigation lights, together with anti-collision lights as combined units, are in the leading edge of the left and right wing tips; a separate navigation light is in the rudder lower fairing. The navigation lights are controlled by a 3-position NAV - OFF/DIM/BRIGHT switch on the EXTERIOR LIGHTING panel on the front cockpit left console. Power is from the main busbar via circuit breaker 107.

12. **Anti-Collision Lights.** White strobe anti-collision lights are with the navigation lights in the leading edge of the left and right wing tips; a separate anti-collision light is in the rudder lower fairing. They are controlled by a 2-position STROBES - ON/OFF switch on the EXTERIOR LIGHTING panel. Power is from the load shedding busbar via circuit breaker 70.

13. **Landing Lamps.** A 450-watt landing lamp is in each wing leading edge. Both lamps are controlled by one 2-position LANDING - ON/OFF switch on the EXTERIOR LIGHTING panel. Control power supplies are taken from the main busbar via circuit breaker 106 and filaments are supplied from the load shedding busbar.

14. **Taxy Lamp.** A 450-watt taxy lamp is on the nose landing gear leg. The lamp is controlled by a 3-position TAXI - OFF/TAXI/AUTO switch on the EXTERIOR LIGHTING panel. The TAXI setting is intended for ground use only and is not to be used when the landing gear is retracted. With AUTO set, the lamp only illuminates when the landing gear is down. This arrangement gives an external indication of the condition of the landing gear. The filament is powered from the load shedding busbar; controlling power is from the main busbar via circuit breaker 106 for the TAXI setting and from the essential services busbar for AUTO.

Accident Data Recorder

15. An accident data recorder (ADR) is interconnected with a data acquisition and processing unit (DAPU) to form an integrated flight data recording system. Both units are in the fuselage between frames 19 and 20. An ADR OFF indicator light/switch is on the lower right side of the front cockpit main instrument panel. This indicator/switch is normally lit before engine start when the No 1 and No 2 battery switches are set to ON, when the ESSENTIAL BUS switch is selected to NORM or when external power is connected; if it is not lit the indicator is to be pressed momentarily to bring the light on, and thus avoid inadvertent data erasure. During engine starting, power from the essential services busbar is supplied to the DAPU and ADR via a power supply relay, which does the following:

a. Extinguishes the ADR OFF indication.

b. Starts the ADR tape drive motor.

16. The continuous loop tape has four data and three audio tracks. Two hours of the parameters listed in Table 2 are recorded on the ADR.

Table 2 - ADR Parameters

Normal acceleration	Turbine speed
Longitudinal acceleration	Engine torque
Pitch acceleration	Engine oil pressure
Roll acceleration	Fuel flow
Yaw acceleration	Exhaust gas temperature
Aileron position	Altitude
Elevator position	Indicated airspeed
Rudder position	Heading
Flap position	Outside air temperature

17. Also recorded are many discrete events, including engine limitation infringements, CWP events etc. The last hour of audio inputs from the front and rear mic/tels and area microphones is also retained. There is a pilot initiated event button switch on the front control column; the switch is also used to enable a double sortie to be recorded by the DAPU as two flights. When the button is pressed in flight a discrete event is recorded and on the ADR audio tracks a chirp of one-second duration will be created. Press the button (after lowering the landing gear, landing and reducing RPM below 89%) to indicate a separate sortie.

18. If the ADR OFF indication does not extinguish after engine start, or comes on in flight, the ADR is not recording. To activate the ADR, press the indicator and check that the light extinguishes.

CAUTION: If, after flight, power is switched off by selecting No 1 and No 2 batteries OFF and the ESSENTIAL BUS switch to ISOLATE before the propeller stops rotating, the data may dump.

19. The DAPU records the start of a flight when IAS exceeds 80 knots and the landing gear is UP and locked. It records the end of a flight when the landing gear is DOWN and locked and either:

a. Engine RPM falls below 60%, or

b. Engine RPM falls below 89% and the pilot initiated event button is pressed (to simulate `end of flight') thus initiating the next sortie without shutting down the engine.

20. The flight number is incremented by one when the DAPU has recognised a start and subsequent end of flight (as defined above). The DAPU should be downloaded after every sortie but must be downloaded after flying 3 sorties; if a fourth sortie is flown without downloading, earliest records are erased and fatigue is accrued at the most damaging level for the erased sorties.

Note: Electrical power must not be removed from the DAPU for at least 10 seconds after `end of flight' conditions (see para 19). This condition is normally satisfied by waiting until the propeller stops before switching the power off.

Equipment Stowages

21. **Maps.** A stowage box for maps is on the right side of each cockpit. Each box has a latched lid to secure the maps. A further stowage is formed by a clip on the glareshield in each cockpit.

22. **Baggage Compartment.** The 20 kg limiting load in the baggage compartment includes the parking equipment stowage bag and its contents and any other items carried in the compartment. The compartment has a net to secure the stowage bag and other bulky items such as personal kit containers. The net, shown on Fig 2, is a nylon webbing strap assembly attached at the back of the compartment by support brackets and at the front by buckles or quick-release fasteners. The net is always to be taut even for a sortie when no equipment is carried.

23. **Stowage Bag.** A stowage bag, to stow loose items required for aircraft parking, is carried in the baggage compartment. A check list, stitched to one end of the bag, itemizes the contents (see Fig 2). The seat apron referred to in the check list is used to restrain the rear seat harness when the aircraft is to be flown solo.

24. **Steering Arm.** Fittings are provided on the aft bulkhead of the baggage compartment to stow a retractable nosewheel steering arm. The arm is used during manual manoeuvring of the aircraft by groundcrew.

Miscellaneous Equipment

25. **Picketing Points.** Points for picketing the aircraft are on the under surface of each wing, under the rear fuselage and on each landing gear leg (see Fig 2).

PART 1

CHAPTER 13 - AVIONICS SYSTEM

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INTRODUCTION

General

1. The avionics system consists of multi-channel U/VHF and 2-channel standby UHF voice communications, Tacan, VOR/ILS/marker beacon (VHF Navigation), dual transponders, TCAS and locator beacon.

2. A communications control system (CCS) provides overall control of the elements of the communications system. The CCS integrates the U/VHF and standby UHF transmit facilities and the audio signals from these equipments; it also integrates the audio signals from the VHF Navigation and Tacan receivers and the central warning system (CWS). The CCS provides intercom between the cockpits, and between the cockpits and a groundcrew intercom point.

DESCRIPTION

Power Supplies

3. Power for the avionics system is provided as follows:

   a. Essential Services Busbar.

      (1) CCS.

      (2) Standby UHF.

      (3) Transponders.

      (4) Navigation mode selector.

   b. Main Busbar.

      (1) U/VHF.

      (2) Tacan.

      (3) VHF Navigation.

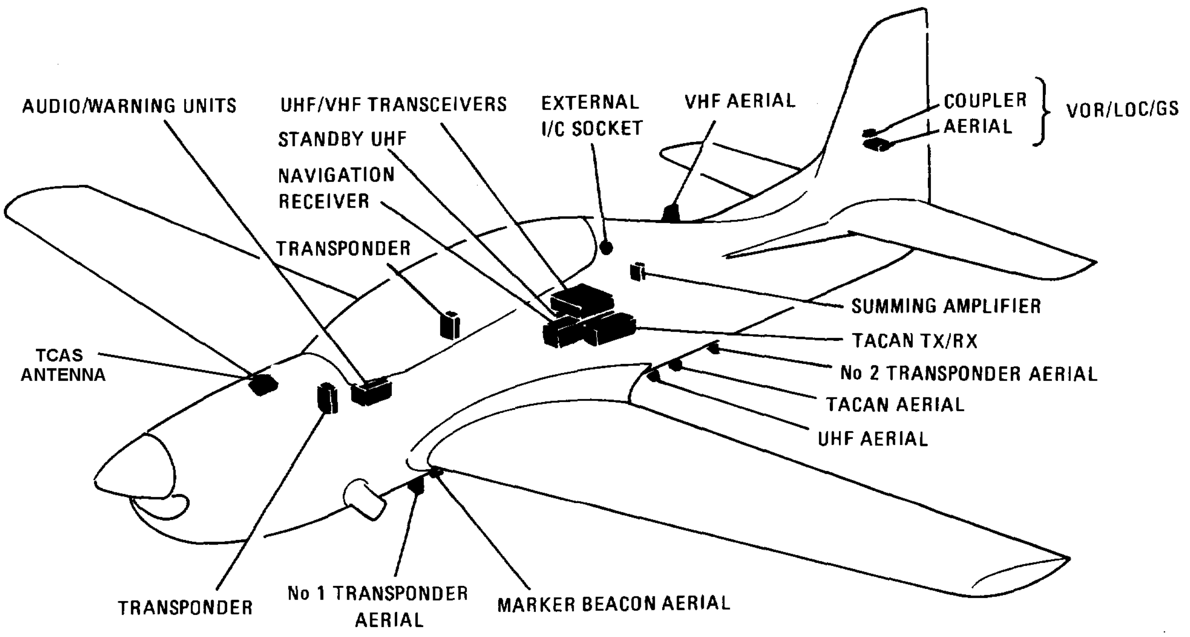
      (4) TCAS.

Groundcrew Intercom Point

4. The groundcrew intercom point is in the oxygen charging recess towards the top of the fuselage, just behind the right wing.

Aerials

5. The VHF aerial is on top of the fuselage. The UHF aerial is on the underside of the fuselage and is shared by the main UHF and the standby UHF; selection of standby UHF in either cockpit connects the aerial to the standby UHF. The VOR/LOC/GS aerials are on the left and right side of the tail fin, and the marker aerial is on the underside of the fuselage beneath the front cockpit. The Tacan aerial is on the underside of the fuselage just aft of the wing. The two transponder aerials are on the underside of the fuselage, No 1 just aft of the nosewheel bay and No 2 just aft of the wing (see Fig 1). The TCAS directional antenna is located on top of the fuselage in front of the cockpit.



1 - 13 Fig 1 Location of Aerials and Equipment

Navigation Mode Selector

6. The navigation mode selector is a spring-loaded square button on the upper instrument panel in both cockpits (see Fig 2 and Fig 3). The button has upper and lower captions marked VOR ILS and TACAN respectively. Either the upper or the lower caption is lit by integral lights to indicate what information is selected to the deviation bar on the horizontal situation indicator (HSI).

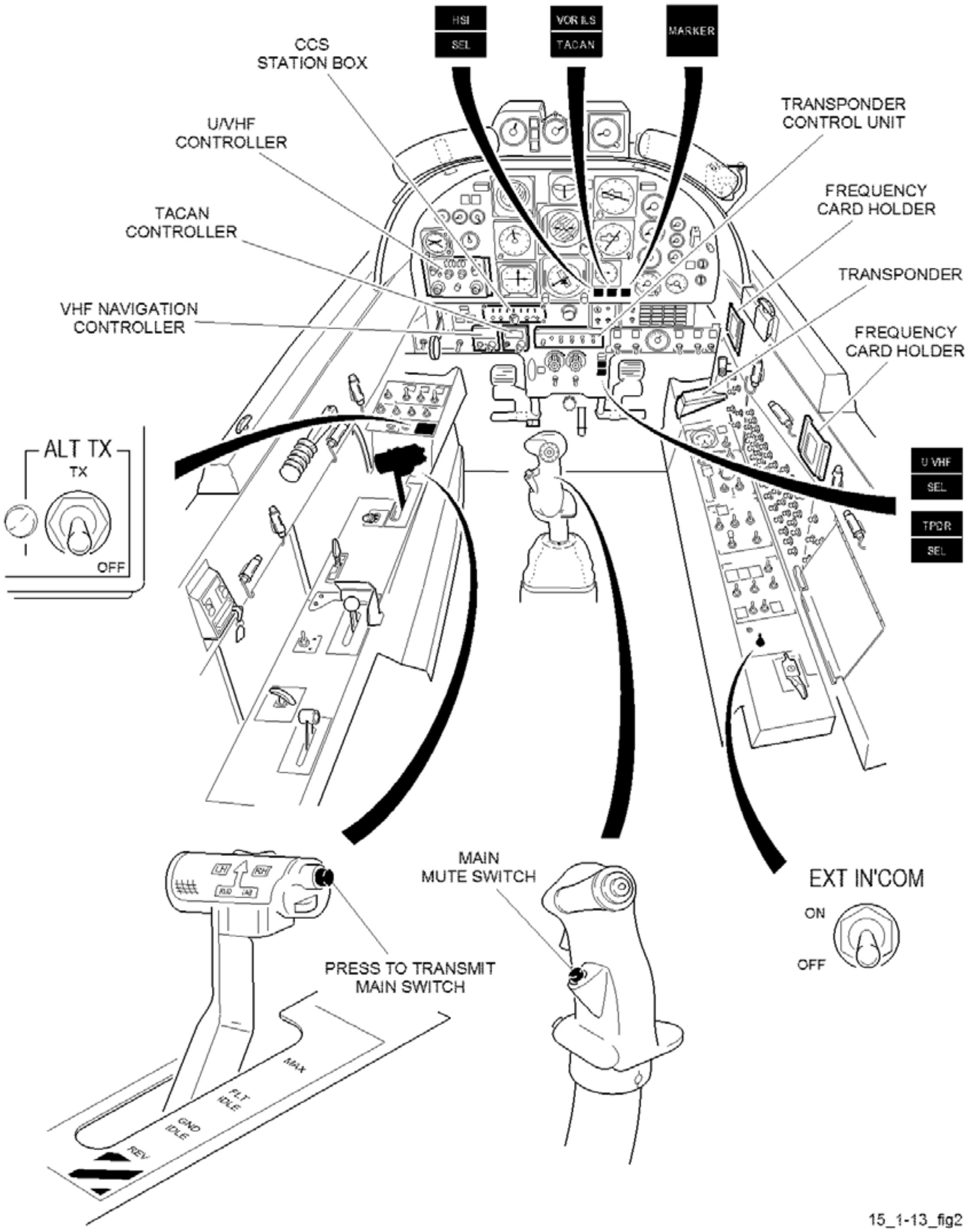
7. With the appropriate equipment switched on, pressing the selector to show VOR ILS selects either VOR derived steering information or ILS derived glidepath and localiser information (depending on the frequency selected); pressing the selector to show TACAN selects Tacan derived information.

8. When the essential services busbar is live, an indication is given on both the selectors irrespective of whether or not the VHF Navigation and/or Tacan is switched on.

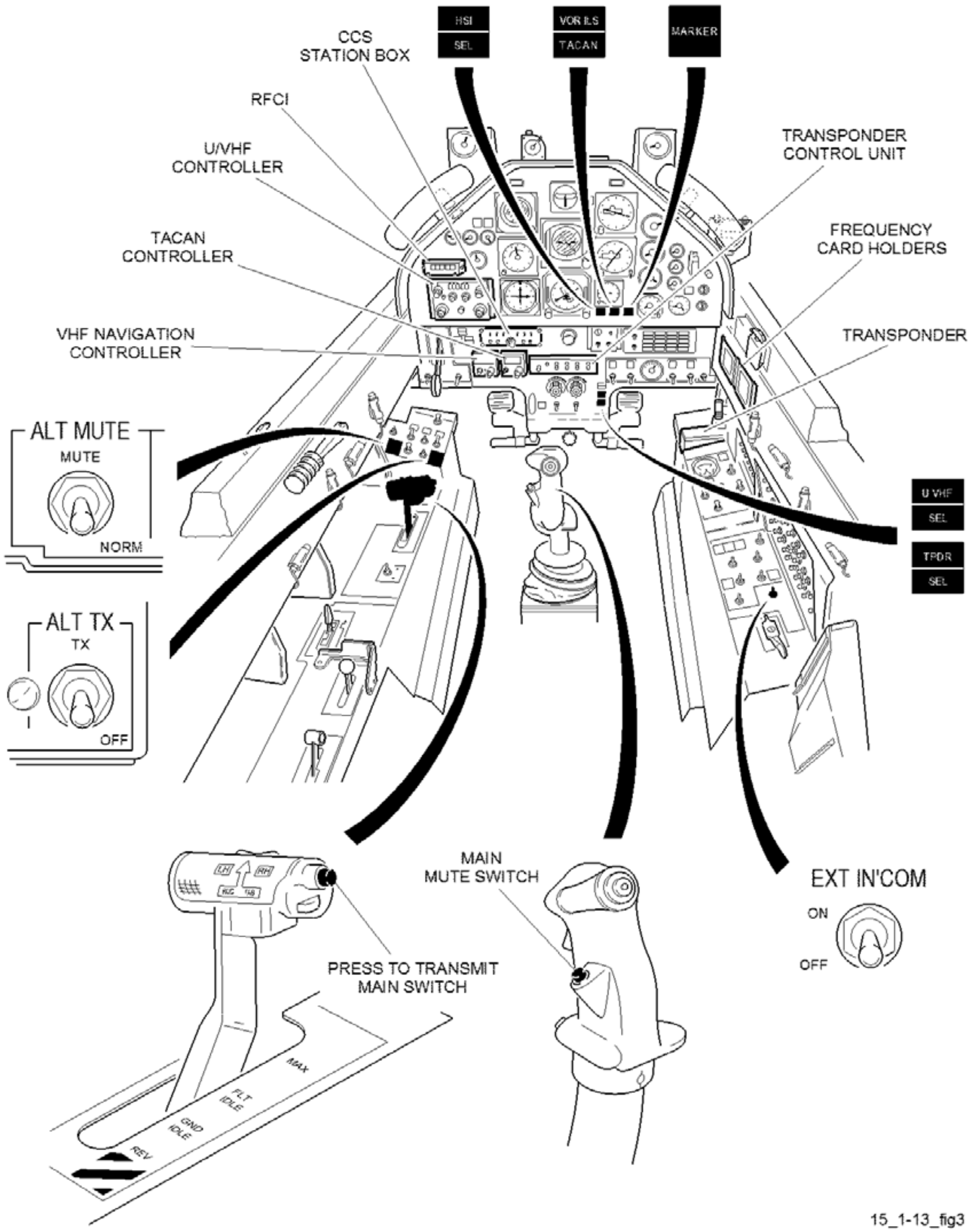
Note: Tacan bearing, VOR bearing and Tacan or DME range are continuous unswitched displays.

Horizontal Situation Indicator Selector

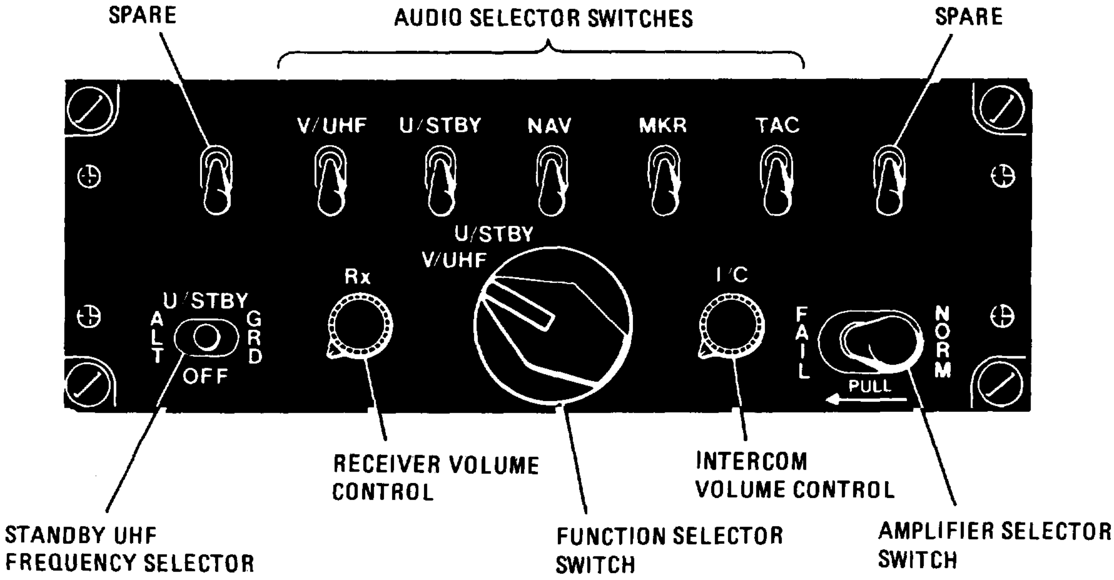
9. A spring-loaded square button marked HSI SEL, on each upper instrument panel, allows the selected track to be determined by either the front cockpit HSI or the rear cockpit HSI when the respective selector indicates SEL.



1 - 13 Fig 2 Units and Controls - Front Cockpit



1 - 13 Fig 3 Units and Controls - Rear Cockpit



1 - 13 Fig 4 CCS Station Box

Communications Control System

10. **General.** The main units of the CCS (ARI 23245/32) are two similar station boxes, one in each cockpit lower instrument panel, a microphone amplifier and an emergency telephone amplifier. The majority of the CCS controls and switches are on the station boxes. A circuit breaker labelled MIC/TEL is on the panel of circuit breakers for in-flight use on the right in the front cockpit; this circuit breaker controls the microphone amplifier and the emergency telephone amplifier.

11. **Microphone Amplifier.** The microphone amplifier pre-amplifies microphone signals for the main U/VHF transceivers, and gives emergency intercom if a station box amplifier fails.

12. **Emergency Telephone Amplifier.** If a station box amplifier fails, all received signals, warning tones, intercom and emergency intercom are routed and amplified through the emergency telephone amplifier.

13. **Station Box.** A station box (Fig 4) in each cockpit provides for selection and control of the U/VHF and standby UHF receiver audio outputs and associated facilities. These comprise intercom, Tacan audio, marker beacon audio and VHF navigation audio. Each station box has the following controls and switches:

a. **Function Selector.** A 2-position rotary switch connects the cockpit microphone and transmit switch to either the U/VHF or the standby UHF. The two switch positions are:

(1) **V/UHF.** This allows transmissions on either VHF or UHF. It also routes the microphone signals to the microphone amplifier to provide emergency intercom (if a station box amplifier fails).

(2) **U/STBY.** This allows transmission on standby UHF.

b. **Amplifier Selector Switch.** A 2-position switch marked NORM/FAIL is gated at NORM and operates as follows:

(1) At NORM, the station box normal microphone amplifier circuit is selected and connected to the associated station box telephone amplifier; intercom is provided via the main amplifier.

(2) At FAIL, the power supply is disconnected from the station box; the telephone signals are routed to the emergency telephone amplifier and then back to the failed station box. A selection of V/UHF on the function selector switch at the failed box then restores cockpit intercom. At FAIL the pilot connected to that box hears the combined selected receiver audio outputs of both station boxes at maximum volume; the RX volume control is ineffective.

c. **Standby UHF Selector.** A 3-position toggle switch, marked U/STBY - ALT/OFF/GRD, selects the standby frequency and supplies power to the standby UHF transceiver. The rear cockpit has priority if a conflicting frequency selection occurs. The switch positions are as follows:

(1) **OFF.** In this position the standby UHF transceiver is inoperative.

(2) **GRD.** Power is supplied to the standby UHF and 243 MHz is selected.

(3) **ALT.** Power is supplied to the standby UHF and the ALTernate frequency is selected.

d. **Audio Selectors.** There are seven 2-position toggle switches (up for on); the two outer switches are not used. The remaining five are marked V/UHF, U/STBY, NAV, MKR and TAC; each selects the audio output from its associated receiver. On selection of the switches the output signals from one or more receivers are connected through the telephone circuits to the pilots' headphones.

Note: Cockpit intercom and audio warnings are not switched.

e. **Receiver Volume Control.** A rotary control, marked RX, controls the audio levels of the receiver signals to the pilot's headphones in that cockpit. The RX control is ineffective if the amplifier selector (para 13b) is set to FAIL.

f. **Intercom Volume Control.** A rotary control, marked I/C, controls the level of intercom audio signals separately in each cockpit. The level of the groundcrew intercom is only controlled from the front cockpit.

14. **Transmit Switches.** Two press-to-transmit (PTT) switches are in each cockpit for the VHF and UHF transmitters. The main switch is a button on the throttle; the other switch, marked ALT TX - TX/OFF, spring-loaded to OFF, is on the left console forward of the throttle. The ALT TX switch is used if a main switch fails.

Note: If both front and rear cockpit PTT switches are operated simultaneously the rear cockpit has priority.

15. **Mute Switches.** Mute switches in each cockpit mute the audio signals from the VHF, UHF, Tacan, Marker and VHF Navigation receivers when uninterrupted intercom is required. The main push-to-mute switch is on the control column in each cockpit. An alternative mute switch, marked ALT MUTE - MUTE/NORM, spring-loaded to NORM, is on the left console forward of the throttle in the rear cockpit. The mute switches are not effective in the cockpit that has the station box amplifier selector switch at FAIL.

Note: Audio warnings are not muted.

16. **Communications Control Switch.** The communications control switch, marked U/VHF SEL, on the lower instrument panel of each cockpit transfers control of the U/VHF system between cockpits. The switch is a square push-on push-off button type with the top half caption illuminated U/VHF in white. Pressing a switch 'on' illuminates SEL in green in the lower half and takes control of the U/VHF system in that cockpit. Pressing the switch to off extinguishes the SEL caption and transfers control of the U/VHF system to the other cockpit.

17. **Tone Generator.** A warning tone generator provides either a pulsed or a swept (lyre) tone to the pilots' headphones. The pulsed tone is activated by excessive g (+7g, -3·6g), high IAS (290 ± 3 knots) or a high angle of attack above approximately 14 to 16 units. If, after an excessive g activation, engine RPM reduce below 90% the audio warning is reactivated until the DAPU is dumped. The lyre tone, activated in event of fire or low oxygen pressure, is fed from the CWS dim and test control unit.

18. **UUPI Tone Generator.** An Ultrasonic Undercarriage Position Indicator (UUPI) tone generator generates a signal when all three landing gear legs are down and locked and the nose landing gear doors are closed. This signal is transmitted with main UHF transmissions. The UUPI is inoperative when VHF is selected or when the wheels are on the ground.

U/VHF Communications

19. **General.** The U/VHF installation comprises the main UHF and VHF transceivers (ARI 23300/59) controlled by a common U/VHF controller (one in each cockpit) which provides for presetting any 16 channels for rapid selection. A standby UHF (ARI 23159) is also installed.

20. **Main UHF.** A PTR 1751PP transceiver provides radio communication in the UHF range 225 to 399·975 MHz. 7000 channels, spaced at 0·025 MHz intervals can be selected. A separate receiver superimposes reception of 243 MHz on both UHF and VHF when TR+G is selected.

21. **VHF.** An AD120 transceiver provides radio communication in the VHF range 118 to 136·975 MHz. 760 channels, spaced at 0·025 MHz intervals, can be selected. Aircrew are not to attempt to transmit on VHF frequencies outside the quoted band.

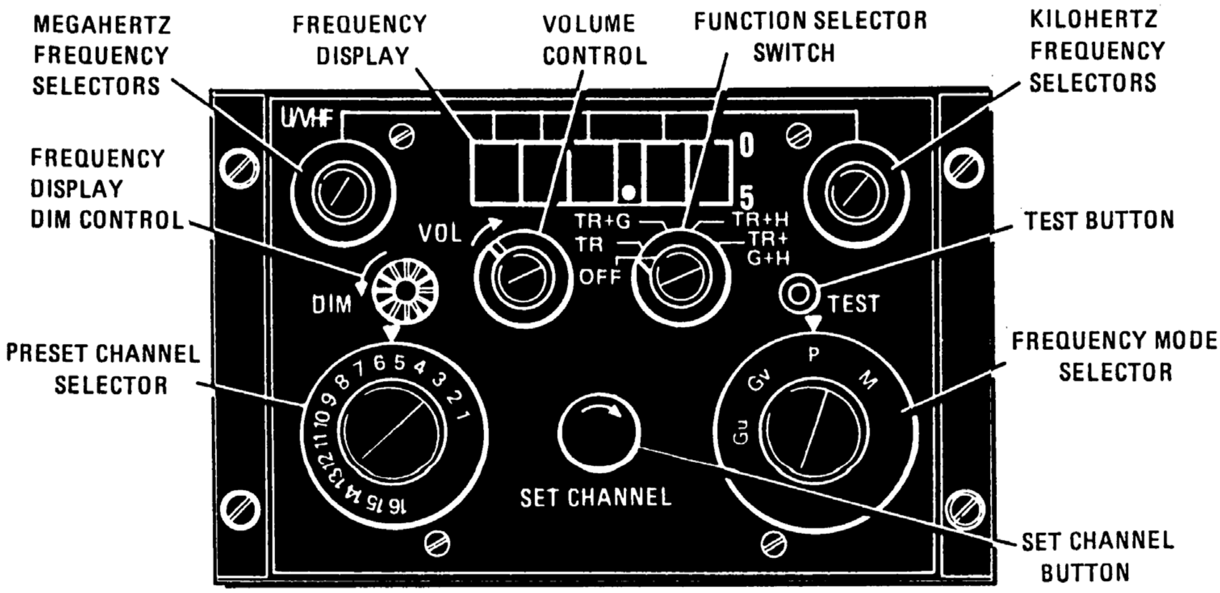
22. **Controls and Indicators.** The controls and indicators comprise a PV 1754L U/VHF controller on the upper instrument panel of each cockpit and a U/VHF SEL selector (para 16). A remote frequency/channel indicator (RFCI) is on the left of the instrument panel in the rear cockpit. The U/VHF controller (Fig 5) has the controls and indicators shown in Table 1.

Note: When manned with two crew, switch the U/VHF controller on in both cockpits. If the unselected controller is not switched on, its frequency display shows a false frequency; its frequency selectors can also change this false frequency, thus giving an illusion of control.

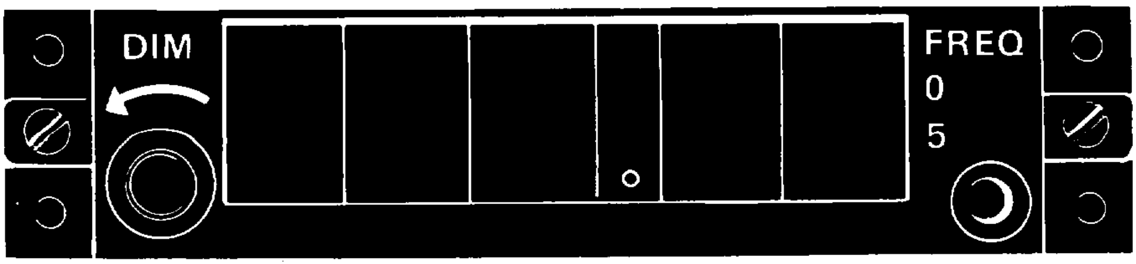
23. **Remote Frequency/Channel Indicator.** The RFCI (Fig 6) allows the rear pilot to monitor frequency/ channel selections while the front pilot has control of the U/VHF. When the U/VHF is in Manual mode the RFCI displays the frequency indicated on the front controller. When in Preset mode the RFCI displays the channel number selected on the front controller; the rear pilot can determine the frequency associated with this channel by pushing and holding the button labelled FREQ on the right of the RFCI. When the rear pilot has control of the U/VHF the RFCI display should be ignored. When the active controller is selected to Gu or Gv the RFCI displays the relevant guard frequency. A button, labelled DIM, adjusts the intensity of the digital display.

24. **Standby UHF.** A transistorized standby UHF provides 2-channel radio communication in the event of a main UHF failure; one channel is preset to 243 MHz and the other is preset to an adjacent frequency. The required channel is selected at the standby UHF switch on the CCS station box in each cockpit. The standby UHF switch, marked U/STBY - ALT/OFF/GRD, operates a UHF changeover relay when selected to either ALT or GRD. The UHF changeover relay connects the UHF aerial to the standby UHF. In the OFF position the UHF aerial is connected to the main UHF. Rear cockpit standby radio frequency selections override front cockpit selections.

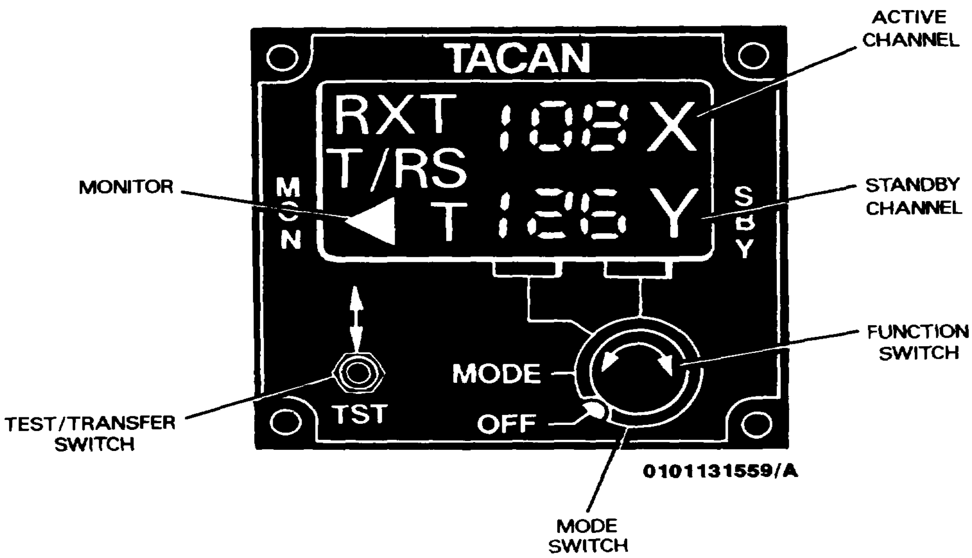
Note: Before solo flight the rear cockpit standby UHF switch is to be checked as set to OFF.



1 - 13 Fig 5 U/VHF Controller



1 - 13 Fig 6 Remote Frequency/Channel Indicator



1 - 13 Fig 7 Tacan Control Unit

Table 1 - U/VHF Controller

Control/Marking	*Effect/Function*
Frequency selectors Left outer Left inner Right outer Right inner	 1st and 2nd digits (hundreds and tens of MHz) 3rd digit (units of MHz) 1st decimal digit (tenths of MHz) 2nd decimal digit (0·025 MHz). Add 0 or 5 to give 3rd decimal digit
Frequency display	An incandescent filament lamp display of the first 5 digits of the selected frequency
DIMmer control	Varies the brightness of frequency display
VOLume control	Varies audio input to the station boxes
Function selector OFF TR TR+G TR+H TR+G+H	 Switches T/R off Switches T/R on Switches T/R and guard receiver on Not used Not used
Channel selector 1 to 16	 Selects desired channel
SET CHANNEL control (Rotate clockwise and press)	Enables pre-setting of 16 channels by first setting frequency and channel selectors and then operating the control
Mode switch Gu Gv P M	 Switches T/R to UHF guard frequency. Display still indicates manually dialled frequency Switches T/R to VHF guard frequency. Display still indicates manually dialled frequency Enables selection of pre-set channels on channel selector. Display still indicates manually dialled frequency Enables frequencies to be dialled manually and displayed. Also enables frequency to be dialled when pre-setting channels
TEST button Pressed (on receive) UHF VHF Gu Gv P M	 Steady tone if receiver serviceable Background noise if receiver serviceable Display indicates 243.00 MHz Display indicates 121.50 MHz Display indicates frequency of channel selected Display indicates 888.88 as display serviceability check
Panel lighting	The control unit is lit by integral lamps controlled by the pilot's instruments dimmer switch on the interior lights panel. The intensity is not variable

Note: In normal operation, the digital display only indicates the frequency in use when the mode selector is set to M (Manual). With Gu, Gv, or P set, the digital display still indicates the frequency dialled on the selectors, even though this frequency is not in operation. Only when the TEST button is pressed (with Gu, Gv or P set) does the frequency display indicate the frequency in operation.

Tacan

25. **General.** A Tacan installation (ARI 23432) provides information on range and bearing of a complementary ground beacon at ranges up to 158 NM (at 25,000 feet, limited by line of sight). The bearing is continually displayed on the HSI in each cockpit. Range, in digital form, and track deviation are displayed on each HSI. The selected track is determined by the cockpit with the HSI selector showing SEL. The system has 252 channels available, has a built-in test facility and comprises a control unit (with integral lighting) on the lower instrument panel of both cockpits and a transceiver.

26. **Control Unit.** Operating any control on either control unit (providing both units are selected on) automatically gives control of the Tacan transceiver to that control unit and causes a monitor symbol to be displayed on the other control unit. Each control unit has the following controls and display:

a. Two concentric rotary switches select the mode of operation and alter the preset channel.

(1) The outer 4-position switch is labelled OFF/MODE/-/-. When set to OFF the DC supply is disconnected; with the navigation mode selected to TACAN the NAV flag is displayed on each HSI. When set to MODE, the inner (function) switch, rotated, selects either receive (RX) or, rotated in the opposite direction, transmit/receive (T/R).

(a) **RX.** The receiver is operative and the transmitter is on standby. Ground identification signals are fed via the CCS to the pilot's headphones to provide positive identification of the ground beacon. With the navigation mode selected to TACAN the selected HSI NAV flag disappears and the magnetic bearing is displayed on each HSI. On each HSI the left/right deviation bar indicates deviation from the selected Tacan radial and either the to-flag or from-flag is displayed.

(b) **T/R.** The system receiver and transmitter are operative, interrogating pulses are transmitted and response pulses from the ground beacon are received. In addition to the indications produced as for RX, range of the beacon is displayed continuously on each HSI.

(2) With the outer switch set to the third (unlabelled) position the function switch selects the hundreds and tens digits. With the outer switch set to the fourth (unlabelled) position the function switch selects the units digit and X or Y. In both cases rotate the switch clockwise to increase and counter-clockwise to decrease. If the non-existent channels 0X, 0Y, 127X or 127Y are selected the display flashes.

b. A 3-position, centre off, transfer/test switch, labelled TST/↔, when selected upwards transfers the standby and active channels. When selected downwards to TST it operates the self-test facility, lights and then extinguishes all the display characters and then displays TST.

c. A liquid crystal display (LCD) shows:

(1) Active and standby channels.

(2) Mode TR or RX.

(3) A monitor symbol indicating that the other controller has control.

(4) TST indicating that the system test is in operation.

Transponder

27. **General.** The Funkwerk TRT800A Mode S Transponder system comprises:

a. The transponder/controller, located centrally in each cockpit lower instrument panel.

b. A control selector/indicator, located on the lower instrument panel in each cockpit.

28. **Operation.** The dual transponder system operation is determined by the selection/indicator on the lower instrument panel and the ‘in use’ cockpit controller. The selector is a spring-loaded square switch with a caption TPDR in the top half, illuminated in white whenever the busbar is live. Pressing the switch to on illuminates a green SEL caption in the bottom half of the button and ensures this cockpit controller is the master. The master controller displays the letter M, confirming control selection. Pressing the switch to off extinguishes the SEL caption in the bottom half of the button and ensures that the cockpit controller is the auxiliary. The auxiliary controller displays the letter A, confirming switch de-selection.

29. **Controls and Indications.** The controls and display on the transponder control unit are shown in Fig 8, with details of the display alphanumerics and symbols shown in Fig 9. The values and meanings of these are listed in Table 2, Table 3 and Table 4. The functions of the transponder controls are listed below:

a. **Display.** See Fig 9 and Table 2, Table 3 and Table 4.

b. **ON/OFF.** To switch on, press for 0.5 seconds. To switch off, press for 3 seconds.

c. **Emergency Squawk.** (Labelled "E"). Activates emergency squawk. Active squawk is stored as new emergency squawk if button is pressed for more than 5 seconds.

d. **Swap Active/Passive Squawk.** (Labelled with double vertical arrow). Changes active and passive squawk.

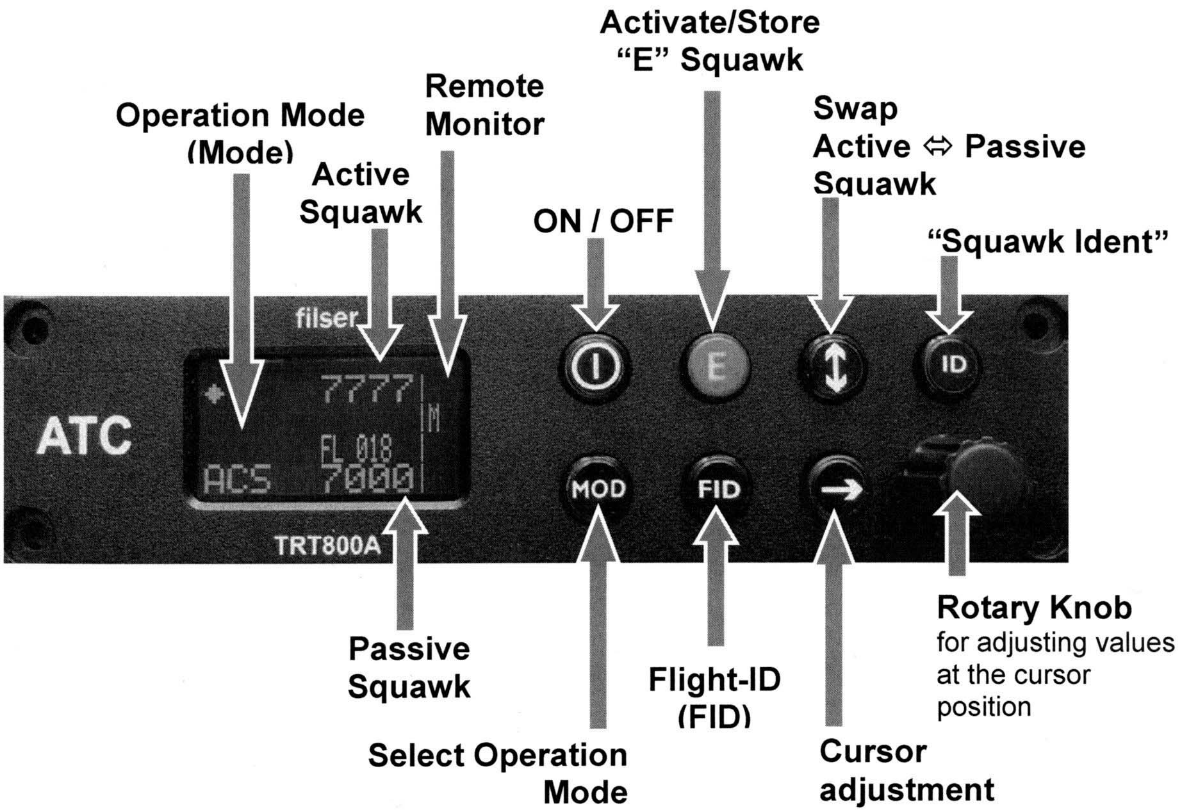
e. **Squawk Ident.** (Labelled ID). Starts squawk ident marking for 18 seconds.

f. **Rotary Knob.** (Unlabelled). Adjusts passive squawk and enters values at current cursor position, select options (see Select Operation Mode).

g. **Cursor Adjustment.** (Labelled with horizontal arrow). Sets cursor position.

h. **Flight-ID.** (Labelled FID). Allows viewing or configuration of Flight ID.

i. **Select Operation Mode.** (Labelled MOD). Selects transponder operational mode.



1 - 13 Fig 8 Transponder Control Unit

30. **Squawk Setting.** The active squawk is displayed in the upper line of the display and the passive squawk is in the lower line. To set the passive squawk, press the cursor adjustment button and turn the rotary knob to set passive squawk numbers. To activate the passive squawk, press the swap active/passive squawk button; this also makes the current active squawk the passive squawk.

31. **Emergency Squawk.** To activate emergency squawk, press the emergency squawk button. The pre-stored emergency squawk ("E Squawk") code activates and the previously used active squawk is stored as the new passive squawk. The passive squawk can be adjusted by using the rotary knob and is activated using the swap active/passive squawk button. To store the current active squawk as the new emergency squawk (replacing the factory setting of 7700 or the previously stored code) press and hold the emergency squawk button for approximately 5 seconds until "S" is indicated.

Note: To prevent the inadvertent overriding of the emergency squawk setting, care should be taken to immediately release the emergency squawk button after pressing it.

32. **Configuring Flight-ID.**

a. To view the programmed FID, the transponder is to be in standby mode.

(1) If not in STBY - press MOD repeatedly until STBY appears.

(2) Press FID button for less than 5 seconds.

b. To configure the Flight-ID, the transponder is to be in standby mode.

(1) Press MOD repeatedly until STBY appears.

(2) Press FID button for more than 5 seconds.

(3) When 'CHANGE FID' is displayed, release FID button.

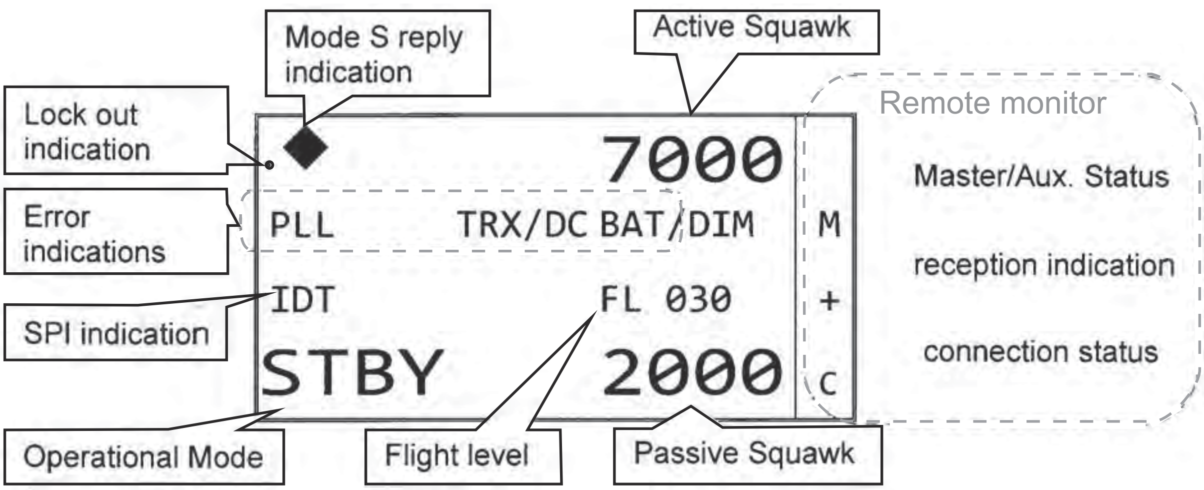
(4) Enter the Flight-ID from the left, without spaces, using the cursor button and rotary knob.

(5) Press and release MOD to save and return to STBY.

Note: There are two transponders fitted, if use of the 'out of use' controller is anticipated, care is to be taken to ensure the Flight ID is correctly configured to match the 'in use' controller.

33. **Display Brightness.** To alter the display brightness, in active mode (not standby) press the cursor adjustment button for 2 seconds and adjust the brightness with the rotary knob. To return to normal operation, press the cursor adjustment button or wait for 5 seconds.

34. **Remote Monitor.** The dual transponder system can be controlled from either cockpit. The remote monitor indications are in the right hand margined part of the display and give the controllers' status. Table 3 identifies the remote monitor symbols.



1 - 13 Fig 9 Transponder Display

Table 2 - Transponder Display Error Messages

Indication	*Meaning*	*Remarks*
PLL	Phased Locked Loop error	Internal error
TRX	Transmit failure	Check antenna and wiring
DC	Low internal voltage	Internal error
FPG	Floating Point Gate Array failure	Internal error
BAT	Battery power low	Battery, generator or internal fault

Table 3 - Transponder Display Values and Meanings

Indication	*Meaning*	*Remarks*
7000	Active Squawk	
2000	Passive Squawk	Can be swapped with active squawk by pressing Swap Active/Passive Squawk button
FL 030	Flight Level	Flight Level (in 100 ft steps)
FLerr	Invalid altitude measuring	Outside of minus 1000 to + 35,000 ft, C mode is inactive
STBY	Transponder is ready to respond	Transponder does not emit squitter or interrogation replies
ACS	Standard condition: mode A, mode C and mode S operational	Transponder responds to mode A, C and S interrogations
A-S	Mode A and S only	Altitude is not transmitted on either C or S requests. All other mode A and mode S data is transmitted
AC-	Transponder replies only on mode A and mode C interrogations	Occurs if no 24 bit address has been entered into the transponder
A-	Transponder replies only on mode A interrogations	Occurs if no 24 bit address has been entered into the transponder
IDT	Transmits Ident-Marking (SPI indicator)	ID (Squawk Ident) has been pressed - active for 18 seconds
♦	Transponder replies on mode S interrogations	
.	Transponder is locked to a ground station and will be directly addressed	Lock information (indicated as a single dot by the diamond)

Table 4 - Remote Status And Traffic Indications

Indication	*Meaning*	*Remarks*
M A X	Master Auxiliary Incorrect setting	 Independent of selected operational mode auxiliary device does not emit downlink formats 'X' is displayed if both transponders are running in the same M/A status
+	Remote message received	Is displayed after reception for a short period of time
C ! D	Remote device connected Remote device connected but different configuration data detected Remote interface is disabled	If remote device is not connected indication remains cleared '!' is displayed if connected transponders have inconsistencies in aircraft dependent configuration setup (e.g. ICAO address) Enable/disable remote data interface in device setup

35. **Limitation.** The TRT800A is cleared to +6g. If this limit is exceeded the system should be monitored for error messages and functionality confirmed by Air Traffic Services.

VHF Navigation Unit

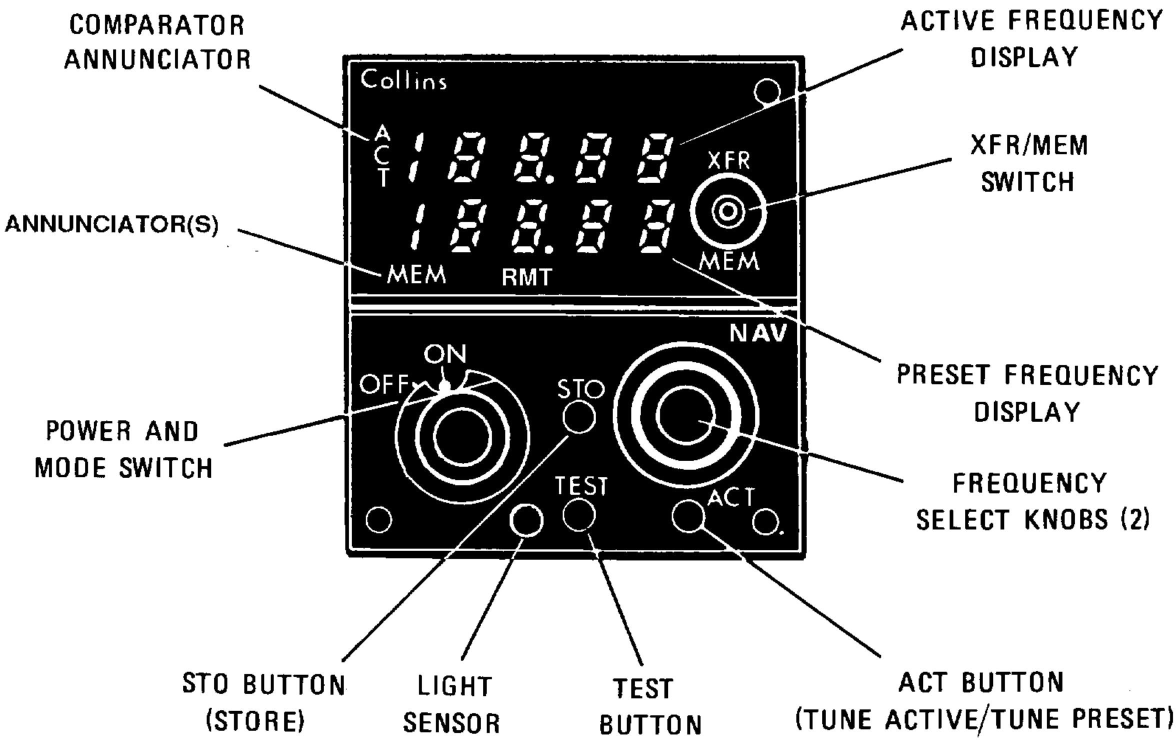
36. **General.** A VOR/ILS/marker beacon installation (ARI 23434) comprises a control unit on the lower instrument panel in both cockpits, a combined VHF navigation and marker beacon receiver, and associated aerials. 160 VOR channels and 40 ILS channels are provided, VOR frequencies in the range 108 to 117·95 MHz can be selected in 50 kHz steps. Localiser frequencies in the range 108·1 to 111·95 MHz can be selected in 50 kHz steps; glidepath frequencies are automatically paired with localiser frequencies.

37. **Displays.** The aircraft navigation situation is depicted on the HSI in each cockpit.

38. **ILS.** When the navigation mode selector is set to VOR ILS and an ILS frequency is selected on the VHF navigation control unit, deviation from the localiser centre line and from the glidepath is shown on each HSI; localiser and marker audio signals are fed to the CCS. If the glidepath signal is weak or inaccurate the VERT warning flag is displayed on each HSI; if the localiser signal is weak or inaccurate the NAV flag is displayed on each HSI. With ILS selected the VOR bearing pointers park horizontally.

39. **VOR.** When the navigation mode selector is set to VOR ILS and a VOR frequency is selected on the VHF navigation control unit, deviation from the VOR centreline and flying to/from are shown on each HSI. The VOR bearing is displayed on a bearing pointer and VOR audio signals are fed to the CCS. If the VOR signal is weak or inaccurate the VOR bearing pointers park horizontally, and the NAV flag is displayed on the selected HSI. The unselected HSI continually displays its NAV flag.

Note: With VOR selected the VERT flags of each HSI are displayed.



1 - 13 Fig 10 VHF Navigation Control Unit

40. **Controls and Indicators.** The controls and indicators comprise those on the VHF navigation control unit (Fig 10), the navigation mode selector and repeater in both cockpits, the HSI selector, and the marker lights. Selecting either control unit ON automatically switches the other control unit on; operating any switch on either control unit automatically gives control of the receiver to that control unit. The preset and active frequencies are displayed on the control unit in command, while the other control unit only displays the active frequency. Table 5 shows the VHF navigation control unit controls.

Table 5 - VHF Navigation Controls

Controls/Marking	*Function*
2-position rotary power and mode switch selecting	OFF - Power off ON - Navigation receiver on
Pair of rotary manual frequency selector switches	Select required frequency
Digital preset frequency display	Displays preset frequency
Digital active frequency display	Displays active frequency
STO button	Used in conjunction with XFR/MEM switch to store up to four preset frequencies
3-position switch, XFR/off/ MEM, spring-loaded to centre off	MEM (held down) - enters previously stored frequencies into the preset frequency display XFR (held up) - transfers preset frequency display to active frequency display and vice versa
ACT button	Displays active frequency only; lower display consists of dashes. When pressed for about two seconds the active frequency can then be altered by the manual frequency control knobs. A further press restores the controller to normal 2-display mode
TEST button	Activates built-in test (BIT) circuit
Light sensor	Determines, automatically, the level of brightness of the displays. The top display is always slightly brighter than the lower
Annunciator MEM display	Illuminated whenever a 'stored' frequency is being displayed in the lower display
Annunciator RMT display	Illuminated whenever the other control unit is in command
Comparator annunciator ACT	Momentarily illuminated when frequencies are being changed. If ACT continues to flash, the actual tuned frequency is not identical to the frequency shown in the active display
Navigation mode selector button, VOR ILS/TACAN	Selects required navigation facility

41. **Marker.** A blue light, inscribed MARKER, on the upper instrument panel of both cockpits, comes on when a marker signal is received; the period of operation of the light is a function of the signal strength at the marker receiver. The filament of the light can be tested for serviceability by pressing the TEST button on the VHF navigation control unit. Power for the test is from the essential services busbar.

42. **Built-in Test.** The serviceability of the system can be checked using the built-in test (see para 54 and para 55).

Traffic Alert and Collision Avoidance System (TCAS)

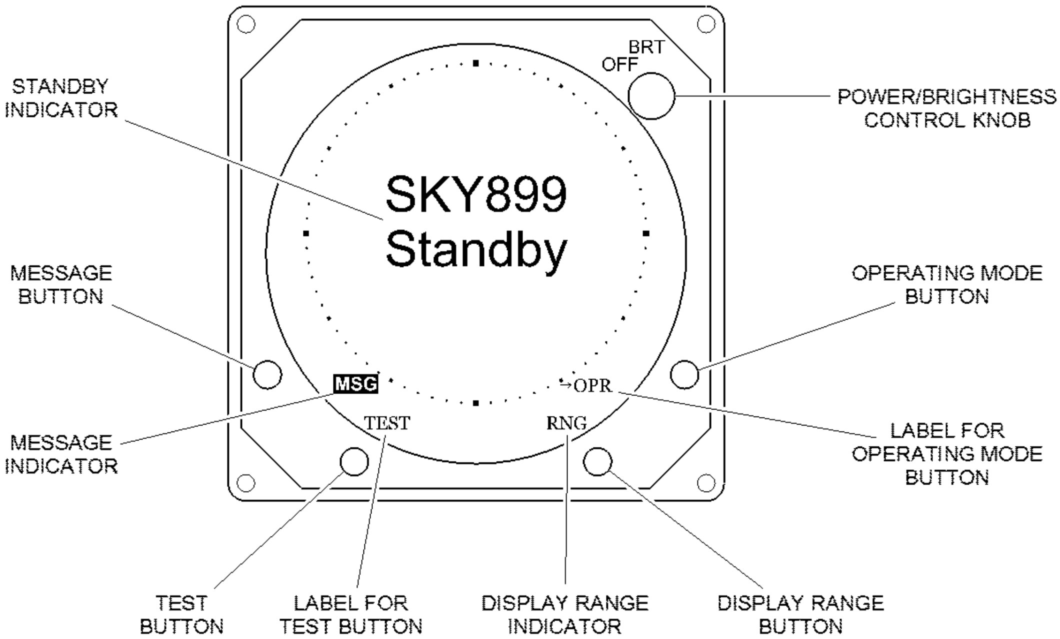
WARNING: The TCAS installation does not detect or track aircraft which are not transponder equipped. Some traffic may not be displayed due to traffic prioritizing or antenna shielding. Evasive manoeuvres should not be attempted based solely on traffic information on the display. Information on the display is provided to the crew as an aid to visual acquisition and is not a replacement for ATC or see-and-avoid principles.

43. **General.** The SkyWatch SKY 899 TCAS (ARI 50045/0) comprises a directional antenna mounted on top of the fuselage in front of the cockpit, a Transmitter Receiver Computer (TRC) located below the cockpit floor, and a Cockpit Display Unit (CDU) in each cockpit.

a. The antenna transmits omni-directional Mode C interrogations, and receives directional replies from transponder-equipped aircraft within 35 NM laterally and 10,000 ft vertically.

b. The TRC converts signals from the antenna into an on-screen picture of intruder locations and, if necessary, aural traffic advisories. The TRC can track up to 35 aircraft simultaneously but, to reduce clutter, only displays the 8 most threatening aircraft. The TRC also has inputs from the directional gyro, servo encoding altimeter, left weight-on-wheels microswitch, undercarriage selector valve and the transponders. The TRC has built-in test equipment to detect faults and verify correct operation.

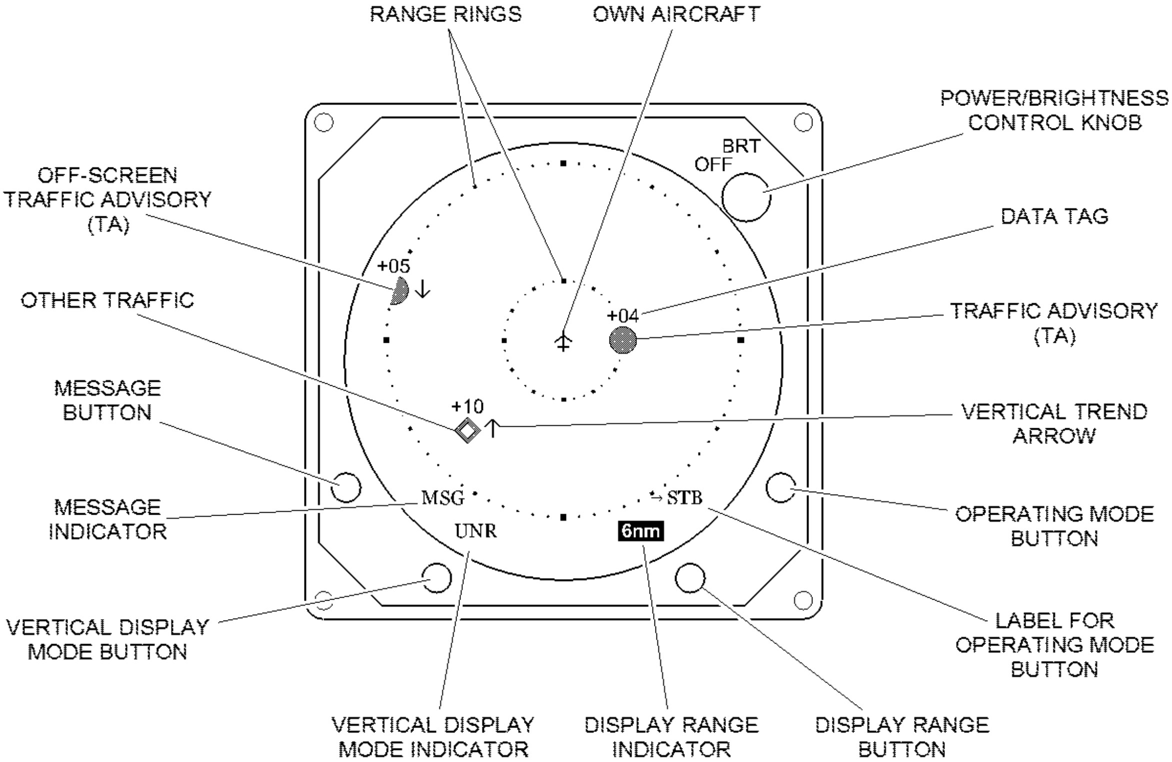
c. A CDU is located in each cockpit on the upper main instrument panel. Each CDU has a combined on/off and brightness knob marked OFF/BRT and 4 pushbuttons. In each operating mode a label indicating the pushbutton function is displayed on the screen next to each button. If no label is displayed, that button is inoperative in that mode.



1 - 13 Fig 11 TCAS CDU Standby Mode Screen

d. In the in-flight operate mode (OPR), the CDU displays the computed position of detected ‘intruder' aircraft relative to the host aircraft. The host aircraft is always depicted at the centre of the display. A solid circle represents a Traffic Advisory (TA) indicating an intruder which may pose an immediate collision threat. TAs may also be accompanied by an aural warning. An open diamond represents Other Traffic (OT). A 2-digit data tag, showing the intruder's relative height in hundreds of feet, is displayed above (for higher traffic) or below (for lower traffic) the traffic symbol. Additionally, higher traffic has a positive symbol and lower traffic a negative symbol. Non-altitude reporting intruders do not display a data tag and are considered to be co-height for the computation of TAs. A vertical trend arrow is displayed, in the correct sense, to the right of the traffic symbol when the intruder is climbing or descending at greater than 500 fpm.

e. With the undercarriage retracted the TCAS operates in Sensitivity Level B (SLB). A TA is generated when an intruder comes within 0.55 NM laterally or 800 ft vertically, or is on a course which will intercept the host ac within 30 seconds. This time is reduced to 20 seconds for non-altitude reporting intruders. In SLB, any new TA is accompanied by an audio warning of ‘Traffic Traffic'.The audio warning sounds once only, but the TA symbol remains for as long as the intruder poses a threat, and for an additional 8 seconds after it ceases to meet the criteria. The audio warning sounds in both cockpits even when only one CDU is selected ON. The warnings cannot be muted. When the undercarriage is selected down the TCAS operates in Sensitivity Level A (SLA). The criteria for TA generation are reduced to minimize nuisance warnings in the takeoff and landing phases and are 0.2 NM laterally or 600 ft vertically, or when the computed intercept is within 20 seconds (15 seconds for non-altitude reporting intruders). In SLA audio warnings are inhibited. As an additional guard against nuisance warnings after takeoff, the transition from SLA to SLB is delayed, via the left main gear weight-on-wheels microswitch, for 60 seconds.



1 - 13 Fig 12 TCAS CDU In-Flight Operate Mode Screen

f. The volume of airspace displayed is selectable using the pushbuttons. Selectable ranges are 15, 6 and 2 NM. An outer circle represents the selected range; an inner circle represents the next range down. An inner ring is not shown in 2 NM scale. Selectable vertical bands are Unrestricted (UNR), Above (ABV), Normal (NRM) and Below (BLW) (see Table 6). A label next to each button indicates the currently selected range or height band. The TCAS continues to track up to 35 ac regardless of the range displayed. OT outside the selected range and/or height is not displayed. However, TAs are generated for intruders outside the selected display zone. An out-of-range TA is shown as a semi-circle at the edge of the display at the correct bearing. An out-of-vertical band TA is shown as a correctly positioned solid circle, however its height is shown at the maximum height selected until it comes within the selected height range.

Table 6 - Vertical Mode Height Bands

Vertical Mode	*Max look-up*	*Max look-down*
ABV	9,000 ft	2,700 ft
NRM	2,700 ft	2,700 ft
BLW	2,700 ft	9,000 ft
UNR	9,900 ft	9,900 ft

g. A message button allows system messages to be displayed. The MSG label is shown, next to the button, in contrast invert whenever a new message is available and unhighlighted when messages have been read. In standby mode the MSG label remains on the screen even when there are no messages.

h. When the TCAS is selected ON, it enters a power-on self test and the display shows the manufacturer's logo. Following the test, if the ac is on the ground, the system enters standby mode and the standby screen is displayed. In standby, the TCAS waits for five minutes for critical sensors to warm up before displaying a failed screen or failure messages. If the TCAS is selected to operate it only waits two seconds before displaying failure messages. In standby the TCAS does not interrogate, process or display traffic. If the TCAS is selected ON in the air, and passes the power-on test, it enters operate mode, in NRM and 6NM scales.

i. In standby mode on the ground, pressing the button labelled OPR switches the TCAS into operate mode, in ABV and 6 NM scales, and the button label changes to STB. In the air, the button is not labelled and standby cannot be selected. The TCAS automatically switches from standby to operate 8-10 seconds after takeoff, via the left weight-on-wheels microswitch, and switches back to standby approximately 24 seconds after landing. This delay prevents the TCAS entering standby during roller landings. The 60-second delay maintains the TCAS in SLA mode to minimize audio warnings during circuits.

Note: After 60 seconds the TCAS enters SLB mode; audio warnings may therefore sound when the undercarriage is up.

j. A button labelled TEST is available in STB or failed mode. Pressing the button initiates a self-test and the test screen is displayed. At the end of the test, an audio ‘Skywatch system test passed' or similar failure message is generated and the display reverts to the previous screen. If a test pass message is heard without the test screen being displayed select the system OFF.

k. The TCAS is powered by the main busbar. The maximum loading is 2 amps. Circuit protection is provided by circuit breakers 90 and 91 in the rear cockpit.

l. To prevent damage, caused by transient power surges, ensure that the TCAS is selected OFF prior to and during engine start.

44. **Normal Use.**

a. After start, turn the OFF/BRT switch ON and to the desired brightness. If required, press the button labelled TEST to initiate a self test.

b. After landing, select the TCAS OFF before switching off the transponder.

45. **Use in Abnormal Conditions.** When the TCAS detects a fault it determines whether the system has failed or is just degraded. A failed system cannot perform any collision warning functions. A degraded system can perform some collision warning functions, but may not be able to provide some features.

a. **Response to a Failed System.**

(1) In the case of a failed system the TCAS displays a ‘SKY899 FAILED' screen. All errors indicated by a fail screen prevent continued operation of the system. If the failure is caused by loss of transponder altitude encoding to the TCAS, the messages ‘Barometric Input Error' and ‘Error 20' will be displayed on the fail screen. In this case, confirm that the transponder is not selected OFF. It may be possible to recover the system by momentarily selecting the transponder OFF and ON.

(2) In any other case, or if the Error 20 remains, and conditions permit, press the TEST button. The resulting self-test may provide another error code to be noted. Press the message button and note any degraded items listed. If the failure condition remains select the system OFF.

b. **Response to a Degraded System.** In the case of a degraded system, MSG will be highlighted on the traffic screen. If conditions permit, press the message button and note the faults listed for any subsequent engineering investigation. Press the EXIT button to revert to the previous screen.

c. If, at any stage, the TCAS provides erroneous information, or becomes a distraction, select the system OFF.

Underwater Locator Beacon

46. An underwater locator beacon, contained in a crash-resistant container, is in the rear fuselage attached to the accident data recorder (ADR). The battery-operated beacon is self-contained and requires no aircraft electrical power. On contact with water, a water-sensitive switch activates the battery. When the beacon is activated, ultra sonic pulses are emitted which can be detected under water, at distances of 6000 to 12,000 feet, depending on conditions, for approximately 30 days.

NORMAL USE

General

47. Set the U/VHF volume at maximum to ensure correct receiver sensitivity; adjust the audio volume with the station box RX volume control.

Ground Intercom

48. To achieve ground intercom ensure either an external DC power supply is connected or both battery switches are ON, and select:

a. The EXT IN'COM switch ON.

b. The amplifier selector to NORM and adjust the front cockpit CCS I/C volume control as required.

Before Flight

49. **General.** Before solo flight check that the rear cockpit standby UHF switch is OFF. Ensure that headset and personal equipment connector are properly connected.

50. **CCS Station Box.**

a. Set the amplifier selector to NORM.

b. Adjust the I/C volume control as required.

c. Set the function selector as required.

d. Switch on the required receiver audio switches.

e. Adjust the RX volume control as required.

51. **U/VHF Transceiver.**

a. Select U/VHF SEL in a cockpit.

b. Select TR or TR+G.

c. Set the VOL control to maximum. Re-adjust station box RX volume control as required.

d. Set Manual. Press the TEST button. Check tone (UHF) or background noise (VHF) is present and 888.88 is on the frequency display.

e. Release the TEST button.

f. Set Manual or Preset and the frequency as required.

g. Repeat the test on the second U/VHF controller by first selecting U/VHF SEL in the other cockpit.

52. **Standby UHF Transceiver.**

a. Set the function selector and audio selector switches on the CCS to U/STBY.

b. Set the standby UHF switch to ALT; check transmission and reception.

c. Adjust RX volume.

d. Set the function selector switch to V/UHF.

e. Set the standby UHF switch to OFF.

53. **Transponder.**

a. Select TPDR/SEL in a cockpit.

b. Turn the transponder ON (turn on both if dual) and ensure in STBY mode. If not, press MOD repeatedly until STBY appears.

c. Set call-sign into the FID and press MOD to save.

d. Press E to confirm that emergency squawk 7700 is set.

e. Reset squawk as required.

f. Set mode as required.

54. **VOR.**

a. Switch the VHF navigation control unit ON and select the frequency of a VOR beacon which is out of range.

b. Select VOR ILS on the navigation mode selector.

c. Select the front cockpit HSI and set the track to 360°.

d. Press and hold the TEST button on the navigation control unit.

e. After approximately two seconds verify that the NAV flag disappears, the deviation bar centres and the to-flag appears.

f. Verify that the VOR pointer shows 360° magnetic bearing.

g. The MARKER light flickers.

h. The navigation control unit should display the diagnostic code `00'. If any other number is displayed record it for later diagnosis.

i. Release the TEST button and verify that the NAV flag on the HSI comes into view and that the VOR pointer parks horizontally.

j. Select the rear cockpit HSI and repeat the test procedure from the rear cockpit.

55. **ILS/Marker Beacon.**

a. Switch the VHF navigation control unit ON and select an ILS frequency.

b. Select VOR ILS on the navigation mode selector.

c. Select the MKR audio switch on the cockpit station box to on.

d. Press and hold the TEST button on the navigation control unit.

e. Verify that the NAV and VERT flags of the HSI are in view.

f. Verify that after approximately three seconds:

(1) The NAV and VERT flags go out of view.

(2) The track deviation bar deflects right approximately 2/3 full scale.

(3) The glidepath pointer deflects down approximately 2/3 full scale.

g. The MARKER lights should flicker and a 30 Hz tone should be heard in the headphone.

h. The navigation control unit should display the diagnostic code `00'. If any other number is displayed record it for later diagnosis.

i. Release the TEST button.

j. Verify that the NAV and VERT flags come into view, the MARKER light goes out and the 30 Hz audio tone ceases.

k. Select the rear cockpit HSI and repeat the test procedure from the rear cockpit.

56. **Tacan.**

a. Select MODE on the tacan control unit function switch.

b. Select TACAN on the navigation mode selector.

c. Select the front cockpit HSI.

d. Set the HSI track pointer to 360° and check digital track read-out (top right) displays 0 ± 1.

e. Select TST on the Tacan control unit TEST/TRANSFER switch. Release and check:

(1) The NAV flag goes out of view for approximately 3 seconds then appears.

(2) The digital distance read-out displays 0 ± 0.5 miles.

(3) The bearing pointer indicates 180 ± 2°.

(4) The 'from' flag is displayed.

(5) The track deviation bar is central.

f. Set the HSI track pointer to 180°; check the 'to' flag is displayed and the track deviation bar is central.

g. Move the front HSI track pointer through 090° and 270° to check the 'to/from' flags reverse.

h. Select the rear cockpit HSI and repeat the test procedure from the rear cockpit.

Systems Operation

57. **U/VHF.**

a. Set the CCS function selector to V/UHF and set the V/UHF receiver audio switch to on.

b. Select U/VHF SEL in the appropriate cockpit.

c. Select the U/VHF rotary function switch to TR or TR+G.

d. With the U/VHF transceiver mode switch at P, select the required channel; with the mode switch at M, set the required frequency manually. Adjust the volume control as required.

e. To transmit on the UHF guard channel (243 MHz) select Gu on the mode switch or select M and set 243 MHz manually.

f. To transmit on the VHF guard channel (121·5 MHz) select Gv on the mode switch or select M and set 121·5 MHz manually.

58. **Transponder.** Pre-flight, select ACS. The transponder will then respond to Mode A, C and S interrogations.

59. **VOR/ILS/Marker Beacon.**

a. Switch the navigation control unit ON. If the active frequency only is displayed press the ACT button for about two seconds.

b. Select the frequency required and transfer to the active (upper) display by pressing the XFR/off/MEM switch to XFR.

c. Select VOR ILS on the navigation mode selector and adjust the track indicator as required.

d. To recall a stored frequency, push the XFR/off/MEM switch to MEM as necessary until the appropriate channel (CH1 to CH4) appears in the upper display; the associated preset frequency shows on the lower display. Transfer to the active display (see para 59b).

e. Any or all of the four preset frequencies can be changed as follows:

(1) Push the XFR/off/MEM switch to MEM as necessary until the required channel appears in the upper display.

(2) Select the new frequency.

(3) Push the STO button twice (within five seconds).

(4) Repeat (1) and confirm the new frequency appears in the lower display.

Note: DME range is displayed on each HSI if the appropriate Tacan channel is selected and the Tacan system is operating. Marker beacon reception is automatic.

60. **Tacan.**

a. On the Tacan control unit select MODE and rotate the function switch to select RX or T/R and select the required channel.

b. Select TACAN on the navigation mode selector.

Note: During a Tacan approach, propeller induced modulation of the Tacan signal may cause each HSI bearing pointer to oscillate ±2° at 1Hz with simultaneous displacement of the track deviation bar.

USE IN ABNORMAL CONDITIONS

Electrical Failure

61. **Compass.** If the compass system fails (warning flags appear on each HSI) both HSIs are inoperative; neither TACAN derived information nor VOR/ILS information can be displayed.

62. **Generator.** If the generator goes off line (GEN caption illuminated) and cannot be reset, full electrical power is available from No 1 battery (and No 2 battery if reconnected). Switch off unnecessary avionics and minimize radio transmissions.

Communications Malfunctions

Note: The absence of sidetone when transmitting is an indication that the power output has fallen below a preset level; the equipment may still be transmitting. Following generator failure a reducing battery voltage causes a progressive loss of sidetone.

63. **Main U/VHF Transceivers.**

a. If the preset channel selector is suspect, use the manual tuning facility.

b. If receiver serviceability is suspect, press the TEST button; UHF serviceability is confirmed if the 1 kHz tone signal is obtained. VHF serviceability is confirmed if background noise is obtained.

Note: The 1 kHz tone is transmitted on the selected frequency while the test button is pressed.

c. At any time that the serviceability of the main U/VHF is suspect, select the function selector and audio selector switches on the CCS to U/STBY and ensure the U/STBY is switched to GRD.

64. **CCS Normal Microphone Amplifier.** If the CCS normal microphone amplifier fails, set the CCS station box amplifier selector to FAIL. When flying dual, advise the occupant of the other cockpit of the action taken.

65. **Transmit Button.** If the throttle lever transmit button fails, use the alternative switch, marked ALT TX, on the left console forward of the throttle.

66. **Transponder Failure.** If the transponder serviceability is suspect, recycle the function switch and the code; if serviceability is still suspect, transfer control to the transponder in the other cockpit.

Aircraft Emergency

67. In the event of an aircraft emergency select transponder emergency code by pushing the emergency select button which then illuminates. Ensure that the function selector is set to ON or ALT.

PART 1

CHAPTER 14 - ICE PROTECTION SYSTEMS

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INTRODUCTION

1. The aircraft has a limited capability of operating in icing conditions and has a restricted clearance. There are only limited areas of the aircraft that have protection: the engine intake, propeller, pitot probes and static ports, together with an ice detector and its mounting mast. The angle-of-attack (AOA) vane and stall warning vane also have heating systems, but the stall warning facility may be lost due to ice build-up on the wing leading edge.

ICE DETECTOR

General

2. Ice detection is provided by a detector unit in the left wing which, when selected, automatically switches on the pitot and static vent heaters, the AOA and stall vane heaters, the propeller de-icing and the air intake heating. The detector unit is switched ON from either cockpit ICE DET switch on the ICE PROTECTION panel on the right console in each cockpit. The front cockpit switch is a 2-position ON/OFF switch and functions only when the 3-position switch in the rear cockpit, marked ON/FRONT/OFF, is set to FRONT.

Operation

3. An ice sensing element, which protrudes through the detector unit and through an aperture in the underside of the wing, vibrates at a constant frequency until it is reduced by ice accumulation. At a preset ice thickness of 0·02 ± 0·005 inch the detector transmits a signal to light the ICE indicator/test switch (blue) (Fig 1) on each cockpit upper instrument panel. The ICE indicator informs the pilot that the ice detection

system has detected ice and has switched on the ice protection systems. Within seven seconds integral heaters automatically de-ice the sensing element of the detector unit and, if the vibration frequency does not further reduce within 60 seconds, the detector unit signal cuts out, causing the ICE indicator to go out and switching off the ice detector automatic mode. If the vibration frequency does further reduce within 60 seconds a timer automatically resets the automatic mode, thereby ensuring that the ice detection system operates continuously during moderate or severe icing conditions.

Note: The ice detector is subject to random operation due to airframe vibration; when selected 'on' it can select the ice protection systems on in any environment. Such spurious operations are usually associated with selection of high engine power, or more than +3g, or landing. Nevertheless, the ice detector has demonstrated a satisfactory capability of detecting icing conditions and of automatically selecting the ice protection services on. However, an ICE warning indication should be confirmed by secondary indications, e.g. ice forming on the canopy and wing leading edges. If, at any time, spurious operation is suspected, select ICE DET OFF then ON to cancel unwanted ice protection system functions.

4. **Power Supply.** The ice detector is supplied from the main busbar.

ENGINE SYSTEMS

Air Intake De-icing

5. The top of the engine air intake duct is continuously de-iced by heat absorption from the propeller gearbox oil. In icing conditions, the bottom of the duct is de-iced by engine P3 bleed air admitted to an internal cavity via a solenoid-operated anti-ice valve. This valve also admits the bleed air to a tube which sprays the hot air onto the inside of the skin of the intake lip. The valve is energized to open.

6. **Anti-ice Valve Control.**

a. **Manual Control.** The anti-ice valve can be selected ON (open) by an INTAKE switch on the ICE PROTECTION panel on the right console in each cockpit. The front cockpit switch is a 2-position ON/OFF switch and functions only when the 3-position switch in the rear cockpit, marked ON/FRONT/OFF, is set to FRONT.

b. **Automatic Control.** If the system is not selected ON manually, provided the ICE DET is selected ON, the control switches are electrically bypassed to open the anti-ice valve if the ice detector detects ice. Opening of the valve occurs simultaneously with the illumination of an ICE warning light/test switch (blue) on the right of each main instrument panel. The valve then remains open while the warning persists.

7. **Valve Position Indication.** An indicator beside the control switch in each cockpit displays INTAKE ON (blue) when the valve is open, whether under manual or automatic control. There is also a slight rise in EGT giving confirmation that the system is operating.

8. **Power Supply.** Power is from the load shedding busbar.

Propeller De-icing

9. The leading edge roots of the propeller blades are electrically de-iced by heater mats. Those on opposite blades form two heater groups which are alternately heated, both under manual and automatic control, for repeated 90-second periods.

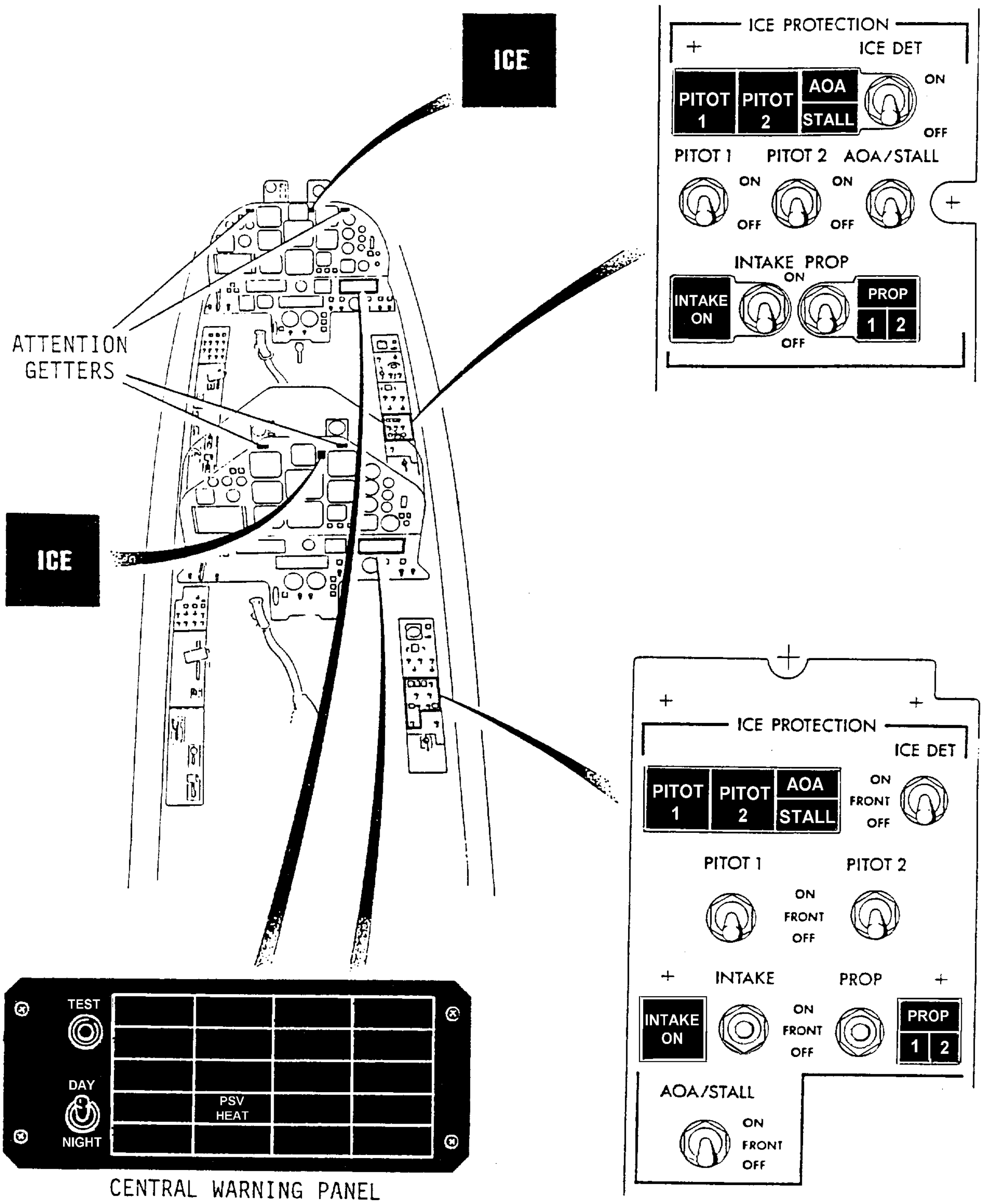
10. **Control.**

a. **Manual Control.** Manual selection of propeller de-icing is by a PROP switch on the ICE PROTECTION panel on the right console in each cockpit. The front cockpit switch is a 2-position ON/OFF switch and functions only when the 3-position switch in the rear cockpit, marked ON/FRONT/OFF, is set to FRONT. An ON selection activates the system, causing the timer to cycle power to both heater groups in turn.

b. **Automatic Control.** If the system is not selected ON manually, provided the ICE DET is selected ON, the control switches are electrically bypassed if the ice detector detects ice. This activates the propeller de-icing timer simultaneously with the initial illumination of the ICE warning light on the right of each main instrument panel. Cyclic heating of the two heater groups continues while the warning persists.

11. **Indication.** A 3-segment electrical indicator, marked PROP/1/2 (blue), beside the control switch in each cockpit is illuminated to confirm the correct sequencing of the heater mats. The upper segment PROP displays continuously when the system is on; the lower segments 1 and 2 display alternately during the heating phase of the associated heater group.

12. **Power Supply.** The heaters are powered by the load shedding busbar via a timer unit, brush block and propeller slip-ring.



1 - 14 Fig 1 Ice Protection Controls and Indicators

Pitot-Static System

13. The pitot tubes and static ports are de-iced by integral 28V DC heaters which are switched manually or automatically.

14. **Manual Selection.** Manual selection is controlled by the PITOT 1 and PITOT 2 switches on the ICE PROTECTION panel on the right console of each cockpit. The front cockpit switches, marked ON/OFF, are operative when the relevant rear switches are set to FRONT. The rear cockpit switches, marked ON/FRONT/OFF, have priority selection.

15. **Automatic Selection.** The heaters are switched automatically when the ICE DET switch on the ICE PROTECTION panel of either cockpit is switched to ON. The pitot-static heaters are then switched to suit conditions encountered by the ice detector; in this mode the PITOT 1 and PITOT 2 switches can be selected to switch the heaters on manually for continuous operation.

16. **Heater Failures.** Heater failure is indicated by an amber PSV HEAT caption on the CWP and an amber PITOT 1 or PITOT 2 caption, as applicable, showing on the ICE PROTECTION panel.

17. **Power Supplies.** Power is supplied to the pitot-static 1 heaters from the main busbar and to the pitot-static 2 heaters from the load shedding busbar.

Stall Warning Vane Heating

18. The stall warning lift detector is de-iced by integral vane, body and plate heaters wired through a landing gear microswitch and thus is only operative when airborne.

19. **Control.**

a. **Manual Control.** Manual control is by selecting ON the AOA/STALL switch on the ICE PROTECTION panel in either cockpit. The front cockpit has a 2-position ON/OFF switch and functions only when the 3-position switch in the rear cockpit, marked ON/FRONT/OFF, is set to FRONT.

b. **Automatic Control.** If the system is not selected ON, providing the ICE DET is selected ON, the manual control switches are electrically bypassed and the heaters switched ‘on’ if the ice detector detects ice.

20. **Heater Failure.** Heater failure is indicated by an amber STALL caption on both ICE PROTECTION panels and an amber PSV HEAT caption on each CWP. Power is supplied via a landing gear microswitch, therefore, a failure is indicated if the heater is selected when on the ground.

21. **Power Supply.** Power is from the load shedding busbar.

AOA Vane Heating

22. The AOA sensor is de-iced by integral nose and vane heaters. A thermostat cut-out operates at 246°C.

23. **Control.**

a. **Manual Control.** Manual control is by selecting ON the AOA/STALL switch on the ICE PROTECTION panel in either cockpit (see para 19a).

b. **Automatic Control.** If the system is not selected ON, providing the ICE DET is selected ON, the manual control switches are electrically bypassed and the heaters switched ‘on’ if the ice detector detects ice.

24. **Indication.** A heater failure or thermostat cut-out is indicated by an amber AOA caption showing on both ICE PROTECTION panels and a PSV HEAT caption is illuminated on each CWP.

25. **Power Supply.** Power is from the load shedding busbar.

NORMAL OPERATION

Before Flight

26. After starting, set the ICE DETector switch to ON, on the ICE PROTECTION panel. Press the ICE indicator on either cockpit instrument panel momentarily to initiate automatic switching. Check that the PSV HEAT caption, blue ICE, INTAKE ON and PROP 1 or 2 and amber STALL indicators are illuminated and that the amber PITOT 1, PITOT 2 and AOA indicators stay out. Check for a slight rise in EGT. Set the ICE DET switch OFF. Select the PROP switch ON and observe that the other PROP 1 or 2 caption is illuminated, then select OFF. If necessary the propeller ice protection may continue to be used with one blade heater mat failed unless, or until, excessive engine/propeller vibration occurs (which is unlikely).

27. The cycle time for system self test is one minute. The cycle time for full propeller blade heating, following manual selection, is three minutes. With a heater mat for one propeller blade failed, the heater for the other blade continues to cycle normally. However, the indication of system operation (90-second alternation between PROP 1 and PROP 2 captions) is disrupted; the indication is only given for the pair of blades being heated, with no caption for the next 90 seconds. Limit periods of preflight checks to four minutes to avoid overheating. When ambient temperature is above 10°C, do not use intake heating on the ground for more than 10 seconds.

28. Select PITOT 1 and 2 ON in the **Checks Before Take-Off**. If icing conditions exist on the ground (OAT at or below +8°C, RVR less than 1000 metres and/or wet runway surface) select INTAKE and PROP ON after start. If the OAT is +10°C or more, but icing conditions are expected shortly after take-off, delay selection of INTAKE and PROP ON until just before take-off.

During Flight

29. Ensure ICE DET and anti-ice systems are selected ON before flying in possible icing conditions. In-flight icing may occur when the ambient temperature is +10°C or less in precipitation or visible moisture, and in air in the vicinity of these conditions.

After Flight

30. After landing switch OFF PITOT 1 and 2 and AOA/STALL heaters. Use the INTAKE and PROP heaters until shutdown if icing conditions persist, then select INTAKE, PROP and ICE DET OFF.

USE IN ABNORMAL CONDITIONS

Engine Icing

31. If loss of power, an unexpected increase of EGT up to the maximum 650°C SRL EGT, reduced maximum obtainable torque or RPM fluctuations (with NTS operating) with the ignition on are experienced either separately or together, then suspect engine icing. Confirm that ICE DET, INTAKE and PROP are selected ON. Climb or descend to get clear of icing conditions.

PSV HEAT Caption

32. If the PSV HEAT caption is illuminated carry out the **FRC PSV Heat** drill.

Note: With the ICE DET selected ON the AOA vane heater thermostat may operate, either on the ground or in flight, and give a PSV HEAT warning suggesting heater failure. If this happens check the ICE PROTECTION panel. If an AOA caption is illuminated, wait three minutes to ascertain whether the warning self cancels as the thermostat cools. If the AOA caption persists, switch the AOA/STALL OFF then ON; if the failure is still indicated, switch OFF (see the **FRC PSV Heat** drill).

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PART 2

LIMITATIONS

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PART 2

CHAPTER 1 - AIRFRAME LIMITATIONS

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The limitations given in this Part are taken from the Release to Service (RTS), which is to be consulted to ascertain the latest release standard.

Note: The limitations given are Normal Operating limitations which may be reached as often as required without undue risk.

General

1. The Tucano T Mk 1 is released in the flying training role by day and night (VMC and IMC) over land and water, at ground level air temperatures in the range minus 10 to +30°C. It may be flown dual or solo. For solo flying the pilot is to occupy the front seat.

Centre of Gravity

2. The centre of gravity (CG) limits are:

a. **Forward Limit:**

(1) **Up to 2300 kg.** 3927mm aft of the Datum point.

(2) **2300 to 3000 kg.** Limit moves linearly aft to 3963 mm aft of the Datum Point at 3000 kg.

b. **Aft Limit:** 4018 mm aft of the Datum point.

Note: The CG position is critical and to maintain CG within limits, either the crew composition may have to be changed, the aircraft changed for one of a different basic moment or, in the other extreme, mass may have to be carried in the baggage compartment.

3. The CG position is to be calculated before every flight taking into account the mass and moment of each crew member, the aircraft, fuel and baggage.

Mass

4. **Take-off and Landing.** The maximum mass for take-off or landing is 3000 kg.

5. **Baggage Compartment.** The maximum mass permitted in the baggage compartment is 20 kg. All items are to be tied down.

Airspeed

6. **Maximum Airspeeds.** The maximum airspeeds are:

   a. **Clean Aircraft:**

      (1) **Flaps and Landing Gear UP:** Sea level to 25,000 feet - 300 knots/0·54 M.

      (2) **Flight in Severe Turbulence:** 230 knots.

   b. **Operation of Airbrake and with Airbrake OUT:** 300 knots/0·54 M.

   c. **Flaps Selection and with Flaps Extended:**

      (1) **MID:** 175 knots.

      (2) **DOWN:** 145 knots.

   d. **Landing Gear:**

      (1) **Raising or lowering and with gear down:** 145 knots.

      (2) **Lowering using emergency system:** 120 knots.

Altitude

7. The aircraft is cleared for operation up to 25,000 feet.

Manoeuvre

8. The normal acceleration limits with landing gear and flaps UP and airbrake IN or OUT are:

   a. **Positive:** +6 g or onset of stall warning/natural buffet whichever comes first.

   b. **Negative:** minus 2·5 g.

   c. **Design never exceed limits:** +7/minus 3.3g.

Note: With the camera equipment (SEM 057) installed in the rear cockpit, the aircraft is limited to between +3g and minus 0·5g, because of the additional loading on the glareshield.

9. The normal acceleration limits with landing gear and/or flaps selected or extended are:

   a. **Maximum:** 1·7g while raising landing gear (above this value the retraction cycle is interrupted and resumes as g is relaxed); plus 2g (AUW up to 2900 kg) and plus 1.8g (AUW above 2900 kg) for all other conditions.

   b. **Minimum:** Zero g.

10. **Flight at Less than +0·5g.**

   a. A single period of steady, inverted flight is limited to 30 seconds, after which 3 minutes are to elapse before further manoeuvres at less than +0·5 g.

   b. Manoeuvring below +0·5g is limited to 20 seconds.

   c. The duration at (or close to) zero g (including vertical flight up and vertical flight down) is limited to 15 seconds. This is to ensure an adequate supply of oil to the propeller control, and fuel and oil to the engine.

d. Following excursions of more than 10 seconds below +0·5g, a recovery period of twice the exposure time is to be allowed before a subsequent excursion.

e. Only three successive excursions below +0·5g are permitted, unless an additional 60-second recovery period is applied.

CAUTION: If the propeller governor oil accumulator becomes exhausted, propeller pitch control is lost until normal oil pressure is restored. Known colloquially as `bogdown', the symptoms are a change in engine note, reducing RPM, reducing torque and rapidly increasing EGT. Unless rapid action is taken to throttle back and restore the oil pressure, engine overtemperature damage may result.

11. **Other Manoeuvre Limitations.**

a. **Flick Manoeuvres.** Flick manoeuvres (i.e. the application of full pro-spin controls in excess of 95 knots) are not permitted.

b. **Rolling Manoeuvres.** Rolling manoeuvres with up to full aileron applied are cleared through bank angles of up to 360° up to 280 knots; the normal acceleration at entry is to be between minus 1g and +4g. Above 280 knots gentle rolling manoeuvres only are permitted.

c. **Stalling.** Intentional stalling is permitted with the landing gear UP or DOWN and the flaps in the UP, MID or DOWN positions. In all cleared configurations the minimum height for stall entry is 4000 feet above ground level (AGL).

d. **Spinning.** Intentional spinning is permitted, subject to the following warnings and limitations and the advice in Part 3, Chapter 2:

WARNING 1: Failure to close the throttle to FLT IDLE in a developed spin may prolong or prevent recovery.

WARNING 2: Ailerons are to be kept as close to neutral as practicable throughout the spin and recovery.

WARNING 3: The rate of spin and the degree of oscillation during the spin exceed the limits laid down in Def Stan 00-970. These characteristics of the spin present a high risk of disorientation for the student pilot and for this reason, when intentional spinning is planned, the aircraft should be captained by an experienced Service pilot.

(1) The recommended maximum altitude for entry is 20,000 ft. The recommended minimum height for entry is 10,000 ft AGL plus 1000 ft per intended turn e.g. a two-turn spin should be entered no lower than 12,000ft AGL.

(2) It is recommended that, where possible, the aircraft be trimmed for straight and level flight down to 100 knots (erect spinning) or 115 knots (inverted spinning) to minimize control forces in the recovery.

(3) Erect spinning with up to 30% torque selected is permitted for spins to the left only.

(4) The maximum speed for application of pro-spin controls is 95 knots.

(5) Flaps, landing gear and airbrake are all to be retracted.

(6) Recovery action is to be initiated after the following maximum number of turns:

(a) Erect spin - Six.

(b) Erect spin with power selected - Four.

(c) Inverted spin - Four.

(7) The minimum height for commencing recovery is 7000 feet AGL. If recovery (i.e., rotation ceased and speed increasing) has not been achieved by 3000 feet AGL the aircraft is to be abandoned.

(8) Deliberate inverted spinning is permitted.

e. **Aerobatics.** General aerobatics in the clean configuration, within the limitations of the Release to Service, are permitted. However, the following are prohibited:.

(1) Aerobatics above 2900kg AUM.

(2) Flick manoeuvres.

Touchdown Sink Rate

12. The maximum permitted sink rate at touchdown is 690 feet per minute.

Tyre Limiting Speed

13. The maximum speed on the ground is 110 knots.

Taxy Distances

14. Taxying distances pre- and post-flight should be limited as follows:

a. For the first movement of the day, in ambient temperatures up to +30°C, there are no limitations on taxying distance.

b. When the turnaround time between flights is longer than one hour, the tyres may again be regarded as cool with an unlimited taxying distance.

c. When taxying prior to a second take off for a second or subsequent flight of the day within one hour of previous taxying movement, the taxy distance should be limited to 6 km.

d. For each 10°C decrease in ground level OAT below +30°C the one-hour turn around time in para 14c above may be reduced by 20 minutes.

CAUTION 1: The tyres do not have fusible plugs and taxying greater distances may overheat the tyres. Heavy brake usage (e.g. after a rejected take-off) results in even higher temperatures, therefore, groundcrew should not be allowed to approach the aircraft for at least 30 minutes after such braking.

CAUTION 2: The wheel brakes are not fitted with an anti-skid system. Heavy foot forces should be avoided. The brake friction pads should be changed following an aborted take-off where the brakes were applied above 70 knots.

Rejected Take-Offs

15. Take-offs may be safely rejected at any stage and at any mass up to MTOM (3000kg), although there is a likelihood of tyre burst should heavy braking be applied.

PART 2

CHAPTER 2 - ENGINE LIMITATIONS

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Engine Operating Limitations

1. The Garrett TPE-331-12B engine with engine electronic control (EEC) operative is cleared for operation subject to the limitations given in Table 2.

2. **Manual Engine Control.** With the EEC inoperative the maximum EGT is to be restricted to 560°C. Other limitations are as in Table 2.

3. **Propeller Limitations.** Propeller limitations are:

   a. Minimum idle: 71% RPM.

   b. Overspeed governor check: 105·5% RPM.

   c. Windmilling: See Table 1.

Table 1 - Propeller Windmilling Limitations

Propeller Speed (%RPM)	*Max Time* (Minutes)
100 to 28	1
28 to 18	One transient
18 to 10	5
10 to 5	30
5 to 0	Unlimited

Note: It is critical that the RPM does not stagnate within the band 18-28% as this is where resonance of the main shaft can occur with the consequential possibility of significant damage.

Table 2 - Garrett TPE-331-12B Operating Limitations

Operating Conditions	*EGT (°C)*	*Torque (%)*	*Propeller Speed (%)*	*Oil Temp (°C)*	*Oil Pressure (Bar)*
Ground Starting (Engine speed 70%)	770 (1)	-	80 (2)	Minus 40 (Minimum)	0 to 8.3 (3)
Ground Starting (Engine speed 100%)	770 (1)	-	104 to 106 (5sec)(4)(6)	Minus 40 (Minimum)	0 to 8.3
Airborne Relighting	770	-	104 to 106 (5sec)	Minus 40 (Minimum)	0 to 8.3
Ground Operations (Engine speed 70%)	560	100	72 to 73	110 (5)	2.8 to 8.3
Ground Operations (Engine speed 100%)	650	100	101 (6)	110 (5)	4.8 to 8.3 (7)
Ground Operations (Air Cond at BOOST)(8)	650	100	82±1	110 (5)	2.8 to 8.3
Reverse (Engine speed 70%)	560	81.8	-	110	4.8 to 8.3
Reverse (Engine speed 100%)	650	81.8	-	110	4.8 to 8.3
Take-off and all flight conditions unless otherwise stated	650	100	101	55 to 110 (5)	4.8 to 8.3 (8, 9 & 11)
Transient (Take-off and all flight conditions)	660 (5sec)	(10)	101 to 104 (30sec)(6)	127 (5)	2.8 to 8.3 (8)

Note 1: The start is to be aborted for any excursion above 770°C. Subsequently, observe the following:

a. If an excursion is less than one second and does not exceed 776°C another start may be attempted.

b. If an excursion is more than one second but less than three seconds and does not exceed 776°C another start may be attempted, but a power check is to be made before flight.

c. If 776°C is exceeded the aircraft is to be placed unserviceable.

Note 2: During the starting sequence it is important that the EGT limits are not exceeded and that the engine does not stagnate, particularly between 18 and 28%.

Note 3: Following cold soaks engine oil pressure may be slow to rise and may then briefly exceed 8·3 bar.

Note 4: Start locks are to be engaged for ground starting. 106% RPM is not to be exceeded. Five seconds transient between 104 and 106% RPM is permissible.

Note 5: Following cold soaks the start up oil temperature may not increase to 55°C until the engine has run at idle for up to five minutes. Ground operation with engine oil temperature above 110°C and up to 127°C is permitted provided the torque is less than 70%. A transient overtemperature to 127°C for take-off or during flight operations is permitted for up to five minutes provided the torque is reduced to less than 70%. For periods in excess of five minutes reduce the torque further to lower the oil temperature and land as soon as practicable. For overtemperatures between 127 and 150°C reduce the torque to the minimum possible for safe flight and land as soon as possible.

CAUTION: Operation with oil temperatures above 150°C may result in oil pressure loss and the resultant loss of propeller control.

Note 6: Propeller speeds between 101 and 104% RPM are permitted for up to 30 seconds only. 104% may be exceeded for five seconds to carry out overspeed governor checks.

Note 7: At idle the minimum oil pressure is 2·8 bar.

Note 8: If oil pressure falls outside (above or below) permitted pressure limits, reduce power to the minimum required for safe flight and land as soon as possible.

Note 9: During flight at less than +0·5g oil pressure indications decrease towards zero. For repetitive negative g and inverted flight manoeuvres in excess of 10 but less than 20 seconds there is to be an interval of normal oil pressure of at least twice the period of operation with subnormal oil pressure. The maximum time for a single period of inverted flight is 30 seconds, after which three minutes are to elapse before further manoeuvres at less than +0·5g.

Note 10: Selections to maximum power may cause a torque overshoot beyond 100% which is quickly recovered. Any torque overshoot that does not rapidly return to the 100% indication, or any transient torque overshoot greater than 115%, should be dealt with by reducing engine torque and the aircraft returned to base as soon as practicable. Torque overshoots greater than 106·5% lasting for longer than five seconds and torque overshoots of between 104·9% and 106·5% lasting for longer than 20 seconds should be dealt with by reducing engine torque and reporting the occurrence on return to base.

Note 11: At altitudes below or equal to 23,000 feet the minimum oil pressure is 4·8 bar. At altitudes above 23,000 feet the minimum oil pressure is 3·4 bar.

Approved Fuels

4. The approved fuels are given in Table 3 and Table 4.

Table 3 - Standard Fuels

NATO Code	*UK Joint Service Designation*
Standard Fuels. The following fuels are approved for normal use:	
F-34	Avtur/FSII
F-40	Avtag/FSII

Table 4 - Alternative Fuel

NATO Code	*UK Joint Service Designation*
Alternative Fuel. The following may be used as an alternative fuel:	
F-35	Avtur
Note: If AL48 (FSII and lubricity additive) is added to F-35 in accordance with DEFSTAN 68-150, then F-35 may be used without restriction. Without AL 48 in the correct proportion, F-35 may only be used at fuel temperature above 0°C.	

Approved Lubricant

5. The following engine oil is cleared for use: OX 27.

Ground Starting and Ground Running

6. **Surface Wind.** The maximum permitted surface wind conditions for engine start given in Table 5:

Table 5 - Engine Start Surface Wind Limits

a. Crosswind component	40 knots. Limit exposure to crosswinds from the left and monitor the oil temperature
b. Headwind component	40 knots
c. Tailwind component	15 knots

7. **Electrical Power for Starting.** The engine may be started using an engine-driven external ground power unit, the trolley battery electrical starter 4FE/5878721, or the internal aircraft batteries. Starting from any other external accumulator power source is not cleared. Following cold soaks at or below 0°C all starts are to be carried out using an approved ground power unit. Use of the internal batteries is to be limited to three start or dry crank cycles. Starts using internal aircraft batteries may be carried out in outside air temperatures between 0°C and minus 10°C provided that either:

a. The aircraft has not been exposed in the environment for more than two hours since leaving a heated hangar; or

b. The aircraft has landed from the previous flight not more than two hours earlier.

CAUTION: When starting the engine using internal batteries the starting cycle may be prolonged. Starts may not be achieved within 60 seconds and may result in rapidly increasing EGT which requires rapid shutdown action. Any start where the RPM stagnate should be aborted.

8. **Start Attempts.** Any start is to be aborted if self-sustaining RPM have not been achieved within 60 seconds. The starter/generator may be used for two failed starts or dry crank cycles each of 60 seconds followed by a successful start. A cooling interval of two minutes is to be observed between start attempts. If the third start attempt is unsuccessful a further cooling period of 15 minutes is to be observed before attempting further starts using the above sequence.

9. **Restarting After Shutdown.** Follow engine shutdown after a period of sustained running, observe a 10-minute cooling period before attempting to restart the engine. After any 10 to 30-minute period following shutdown, the propeller is to be turned by hand through 90° immediately before starting.

CAUTION: In the event of a failed start, fuel is dumped overboard via the engine bay combined drain system and could fall on a hot exhaust duct giving a potential fire hazard. In addition to the cooling period, during the restart, station a fire-watch adjacent to the right exhaust.

10. **Reverse Pitch.** Periods of ground running with REVerse pitch selected are be limited to five minutes subject to the oil temperature limitations. Between such periods observe a 30-minute interval.

Engine Handling

11. With EEC to NORMAL there are no restrictions.

12. Selection of MANual and reversion to NORMAL is permitted as required subject to:

a. Engine torque is to be at 30% or below when selecting EEC NORMAL to MANual and 20% or below when selecting EEC MANual to NORMAL.

b. The use of REVerse thrust is prohibited during landing with MANual selected.

c. After each reversion from MANual to NORMAL the pilot is to verify that the EGT is at or below 650°C.

Relighting

13. Relights should be attempted in the range 115 to 200 knots below 20,000 feet. If the oil temperature is less than +4°C the chance of a successful relight is lowered.

PART 2

CHAPTER 3 - MISCELLANEOUS LIMITATIONS

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Runway Surface

1. The aircraft may be operated from paved surface runways only.

Surface Wind

2. The following are the maximum permitted surface wind conditions for:

a. **Canopy Opening.** The maximum windspeed for opening the canopy is 40 knots. To avoid possible injury and/or damage to the structure external assistance is required when windspeed components exceed the following:

(1) Headwind - 25 knots.

(2) Tailwind - 25 knots.

(3) Crosswind from the left - 20 knots.

(4) Crosswind from the right - 15 knots.

WARNING: The canopy may blow closed, even in light winds, and cause damage to the structure and/or injury to occupants. Insert the canopy locking pin to prevent this.

b. **Engine Start.** See Chapter 2.

c. **Taxying.**

(1) Windspeed - 40 knots.

(2) Exposure to crosswind (particularly from the left when the oil cooler on the right intake is shielded by the aircraft nose) or tailwind components is to be kept to a minimum to keep the oil

temperature below 110°C. Additionally, crosswinds deflect engine exhaust over the downwind main wheel increasing tyre temperature.

d. **Take-off or Landing.**

(1) Crosswind component - 30 knots.

(2) Headwind component - 40 knots.

(3) Tailwind component - 10 knots.

Crew Changes

3. Crew changes, whilst the engine is running, are permitted. The engine must be running in reverse thrust, for the period that the canopy is opened, to limit carbon monoxide build up in the cockpit from engine exhaust entry. Since running in reverse thrust removes the flow of air through the engine oil cooler, the time limit for such running is five minutes within the overriding oil temperature limitations. Due to the possible presence of fumes, the incoming crew are to adopt the same procedure in the use of the environment conditioning system and the selection of 100% oxygen that they would have made for a normal engine start.

Aircraft Arresting Gear Trampling

4. The aircraft may cross tensioned arresting gear cables which are unsupported and in contact with the runway.

5. Taxying across rigged and supported arresting cables, with support discs at 6-foot nominal spacing, may be carried out at a slow walking pace, provided the landing gear doors are closed, the mainwheel brakes are off and the nose of the aircraft is aimed at midway between adjacent support disc. The aircraft may cross a retracted BAK-14 arrester cable support system without restriction.

WARNING: Taxying over a supported arresting cable is prohibited, with either a deflated nosewheel tyre and/ or following lowering of the landing gear using the standby system, because of the risk of unintentional engagement of the cable by aircraft structure.

Aircraft Arresting Barriers

6. The aircraft is not cleared to use aircraft arresting barriers.

Icing Conditions

7. The aircraft has a limited capability in icing conditions. The aircraft's surfaces are to be monitored for ice accretion, and if icing is suspected the aircraft is to be flown out of such conditions as soon as possible. Clearance to operate in icing conditions defined as \`light', \`light/moderate' or \`moderate' (Meteorological Office definitions) is subject to the exposure limits set out in Table 1 and the following conditions:

a. Where icing exists at ground level the aircraft may be operated for the periods annotated \`acceptable'; this covers total exposure during climb plus descent and approach in icing conditions, but not any time spent in non-icing conditions above the icing layer.

b. Where the icing level occurs at some altitude above ground level, such that it is possible to fly below the icing layer to assist the clearance of ice from the canopy prior to landing, the total exposure times may be extended to those annotated \`marginal'.

c. Flight in icing conditions is not to be continued into the region annotated \`unacceptable'.

WARNING: Exposure to icing conditions for periods longer than \`marginal' may result in ice covering the whole of the canopy. Furthermore, if the outside air temperature (OAT) is below 0°C, even out of icing conditions, ice may not clear adequately for the pilot to be able to see external references for landing.

8. Flight in icing conditions with the landing gear down should be kept to the minimum necessary for a safe take-off plus normal approach and landing.

Table 1 - Limitations for Flight in Icing

Met Office Icing Severity Grading	*Exposure Time (Minutes)*	*Resulting Forward Visibility*
Light	0 to 6 6 to 14 above 14	Acceptable Marginal Unacceptable
Light/Moderate	0 to 4 4 to 7 above 7	Acceptable Marginal Unacceptable
Moderate	0 to 2 2 to 5 above 5	Acceptable Marginal Unacceptable

Humidity/Rain

9. The aircraft may be operated with dew-points up to + 20°C. Provided the aircraft is fitted with all protective blanks/covers and the control column lock is engaged, the aircraft can be parked in heavy/driving rain. If exposure to heavy rain is expected to exceed 1 hour the canopy cover is also to be fitted.

Snow

10. The aircraft is not cleared for operation in snow or from surfaces covered with snow/slush. Unavoidable operations in snow/slush should be treated with caution. Accumulations of slush/ice in the recess below the operating cam for the nose undercarriage weight-on-ground switch may result in malfunction of the switch, with an inability to move the throttle aft of FLIGHT IDLE after touchdown.

Instrument and Night Flying

11. The aircraft is cleared for instrument flight in IMC and at night.

Aircraft Approach Criteria

12. **Approach Category.** The aircraft Approach Category is B.

Avionic Installations

13. The following avionic installations may be used subject to the Notes below:

a. Communications control system (Note 1).

b. V/UHF/STBY UHF systems (Notes 2, 3 and 4).

c. ILS/VOR (Notes 5 and 6).

d. Tacan (Note 7).

e. SSR transponders (Note 8).

f. Main and standby compass systems.

g. TCAS (Note 9).

Note 1: In conjunction with the Mk 4A and Mk 4D flying helmets.

Note 2: Operation of the V/UHF radios may induce disturbances to the engine instruments. These disturbances are not to the engine system itself.

Note 3: Above FL 160 at frequencies in the upper quarter of the UHF band, the maximum communication range is decreased in the head-on aspect.

Note 4: Communications quality may be degraded at frequencies in the upper quarter of the UHF band between aircraft aspects of 270° and 340° with the aircraft banked to the left, and between 020° and 090° with the aircraft banked to the right.

Note 5: VHF transmissions may deflect the localiser and VOR track deviation bar and cause the NAV flag to appear.

Note 6: UHF transmissions may cause the VERT flag to appear.

Note 7: UHF transmissions may cause interference and cause the NAV flag to appear.

Note 8: At intermediate ranges from an interrogator some loss of replies may occur.

Note 9: The TCAS installation does not detect or track aircraft which are not transponder equipped. Some traffic may not be displayed due to traffic prioritizing or antenna shielding. Evasive manoeuvres should not be attempted based solely on traffic information on the display. Information on the display is provided to the crew as an aid to visual acquisition and is not a replacement for ATC or see and avoid principles.

Electrical System

14. Before take-off the generator current is to be less than 100 amps with the landing lamps OFF.

15. If the generator fails, the electrical load is to be reduced to a minimum and the aircraft landed as soon as possible. Battery operation of the essential loads cannot be guaranteed for more than 30 minutes.

Air Conditioning System

16. The air conditioning system is cleared for use subject to the following:

a. AUTO should be selected before selecting ON.

b. The system is to be selected ON immediately following engine start.

c. The crew should be on 100% oxygen until after the air conditioning has been selected to BOOST after start. For ground operation with the air conditioning off, 100% oxygen should be used.

d. Ground running at OAT above 20°C should be limited to 20 minutes pre- and post-flight.

e. BOOST is recommended for all flight conditions.

f. MANual should only be selected if the temperature control system fails in AUTO. If shutdown of the air conditioning system is considered an unacceptable first course of action and operation on MANual becomes necessary, follow the procedures given in Part 1, Chapter 8.

g. RAM air may be used if the air conditioning system fails, but only when absolutely necessary.

WARNING: On some aircraft the air conditioning system efficiency may be degraded significantly by leakage at ducting joints. Under these circumstances, pilot heat stress could be experienced, particularly in high cockpit workload conditions at high speed, low level in ambient temperatures between +25°C and +30°C. For this reason, pending improvements to duct sealing design and air distribution in the cockpit, take particular care to avoid and/or recognize symptoms of heat stress during flights exceeding 15 minutes in these conditions.

CAUTION: The MANual selection supplies very hot air to the cockpit and temperature control is difficult. Repeated overheat shutdown of the system is very likely; this is accompanied by an AIR COND warning. Prolonged operation with MANual HOT selected could lead to failure of the front SSR transponder.

Fuel System

17. The fuel system tends to feed from one side or the other rather than together. Check before flight that all four booster pumps function normally and monitor the fuel gauges to ensure asymmetry does not exceed 100 kg.

18. **Suction Defuelling Point.** The suction defuelling point is not to be used for pressure refuelling. Nor is the point to be used for routine defuelling; its use is to be restricted to emergency defuelling if the landing gear has collapsed.

Ice Protection System

19. Limit periods of preflight checks of the ice protection system to four minutes to prevent overheating. When the ambient temperature is above 10°C the intake icing should not be used for more than 10 seconds.

Emergency Escape

20. **Ground Emergency Egress.** The canopy fracturing system using either internal or external handles is cleared only for ground emergency egress. It is not designed, or cleared, for airborne use.

WARNING 1: There is a significant risk of damage to the front occupant's aircrew equipment assembly (AEA) during ejection from fragments of the front canopy; there is also a risk of minor laceration injuries to the limbs. In particular, the integrity of immersion coveralls (inner or outer) cannot be assured. The extent of injuries is minimised by reducing ejection speed and by wearing maximum thickness AEA.

WARNING 2: The ejection seats were designed and cleared for the boarding weight range of 68.4 kg to 108.2 kg (nude weight plus AEA) and the 3rd to 99th percentile nude size range. Use by aircrew or passengers whose anthropometric weight and size ranges are outside these limits increases the possibility of ejection-related injuries.

WARNING 3: Night vision goggles are not to be used.

WARNING 4: Operators should be aware that, due to physiological differences, female aircrew may be more susceptible to ejection injuries when compared to their equivalent-weight male counterparts.

21. **Ejection.** The escape system using the Martin Baker 8LC1 and 8LC2 ejection seats is cleared for use throughout the flight envelope; at ground level the minimum airspeed for successful operation is 70 knots.

Note 1: The approved scale of AEA is contained in AP 108B-0001-1 Schedule No 9.

Note 2: The preferred speed for premeditated ejection is 115 knots.

Note 3: High sink rates, high roll rates and/or adverse roll attitudes have significant effects on the terrain clearance required for a successful escape.

22. **Command Ejection.** The command ejection facility is cleared for use.

Note 1: The command ejection system ejects the rear crew member first. To ensure adequate separation, particularly at low IAS, there is a 1·4 second delay before the front crew member is ejected. Aircrew should be aware of the need for such a delay, if the command ejection system has been selected OFF.

Note 2: Following command ejection and in the event of seat separation failure, the front seat pilot must first pull his seat firing handle before operating the manual separation handle.

Electromagnetic Compatibility

23. The aircraft is cleared for use in the external electromagnetic environment given in Table 2.

Note: At the field strength levels given for HIRTA Codes B and C, significant radio frequency-induced disturbances may occur to the engine instruments; these are not disturbances to the engine system itself.

Table 2 - EMC Field Strength Limits

Frequency Band	*Frequency Band Code*	*'OLD' (Previous) Low Flying Grade*	*Susceptibility Grade*	*Power Density / Field Strength Limit*
0.525 - 2.0 MHz	A	2	VERY LOW	Up to and including $26W/m^2$ (100V/m)
2.0 - 32.0 MHz	B	3	LOW	Up to and including $6W/m^2$ (50V/m)
32.0 - 790.0 MHz	C	3	MED	Up to and including $1 W/m^2$ (20V/m)
0.79 - 4.5 GHz	D	2	LOW	Up to and including $100 W/m^2$ (200V/m)
4.5 - 40 GHz	E	2	LOW	Up to and including $100 W/m^2$ (200V/m)
Fylingdales HIRTA:				
32.0 to 790.0 MHz	C	2	LOW	Up to and including $10 W/m^2$ (60V/m)

PART 3

HANDLING

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PART 3

CHAPTER 1 - STARTING, TAXYING AND TAKE-OFF

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General

1. The checks referred to in this chapter are listed in the Flight Reference Cards (FRC).

WARNING: The ejection seats and the MDC systems are a potential source of danger since their inadvertent operation can cause fatal injuries. Therefore, safety precautions are to be observed at all times, i.e. the aircraft is to be left either **Safe for Parking** or **Safe for Maintenance**, as applicable, as defined below:

a. **Safe for Parking.** Safety pins fitted to the ejection seat firing handle and the canopy fracture firing handle in each cockpit.

b. **Safe for Maintenance.** In addition to the safety pins fitted under sub para a, safety pins are also to be fitted to the manual override sears.

CG Calculation

2. The CG position in the Tucano is critical. It is easily possible to exceed the aft CG limit if the heavier crewmember occupies the rear cockpit and/or baggage is carried in the baggage compartment. Before every flight, determine the CG position to ensure that it remains within the allowable limit of 4018 mm aft of datum. The CG is closest to the aft limit at high and very low fuel states, therefore, the calculation should be carried out for maximum and minimum fuel states expected during the sortie.

3. To calculate the CG, determine the total moment using the aircraft moment (from Section 1 of the F700), the crew moments (Table 1), the fuel moment (Table 2) and the baggage moment (Table 3). Divide the total moment by the aircraft total mass to establish the CG position in metres aft of the datum point. For example:

Aircraft mass and moment: 2152.7 kg & 8499.23 mm
Crew: front 78 kg, rear 82 kg
Fuel: 540 kg
Baggage: 12 kg
Total Mass: 2152.7 + 78 + 82 + 540 + 12 = 2864.7 kg
Moment: 8499.23 + 262.9 + 391.1 + 2151.4 + 74.4 = 11379.03 kg.m

CG is 11379.03 divided by 2864.7 = 3.972 or 3972 mm aft of datum (within limits).

Table 1 - Crew Moment

Crew		
Boarding Mass (kg)	*Moment (mm)*	
	Front	*Rear*
64	215.7	305.3
66	222.4	314.8
68	229.2	324.4
70	235.9	333.9
72	242.6	343.4
74	249.4	353.0
76	256.1	362.5
78	262.9	372.1
80	269.6	381.6
82	276.3	391.1
84	283.1	400.7
86	289.8	410.2
88	296.6	419.8
90	303.3	429.3
92	310.0	438.8
94	316.8	448.4
96	323.5	457.9
98	330.3	467.5
100	337.0	477.0
102	343.7	486.5
104	350.5	496.1
106	357.2	505.6

Table 2 - Fuel Moment

Fuel			
Mass (kg)	*Moment (mm)*	*Mass (kg)*	*Moment (mm)*
20	74.7	300	1165.8
40	149.5	320	1244.8
60	224.4	340	1324.6
80	300.2	360	1404.7
100	377.2	380	1485.0
120	454.6	400	1565.2
140	532.4	420	1646.4
160	610.7	440	1729.2
180	689.8	460	1811.0
200	768.0	480	1895.0
220	847.4	500	1980.0
240	926.4	520	2065.4
260	1005.7	540	2151.4
280	1086.4	545	2172.9

Table 3 - Baggage Moment

Baggage	
Mass (kg)	*Moment (mm)*
2	12.4
4	24.8
6	37.2
8	49.6
10	62.0
12	74.4
14	86.8
16	99.2
18	111.6
20	124.0

Preparation for Flight

4. On arrival at the aircraft carry out the **Initial, External, Cockpit, Ejection Seat** and **Pre-Start** checks. Do not waggle the controls during the **External** checks.

WARNING: The propeller poses a serious potential source of danger. Personnel entering the arc of a rotating propeller may suffer fatal injuries. Therefore, safety precautions are to be observed at all times. The propeller must be treated as live whenever electrical power is applied to the aircraft. Particular care should be taken following any failed start attempt.

5. To achieve the design eye point, adjust the height of the seats as follows:

a. In the front cockpit, with the head held naturally (not against the headbox), the engine cowl should just be visible between the AOA indicator and the accelerometer. However, for LCC safety clearance reasons, there must be at least room for a closed fist between the top of the helmet and the canopy.

b. In the rear cockpit the attention-getters must be visible and there must be room for a flat hand between the top of the helmet and the canopy.

c. If the propeller rotates instantaneously when the batteries are switched on then switch batteries off and disconnect external power.

Starting the Engine

6. Before every start:

a. Rotate the propeller through 90°; this is to overcome a problem caused by uneven internal cooling. It also permits a check for possible compressor rub and allows inspection of compressor blades.

b. Consider surface wind limitations (see Part 2, Chapter 2); if the tail is into wind, the start may be hotter than normal.

c. There are to be no personnel or equipment near the propeller and the ground surface is to be free of loose objects, small stones, etc.

d. The canopy is to be closed and locked.

Note: Toxic exhaust fumes can enter the cockpit as soon as the engine is running, therefore, 100% oxygen is to be selected before engine start.

7. Start the engine in accordance with the FRC. Once initiated, control of the starting system is automatic, but can be manually cancelled at any time during the cycle.

8. Engine light up normally occurs within 10 seconds of start initiation. During the start the EGT steadily increases to about 670°C and then fluctuates in pulses of approximately 20°C around 690°C, caused by the EEC scheduling fuel enrichment. The highest EGT normally reached is approximately 700°C at approximately 38% RPM. If the EGT rises rapidly through 730°C or is likely to exceed 770°C, select the EMERG SHUT DOWN lever to OFF/FEATHER and the START switch to STOP.

CAUTION: If the propeller start locks are not engaged, EGT rise is very rapid and may exceed the limit unless the start is terminated promptly.

9. Ignition cuts out at approximately 60% RPM and the engine RPM stabilizes at 72 to 73% with an EGT approximately 450°C.

Failure to Start

10. If the engine fails to start at the first attempt, refer to the **FRC Engine Start** drill. If all switches and indications are correct, the most likely cause of failure is the power supply, which should be changed. The starter motor is limited to a maximum of 3 starts (including dry cranks), each of up to 60 seconds duration at 2-minute intervals, followed by a 15-minute rest period.

Checks after Starting

11. Carry out the **After Start** checks.

Taxying

12. Carry out the **Taxy** checks. The initial selection of REVerse brings the propeller out of the start locks. During taxying use the throttle in the beta range to control forward speed; little or no use of wheelbrakes is necessary. Nosewheel steering gives precise directional control. Differential braking should not normally be used. The view from both cockpits is good to the front and the sides.

13. Carry out the **Checks Before Take-Off**.

Take-Off Procedures

14. **Normal Take-Off.**

a. The normal configuration for take-off is with the flaps set to MID.

b. Align the aircraft on the runway with the nosewheel straight (rudder bar central), and fully apply the wheelbrakes. Carry out the **Runway Checks**.

c. Before take-off select the ENGINE SPEED switch to 100%. When lined up select 20% torque and ensure that RPM are 100 ± 1%, EGT is increasing and oil temperature and pressure indicate in the green sectors. Release the brakes and smoothly apply full power (approximately 87% torque in ISA sea level conditions). Torque rises quickly; the maximum permitted torque is 100% with a maximum overswing of 115%. RPM may reach a transient maximum of 101-104% for up to 30 seconds. The EGT, rising more slowly than the torque, may overswing to a maximum of 660°C for 5 seconds, before settling at the red line maximum of 650°C. Keep straight with rudder/nosewheel steering; initial directional control requires right rudder. Check that the maximum values of torque and EGT are not exceeded (see Part 2, Chapter 2).

Note: Depending on conditions, the EEC will limit the engine output either at 100% torque or at 650°C EGT. The engine is serviceable if either torque or EGT is at its limit.

d. At 80 knots, smoothly rotate to the take-off attitude (about 7° nose up). When safely airborne retract the landing gear and flaps. Pitch and roll trim changes are negligible, but directional trim changes rapidly with speed and, by approximately 110 knots, the rudder is in trim with the take-off setting of 3 divisions right rudder.

15. **Maximum Performance Take-Off.**

a. Open the throttle to full power against the wheelbrakes, releasing them either when full power has stabilized or when the brakes begin to slip.

b. At V_R (obtained from AP101B-4901-16, the Tucano T Mk 1 Operating Data Manual) firmly and smoothly rotate the aircraft to a 15° nose-up attitude. When safely airborne, retract the landing gear. When clear of obstacles, retract the flaps.

16. **Flapless Take-Off.** If a take-off is made with flaps UP, initiate rotation at 85 knots and select 10° nose up. Other than the slightly longer ground roll, there is little difference from a normal take-off.

17. **Crosswind Take-Off.** Crosswinds from the right reduce the need for right rudder during the initial take-off roll; crosswinds from the left increase the need. Normal take-off technique is recommended with some into-wind aileron applied to maintain wings level. If a maximum performance take-off is required and the crosswind component is greater than 20 knots from the right, full power against the wheelbrakes may cause the right wing to lift and the aircraft to skip to the left. In this event reduce power by 10 to 20% torque and release the wheelbrakes before opening the throttle fully.

18. **Abandoned Take-Off.** To abandon take-off set the throttle to full REVerse, and use wheelbrakes as necessary. To stop in the minimum distance, use the emergency braking technique (see Part 3,Chapter 3).

Loss of Power after Take-Off

19. Tucano engine failures are rare, but failure of the electronic control system, resulting in total loss of power, is more commonplace. Although there is only a short delay following selection of the EEC to MANual mode before power is restored, the time taken to analyse the failure and react to it may place the aircraft at risk, if the failure occurs just after take-off.

20. Following a loss of power after take-off, the best course of action depends on several factors, such as:

a. Height, position and speed at which the failure occurs.

b. Runway length and nature of overrun area.

c. Undercarriage position and nature of emergency.

d. Aircraft mass.

e. Wind velocity, visibility and cloud base.

f. Status of crew (e.g. passenger, student navigator).

g. Position of obstructions and inhabited areas.

h. Position of other aircraft that may prevent a turnback.

21. The actions following a loss of power should be discussed during the take-off emergencies brief in accordance with the following general guidelines:

a. **Gear Down and Runway Remaining.** If the gear is down and there is sufficient runway ahead, abandon the take-off or land straight ahead.

b. **Gear Selected UP and Below Turnback Parameters.** Once the gear has been selected UP, but the aircraft is below turnback parameters, land straight ahead or eject. If height permits, check the RPM. If it is stable, carry out the **FRC Engine Control Malfunction** drill, it may be preferable to leave full power applied while selecting EEC to MANual and accept the resulting EGT exceedance. Ejection below 100 knots is possible within the seat limitations, but the decision to eject must be immediate.

c. **Above Turnback Parameters.** Check the RPM; if it is decaying, attempt a turnback or eject. If the RPM is stable, carry out the **FRC Engine Control Malfunction** drill.

22. **The Turnback.** The turnback parameters of 130 knots and 500 feet are the minimum requirements to initiate a turnback, assess the likely outcome and make a decision by 300 feet AGL to either continue the manoeuvre or eject. The minimum turnback parameters do not guarantee a successful forced landing. The 2 methods of flying the turnback manoeuvre are as follows:

a. **Direct.** The direct method is used when the aircraft is relatively distant from the airfield as will occur when operating from a short runway in light winds.

(1) Select the ESDL to OFF/FEATHER.

(2) Fly a turn at 45° of bank into any crosswind, maintaining a minimum of 115 knots clean and 110 knots with MID flap.

(3) Lower MID flap to enable the stick shaker as additional stall warning.

(4) Make a brief distress call.

(5) When the airfield is in view, assess whether a successful forced landing is likely.

(6) If the decision is to eject, turn away from built-up areas and eject by 300 feet AGL. If the decision is to continue, lower the landing gear on the standby lowering system and complete the remainder of the **FRC Emergency Shutdown** drill.

b. **Dumb-bell.** The dumb-bell method is flown if the aircraft is so near to the airfield that insufficient runway will remain after completing the turnback manoeuvre. This will occur in strong winds or after overshooting. The dumb-bell expends the excess energy to leave more runway available for landing.

(1) Select the ESDL to OFF/FEATHER.

(2) Fly a turn at 45° of bank away from any crosswind. When 45° off runway track, reverse the turn to line up with the runway. Maintain a minimum of 115 knots clean and 110 knots with MID flap.

(3) Proceed as in sub para 22a(3) to 22a(6) above.

23. **Practical Considerations.** It is not possible to cater for every combination of circumstances that apply during a turnback. The sole imperative is a timely decision to eject. Ejection seat performance data show that 300 feet AGL is the minimum height for a safe ejection given reasonable combinations of crew, dive angle, angle of bank, rate of descent and type of emergency. However, any delay in ejecting (such as may occur if, for example, a passenger occupies the rear seat) may put the second ejectee out of seat limits. The take-off emergencies brief should address the circumstances that pertain to each situation. The geometry of the ejection may be improved by arresting the rate of descent, but it takes time to do so. Finally, consider the likely area of aircraft impact if abandonment becomes necessary and allow time to minimise the hazard to others before ejecting.

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PART 3

CHAPTER 2 - HANDLING IN FLIGHT

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ENGINE AND PROPELLER CONTROL AND HANDLING

Engine Electronic Controller

1. The Engine Electronic Controller (EEC) is a component of the engine control system. With the EEC switch selected to NORMAL, the EEC manages both fuel and propeller blade angle to provide single lever control throughout the flight envelope and carefree engine handling with automatic torque and EGT limiting. In the event of malfunction, the EEC can be isolated by switching the EEC switch to MANual; in this mode, fuel flow is controlled by a mechanical linkage from the throttle.

2. **EEC NORMAL Mode.** In NORMAL mode the throttle demand is passed through the EEC to the FCU, the EEC signal being proportional to throttle position. The EEC automatically restricts the demand if maximum values of EGT or torque are approached. For example, on take-off in ISA conditions, the EEC limits the power with full throttle to 650°C EGT with a corresponding torque of approximately 87%. Fig 1 shows the approximate regions of EEC limiting at maximum power, ISA conditions. The limiting regions change with ambient temperature; the EGT limited region decreases at temperatures below ISA and increases at temperatures above ISA. Fig 2 shows the approximate value of torque versus altitude in ISA conditions at maximum power and an IAS of 150 knots.

3. **Switching to MANual Mode.** Set 30% torque, if practicable (or throttle to mid-quadrant if the torque does not respond to throttle movement) and switch the EEC to MANual mode. The immediate response to a selection of MANual varies from aircraft to aircraft, but may be accompanied by a marked torque reduction that results in rapid deceleration. Advance the throttle to restore power and confirm that the EEC caption is illuminated.

4. **Flight in MANual Mode.**

a. In MANual mode the throttle is linked directly to the FCU and normal torque and EGT limiting are not available. Care is needed to ensure that the MANual EGT limit of 560°C and the torque limit of 100% are not exceeded. There is no limitation on the rate of throttle movement. Thrust pulsation and NTS operation are likely at FLT IDLE in MANual mode; if they occur, advance the throttle to increase fuel flow.

b. For most throttle positions forward of GND IDLE, but short of MAXimum power, the MANual mode gives about 15 to 20% less fuel than the NORMAL mode. Therefore, higher throttle positions are necessary to achieve the required power in MANual mode. However, at or near MAXimum power settings, under certain ambient conditions, fuel flow may be increased in MANual mode, potentially resulting in a temperature exceedance. Additionally, the response of the torque gauge to throttle movement is less damped and it is more difficult to set the torque accurately.

c. The response of the EGT to throttle movement differs widely between aircraft. On some aircraft, the EGT is very responsive, and indiscriminate opening of the throttle will result in the EGT exceeding the 560°C limitation. Similarly, the maximum power available within the EGT limitation varies from aircraft to aircraft. As a precaution, in the circuit, 50% torque should be considered as the maximum power available without risk of exceeding the EGT limitation. As height increases, the EGT for a given torque setting increases, and the EGT limitation may be exceeded at power settings below 50% torque.

d. If the EEC has failed and flight is to be continued with the EEC in MANual, comply with the following considerations:

(1) Land as soon as practicable.

(2) Below 10,000 feet, the maximum power available, without risk of overtemperature, is 50% torque.

(3) The maximum permissible EGT is 560°C. Automatic limiting is not available and the EGT must be controlled with the throttle.

(4) Do not select throttle to REVerse on landing or shutdown.

(5) Shut down when clear of the runway to prevent engine overtemperature and brake overheat.

CAUTION 1: Should the EEC trip to MANual, especially at high power selections, there is a risk that the manual limit for EGT (560°C) will be rapidly exceeded. Therefore, in the event of an automatic trip to MANual, power demand should be reduced promptly.

CAUTION 2: The throttle is not to be moved aft of GND IDLE when in MANual mode. Serious damage to the engine may occur if this limitation is not observed.

5. **Reversion to NORMAL.** For training purposes, switching between NORMAL and MANual may be carried out as required. Before selecting EEC NORMAL from MANual, ensure that 20% torque is set. On selecting NORMAL, power increases suddenly and the aircraft may be difficult to control. For this reason, reversion to NORMAL should not be carried out close to the ground or in formation. Confirm that the EEC caption has gone out. Apply full power and ensure that EGT is controlled at 650°C.

6. **Single Switch Control.** To allow the rear seat pilot to select EEC to MANual promptly, the aircraft should be flown with the rear cockpit EEC switch set to MANual. The rear seat pilot can thus switch the EEC to MANual by selecting the MASTER ENGine SWitch to REAR.

CAUTION: Except in emergency, the setting of the MASTER ENGine SWitch should be not be altered after engine start, as damage to the engine may result.

Engine Handling

7. The engine is not to be shut down from a high power setting except in emergency.

8. The start switch in each cockpit should be selected to RUN, in accordance with the FRCs.

CAUTION: Whilst airborne, if STOP is selected in the cockpit which has engine control, the EEC is turned off. This will result in the EEC reverting to MAN without any associated CWP warning.

9. Slam throttle advances up to MAXimum power are permitted throughout the flight envelope, in NORMAL and MANual modes. The power takes approximately 3 seconds to increase from FLT IDLE to MAXimum in either mode at indicated airspeeds above 100 knots; below 100 knots power increase is slower, particularly in NORMAL mode.

CAUTION: A slam throttle advance in MANual mode may result in the EGT exceeding the 560°C limitation.

Flight at Less than + 0.5g

10. The limitations on flight at less than + 0.5g (see Part 2, Chapter 2) are principally due to the lack of supply of high pressure engine oil to the propeller pitch change mechanism at less than +0.5g. Under these conditions, oil is supplied to the pitch change mechanism by the oil accumulator which has a limited capacity. Once this supply is used up, propeller pitch control is lost and the engine will bogdown (see Part 1, Chapter 4, para 85). If this occurs at a high power setting, engine overtemperature is inevitable.

11. To avoid exhausting the oil accumulator too quickly, do not move the throttle excessively while experiencing less than +0.5g and while the accumulator is recharging; the accumulator will only recharge when the oil pressure is in the green. In addition, oil pressure is required to maintain the correct propeller pitch during speed changes; if large speed changes occur during flight at less than +0.5g, the accumulator is exhausted more quickly and replenishment, once oil pressure is restored, takes longer. The limitations on flight at less than +0.5g reflect these considerations by increasing the recharge time in proportion to exposure time.

WARNING 1: There is a flow out of the accumulator under all g conditions. Consequently, even small excursions of 10 seconds or less may eventually lead to loss of propeller pitch control, if repeated often without allowing sufficient time for accumulator replenishment.

WARNING 2: Under prolonged conditions of flight at or near zero g, the ball valve that acts to shut off the engine oil breather is able to float freely. Engine oil may escape from the engine if the zero g limitation is not observed.

Thrust Pulsation

12. The negative torque sensing (NTS) system detects negative torque and signals the propeller to move towards feather. NTS operation is felt as longitudinal pulsing which occurs approximately every 2 seconds.

13. Thrust pulsation may be felt during aerobatics when accelerating under gravity with the throttle at or near flight idle, e.g. after a stall turn. It is also evident at low throttle settings with the EEC in MANual or with intake ice protection ON. To stop the NTS operating under these circumstances, move the throttle forward.

14. NTS pulsing also occurs during the rundown following engine flameout and during the run up whilst relighting. Operation of the NTS system also operates the ignition system to provide an automatic relight capability in the event of a fuel interruption or flameout. The IGNITER ON indicator light illuminates during NTS operation and may remain lit for up to 10 minutes afterwards.

Engine and Propeller Icing

15. The aircraft can be operated for short periods in icing conditions (see Part 2, Chapter 3).

GENERAL HANDLING

General

16. The aircraft is very responsive to control inputs throughout its speed range. The elevator and ailerons are light and precise. Rudder loads can be quite high, and accurate directional control needs anticipation to counter the trim changes that occur with speed and power variations. The forward view from both cockpits is good but the rearward view is restricted by the fuselage and ejection seat.

Climbing

17. Full power is used for the climb; recommended speeds are 150 knots to 10,000 feet, 140 knots to 20,000 feet and 130 knots above 20,000 feet. For the maximum rate of climb, set full power and climb at 127 knots from 500 feet reducing by 1 knot per 2000 feet increase in altitude to a minimum of 115 knots.

Flying Controls

18. **Ailerons.** Roll control is good throughout the speed range with light forces. Roll performance is good with rolls to the right being slightly slower than rolls to the left due to torque effect.

19. **Elevator.** Pitch control is light and responsive with a linear variation of stick force with g.

20. **Rudder.** When in trim the rudder forces are light at very low speed and become progressively heavier as speed increases. Application of rudder produces only a small rolling moment, but large rudder deflections cause a marked pitch down as the tailplane is yawed out of the influence of the propeller slipstream. The low speed and high power condition requires approximately half right rudder deflection (4 divisions of right rudder trim). The high speed with low power condition requires a few degrees of left rudder (0·5 division of left rudder trim) to maintain the aircraft in balance. Between these extremes, the required rudder position changes more at low speed than at high speed.

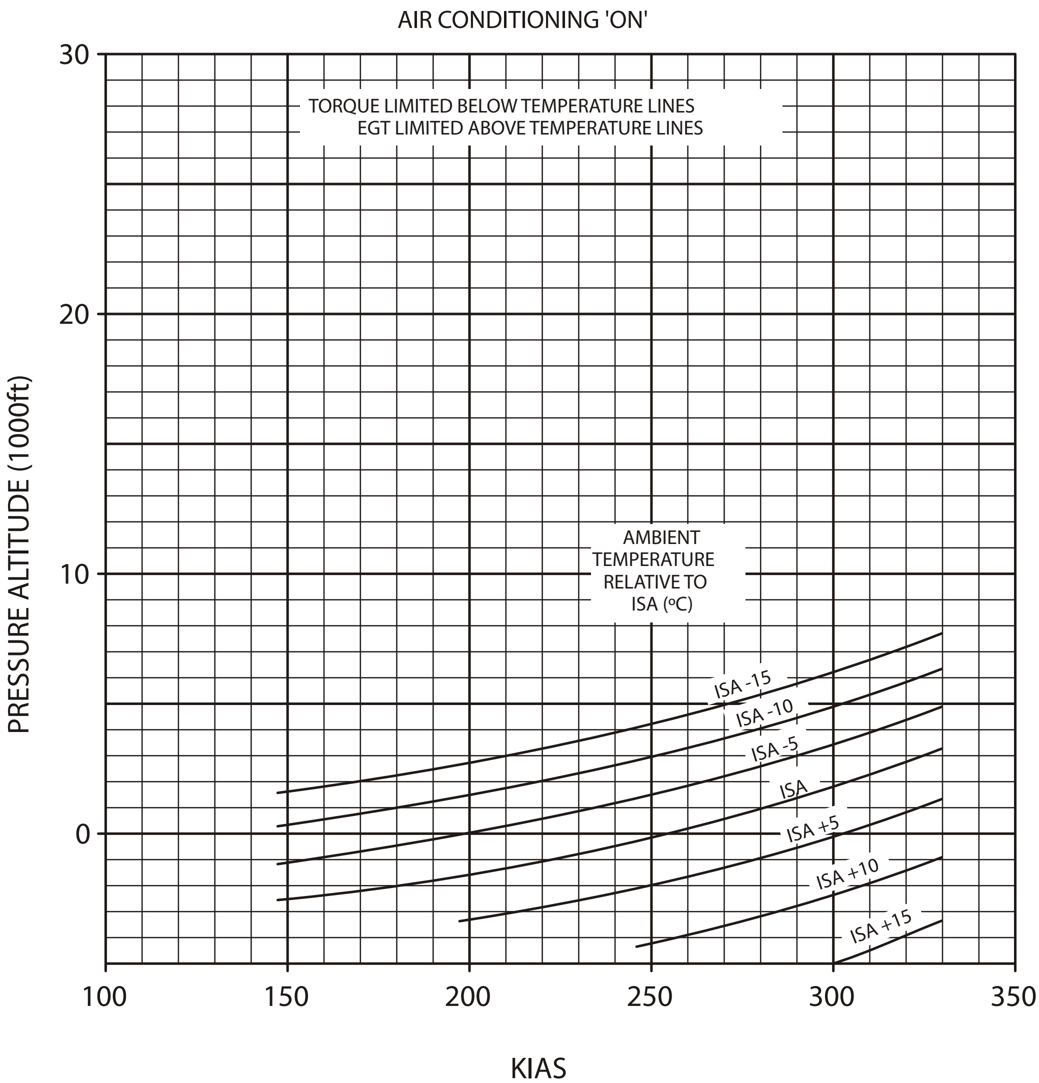
Changes of Trim

21. **Flaps.** Lowering the flaps to MID at about 150 knots causes a small but easily controlled nose-up trim change. Selecting flap DOWN produces an additional nose-up trim change. Raising the flaps from DOWN to UP results in a nose down trim change. Because of the awkward location of the flap lever, especially in the rear cockpit, and because the lever feels heavy to move, mis-setting of the flaps is possible. Take care when selecting flaps particularly from UP to MID where it is possible to overshoot to DOWN and thus overstress the flaps.

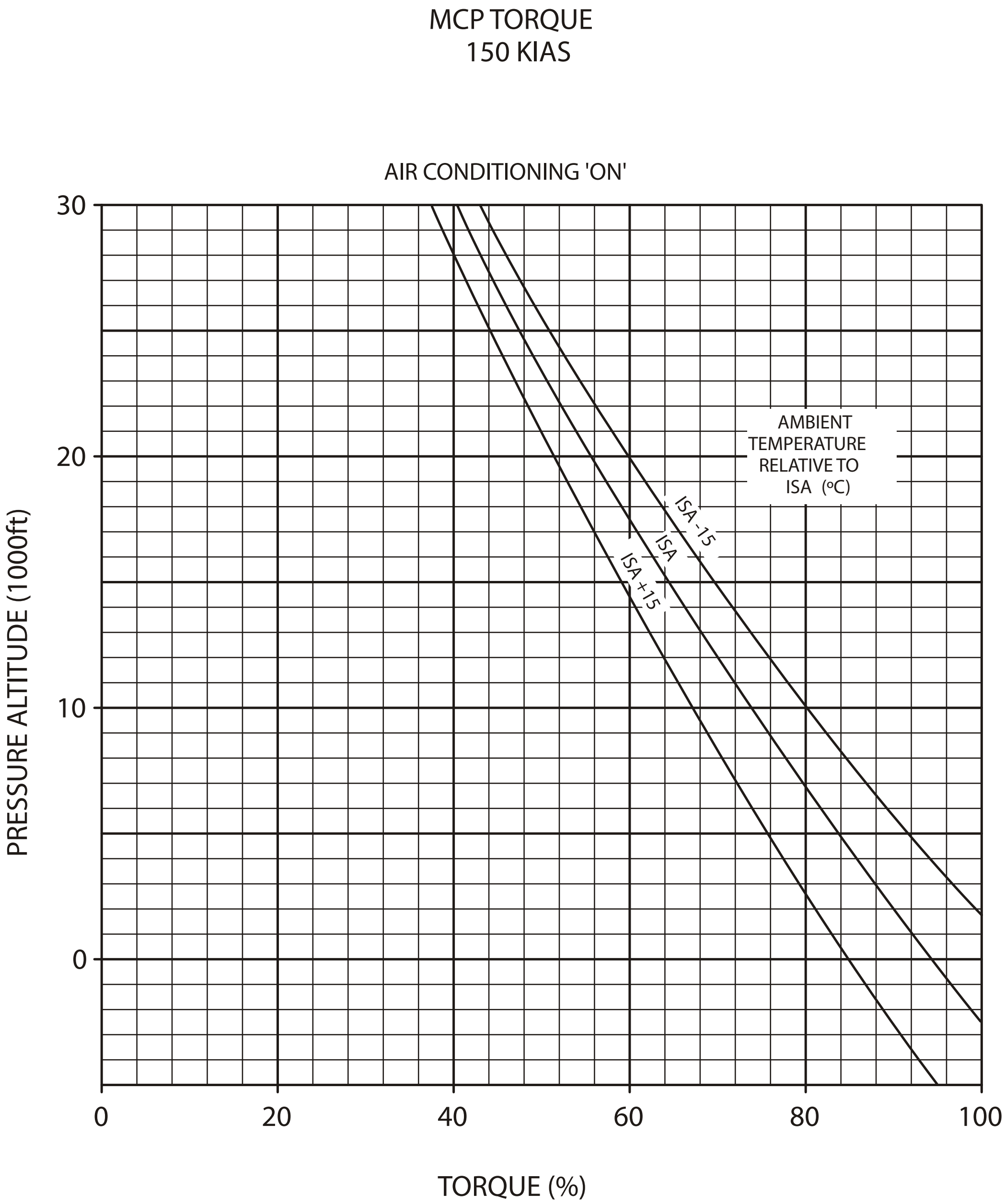
22. **Landing Gear.** Operation of the landing gear causes small disturbances in pitch and yaw with a negligible trim change.

23. **Airbrake.** Trim changes following airbrake operation are insignificant below 150 knots. As speed is increased above 150 knots the trim changes increase and in general are more marked on retraction than on extension. By 300 knots the nose-down pitch transient on retraction is quite sharp followed by a small residual nose-down change; the transient nose-up pitch change on extension is not so sharp, although it is of longer duration and there is a small residual nose-up change. The control column force required to resist these trim changes is small.

EGT/TORQUE LIMITS



3 - 2 Fig 1 Approximate Regions of EEC Limiting at Maximum Power



3 - 2 Fig 2 Approximate Change of Maximum Power Torque with Altitude

24. **Power.** Changes of power cause changes to pitch trim (see para 27) and have a large effect on directional trim particularly at low speed. At 80 knots, application of MAX power from FLT IDLE causes a marked yaw to the left which requires approximately half right rudder deflection to counter with moderate foot loads; full (5 divisions) right rudder trim is required to re-trim. Selection of power from MAX to FLT IDLE has the reverse effect. As speed is increased, the effect of power changes reduces and moderate foot loads are required to remain in trim.

25. **Acceleration and Deceleration.** As speed is increased, nose-down trimming is required to maintain level flight, together with directional trimming to the left. During decelerations the required trim changes are reversed, becoming more pronounced in the low airspeed range.

Flying at High Mach Number

26. The handling and behaviour of the aircraft relate to the indicated airspeed except that roll control becomes more sensitive at high Mach number.

Low Speed Handling

27. **General.** The low speed behaviour of the aircraft is docile; the aircraft is fully controllable down to the point of stall (CL Max) and the controls remain effective even beyond the stall. Recovery at all stages is immediate when the control column is moved forward; however, use of power causes a nose-up trim change. The unaccelerated stalling speed at any mass with FLT IDLE power is shown at Fig 3. Table 1 summarises the onset speeds of audio warning, stick shaker and airframe buffet, and the speed and AOA at the stall, in different configurations, at a mass of 2500 kg. Variations in the position of the centre of gravity have no noticeable effect.

28. **Clean Configuration, Flaps and Landing Gear UP.** The first indication of an approaching stall is the audio warning, followed by the onset of buffet. As speed is decreased, buffet increases and some slight lateral unsteadiness develops; this is easily controlled with ailerons. At the stall, the buffet level becomes moderate, the nose drops, a gentle wing drop may occur, and a high sink rate develops. The stalling speed varies slightly depending on the rate of deceleration. Beyond the stall, with the control column fully back, the nose slowly pitches down, although the aircraft can be flown in the fully developed stall using conventional techniques. However, the IAS slowly increases to about 85 knots, mild pitch oscillations may occur, and the airframe buffet remains moderate.

29. **Flaps and Landing Gear DOWN.**

a. **Landing Gear DOWN and Flaps MID.** With landing gear DOWN and flap at MID, the first indication of an approaching stall is the audio warning, followed quickly by the stick shaker. Light airframe buffet may be felt before the aircraft stalls. Beyond the stall, the behaviour is similar to that described for the clean configuration, but the sink rate is greater.

b. **Landing Gear and Flaps DOWN.** With landing gear and flap DOWN, the stall characteristics are similar to those with MID flap, except that there is almost no pre-stall airframe buffet. Beyond the stall, the behaviour is similar to that previously described in sub-para 29a, but the sink rate is even greater.

30. **Airbrake.** Low speed handling characteristics with the airbrake extended are little different from those of a clean aircraft, except that there is an associated slight level of buffet, which tends to mask the buffet onset by about one knot as speed is decreased towards the stall.

31. **Recovery.** Recovery at any stage is immediate upon moving the control column forward. Application of full power accelerates the aircraft rapidly out of the stall with no pitch change being required, though there is a large nose-up trim change. If a marked wing drop develops from a stall with flaps DOWN, the resulting speed rise on recovery may cause the flaps and landing gear speed and g limits to be exceeded; therefore, use reduced power on recovery from such stalls to keep within speed and g limits.

Accelerated Stalls

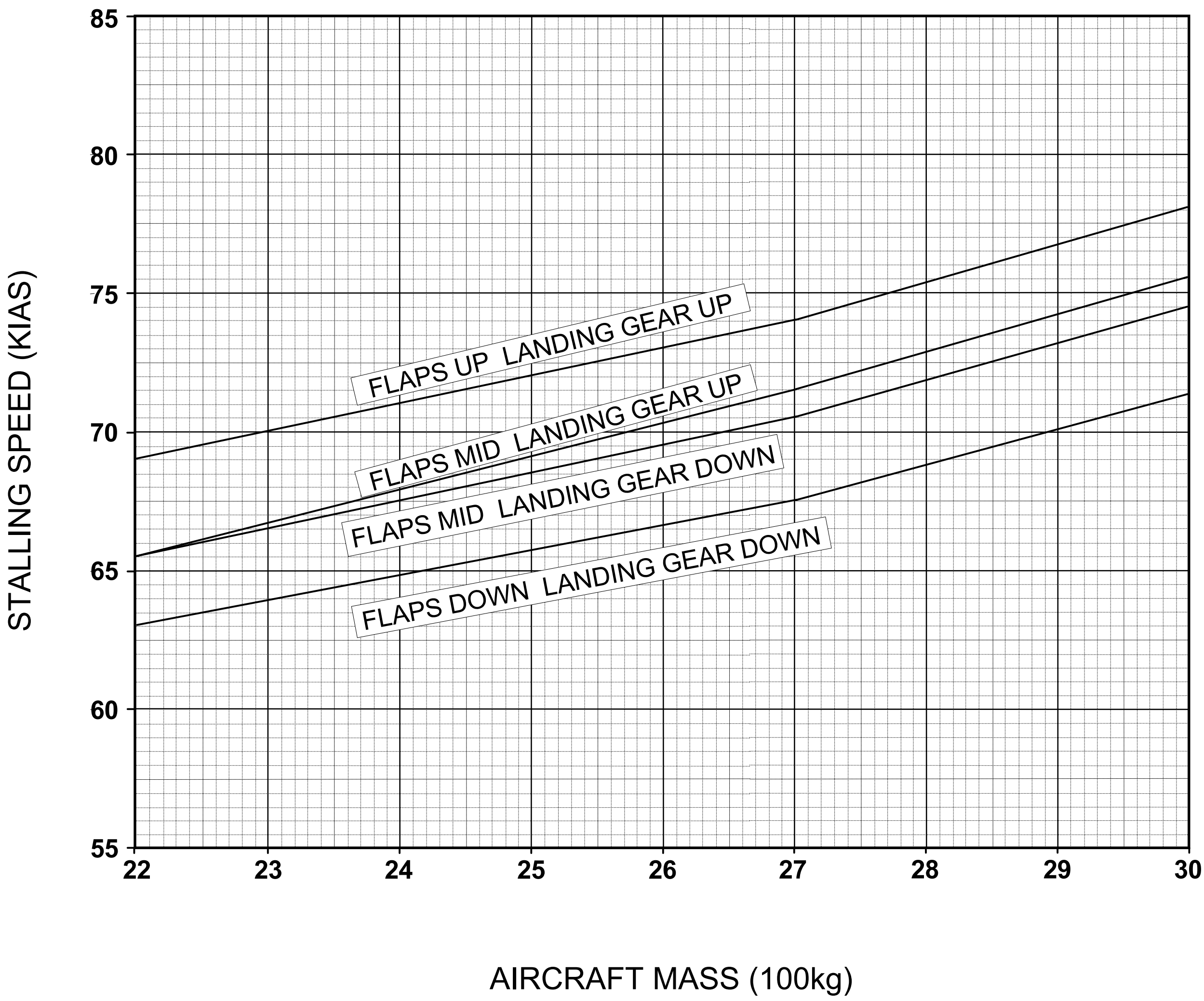
32. There is normally a small, though very clear, buffet boundary that provides a good natural warning of the stall at all altitudes. The usual stall characteristics are moderate to heavy buffet, a reduction in pitch rate,

mild pitch nodding and, sometimes, a wing drop. Recovery from the stall is immediate on easing the control column forward.

WARNING: A very abrupt wing drop, which rolls the aircraft through up to 90° in about 0·5 second, may occur. Flight testing on a limited sample of aircraft has normally shown this to occur shortly after entering buffet, although abrupt wing drops have been experienced at medium altitudes and above without prior buffet or audio stall warning. Rotation ceases immediately upon relaxation of the back pressure on the control column. If the roll is in the direction of turn the aircraft is placed inverted or semi-inverted and 20° to 30° nose down.

Table 1 - Buffet Onset and Stalling Speeds (AOA) at 2500 kg AUM

Configuration	*Nominal Torque %*	*Audio Warning Speed (AOA)*	*Control Column Vibration Speed (AOA)*	*Buffet Speed (AOA)*	*Stall Speed (AOA)*
Flaps - UP, Landing Gear - UP	Flight Idle	80(14)	N/A	74(16)	72(20)
Flaps - MID, Landing Gear - DOWN	Flight Idle	77(14)	75(15)	72(17)	69(21)
Flaps - DOWN, Landing Gear - DOWN	Flight Idle	72(14)	70(15)	67(20)	66(23)
Note: Stall speeds are dependent on AUM (see Fig 3); AOA values are independent of AUM.					



Note: Airspeed tolerance is +0, minus 3 knots

3 - 2 Fig 3 Stalling Speeds

Spinning

33. **General.** The aircraft is spin resistant, but can be made to spin by using the recommended technique. The spin characteristics are inconsistent and often oscillatory but, in all cases, the spin recovery actions are effective (see para 37).

CAUTION: If the rudder pedals are adjusted to the fully forward position, it is possible to trap the welt of the front seat pilot's right boot heel between the pedal and the floor structure, when full right rudder is applied. Pilots with long legs should keep the heel of their right boot to the outside of the arc of rudder pedal movement.

Note 1: During spins at high aircraft masses, increased rotation rates and control forces will be experienced.

Note 2: See Part 2, Chapter 1 for limitations on spinning.

34. **Normal Erect Spin.**

a. **Before Entry.** Before intentionally entering a spin, trim the aircraft for straight and level flight down to 100 knots.

b. **Entry.** Between 80 and 95 knots, enter the spin by smoothly and progressively applying full rudder in the intended direction of the spin and simultaneously moving the control column fully aft, ensuring that the ailerons remain neutral.

c. **Spin Characteristics to the Left.** As the aircraft enters the spin, the nose rises to about 16° nose-up and yaws in the direction of the applied rudder. During the first turn, which takes about 4 seconds, the nose drops to about 50° to 60° nose-down and the aircraft rolls rapidly in the direction of yaw. Hesitations about all 3 axes may become apparent after the first half turn, increasing in amplitude with each successive turn. These hesitations are accompanied by rudder tramping and aileron snatching, and the forces required to maintain full pro-spin controls can be high. To minimize the aileron snatching, the control column should be held with both hands. The rate of rotation stabilizes at about 3 to 4 seconds per turn and the indicated airspeed fluctuates between 80 and 120 knots. Height loss in the stabilized spin can be as high as 650 feet per turn.

d. **Spin Characteristics to the Right.** Spins to the right are generally smoother than spins to the left. The rate of roll on entry is slightly higher and the aircraft stabilizes in a lower nose attitude than in a spin to the left. Oscillations are less likely to develop. The rate of rotation is higher in stabilized spins to the right, at approximately 2·5 seconds per turn, but with the height loss per turn similar to that for spins to the left (up to 650 feet per turn).

35. **Inverted Spin.**

WARNING: The inverted spin can be very disorientating, particularly during the spin entry when there is a risk of mis-identifying the spin direction.

a. **Entry.** From straight and level flight at 140 knots with 20-25% torque set, pitch the nose up to between 25° and 30° above the horizon. At 110 knots, set the throttle to FLT IDLE and apply full aileron to roll inverted. At 95 knots, which may occur before the aircraft has reached the wings level inverted position, simultaneously centralize the ailerons, apply full rudder in the intended direction of spin and push the control column fully forward. A cleaner, less hesitant entry is achieved by applying the full rudder opposite to the direction of the roll used to invert the aircraft. If an entry to an inverted spin is attempted at a speed greater than 95 knots, an inverted flick roll may result; this is a prohibited manoeuvre. If the entry speed is below 90 knots, reduced elevator authority may result in an untidy entry.

WARNING: Full nose-down trim can be applied inadvertently, when the control column is held fully forward. If this occurs during an inverted spin, the nose will tuck under on recovery. The pilot will encounter very high control forces and may believe that the aircraft is not responding to control inputs. When using both hands on the control column during inverted spinning, avoid the trim switch. If nose-down trim has been inadvertently applied, select nose-up trim during the recovery to reduce control forces.

b. **Spin Characteristics.** Following an inverted autorotation, where the predominant motion is roll (in the opposite direction to the applied rudder), the aircraft quickly settles in a smooth rotation with the aircraft nose about 50° below the horizon. The motion is predominantly yaw, with no discernible oscillations. During the spin, the horizon is not visible; use a prominent ground feature below the aircraft to aid counting turns. The rate of rotation is slower than in the erect spin, with each turn taking approximately 4 seconds. Height loss can be as high as 700 feet per turn. There is little difference in characteristics between left and right inverted spins.

36. **Spin from Manoeuvre.** It is possible for the aircraft to depart from controlled flight during poorly executed aerobatics, and during mishandling at low speeds and high angles of attack. The cues to departure are usually strong, with the point of departure characterized by a marked wing drop and undemanded roll and yaw, the yaw being less discernible than the roll. If the aircraft departs from controlled flight, carry out the ►◄ **Incipient Spin Recovery** drill. If the aircraft does not recover within 3 seconds, carry out the ►◄ **Fully Developed Spin Recovery** drill. Spins from manoeuvre may be carried out with any power setting, but the entry speed is not to exceed 95 knots and the throttle is to be set to FLT IDLE as soon as departure is recognized.

37. **Recovery from the Spin.** The spin recovery drills for erect and inverted spins are the same. When carrying out the drills, the first turn may be considered to be the incipient stage.

a. **Incipient Spin Recovery.** To recover from erect and inverted spins, before the aircraft has completed the first turn:

(1) Throttle to FLT IDLE.

(2) Centralize the controls.

(3) When rotation stops, level the wings and recover to straight and level flight.

Note: If the aircraft does not recover within 3 seconds of centralizing the controls, carry out the ►◄ **Fully Developed Spin Recovery** drill.

b. **Fully Developed Spin Recovery.** To recover from erect and inverted fully developed spins:

(1) Check the height.

(2) Set the throttle to FLT IDLE.

(3) Check the direction of the needle.

(4) Apply full rudder to oppose the direction of the turn needle.

(5) Centralize the control column.

(6) Immediately rotation stops, centralize the rudder.

(7) Level the wings and pull out of the dive, moving the throttle off the flight idle stop to prevent tailplane blanking and high drag.

WARNING 1: If recovery (rotation ceased, speed increasing) has not occurred by 3000 feet above ground level, eject.

WARNING 2: The throttle is to be set to FLT IDLE in the ►◄ **Spin Recovery** drill; failure to set the throttle to FLT IDLE may result in a very lengthy recovery or even failure to recover.

c. **Recovery from Erect Spins.** During recovery, as the angle-of-attack reduces, the rate of rotation increases momentarily in spins to the left, and some sideslip may occur as the rotation ceases. Recovery is normally effected in one to 2 turns from spins to the left, and a half to one turn from spins to the right. Height loss during recovery may be up to 3200 feet.

d. **Recovery from Inverted Spins.** Recovery is normally effected in approximately one turn with the aircraft close to the vertical. Height loss during recovery may be up to 3200 feet.

38. **Mishandling the Spin.** Mishandling the controls can generate a spin of agitated or oscillatory motion, but the recommended spin recovery is always effective. If a spin develops through mishandling, recovery action is to be taken immediately.

a. **Effect of Mishandling at Spin Entry.**

(1) **Erect Spins.**

(a) **Application of Full Rudder before Control Column Aft.** A slow hesitant entry results, often without the normal autorotation stage. Occasionally the aircraft dives out of the manoeuvre with a large angle of sideslip. The spin, if it develops, may well be oscillatory, particularly if it is to the left.

(b) **Application of Control Column Fully Aft before Rudder.** A slightly slower than normal entry results with a tendency to be oscillatory, if it is to the left.

b. **Effect of Mishandling During the Spin.**

(1) **Relaxation of Full Aft Control Column.** If the control column is moved from the fully aft position, the spin becomes more rapid and is generally smoother.

(2) **Relaxation of Rudder.** If the rudder deflection is reduced, the rotation slows, but any tendency to oscillate is increased. If the rudder is centralized, the spin stops after 2 to 3 turns regardless of control column position.

(3) **Application of Outspin Aileron.** Small amounts of outspin aileron have little effect. Half to full outspin aileron tends to dampen any oscillatory behaviour and produces a slower spin with a higher nose attitude.

(4) **Application of Inspin Aileron.** Inspin aileron results in a very oscillatory spin. The force required to maintain the inspin aileron is very high. Spins to the left become quite violent with divergent oscillations in pitch and roll.

c. **Effect of Landing Gear, Flaps and Airbrake.** The aircraft is only cleared for spinning with landing gear and flaps UP and airbrake IN. However, tests have demonstrated that the aircraft promptly recovers from one-turn spins in the following configurations:

- Landing gear DOWN, flaps UP and airbrake IN.
- Landing gear UP, flaps DOWN and airbrake IN.
- Landing gear UP, flaps UP and airbrake OUT.

39. **Spinning with Power Applied.**

a. Spinning with power applied is permitted only for erect spins to the left with up to 30% torque applied. Recovery is to be initiated after a maximum of 4 turns. To recover from a spin with power applied, carry out the ►◄ **Fully Developed Spin Recovery** drill; it is important that the throttle is set to FLT IDLE during the recovery drill (see para 37b, Warning 2). Recovery may take slightly longer than for a spin with power at FLT IDLE.

b. Power has a disturbing effect on a spin to the right, therefore, spins to the right with power applied are not permitted.

c. Power has a calming and flattening effect on a spin to the left, with the aircraft settling at approximately 15° nose-down. The spin is smooth without discernible roll, pitch or yaw hesitations. If power is reduced in the incipient stage, the nose drops markedly and changes in the spin characteristics (in particular a hesitation in yaw) may give a false impression of recovery. If power is left on for a sufficient number of turns, the spin becomes flat and, initially, closing the throttle may not have any significant effect. At 30% torque, a flat spin develops after approximately 4 turns. At higher power settings, the flat spin occurs after 2 to 4 turns.

Aerobatics

WARNING: All flight at less than +0·5g depletes the propeller oil accumulator. Excessive throttle movement or large speed changes while flying at, or recovering from flight at, less than +0·5g increase the demand from the accumulator and delay recharge. Only count recovery time when the oil pressure indication is in the green sector.

40. **General.** Aerobatics are only permitted in the clean configuration. Intentional departures are not permitted above 95 knots. It is important to intersperse periods of positive g throughout a sequence, to avoid exhausting the inverted oil system accumulator. Vertical manoeuvres (vertical roll, stall turns) should be entered from below 200 knots, or the time spent in the vertical is such that the zero-g limitation will be exceeded. A typical aerobatic sequence at 5000 feet requires approximately 70% torque in order to maintain height. The changes in directional trim with speed and power require close attention to maintain accurate balanced flight.

CAUTION: Full nose-down trim can be applied inadvertently during inverted manoeuvring, or at other times when a push force is applied to the control column. If such manoeuvring results in a vertical dive, the nose may appear to tuck under and a very strong pull is required to return the aircraft to level flight. When applying a push force to the control column, avoid the trim switch. If nose-down trim has been inadvertently applied, select nose-up trim during the recovery to reduce control forces.

Note: During manoeuvres involving vertical or near vertical descent with the throttle at FLT IDLE, NTS operation occurs; this is manifested by thrust pulsation at 140 to 160 knots.

41. **Speeds.** Until experience is gained, 180 to 200 knots is the recommended speed for entry to most aerobatic manoeuvres. For a roll off the top, use 220 knots.

42. **Looping Manoeuvres.** A loop is entered at 180 to 200 knots, which gives a speed of approximately 100 knots over the top and requires approximately 1800 feet to execute. Normal acceleration on entry should be 3.5 to 4g. The buffet, when it occurs, is well defined and causes no handling difficulties.

43. **Stall Turns.** The pronounced effect of slipstream at low speed results in different techniques for stall turns to the left and right. To the left, apply full rudder at approximately 70 knots and reduce the power as the nose yaws through the horizon. To the right, reduce power to FLT IDLE at or before 100 knots and apply full rudder at 80 knots.

44. **Inverted Flying.** Illumination of the OIL P caption is delayed for a nominal 20 seconds to eliminate transient warnings. Periods of manoeuvring flight below +0·5g are not to exceed 20 seconds. A single period of non-manoeuvring inverted flight is limited to 30 seconds (see Part 2, Chapter 1).

45. **Compass.** After aerobatics, the compass should be fast erected in unaccelerated, balanced flight, whether or not it indicates that it is synchronized.

Formation Flying

46. Control in formation is precise; engine response to small throttle movements is good, but care is required to maintain directional trim. Any trim changes are easily controlled. At low IAS, use of airbrake improves longitudinal station keeping.

47. The view from both cockpits is good in all formation positions.

Instrument Flying

48. The instrument layout is good and the instruments are easily read, allowing accurate flight path changes to be made.

49. Setting 30% torque, with landing gear and flaps DOWN, gives a rate of descent of approximately 500 feet per minute on the glidepath. On the approach, small accurate heading changes are easily made.

Night Flying

50. Internal lighting of both cockpits is generally poor, being complex and difficult to adjust to the correct levels for all flight conditions. Glare effects are noticeable, with a `halo' effect around the main forward view. Moreover, the many controls and the difficulty of their operation make in-flight adjustment difficult. Only simple adjustments should be made when close to the ground.

Descending

51. The descent configurations and settings are:

a. **Maximum Rate.** Set the throttle to FLT IDLE, select the airbrake OUT and descend at 0·54M/300 knots.

b. **Normal/Instrument Descent.** Set the throttle to FLT IDLE, select the airbrake OUT and descend at 180 knots.

c. **Slow Rate Descent.**

(1) With the airbrake IN, set 20% torque and descend at 180 knots.

(2) With the airbrake IN, set 10% torque and descend at 140 knots.

d. **Configured Descent.** With the landing gear DOWN, the flaps at MID and the airbrake IN, set 15% torque and descend at 115 knots.

Gliding

52. The recommended gliding speed for best range is 115 knots, reducing to 110 knots with the landing gear down. The rate of descent is approximately 900 feet per minute with a feathered propeller. This rate of descent gives 2·1 NM per 1000 feet in still air. At speeds above 115 knots there may be a slow rotation of the feathered propeller.

PART 3

CHAPTER 3 - APPROACH AND LANDING PROCEDURES

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General

1. The checks referred to in this chapter are listed in the Flight Reference Cards.

2. The view from the front cockpit is good. From the rear cockpit, the helmet of the pilot in the front cockpit may intrude into the direct forward view, but there is sufficient view to complete the landing.

Visual Circuit Procedure

3. Start the downwind leg at 140 knots with 20% torque set. Carry out the **Pre-Landing Checks**. With MID flaps selected and landing gear DOWN, allow the speed to decay to 115 knots by the end of the downwind leg. Set 30% torque to maintain 115 knots.

4. Select flaps DOWN and 20% torque, then commence the final turn maintaining 110 knots. When lined up on the final approach, gradually reduce the airspeed in order to arrive at the runway threshold at the correct speed.

5. For a normal powered approach the recommended threshold speed is 90 knots plus the addition of one knot per every 100 kg of total fuel mass remaining, rounded up to the nearest 100 kg. For example, with a fuel mass of 150 kg, the recommended threshold speed will be 92 knots.

6. Approximately 8 kg of fuel are required for a full circuit; 2 to 3 kg are used from the start of the downwind to landing. The time taken to increase power from FLT IDLE to MAXimum is approximately 3·5 seconds.

Landing Procedure

7. Propeller slipstream is an important factor in the landing technique. It has the following effects on aircraft handling:

   a. It provides significant lift over the inboard section of the wings; this lift reduces when the throttle is set to FLT IDLE.

b. It enhances tailplane effectiveness; when the throttle is set to FLT IDLE, tailplane effectiveness reduces.

8. When the throttle is set to FLT IDLE, the above effects add to the increase in drag due to disking and the nose-down trim change; this makes it difficult to flare progressively. It is important to achieve the recommended threshold speed; as the touchdown point approaches, gradually close the throttle and flare to allow the aircraft to settle onto the runway. Lower the nosewheel after touchdown and select full REVerse; this slows the aircraft effectively and thus it is often not necessary to use brakes during the landing run.

CAUTION: A landing made with pressure applied to the brake toe pads could result in burst tyres. To prevent inadvertent brake application at touchdown check on final approach that the feet are clear of the toe pads.

Note: When landing at high aircraft masses above 2900 kg, aircrew should be alert to the possibility of higher than normal sink rates, requiring greater anticipation in the flare.

Use of Reverse Thrust and Braking

9. The throttle cannot be moved aft of FLT IDLE until the nosewheel weight-on-ground switch operates a solenoid. After lowering the nosewheel, release any aft pressure on the throttle by slight forward movement to enable the beta-baulk to withdraw, then select full REVerse. If the beta-baulk does not withdraw, push the control column forward to compress the nose oleo and operate the weight-on-ground switch. Selecting reverse thrust at high speed can destabilize the aircraft directionally, and it may be difficult to steer; if this occurs, move the throttle forward to reduce reverse thrust. On reaching taxying speed, move the throttle to the GND IDLE detent and select ENGINE SPEED to 70%.

CAUTION 1: The throttle is not to be moved aft of GND IDLE when in MANual mode.

CAUTION 2: The wheel brakes are not fitted with an anti-skid system. Avoid heavy foot forces.

10. **Emergency Braking.** Although there is no anti-skid, the brakes may be applied firmly if the aircraft weight is on the main wheels. Increase toe pedal pressure progressively as speed reduces.

11. **Aerodynamic Braking.** A nose high attitude after touchdown does not reduce the landing run; the throttle cannot be moved aft of FLT IDLE and the propeller will produce forward thrust to stabilize the speed at about 70 knots. Landing with airbrake extended has no adverse handling effects and only slightly reduces the landing run.

Rolling

12. Carry out a normal approach and touchdown. Hold the nosewheel off after touchdown and apply full power. Open the throttle slowly to reduce the directional problems caused by torque and slipstream. At 80 knots, smoothly rotate to the take-off attitude. When safely airborne, raise the landing gear and flaps and complete the **Checks After Take-Off**.

Overshooting

13. To overshoot, level the wings, smoothly apply full power and select a climbing attitude. When the aircraft is safely climbing, select gear and flap UP. The flap is selected from DOWN to UP in a single selection; because the aircraft accelerates rapidly and flap travel is slow, there is no danger of sink as the flap retracts. Complete the **Checks After Take-Off**.

Instrument Approaches

14. The settings shown in Table 1 are recommended for an instrument approach.

Table 1 - Instrument Approach Settings

Approach Stage	*Torque %*	*Flaps*	*Landing Gear*	*Airspeed (knots)*
Downwind	20 to 30	UP	UP	140
Base Leg	30	MID	DOWN	115
Glidepath	30	DOWN	DOWN	110

Flapless Landing

15. The drag produced by the propeller at low power settings and the instant engine response allow a normal circuit and approach to be flown for a flapless circuit. Set 25% torque to stabilize at 115 knots at the end of the downwind leg and 10% torque initially for the final turn. Fly the final turn and final approach at 110 knots; maintain this speed to the threshold to provide satisfactory forward visibility for the rear seat pilot. A higher-than-normal attitude is required throughout the circuit and at touchdown. Over the threshold, set FLT IDLE and touch down below threshold speed.

Mid Flaps Landing

16. Landing with flaps selected to MID instead of DOWN has a minimal effect on handling and performance. Use normal approach and threshold speeds.

Crosswind Landing

17. Landing in crosswinds using the crab technique presents no difficulty. Align the nose with the runway just before touchdown at the normal speed. There is very little roll associated with large rudder inputs, but into wind aileron during the landing roll is advantageous in strong crosswinds.

Airbrake-Out Landing

18. Landing with the airbrake out presents no difficulties and reduces the landing roll very slightly. An overshoot in this configuration is equally straightforward.

Practice Forced Landing Procedure

19. In a glide at 115 knots with the engine shut down and the propeller feathered, flaps and landing gear UP and airbrake IN, the rate of descent is approximately 900 ft per minute. To simulate a feathered propeller when practising forced landings, set 8 to 10% torque at 115 kts. It is necessary to make small throttle adjustments to maintain this setting during a long descent.

20. Aim for a high key position at 2500 feet AGL at 115 knots. Carry out the normal **Pre-Landing Checks** and reduce speed to 110 knots. Low key is at 1500 feet AGL abeam the threshold. When certain of reaching the desired touchdown point, select flaps DOWN and maintain 110 knots until starting the flare. Threshold speed is achieved during the flare. To lose excess height, the aircraft can be safely sideslipped in all configurations (see also Part 4, Chapter 2).

Note: The propeller produces very high drag if the throttle is set to FLT IDLE at low airspeeds.

Landing in EEC Manual

21. Fly a normal approach; after landing, lower the nosewheel as normal and gently bring the throttle aft to idle. There is a distinctive note as the propeller gives zero thrust; do not move the throttle aft of this point. However, the zero-thrust throttle setting changes with forward speed so, as speed reduces, the throttle can be moved progressively aft. In this manner, the aircraft will decelerate without excessive use of the brakes.

22. There is a risk of an engine bogdown when taxying with the EEC in MANual. Therefore, after landing in MANual, carry out the following procedure:

a. **Actual EEC Failure.** Carry out the **After Landing** and **Shutdown Checks** after clearing the runway, or earlier if the EGT starts to rise.

b. **Practice EEC Failure.** When speed is down to taxying speed, select EEC to NORMAL. Once the EEC has been reset to NORMAL, there are no restrictions on taxying.

CAUTION: To avoid damaging the engine and overheating the brakes, do not taxy with the EEC in MANual.

Checks After Landing

23. Carry out the **After Landing** checks.

Engine Running Crew Change

24. Engine running crew changes are to be carried out as laid down in Part 2, Chapter 3. The pilot-initiated event button is to be pressed by the accepting crew before taxying.

Shutdown Procedure

25. Use low power for 3 minutes before carrying out the Shutdown checks. Include approach, landing and taxy time in this 3-minute period. If on shutdown the prop continues to rotate at about 15%, then switch batteries off.

Note: Loss of electrical power to the DAPU before the engine stops may result in errors that render the DAPU data irrecoverable. Do not select the generator and batteries OFF until the propeller is stationary.

PART 3

CHAPTER 4 - FLIGHT IN ADVERSE WEATHER

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Ambient Temperature Variations

1. The aircraft is cleared to operate in ground level outside air temperature (OAT) between minus 10°C and +30°C at sea level. The engine produces less power in high ambient temperature conditions than in low temperature conditions; at sea level, an increase of 10°C causes a power reduction of 6% torque (see AP 101B-4901-16, the Tucano T Mk 1 Operating Data Manual).

Operating in Icing Conditions

2. **On the Ground.** Intake icing may occur during ground operations when the OAT is at or below +8°C, with the Runway Visual Range (RVR) less than 1000 metres (Met visibility less than 750 metres) and/or a wet runway surface.

3. **In flight.**

a. In flight icing may occur when the ambient temperature is +10°C or less in precipitation or visible moisture, and in air in the vicinity of these conditions. If icing conditions cannot be avoided, the aircraft may be operated in icing conditions in accordance with the limitations given in Part 2, Chapter 3.

b. There is no airframe ice protection apart from pitot head and static vent, AOA and stall vane heaters. The engine intake and propeller have de-icing systems. Unprotected areas such as the spinner and canopy tend to build ice rapidly. Heavy accretions can occur on the nose of the spinner and on the flanges around the spinner cutouts for the propeller blades. The oil cooler intake may be restricted, resulting in temperatures approaching 110°C. Monitor oil temperature closely in icing conditions. If increases of 3 to 5°C per minute are observed, assume that the engine oil cooler is partially blocked by ice.

c. Icing degrades the aircraft's performance and handling qualities; avoid icing conditions if possible. Even small amounts of ice accretion on wings and tailplane leading edges degrade performance at the stall and increases stall and pre-stall buffet speeds. In prolonged or severe icing conditions, ice may accumulate very rapidly on aerofoil leading edges.

WARNING: Tests have shown stalling speed increases of up to 25 knots in the clean configuration and of 10 to 15 knots with flaps and landing gear down. The stall warning given by the audio and aircraft buffet is retained, but that given by the stick shaker is probably lost; consequently the stall warning margin may be very small. Exercise appropriate caution during flight with ice accretion on the wing leading edges. If a landing has to be made in that condition, increase threshold speed by 15 knots.

Starting and Taxying in Icing Conditions

4. **Starting.** All bleed air should be off during engine starting. Set the air conditioning temperature control switch to AUTO and the rotary temperature selector switch to a mid position before engine start. Optimize the direction of flow from the punkah louvres. If the OAT is between minus 10°C and +5°C or between +20°C and +30°C, consider using 100% RPM to maximize the effectiveness of the air conditioning. Test the ice protection system and leave INTAKE and PROP ON.

5. **Taxying.** Taxy cautiously, using reverse thrust rather than wheelbrakes to control speed. Do not attempt to take-off if the lifting or control surfaces are contaminated with ice or snow. Select PITOT 1 and 2 heaters ON during the **Checks Before Take-Off**. If icing conditions are not present but are expected shortly after take-off, select INTAKE and PROP ON on the runway and AOA/STALL heaters after take-off.

Take-Off on a Wet or Contaminated Runway

CAUTION: The aircraft is not cleared for operation in snow or from surfaces covered with snow/slush. Unavoidable operations in snow/slush should be treated with caution. Accumulations of slush/ice in the recess below the operating cam for the nose undercarriage weight-on-ground switch may result in malfunction of the switch, with an inability to move the throttle aft of FLIGHT IDLE after touchdown.

6. Before take-off on a wet or contaminated runway with the OAT at +8°C or below, select INTAKE and PROP ON. If the contamination is from slush or snow, keep the landing gear DOWN until 140 knots and then cycle it once before commencing the (clean) climb. Once in the climb, if icing is not a consideration, select INTAKE, PROP and AOA/STALL heaters OFF.

Flight in Icing Conditions

7. Select INTAKE and PROP ON before the aircraft enters known icing conditions. Normal engine handling may be used.

CAUTION: Do not delay selection of the INTAKE system until after entering icing conditions because the engine ingests, within seconds of switch on, any ice that has already formed on the intake lip; engine damage may result.

8. When in icing conditions, always operate the air conditioning system at AUTO BOOST fully HOT to obtain the maximum temperature of air over the inside of the front of the canopy and thus promote clearance of external ice. This airflow is marginally improved by closing all 4 of the body spray punkah louvres (2 in each cockpit).

9. Flight in icing conditions with the landing gear down may result in a malfunction of the nose weight-on-ground switch. If this prevents retraction of the beta baulk, it will not be possible to move the throttle aft of FLT IDLE after landing.

10. Whenever icing conditions have been encountered, attempt to de-ice before landing if time and weather conditions permit. Ice clears more quickly at high speed and low level. As ice melts and slides back across the tailplane and elevators, marked and sometimes rapid changes in trim and control column forces may be experienced. If a landing has to be made with visible ice accretion on the wing leading edges, increase threshold speed by 15 knots. If still in icing conditions after landing, keep INTAKE and PROP ON until shutdown.

Flight in Turbulence

11. The recommended speed band for flying in turbulence is 150 to 180 knots; the maximum speed is 230 knots.

12. In turbulent conditions it is not uncommon for the torque indication to fluctuate. Turbulent conditions with wind shear of ±10 knots have been known to generate torque indication fluctuations of up to 10% torque.

Flight Following a Lightning Strike

13. Following a known, or suspected, lightning strike, treat all instrument information with caution; in particular, heading and navigation information may be suspect. The CWP should indicate any system failures. The engine control may have reverted to manual; in this event, or if the engine is behaving erratically, select EEC to MANual and land as soon as practicable.

Landing on a Wet or Contaminated Runway

CAUTION: The aircraft is not cleared for operation in snow or from surfaces covered with snow/slush. Unavoidable operations in snow/slush should be treated with caution. Accumulations of slush/ice in the recess below the operating cam for the nose undercarriage weight-on-ground switch may result in malfunction of the switch, with an inability to move the throttle aft of FLIGHT IDLE after touchdown.

14. On wet runways, there is considerable loss of wheelbrake effectiveness, but the braking effectiveness of the propeller remains good. Touch down firmly at the correct speed, lower the nosewheel and select full REVerse. If it is essential to use wheelbrakes as well, apply them with care. Intake icing may occur during ground operations, when the OAT is at or below +8°C with the RVR less than 1000 metres (Met visibility less than 750 metres) and/or the runway surface wet; in these conditions switch the INTAKE and PROP ON. Accumulations of slush/ice in the recess below the operating cam for the nose gear weight-on-ground switch may result in malfunction of this switch. If this prevents retraction of the beta baulk, it is not possible to move the throttle aft of FLT IDLE after landing.

Landing in Turbulent Conditions

15. When landing in moderate or greater turbulence, add 5 knots to the threshold speed. Land using the normal technique.

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PART 4

EMERGENCIES AND MALFUNCTIONS

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PART 4

CHAPTER 1 - INDEX OF EMERGENCIES AND MALFUNCTIONS

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Para
General … … … … … … … … … 1

General

1. Details of emergency handling procedures, system malfunctions and malfunctioning drills are in the appropriate chapters of this Manual, and in the Flight Reference Cards (FRC) as shown in Table 1.

Table 1 - Emergency Handling Procedures - References

Emergency/Malfunction	*Aircraft Manual*			*FRC Tab Ident*
	Part	*Chap*	*Para*	
ABANDONING				
Automatic sequence failure after ejection	1	9	81	Abandon
Ejection at low level	4	2	1	-
Ejection drill	1	9	76-78	Abandon
Ejection seat fails to fire	1	9	80	Abandon
Emergency ground egress	4	2	6	Egress
Escape on/in water	4	2	9	-
ADVERSE WEATHER				
Icing	3	4	2-10	Icing
Flight following a lightning strike	3	4	12	-
Pitot static failure to airspeed indicators system	1	11	58	-
Pitot static failure to altimeters system	1	11	59	-
AIR CONDITIONING				
Air conditioning failure	1	8	24	Air Cond
Temperature control failure	1	8	26	Air Cond
Smoke or fumes	1	8	23	Smk fumes
AVIONICS				
Aircraft emergency	1	13	77	-
Communications malfunctions	1	13	73-76	Comms
Compass failure	1	13	71	-
CANOPY				
Canopy caption	1	9	83	Canopy
Canopy Demisting	1	8	21	Cpy Mist
Detached miniature detonating cord	4	2	12-14	-
Flight with canopy damaged	4	2	10-11	-

(Continued)

Table 1 - continued

Emergency/Malfunction	*Aircraft Manual*			*FRC Tab Ident*
	Part	*Chap*	*Para*	
CENTRAL WARNING SYSTEM				
Continuous Stall Warning	1	2	16-19	Comms
ELECTRICAL				
Circuit breakers	1	1	37	C/B
Essential busbar failure	1	1	38	-
Generator failure	1	1	34	Gen
Ground supply contactor failure	1	1	33	-
Inverter failure	1	1	36	Inv
ENGINE SYSTEMS				
Abnormal oil temperature	1	4	94	Oil
EGT and torque indication malfunctions	1	4	83	EEC
Engine controller malfunction	1	4	80	EEC
Loss of power after take off	3	1	19-20	EFATO
Engine and propeller malfunctions	1	4	77	-
Engine mechanical failure	1	4	91	Mech Fail
Oil pressure failure	1	4	93	Oil
Propeller Malfunctions	1	4	84	-
Relight procedures	1	4	89-90	Relight
Undemanded propeller rotation on ground	-	-	-	Propeller
FIRE				
Engine fire	1	4	76	Fires
Fire detection	1	2	8-10	FDET
FLIGHT CONTROLS				
Airbrake fails to retract	1	6	33	-
Airbrake undemanded retraction	1	6	34	-
Flaps fail to respond to selection	1	6	32	Flaps
Trim runaway	1	6	31	Trims
FLIGHT INSTRUMENTS				
CSI Failure	1 + 4	11+ 2	58 + 19	-
Power supply failure to attitude indicators	1	11	55	-
Power supply failure to HSI	1	11	56	-
Power supply failure to main altimeters	1	11	53	-
Power supply failure to standby altimeters	1	11	54	-
HYDRAULICS				
Hydraulic failures	1	5	20	Hyd

(Continued)

Table 1 - continued

Emergency/Malfunction	*Aircraft Manual*			*FRC Tab Ident*
	Part	*Chap*	*Para*	
FUEL				
Fuel filter blockage FUEL FLTR	1	3	25	Fuel
Fuel pressure failure	1	3	23-24	Fuel
Low fuel level	1	3	26	Fuel
LANDING EMERGENCIES				
Forced landing	4	2	15-16	Fcd Ldg
Hazardous landings	4	2	17-18	Haz Ldgs
LANDING GEAR				
Emergency retraction on ground	1	7	10	Gear
Gear selected down but 3 Greens not obtained	1	7	23	Gear
Gear selected up but Greens / Reds remain	1	7	22	Gear
Gear selector cannot be moved on up selection	-	-	-	Gear
Gear malfunction indicators	1	7	22-23	Gear
Nosewheel shimmy	1	7	26	-
Nosewheel steering failure	1	7	24	-
Standby lowering system	1	7	9	Gear
Wheelbrakes failure	1	7	25	-
OXYGEN				
Breathing difficulties	1	10	37-38	Oxy
Excessive oxygen consumption	1	10	39	Oxy
OXY caption illuminated	1	10	34	Oxy
Symptoms of hypoxia	1	10	40	Oxy
SPINNING				
Recovery procedure	3	2	36	-

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PART 4

CHAPTER 2 - EMERGENCY PROCEDURES

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Ejection at Low Level

1. The procedures to be used to abandon the aircraft are given in Part 1, Chapter 9 and in the FRC. The following text discusses ejection at low level and seat performance in given flight conditions.

2. Successful ejection at low level requires the limitations on dive angle, bank angle, airspeed and terrain clearance given in Fig 1 or Fig 2, and Fig 3 to be observed. The minimum ejection terrain clearances stated are the minimum heights required above ground level, presuming the surface to be level and unobstructed.

3. The aircrew must make the final decision about the minimum safe height from which an ejection can be made in the prevailing conditions, but every effort is to be made to initiate ejection while the aircraft is well above the minimum height.

4. Fig 1, Fig 2, and Fig 3 show the ejection seat performance capability either when fired individually or when fired by the command ejection system from the instant of pulling the (first) seat firing handle. No allowance has been made for pilot reaction time. The data are presented in terms of IAS and actual (not barometric) height, and are applicable to steady-state, unaccelerated flight conditions.

5. The data apply to ISA sea level conditions. Altitude effects on seat performance require that the given terrain clearance must be increased by 2% for every 1000 feet above sea level.

Emergency Ground Egress

6. The ejection seats are not to be used on the ground at less than 70 knots. When stationary:

a. Select ESDL to OFF/FEATHER.

b. Ensure that the seat firing handle safety pin is inserted correctly.

c. Open the canopy and leave the aircraft (if unable see para 7 below).

d. Unstrap completely: release the QRF, PEC and PSP. Release the leg-restraint garters, or pull through the lines (depending upon time available).

e. Vacate the aircraft and move clear upwind.

7. If it is impossible to open the canopy, use the following procedure:

WARNING: Do not use the MOR handle.

a. Warn the other occupant.

b. Don the oxygen mask and lower the visors.

c. Remove the canopy fracture handle safety pin.

d. Sit erect and close the eyes tightly.

e. Operate the canopy fracture handle.

f. Push the canopy fragments clear and vacate the aircraft clear upwind.

8. If a single ejection takes place and the remaining pilot subsequently lands the aircraft, operation of the canopy fracture handle may be the only means of egress, if rapid evacuation is necessary. After operation of either ejection seat the outer tube of the ejection gun barrel is extended and may impede the normal opening of the canopy. If time and circumstances permit, appropriate engineering assistance may be requested to allow the pilot to get out. However, the pilot should not hesitate to use the canopy fracture handle if circumstances warrant it.

Escape on/in Water

9. If the canopy is completely submerged, *eject*. If the aircraft is floating or partially submerged, unstrap and disconnect completely and then open the canopy. If the canopy does not open, use the canopy fracture handle. After vacating the aircraft, inflate the life preserver. If practicable, withdraw the PSP from the cockpit, clear the aircraft, inflate and board the liferaft.

Flight with Canopy Damaged

10. If the canopy is damaged, lower the visor and seat, and reduce airspeed to below 150 knots. Canopy damage may degrade aircraft handling characteristics, therefore, before making an approach, carry out a low speed handling check at a safe height to assess the affect on handling.

11. Canopy damage may cause a suction effect, increasing cockpit altitude above aircraft altitude. Consider this when using the oxygen equipment. Internal and external communication may be difficult due to airflow noise.

Detached Miniature Detonating Cord

12. If the canopy is damaged, some miniature detonating cord (MDC) may hang in the cockpit. If the visor is kept down and direct contact with the MDC is avoided, any subsequent detonation should not cause injury. However, survival equipment may be damaged if the MDC is in contact with it.

13. If possible, cut away loose MDC; this does not cause it to detonate. If the MDC cannot be cut or broken, keep it clear of the body and aircrew equipment, particularly the eyes and visor. If necessary, an immediate ejection may be initiated. Injury caused by the MDC is likely to be less than if ejection is delayed.

14. If the rear occupant initiates ejection with command ejection selected, the front occupant could be severely injured should he be handling loose MDC at the time. It is recommended that, if a command ejection is likely when intercommunication is not possible, any loose MDC in the front cockpit be left untouched apart from the speedy removal of any cord in contact with the visor or face.

Forced Landings

15. **Gliding Performance.** Fig 4 gives a pictorial presentation of glide performance. At 115 knots, the aircraft covers more than 2 NM per 1000 feet in still air conditions with propeller feathered, landing gear and flaps UP and airbrake IN.

16. **Pattern.** Fig 5 gives a pictorial presentation of the forced landing pattern. Excess height can safely be lost in all configurations by sideslipping. The procedure for a forced landing is the same as for a practice forced landing (see Part 3, Chapter 3) except that the **Emergency Pre-Landing Checks** are carried out between high and low key instead of the **Pre-Landing Checks**.

Hazardous Landings

17. If a landing is to be made with unsafe landing gear indications, carry out the **FRC Hazardous Landing** drill. Make a normal, powered approach; when a landing is assured, shut down the engine by selecting the ESDL to OFF/FEATHER. Be prepared for a pitch up to occur due to a momentary increase in thrust as the propeller feathers.

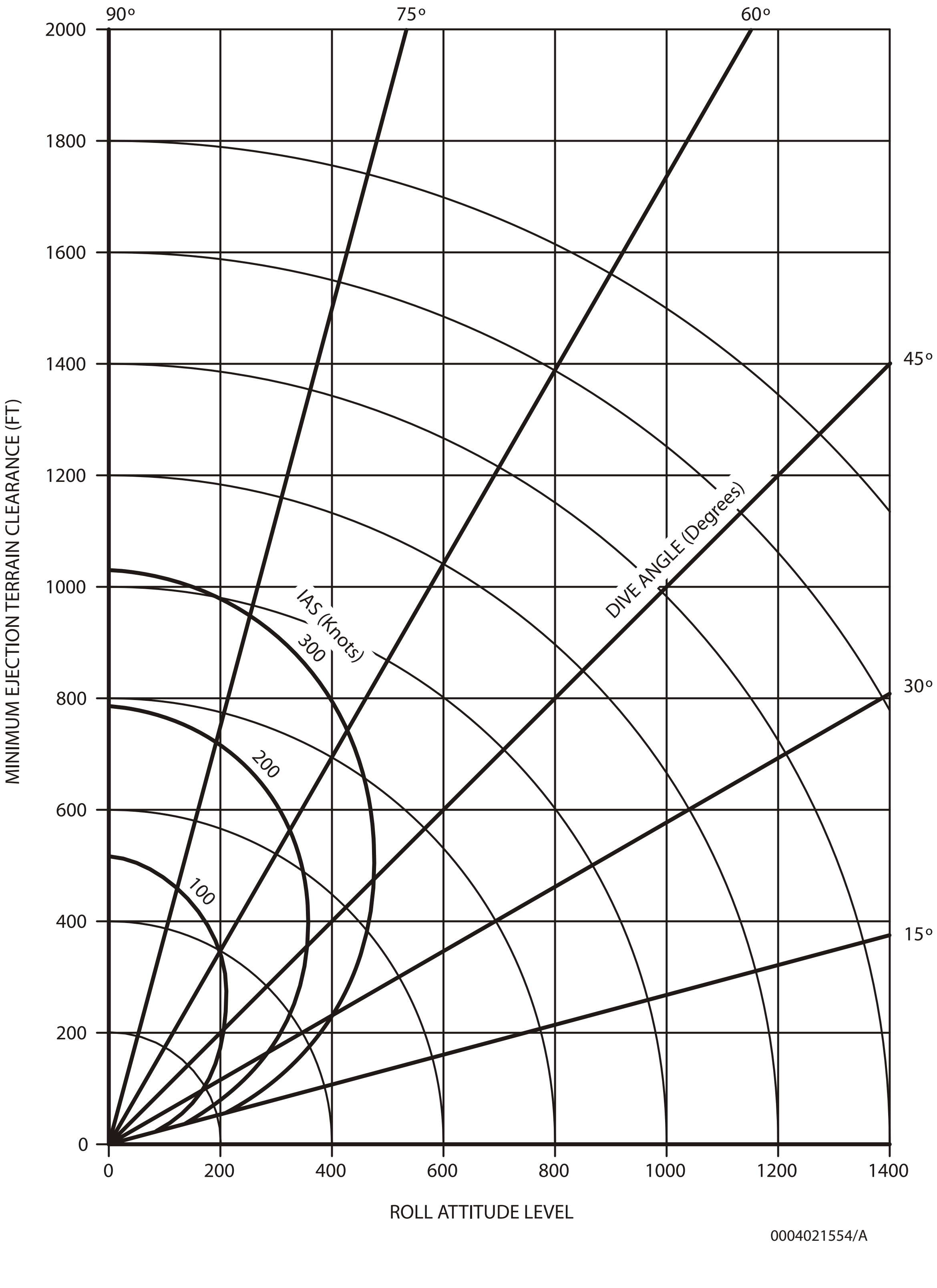
18. If the landing was abnormal and/or a hazard still exists after the aircraft has come to a halt, set the essential bus to ISOLATE, the batteries to OFF and carry out the **FRC Emergency Ground Egress** drill. Alternatively, if the unsafe landing gear indication resolves itself on touch down and/or if no hazard exists, carry out the **After Landing Checks** and the **Shutdown Checks** before vacating the aircraft.

CSI Failure

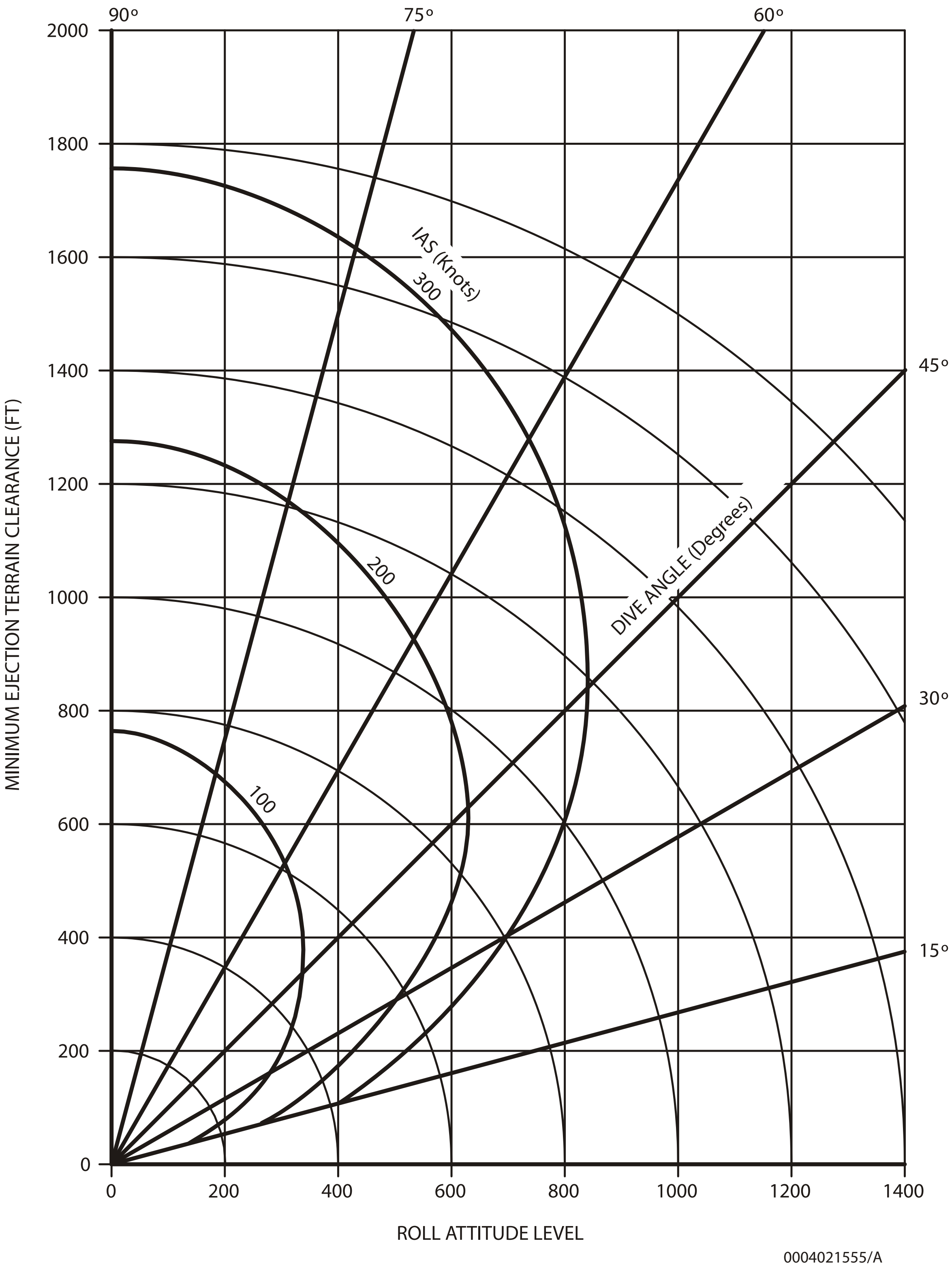
19. If the CSI fails and a shepherd aircraft is not available or is not appropriate in the circumstances, fly an approach using the AOA indicator and indexer. With the landing gear and flaps up and AOA at minus 7, the speed should be 120 ± 4 knots and the pre-landing checks can be completed. Fly the approach (landing gear and flaps down) with the AOA at zero; the speed should be 90 ± 3 knots. If the indexer is 'on speed' (green circle) the speed will be 77 ± 3 knots (see Part 1, Chapter 11).

Note 1: The above values are only true at an AUM of 2650 ± 50 kg.

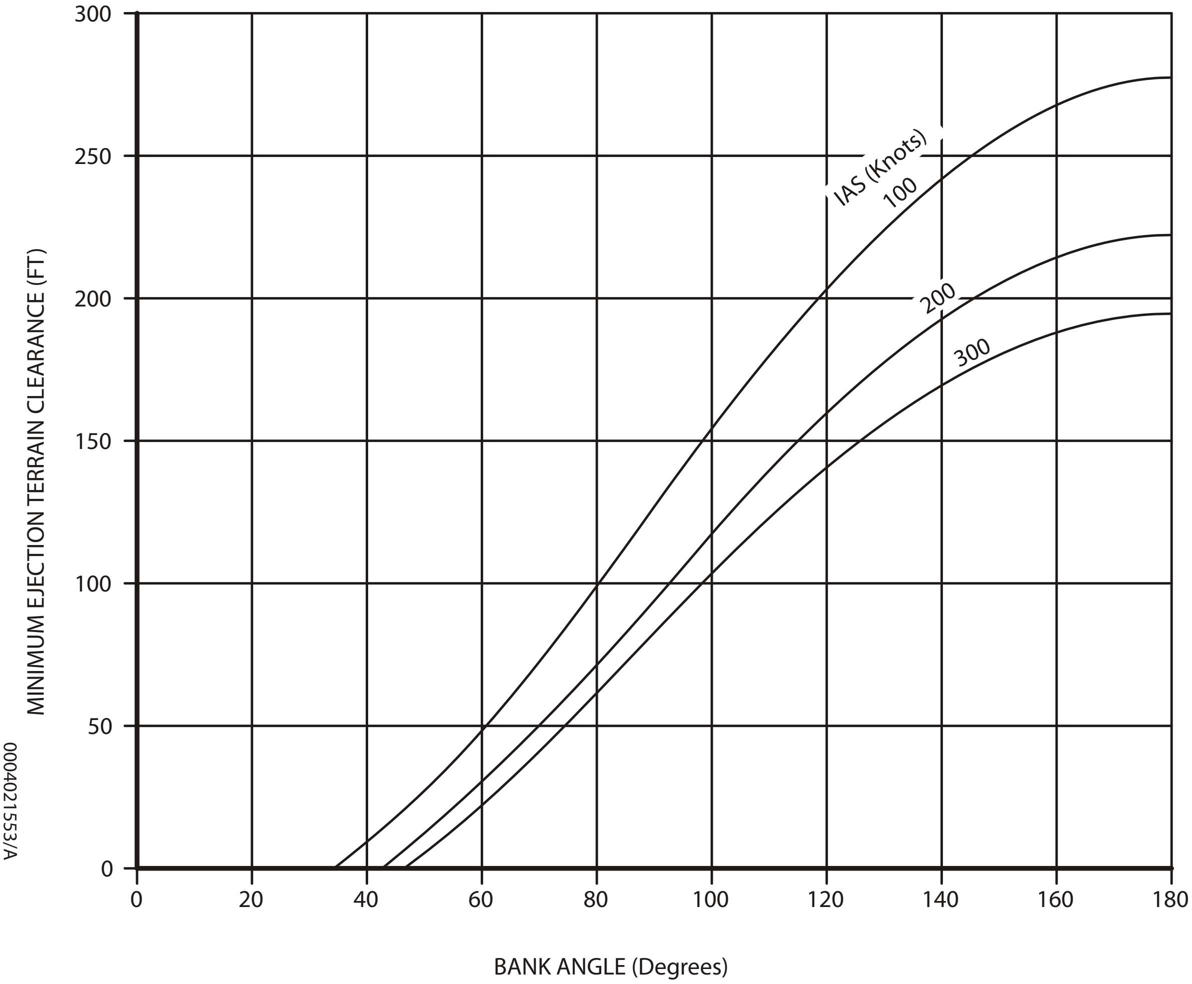
Note 2: Embodiment of SM 109 removes the AOA indexer from both cockpits and the AOA indicator from the front cockpit.



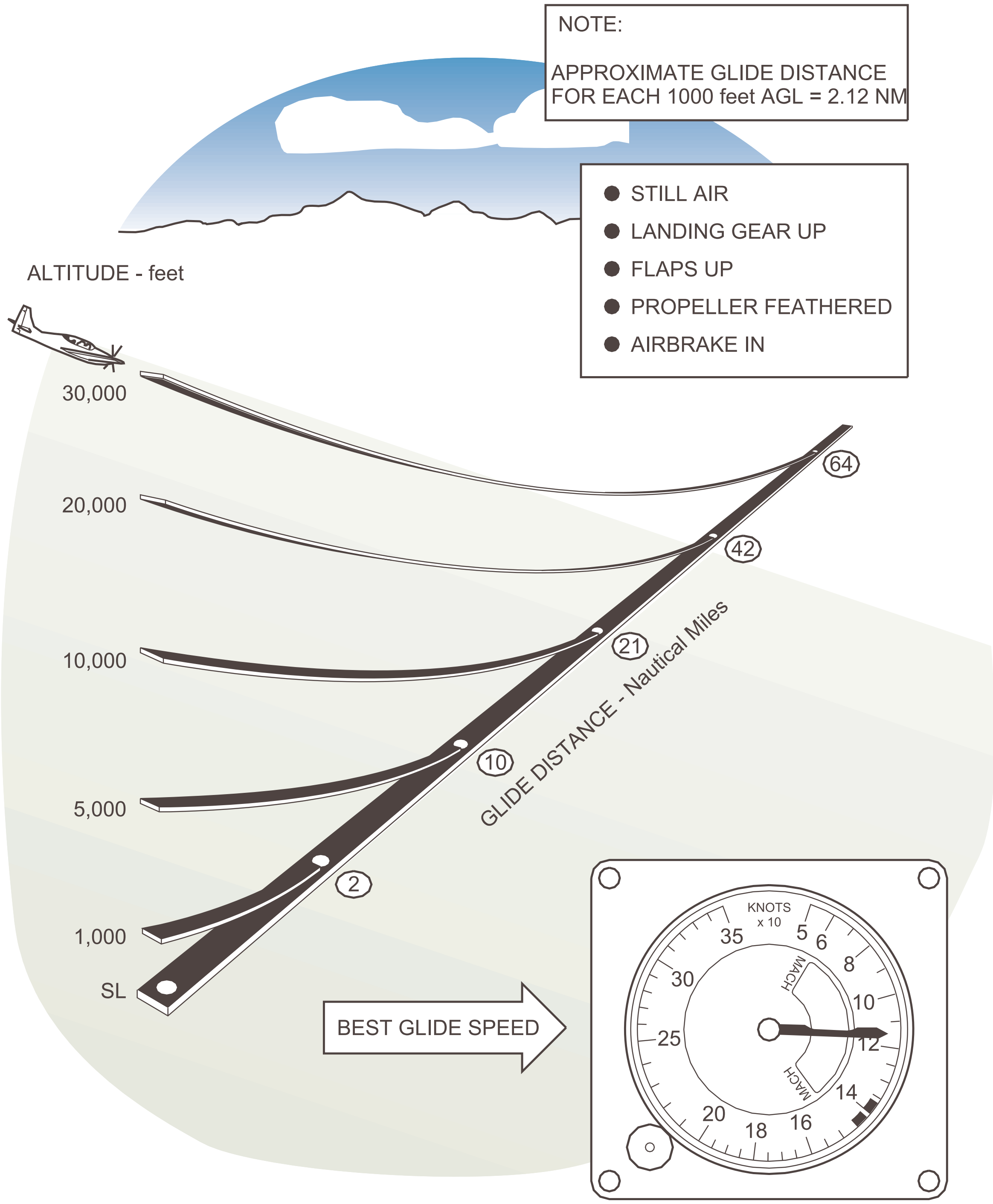
4 - 2 Fig 1 Minimum Ejection Terrain Clearance vs IAS and Dive Angle (Independent Ejection)



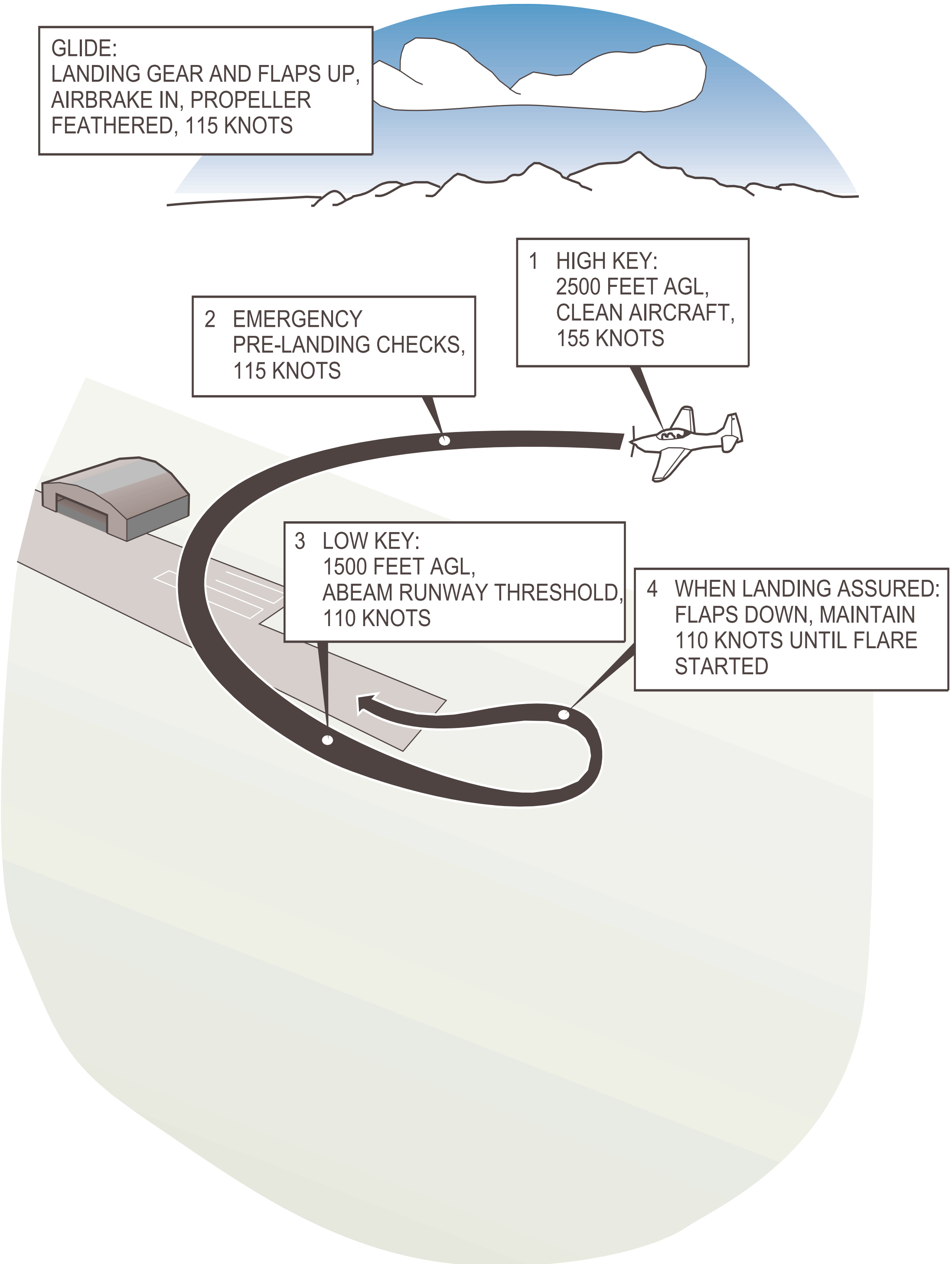
4 - 2 Fig 2 Minimum Ejection Terrain Clearance vs IAS and Dive Angle (Command Ejection)



4 - 2 Fig 3 Minimum Ejection Terrain Clearance vs IAS and Bank Angle



4 - 2 Fig 4 Gliding Distance vs Altitude



4 - 2 Fig 5 Forced Landing Procedure

PART 5

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PART 5

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1 Stowage - Safety pins (MOR SEAR) and CANOPY STRUT lock pin
2 Utility light
3 Emergency landing gear lever - LDG GEAR STBY LOWER - NORMAL/DOWN
4 Emergency air brake selector - AIRBRAKE STBY UP - PULL & TURN TO LOCK
5 EMERG SHUT DOWN lever - NORMAL/OFF/FEATHER
6 FLAPS selector - UP/MID/DOWN
7 SEAT ADJ switch - UP/DOWN
8 Emergency light (4)
9 Background light (4)
10 Canopy locking lever
11 Stowage - SEAT FIRING handle safety pin
12 Power lever FRICTION adjuster
13 Power lever - REV/GND IDLE/FLT IDLE/MAX
14 Rudder trim switch - RUD TAB - LH/centre off/RH
15 Press - to - transmit switch
16 AIRBRAKE switch - IN/centre off/OUT
17 TRIM cut out switch - ISOL/NORM
18 STALL WNG switch - ISOL/NORM
19 ALTernative TX switch - TX/OFF
20 EXTERIOR LIGHTING switches (4), l to r: STROBES - ON/OFF,
NAV - BRIGHT/DIM/OFF, LANDING - ON/OFF, TAXI - AUTO/TAXI/OFF
21 ENGINE SPEED switch - 100% / 70%
22 ENGINE START switches (3), l to r: EEC - NORMAL/MAN/CRANK
FUEL IGN - NORMAL/EM'GY, Start Switch - START/RUN/STOP
23 ENGINE START - indicators (3), l to r: MONO P FAIL (amber) (inoperative)
IGNITER ON (white), STARTER ON (amber)
24 Control column
25 Pilot initiated event switch. Unmarked
26 Not used
27 Main audio mute switch. Unmarked
28 Elevator/aileron trim switch. Unmarked
29 Not used
30 Gust lock lever
31 Rudder pedal adjuster
32 Wheelbrake toe pad
33 PARKING BRAKE handle and indicator, PARK BRAKE (amber)
34 INTERIOR LIGHTS switches (2), l to r: NORMAL - ON/OFF, EMERG - BRT/DIM/OFF
35 INTERIOR LIGHTS dimmers (2), l to r: PANELS, INSTRUMENTS
36 Selector/indicator switches (3) upper: COMPASS (white)/SEL (green),
mid: U/VHF (white)/SEL (green), lower: TPDR (white/SEL (green)
37 Not used
38 Not used
39 HYDraulic cut off switch - CUT OFF/NORMAL
40 LDG GEAR selector - UP/DOWN
41 GND UP ENABLE switch - ON/OFF
42 Landing gear position lights (3) - In transit: red, Locked down: green
43 CCS station box
44 VHF NAVigation control unit
45 TACan control unit
46 Not used
47 Not used
48 Not used
49 Not used
50 Area microphone
51 Transponder control unit
52 Compass control panel
53 PORT fuel PUMPS switches (2) - ON/OFF and indicators (2),
l to r: MAIN (amber), AUX (amber)
54 FUEL contents gauge (pre-Mod 0492) / OAT gauge (post-Mod 0492)
55 STB fuel PUMPS switches (2) - ON/OFF and indicators (2),
l to r: MAIN (amber), AUX (amber)
56 CWP
57 FIRE DET test switch - FIRE TEST/FIRE FAULT
58 ADR fail indicator ADR OFF (amber)
59 U/VHF control unit
60 Not used
61 Clock
62 Flap position indicator
63 Trim position indicators (3), l to r: aileron, rudder, elevator
64 Not used
65 Airbrake unlocked indicator - AIR BRAKE (white)
66 Landing gear not locked down indicator U/C(amber)
67 CWS attention getter (red) (2)
68 Rear view mirror (2)
69 Angle of attack indicator and indexer
70 TCAS Cockpit Display Unit
71 Combined speed indicator
72 Standby attitude indicator
73 Horizontal situation indicator
74 Not used
75 Attitude indicator
76 Turn and slip indicator
77 Accelerometer
78 Ice warning indicator/switch ICE (blue)
79 Standby altimeter
80 Encoding altimeter
81 Not used
82 Vertical speed indicator
83 HSI selector/indicator switch - HSI (white)/SEL (green)
84 Nav mode selector/indicator switch - VOR ILS (green)/TACAN (green)
85 ILS marker indicator MARKER
86 Fuel totalizer/flow indicator
87 EGT gauge
88 Engine RPM gauge
89 Engine TORQUE gauge
90 OXYgen contents gauge
91 OIL temperature gauge
92 OIL pressure gauge
93 OAT gauge (pre-Mod 0492) / FUEL contents gauge (post-Mod 0492)
94 OXY flow indicators (2) and pillar light - upper: FRONT, lower: REAR
95 FUEL OFF indicator (amber)
96 FUEL CUT OFF switch
97 Standby magnetic compass
98 CANOPY FRACTURE firing handle and safety pin
99 Frequency card holder (2)
100 Transponder

Circuit breaker panel:

101 C/B's - (in-flight use)
102 C/B's - (not for in-flight use)

ELECTRICS panel (forward section):

103 Ground power unit indicator - GPU ON LINE (amber)
104 Voltammeter
105 VOLTS switch - BAT 1/BUS/BAT 2

AIR CONDitioning panel:

106 BLEED switch - ON/OFF/RESET
107 Boost switch - NORM/BOOST
108 RAM air lever - OPEN/SHUT
109 Auto temp control - COLD/HOT
110 Mode switch - AUTO/MAN
111 Manual temp switch - HOT/COLD

ELECTRICS panel (rear section):

112 BATTERY switches (2) - ON/OFF,
l to r: No. 1 Battery, No. 2 Battery and O/HEAT 1/2 amber caption (inoperative)
113 GENerator switch - ON/RESET/OFF
114 ESSENTIAL BUS switch - NORM/ISOLATE
115 SHED BUS switch - NORM/REGAIN

ICE PROTECTION panel:

116 ICE DETector switch - ON/OFF
117 Fail indicators (3), l to r: PITOT 1, PITOT 2, AOA/STALL (all amber)
118 Heater switches (3) - ON/OFF, l to r: PITOT 1, PITOT 2, AOA/STALL
119 Not used
120 Not used
121 Engine INTAKE and PROPeller heater switches (2), - ON/OFF and indicators (2),
l to r: INTAKE ON (blue), PROP 1/2 (blue)

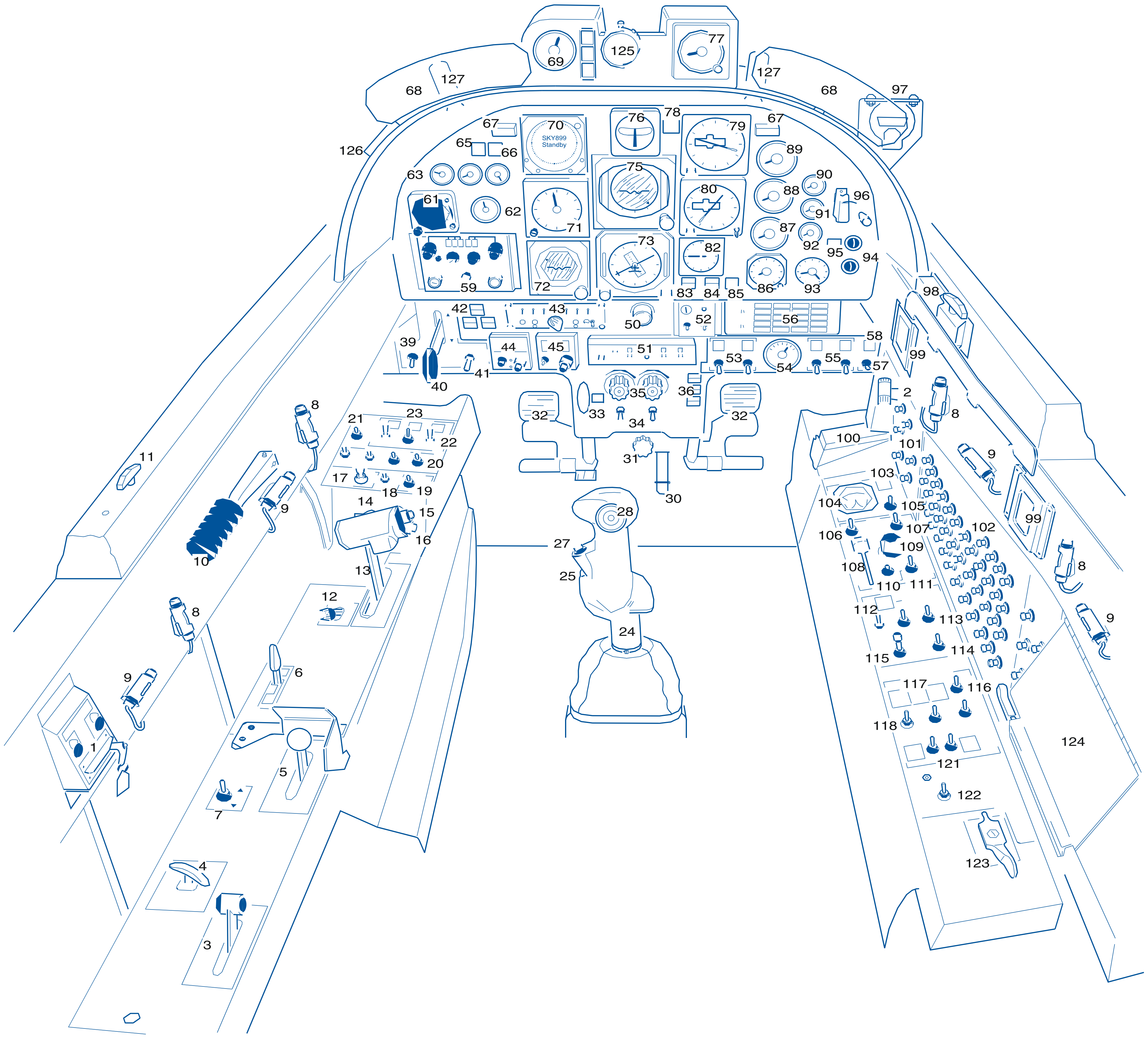
Rear panel:

122 EXT IN'COM switch - ON/OFF
123 OXY SUPPLY selector - ON/OFF

Miscellaneous:

124 Map stowage
125 Stopwatch
126 Map clip
127 Map reading light

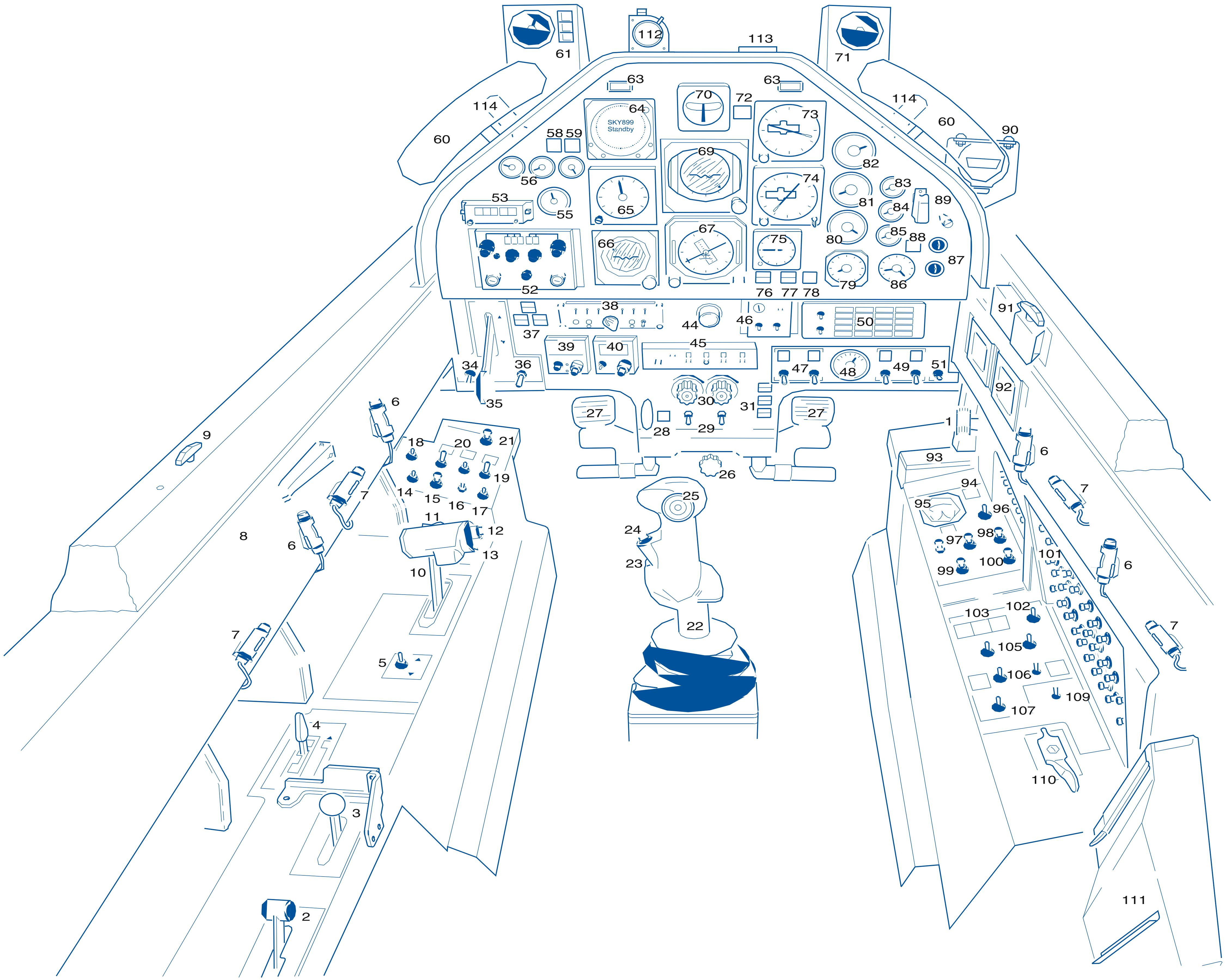
Key to Fig 1 - Front Cockpit



5 - 1 Fig 1 Front Cockpit

1	Utility light
2	Emergency landing gear lever - LDG GEAR STBY LOWER - NORMAL/DOWN
3	EMERG SHUT DOWN lever - NORMAL/OFF/FEATHER
4	FLAPS selector - UP/MID/DOWN
5	SEAT ADJ switch - UP/DOWN
6	Emergency light (4)
7	Background light (4)
8	Canopy locking lever
9	Stowage - SEAT FIRING handle safety pin
10	Power lever - REV/GND IDLE/FLT IDLE/MAX
11	Rudder trim switch RUD TAB - LH/centre off/RH
12	Press - to - transmit switch
13	AIRBRAKE switch - IN/centre off/OUT
14	ALTernative MUTE switch - MUTE/NORMAL
15	TRIM cut out switch - ISOL/NORM
16	STALL WNG switch - ISOL/NORM
17	ALTernative TX switch - TX/OFF
18	ENGINE SPEED switch - 100% / 70%
19	ENGINE START switches (3), l to r: EEC - NORMAL/MAN/CRANK, FUEL IGN - NORMAL/EM'GY, Start Switch - START/RUN/STOP
20	ENGINE START indicators (3), l to r: MONO P FAIL (amber) (inoperative), IGNITER ON (white), STARTER ON (amber)
21	MASTER ENG SW - FRONT/REAR
22	Control column
23	Inactive switch (not used)
24	Main audio mute switch. Unmarked
25	Elevator/aileron trim switch. Unmarked
26	Rudder pedal adjuster
27	Wheelbrake toe pad
28	PARKING BRAKE handle and indicator - PARK BRAKE (amber)
29	INTERIOR LIGHTS switches (2), l to r: NORMAL - ON/OFF, EMERG - BRT/DIM/OFF
30	INTERIOR LIGHTS dimmers (2), l to r: PANELS, INSTRUMENTS
31	Selector/indicator switches (3) upper: COMPASS (white)/SEL (green) mid: U/VHF (white)/SEL (green), lower: TPDR (white/SEL (green)
32	Not used
33	Not used
34	HYDraulic cut off switch - CUT OFF/NORMAL
35	LDG GEAR selector - UP/DOWN
36	GND UP ENABLE switch - ON/OFF
37	Landing gear position lights (3) - In transit: red, Locked down: green
38	CCS station box
39	VHF NAVigation control unit
40	TACan control unit
41	Not used
42	Not used
43	Not used
44	Area microphone
45	Transponder control unit
46	Compass control panel
47	PORT fuel PUMPS switches (2) - ON/OFF and indicators (2), l to r: MAIN (amber), AUX (amber)
48	FUEL contents gauge (pre-Mod 0492) / OAT gauge (post-Mod 0492)
49	STB fuel PUMPS switches (2) - ON/OFF and indicators (2), l to r: MAIN (amber), AUX (amber)
50	CWP
51	FIRE DET test switch - FIRE TEST/FIRE FAULT
52	U/VHF control unit
53	Remote frequency channel indicator
54	Not used
55	Flap position indicator
56	Trim position indicators (3), l to r: aileron, rudder, elevator
57	Not used
58	Airbrake unlocked indicator - AIR BRAKE (white)
59	Landing gear not locked down indicator - U/C(amber)
60	Rear view mirror (2)
61	Angle of attack indicator and indexer
62	Not used
63	CWS attention getter (red) (2)
64	TCAS Cockpit Display Unit
65	Combined speed indicator
66	Standby attitude indicator
67	Horizontal situation indicator
68	Not used
69	Attitude indicator
70	Turn and slip indicator
71	Accelerometer
72	Ice warning indicator/switch ICE (blue)
73	Standby altimeter
74	Servo altimeter
75	Vertical speed indicator
76	HSI selector/indicator switch - HSI (white)/SEL (green)
77	Nav mode selector/indicator switch - VOR ILS (green)/TACAN (green)
78	ILS marker indicator MARKER
79	Fuel totalizer/flow indicator
80	EGT gauge
81	Engine RPM gauge
82	Engine TORQUE gauge
83	OXYgen contents gauge
84	OIL temperature gauge
85	OIL pressure gauge
86	OAT gauge (pre-Mod 0492) / FUEL contents gauge (post-Mod 0492)
87	OXY flow indicators (2) and pillar light - upper: FRONT, lower: REAR
88	FUEL OFF indicator (amber)
89	FUEL CUT OFF switch - CLOSE/FRONT/OPEN
90	Standby magnetic compass
91	CANOPY FRACTURE firing handle and safety pin
92	Frequency card holder (2)
93	Transponder
ELECTRICS panel:	
94	Ground power unit indicator - GPU ON LINE (amber)
95	Voltammeter
96	VOLTS switch - BAT 1/BUS/BAT
97	BATTERY switches (2) - ON/FRONT/OFF, l to r: No. 1 Battery, No. 2 Battery and O/HEAT 1/2 amber caption (inoperative)
98	GENerator switch - ON/RESET/OFF
99	SHED BUS switch - NORM/REGAIN
100	ESSENTIAL BUS switch - NORM/ISOLATE
Circuit breaker panel:	
101	C/B's - (not for in-flight use)
ICE PROTECTION panel:	
102	ICE DETector switch - ON/OFF
103	Fail indicators (3), l to r: PITOT 1, PITOT 2, AOA/STALL (all amber)
104	Not used
105	Heater switches (2) - ON/OFF, l to r: PITOT 1, PITOT 2
106	Engine INTAKE and PROPeller heater switches (2), - ON/FRONT/OFF and indicators (2), l to r: INTAKE ON (blue), PROP 1/2 (blue)
107	AOA/STALL heater switch (3) - ON/FRONT/OFF
108	Not used
Rear panel:	
109	EXT IN'COM switch - ON/OFF
110	OXY SUPPLY selector - ON/OFF
Miscellaneous:	
111	Map stowage
112	Stopwatch
113	Map clip
114	Map reading light

Key to Fig 2 - Rear Cockpit



5 - 1 Fig 2 Rear Cockpit

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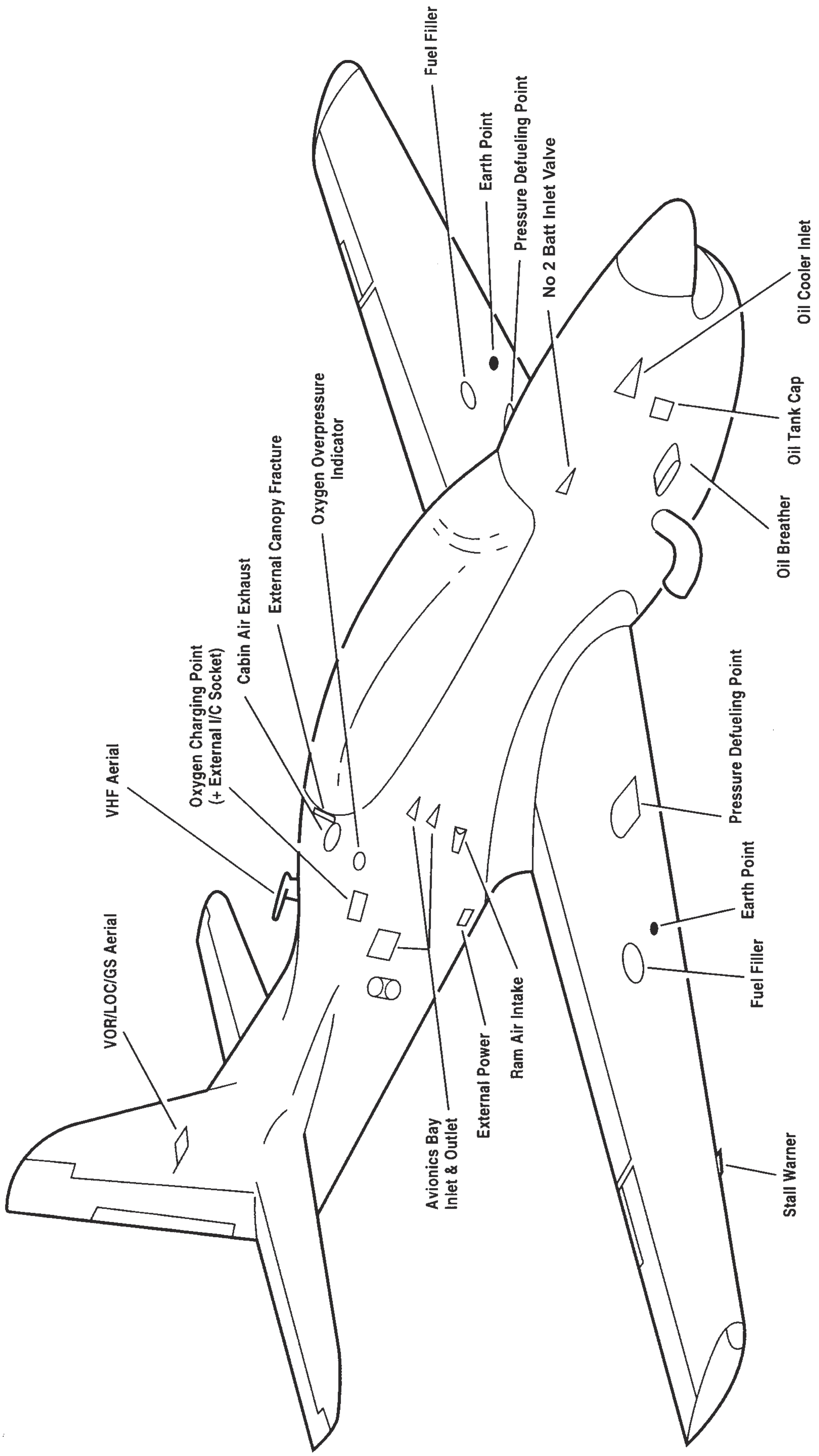
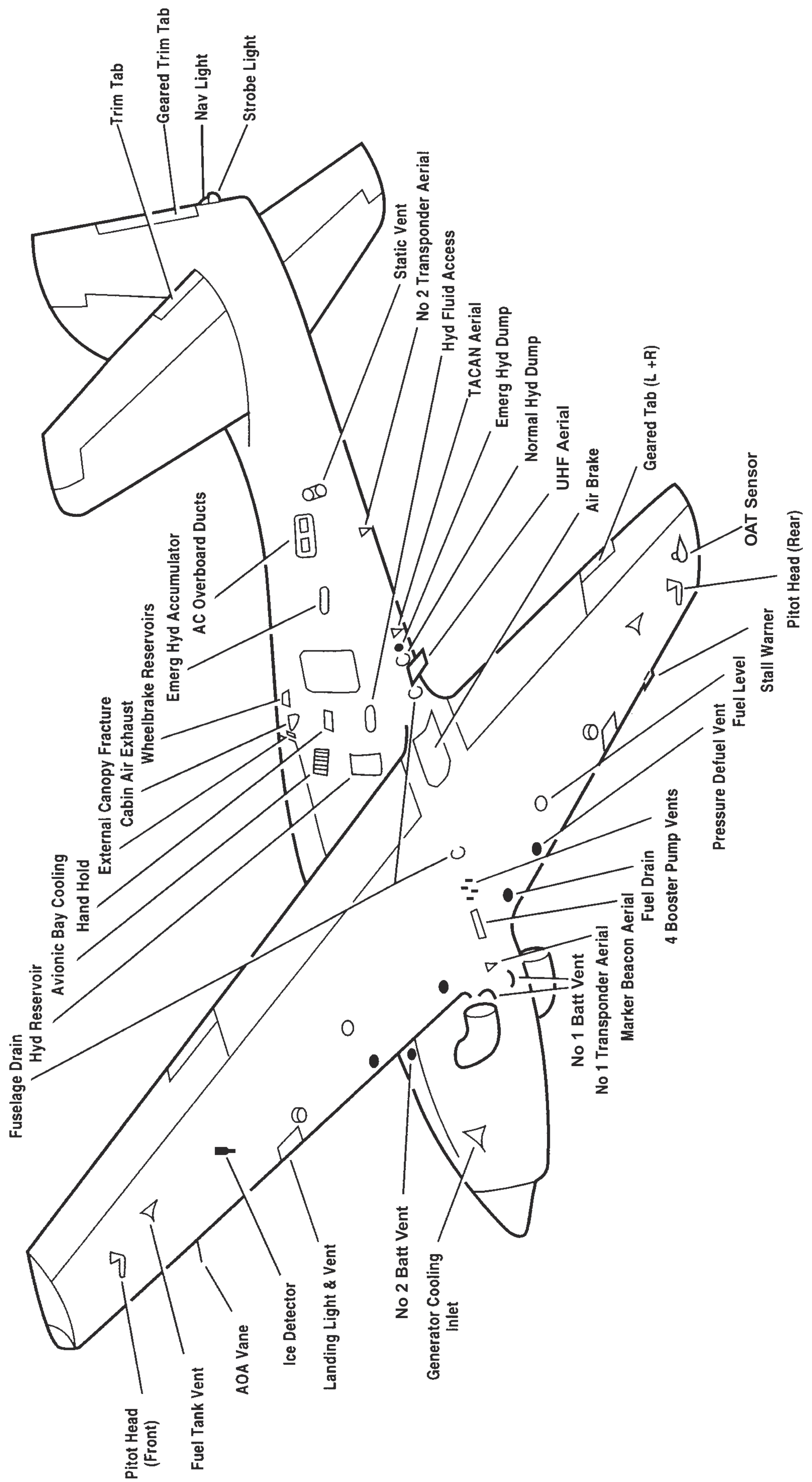


5 - 1 Fig 3 External Checks Front



5 - 1 Fig 4 External Checks Rear