# PHANTOM FGR Mk 2

## AIRCREW MANUAL - BOOK 1



BY COMMAND OF THE DEFENCE COUNCIL

Prepared by RAF Handling Squadron

## NOTES TO USERS

1. The Manual is complementary to the Phantom FGR2 Aircrew Manual - Weapons System (AP 101B-0902-I5B) and to the associated Flight Reference Cards (AP101B-0902-14A).

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

Preliminaries
Part 1 - Description and Management of Systems
Part 2 - Limitations
Part 3 - Handling
Part 4 - Emergencies
Part 5 - Cockpit Illustrations

Each Part is divided into Chapters as listed on its marker card. Each sheet is identified by a Part, Chapter, Page reference at the foot of the page. Thus, a page bearing the reference 1-3 Page 7 is page 7 of part 1, chapter 3.

3. The limitations quoted in Part 2 are mandatory. Instructions containing the words 'is to' or 'are to' are also mandatory.

4. The Manual and its associated Flight Reference Cards aim to provide the best operating information, instructions and advice currently available. Although they provide guidance for most eventualities, they are not substitutes for sound judgement and good airmanship; moreover, they assume adequate knowledge of the pertinent volumes of the AP 3456 series. Furthermore, circumstances might require aircrew to depart from or modify the prescribed procedures and drills. Consequently, the Manual and Flight Reference Cards should not be regarded as documents which are to be adhered to inflexibly at all times - other than as explained in para 3.

5. Amendment Lists will be issued as necessary and each amendment list instruction sheet will state the main purpose of the amendment and will include a list of modifications covered. The List of Pages will also be updated with each amendment. New or amended matter of importance will be indicated by symbols positioned in the text thus: ◆....◆ to show the extent of amended text and thus: ◆◆ to show where text has been deleted. The number of the amendment list by which a sheet was initially issued or re-issued will appear at the bottom of the odd-numbered pages and any amendment symbols on either page forming a sheet will, therefore, refer to that amendment list. However, when a new chapter is issued with an amendment list, or an existing chapter is completely revised, this fact will be noted within the heading of the chapter and the symbols will not appear.

6. The following conventions are observed throughout the Manual:

a. The actual markings on controls or indicators are shown in the text by capital letters.

b. Unless otherwise stated, all airspeeds and heights quoted are calibrated values.

c. **WARNINGS** are inserted only when the serious consequences of not following a certain procedure might otherwise be overlooked.

d. 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.

e. Information requiring emphasis is printed in **bold print** or *italics*.

7. Modification numbers are only referred to in the text 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 Manual with a cross reference to the location in the text for the modification details.

**IMPORTANT**

◆ **Comments and suggestions should be forwarded to the Officer Commanding, Royal Air Force Handling Squadron, Boscombe Down, Salisbury SP4 0JF, or GPTN 8431 - 2041.** ◆

## AMENDMENT RECORD SHEET

To record the incorporation of an Amendment List in this publication, sign against the appropriate A L No and insert the date of incorporation.

| A L No | AMENDED BY | DATE |
|---|---|---|
| 1 | Incorporated | |
| 2 | Incorporated | |
| 3 | Incorporated | |
| 4 | Incorporated | |
| 5 | Incorporated | |
| 6 | B. C. Gasson (covering 6–12) | 21.1.77 (covering 6–12) |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | B. C. Gasson | 22.4.77 |
| 14 | [illegible signature] | 8.6.78 |
| 15 | | 19.6.79 |
| 16 | | 6.2.81 |
| 17 | D A Chinnery | 7.6.82 |
| 18 | [illegible signature] | 22.2.83 |
| 19 | [illegible signature] | 11.6.84 |
| 20 | [illegible signature] | 11-8-89 |
| 21 | [illegible signature] | 11-8-89 |
| 22 | [illegible signature] | 5.4.90 |
| 23 | [illegible signature] | 5.11.90 |
| 24 | [illegible signature] | 5.2.92 |
| 25 | | |
| 26 | | |
| 27 | | |
| 28 | | |
| 29 | | |
| 30 | | |
| 31 | | |
| 32 | | |
| 33 | | |
| 34 | | |
| 35 | | |
| 36 | | |
| 37 | | |
| 38 | | |
| 39 | | |
| 40 | | |
| 41 | | |
| 42 | | |
| 43 | | |
| 44 | | |
| 45 | | |
| 46 | | |
| 47 | | |
| 48 | | |
| 49 | | |
| 50 | | |
| 51 | | |
| 52 | | |
| 53 | | |
| 54 | | |
| 55 | | |
| 56 | | |
| 57 | | |
| 58 | | |
| 59 | | |
| 60 | | |
| 61 | | |
| 62 | | |
| 63 | | |
| 64 | | |
| 65 | | |
| 66 | | |

**RESTRICTED**

*(Continued overleaf)*

~~1/87 ... 87~~
~~1/89 ... 89~~

| AL No | AMENDED BY | DATE |
|---|---|---|
| 67 | | |
| 68 | | |
| 69 | | |
| 70 | | |
| 71 | | |
| 72 | | |
| 73 | | |
| 74 | | |
| 75 | | |
| 76 | | |
| 77 | | |
| 78 | | |
| 79 | | |
| 80 | | |
| 81 | | |
| 82 | | |
| 83 | | |
| 84 | | |
| 85 | | |
| 86 | | |
| 87 | | |
| 88 | | |
| 89 | | |
| 90 | | |
| 91 | | |
| 92 | | |
| 93 | | |
| 94 | | |
| 95 | | |
| 96 | | |
| 97 | | |
| 98 | | |
| 99 | | |
| 100 | | |
| 101 | | |
| 102 | | |
| 103 | | |

| AL No | AMENDED BY | DATE |
|---|---|---|
| 104 | | |
| 105 | | |
| 106 | | |
| 107 | | |
| 108 | | |
| 109 | | |
| 110 | | |
| 111 | | |
| 112 | | |
| 113 | | |
| 114 | | |
| 115 | | |
| 116 | | |
| 117 | | |
| 118 | | |
| 119 | | |
| 120 | | |
| 121 | | |
| 122 | | |
| 123 | | |
| 124 | | |
| 125 | | |
| 126 | | |
| 127 | | |
| 128 | | |
| 129 | | |
| 130 | | |
| 131 | | |
| 132 | | |
| 133 | | |
| 134 | | |
| 135 | | |
| 136 | | |
| 137 | | |
| 138 | | |
| 139 | | |
| 140 | | |

AIL RECORD

| *AIL No* | *Date of Issue* | *Location Part-Chap* | *Signature* | *Cancelled By* | *Signature* | *Date* |
|---|---|---|---|---|---|---|
| 2-83 | SEPT '83 | 1-12 | D.A. Oakes. | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## ANA RECORD

| *ANA No* | *DTG* | *Location Part-Chap* | *Signature* | *Cancelled By* | *Signature* | *Date* |
|---|---|---|---|---|---|---|
| 1/2 | — | — | — | Cancelled by pre-AL21 amendments | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## LIST OF PAGES

This list shows all the pages which should be present in this manual at AL24. Pages which should have manuscript amendments are marked with an asterisk.

| *Page* | *Issued by* |
|---|---|
| **Preliminaries** | |
| Title page | AL23 |
| Amendment record sheet | Initial |
| AIL/ANA record sheet | AL21 |
| Prelim Page 1 | AL24 |
| Prelim Page 3 | AL24 |
| Prelim Page 5 | AL22 |
| Prelim Page 7 | AL23 |
| **Part 1** | |
| Marker card | AL20 |
| **Part 1 Chapter 1** | |
| 1-1 Page 1 | AL20 |
| 1-1 Page 3 | AL20 |
| 1-1 Page 5 | AL20 |
| 1-1 Page 7 | AL9 |
| **Part 1 Chapter 2** | |
| 1-2 Page 1 | AL24 |
| 1-2 Page 3 | Initial |
| 1-2 Page 5 | AL24 |
| **Part 1 Chapter 3** | |
| 1-3 Page 1 | AL20 |
| 1-3 Page 3 | AL21 |
| 1-3 Page 5 | AL17 |
| **Part 1 Chapter 4** | |
| 1-4 Page 1 | AL18 |
| 1-4 Page 3 | AL21 |
| 1-4 Page 5 | AL23 |
| 1-4 Page 7 | AL22 |
| 1-4 Page 9 | AL17 |
| 1-4 Page 11 | AL17 |
| **Part 1 Chapter 5** | |
| 1-5 Page 1 | AL21 |
| 1-5 Page 3 | AL17 |
| 1-5 Page 5 | AL24 |
| 1-5 Page 6A | AL20 |
| 1-5 Page 6C | AL20 |
| 1-5 Page 7 | AL22 |
| 1-5 Page 8A | AL20 |
| 1-5 Page 9 | AL21 |
| 1-5 Page 11 | AL16 |
| 1-5 Page 13 | AL24 |
| 1-5 Page 15 | AL24 |
| 1-5 Page 17 | AL24 |
| 1-5 Page 19 | AL22 |
| **Part 1 Chapter 6** | |
| 1-6 Page 1 | AL24 |
| 1-6 Page 3 | AL18 |
| 1-6 Page 5 | AL21 |
| 1-6 Page 7 | AL24 |
| 1-6 Page 9 | AL21 |
| 1-6 Page 11 | AL12 |
| 1-6 Page 13 | AL12 |
| 1-6 Page 15 | AL12 |
| **Part 1 Chapter 7** | |
| 1-7 Page 1 | AL24 |
| 1-7 Page 3 | AL19 |
| 1-7 Page 5 | AL19 |
| 1-7 Page 7 | AL20 |
| 1-7 Page 9 | AL19 |
| 1-7 Page 11* | Initial |
| **Part 1 Chapter 8** | |
| 1-8 Page 1 | AL18 |
| 1-8 Page 3 | AL15 |
| 1-8 Page 5 | AL21 |
| 1-8 Page 7 | AL20 |
| 1-8 Page 9 | AL20 |
| 1-8 Page 11 | AL20 |
| 1-8 Page 13 | AL24 |
| 1-8 Page 15 | AL24 |
| **Part 1 Chapter 9** | |
| 1-9 Page 1 | AL21 |
| 1-9 Page 3 | AL22 |
| 1-9 Page 5 | AL22 |
| 1-9 Page 7 | AL22 |
| **Part 1 Chapter 10** | |
| 1-10 Page 1 | AL17 |
| 1-10 Page 3 | AL24 |
| **Part 1 Chapter 11** | |
| 1-11 Page 1 | AL24 |
| **Part 1 Chapter 12** | |
| 1-12 Page 1 | AL20 |
| **Part 1 Chapter 13** | |
| 1-13 Page 1 | AL21 |
| 1-13 Page 3 | AL21 |
| 1-13 Page 5 | AL24 |
| 1-13 Page 6A | AL22 |
| 1-13 Page 7 | AL21 |
| 1-13 Page 9 | AL24 |
| 1-13 Page 11 | AL24 |
| 1-13 Page 13 | AL24 |
| 1-13 Page 15 | AL16 |
| 1-13 Page 17 | AL17 |
| 1-13 Page 19 | AL19 |
| 1-13 Page 21 | AL16 |
| **Part 1 Chapter 14** | |
| 1-14 Page 1 | AL22 |
| 1-14 Page 3 | AL20 |
| 1-14 Page 5 | AL22 |
| **Part 2** | |
| Marker card | AL14 |
| **Part 2 Chapter 1** | |
| 2-1 Page 1 | AL24 |
| 2-1 Page 3 | AL21 |
| 2-1 Page 5 | AL16 |
| **Part 2 Chapter 2** | |
| 2-2 Page 1 | AL24 |
| 2-2 Page 3 | AL24 |
| 2-2 Page 5 | AL24 |
| 2-2 Page 7 | AL24 |
| 2-2 Page 9 | AL24 |
| 2-2 Page 11 | AL22 |
| 2-2 Page 13 | AL22 |
| **Part 3 Chapter 3** | |
| 2-3 Page 1 | AL24 |
| 2-3 Page 3 | AL24 |
| **Part 3** | |
| Marker card | AL12 |
| **Part 3 Chapter 1** | |
| 3-1 Page 1 | AL24 |
| 3-1 Page 3 | AL24 |
| 3-1 Page 5 | AL24 |
| **Part 3 Chapter 2** | |
| 3-2 Page 1 | AL24 |
| 3-2 Page 3 | AL24 |
| 3-2 Page 5 | AL24 |
| 3-2 Page 7 | AL24 |
| 3-2 Page 9 | AL24 |
| 3-2 Page 11 | AL24 |
| 3-2 Page 13 | AL24 |
| 3-2 Page 15 | AL24 |
| **Part 3 Chapter 3** | |
| 3-3 Page 1 | AL24 |
| 3-3 Page 3 | AL24 |
| 3-3 Page 5 | AL24 |
| **Part 3 Chapter 4** | |
| 3-4 Page 1 | AL24 |
| 3-4 Page 3 | AL24 |
| **Part 3 Chapter 5** | |
| 3-5 Page 1 | AL24 |
| **Part 3 Chapter 6** | |
| 3-6 Page 1* | AL13 |
| **Part 3 Chapter 7** | |
| 3-7 Page 1 | AL12 |
| **Part 4** | |
| Marker card | AL11 |
| **Part 4 Chapter 1** | |
| 4-1 Page 1 | AL24 |
| 4-1 Page 3 | AL24 |
| **Part 4 Chapter 2** | |
| 4-2 Page 1 | AL24 |
| 4-2 Page 3 | AL24 |
| 4-2 Page 5 | AL24 |
| 4-2 Page 7 | AL24 |
| 4-2 Page 9 | AL22 |
| **Part 5** | |
| Marker card | AL10 |
| 5-1 Page 1 | AL15 |
| 5-1 Page 3 | AL24 |
| 5-1 Page 5 | AL22 |
| 5-1 Page 7 | AL22 |
| 5-1 Page 9 | AL21 |
| 5-1 Page 11 | AL21 |
| 5-1 Page 13 | AL22 |
| 5-1 Page 15 | AL22 |
| 5-1 Page 17 | AL21 |

*Intentionally Blank*

# INTRODUCTION

## General Description

1. The Phantom FGR Mk 2 is a 2-seat air defence aircraft powered by two Spey Mk 201, 202 or 203 engines which each develop a maximum nominal thrust of approximately 12,250 pounds. Reheat operation increases the maximum nominal thrust to approximately 20,515 pounds each. The aircraft is capable of sustained supersonic operation. The crew consists of the pilot, occupying the front cockpit, and the navigator occupying the rear cockpit. Aircraft XT891 to XT914 and XV393 to XV398 are dual control aircraft (Blocks 31 to 33).

## Exterior

2. The aircraft features a low mounted swept-back wing with dihedral at the wing tips, and a one-piece stabilator, with anhedral, mounted low on the aft fuselage. The wings have hydraulically operated leading edge and trailing edge flaps, ailerons, spoilers, and air brakes. All the control surfaces are moved by irreversible hydraulic power cylinders to provide control effectiveness throughout the entire speed range. A self-charging pneumatic system provides normal and emergency operation of the canopy, as well as emergency operation of the landing gear wing flaps and lower auxiliary air doors. The pressurised cockpit is enclosed by clamshell canopies. A mirror is fitted externally on the aft canopy forward bow to improve the navigator's view in the 6 o'clock low astern position. A brake parachute, contained in the aft end of the fuselage, is provided to reduce landing roll distances. An arrester hook is fitted.

## Interior

3. The interior configuration of the aircraft is shown in the general arrangement illustration. Although the cockpits have separate canopies the cockpit pressure/oxygen environment is common. Each cockpit incorporates an ejection seat which is adjustable in the vertical plane. The forward cockpit instrument panel contains the flight and engine instruments. Engine controls, autopilot and fuel management panels are on the left console. Communication, navigation, heating and lighting controls are on the right console. Left and right vertical panels forward of the consoles contain the flight control trim position indicators and the telelight panels. The rear cockpit instrument panel contains the necessary instruments for navigation, plus miscellaneous switches and indicator lights. A radar indicator and controls are below the instrument panel. The left and right sides of the cockpit contain the circuit breaker panels, and the left side holds the communication and oxygen controls. A map holder is fitted in the rear cockpit of single stick aircraft. See part 5 for instrument panel and console illustrations.

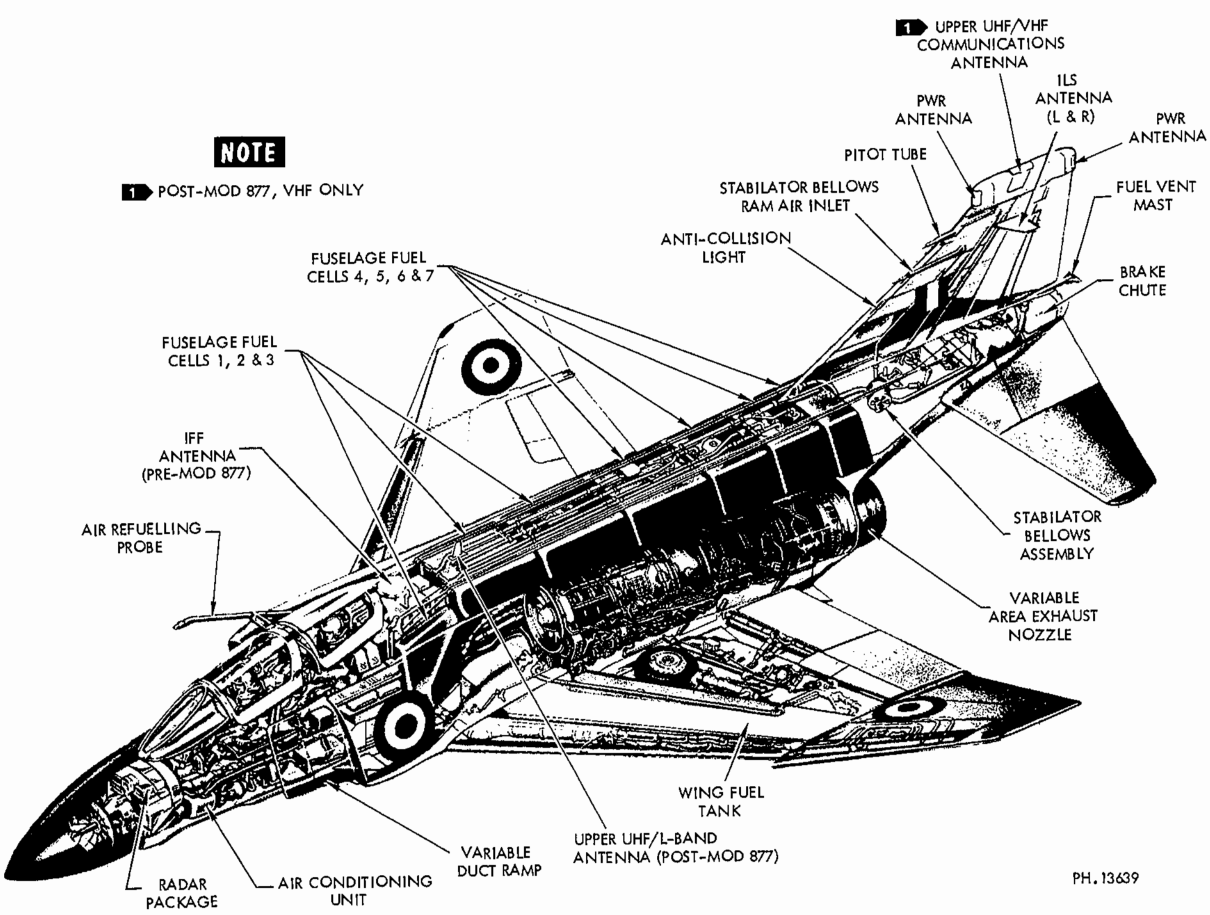
## Dimensions

4. The approximate aircraft dimensions are:

| | |
|---|---|
| Wing Span: | (wings spread): 38 ft, 5 in<br>(wings folded): 27 ft, 6.5 in |
| Length: | 57 ft, 7 in |
| Height: | (to top of fin): 16 ft, 3.4 in |

## LIST OF MODIFICATIONS MENTIONED IN THE TEXT

| *Mod* | *Brief Title* | *Location* |
|---|---|---|
| | ◆◆ | |
| 54 (Def) | Emergency brakes system pressure gauge | 1-8, para 42<br>5-1, Fig 4 |
| 74 (Def) | Changes AUX AIR DOOR caption speeds | 1-6, para 15 |
| | ◆◆ | |
| 639 | Replaces CSDU underspeed switch with electronic under-frequency circuit | 1-5, para 5 |
| | ◆◆ | |
| 702 | Makes airframe provision for aircrew NBC protection | 1-4, para 35<br>1-5, Fig 4/Table 8<br>1-12, para 6<br>1-14 various |
| 721 | ARI 23300/5 V/UHF | 1-13 various<br>1-5 para 22 |
| 723 | Introduction of RADAR and HEAT head-up captions | 1-2, para 4<br>1-5, Table 10<br>1-11, para 10 |
| 770 | Introduction of a CW power monitor indicator | 5-1 various |
| 783 | Introduces telescopic sighting system | 5-1 various |
| 804 | Introduces Digital Computer Sub-System | 5-1 various |
| 806 | Introduces a MODE 3A/MODE Selector switch | 1-13, para 45 |
| 823 | Introduction of towed target system | 1-5 Tables 8, 10, 11 |
| 848 | Introduces a relay to bypass the dimming relay in the event of a RH GEN OUT/BUS TIE OPEN failure | 1-5 various, 3-1 para 2 |
| 855 | Introduces AN ALE 40 post 1980 weapon update | 1-5 various |
| 877 | Introduces a dual function upper UHF/L-band aerial | Prelim, Fig 1 |
| 920 | Stick top weapon selector | 1-9, para 28 |
| 954 | Introduces AN/ALE 40 enable switch (post-mod 855) | 5-1 |
| ◆980 | Modified intercom system | 2-3 para 8 |
| 1005 | UHF channel spacing changed to 25 MHz | 1-13 para 14A ◆ |
| 5055 | Temporary replacement of LRU with ballast weights | 1-13, para 47 |
| 5102 | Introduces TIRS | 5-1, Fig 8 |
| ◆STI/677 | Engine start 60-second relays disabled | 3-1 para 6 ◆ |
| SEM/037/STC | Removal of FLARE light from AN/ALE 40 switch bracket | 5-1, various |
| SEM/065/STC | Transfer of ENG warning and FIRE TEST circuits to Essential 28V DC bus | 1-5, Table 2/10<br>1-6, para 65 |




**Preliminaries Fig 1 General Arrangement**
◆ *(Embodiment of Mod 877)* ◆

**Table 1 - Aircraft Serial Numbers and Block Numbers**

| *Block Number* | *Serial Numbers* | *Number of Aircraft in Block* |
|---|---|---|
| 31 | XT 891 to 895 | 5 |
| 32 | XT 896 to 906 | 11 |
| 33 | XT 907 to 914<br>XV 393 to 398 | 14 |
| 34 | XV 399 to 417 | 19 |
| 35 | XV 418 to 436 | 19 |
| 36 | XV 437 to 422<br>XV 460 to 475 | 22 |
| 37 | XV 476 to 495 | 20 |
| 38 | XV 496 to 501 | 6 |

# LIST OF ABBREVIATIONS USED IN THE TEXT

AA Aircraft allowance
AAL Aircraft approach limitation
AAR Air-to-air refuelling
AC Alternating current
ACC Automatic code change
◆ ACM Air combat manoeuvring ◆
ADF Automatic direction finding
ADI Attitude director indicator
AEA Aircrew equipment assembly
AFCS Automatic flight control system
AGL Above ground level
AMCS Airborne missile control system
AOA Angle of attack
AOAS Angle of attack system
ARI Aileron-rudder interconnect
AR5 Aircrew respirator NBC No 5
ACTRU Air traffic control reporting unit
AUW All-up weight
BAI Back-up attitude indicator
BDHI Bearing and distance heading indicator
BIT Built-in test
BLC Boundary layer control
BRSL Bomb release safety lock
BST Boresight
C Celcius (centigrade)
CADC Central air data computer
CAS Calibrated airspeed
c/b Circuit breaker
CG Centre of gravity
CL Centreline
CNI Communication, navigation, identification
CSD Constant speed drive
CSDU Constant speed drive unit
◆CSS Control stick steering ◆
DAA Digital auto acquisition
DC Direct current
DCSS Digital computer sub-system
DG Directional gyro
DH Decision height
DSB Double sideband
EOA Engine out allowance
FRC Flight reference cards
FSII Fuel system icing inhibitor
g Acceleration due to gravity
GCA Ground controlled approach
GMT Greenwich mean time
HDU Hose drum unit
HF High frequency
HP High pressure
HSD High speed drogue
HSI Horizontal situation indicator
Hz Hertz (cycles per second)
IAS Indicated airspeed
ICS Intercom system
IFF/SSR Identification friend or foe/secondary surveillance radar
IFR In-flight refuelling
IGV Inlet guide vane
ILS Instrument landing system
IMN Indicated Mach number
CU IN Cubic inch
INAS Inertial nav/attack system
I/P Identification pulse
ISA International standard atmosphere
KCAS Knots calibrated airspeed
lbf in² Pounds per square inch
LCG Load classification group
LCN Load classification number
LCOSS Lead computing optical sight system
LOX Liquid oxygen
LP Low pressure
LRU Line replacement unit
LSW Life-saving waistcoat
MAC Mean aerodynamic chord
mb Millibar(s)
MDH Minimum decision height
MI Magnetic indicator
MIL Military thrust
NBC Nuclear, biological and chemical
OAT Outside air temperature
PAR Precision approach radar
PC Power control system
PEC Personal equipment connector
PIO Pilot induced oscillation
◆◆
PSI Pounds per square inch
PSP Personal survival pack
PUAG Purpose use arresting gear
PWR Passive warning receiver
QRF Quick-release fitting
RAT Ram air turbine
RF Radio frequency
RHAG Rotary hydraulic arresting gear
rh/Pt Rhodium platinum
RMI Radio magnetic indicator
RPM Revolutions per minute
SAI Standby attitude indicator
SBY Standby
SCH Simplified combined harness
SEAM Sidewinder expanded acquisition mode
SG Specific gravity
SL Sea level
SPC Static pressure compensator
SPRAG Spray arresting gear
SSB Single sideband
Tacan Tactical air navigation
TAI True airspeed indicator
TGT Turbine gas temperature
TIRS Tactical information retrieval system
TMN True Mach number
TRU Transformer rectifier unit
UHF Ultra high frequency
VCH Visual commital height
VHF Very high frequency
XPDR Transponder

*Intentionally Blank*

# PART 1

## CHAPTER 1 — BLEED AIR SYSTEMS

### Contents



### Illustrations



## AIR CONDITIONING, PRESSURISATION AND RAIN REMOVAL SYSTEM

### General Description

1. The cabin turbine which is mounted on the right wall of the aircraft is supplied with air ducted from the 7th or 12th stage of both engine high pressure compressors. The cabin turbine provides air for:

Cockpit pressurisation and air conditioning.

◆ Air ventilated suits (pre-mod 702). ◆

Windscreen demisting.

◆ 2. The cockpits are pressurized, and pre-mod 702 the ◆ air ventilated suits for both crew members are supplied with conditioned air from the cockpit air conditioning unit. The air which pressurises and heats the cockpits is used also to keep the inside of the windscreen free of fog and frost. Bleed air is used for windscreen rain removal. The cockpit air conditioning unit utilises high temperature, high pressure, engine compressor bleed air from either or both engines. The cockpit (and pre-mod 702, the air ventilated suit) air conditioning system consists of two air-to-air heat exchanges, an expansion turbine, pressure regulating mixing and shut-off valves and the controls necessary to select cockpit temperature, air ventilated suit temperature (pre-mod 702), demisting, rain removal and ram air operation. Separate temperature ranges and control systems for the cockpit (and pre-mod 702 the air ventilated suit) are provided.

3. High temperature/high pressure engine compressor bleed air passes through the primary and secondary heat exchanger and is expanded through a cooling turbine. After being mixed with hot compressor bleed air as required by the pilot's temperature selection, the conditioned air enters the cockpits through several manifolds. One manifold is near the navigator's feet, one is near the pilot's feet, one is along the lower surface of each windscreen side panel and another at the base of the flat optical panel of the windscreen. In addition, two air nozzles, one on each side, are positioned just below the canopy sill of the navigator's cockpit.

4. The inlet bleed air pressure to the air conditioning system is controlled by the RAIN REM — ON/OFF LOW/NORM — CABIN AIR FLOW switch (see para 20).

**Engine Bleed Air**

5. Bleed air is ducted from the 7th or 12th stage of the engine high pressure compressor. When bleed air pressure falls below 75 PSI air is ducted from the 12th stage. If the pressure is above 85 PSI, the 7th stage pressure switch is opened and air is ducted from the 7th stage provided ISOLATE is not selected.

6. A bleed air overpressure warning system is provided and consists of a pressure switch in the compensating duct adjacent to the cabin refrigeration unit and an ENG BLEED OVERPRESS caption on the telelight panel in the forward cockpit. If the bleed air pressure increases above $242 \pm 12$ PSI, the bleed air overpressure switch actuates the telelight. *Continued operation of the aircraft in the overpressure condition may result in damage to the cabin and equipment refrigeration units.*

7. The bleed air overpressure warning system is powered by the 28/14 volt DC Warning Lights busbar and is protected by circuit breaker 3E on the No 2 circuit breaker panel in the rear cockpit.

**Cockpit/Air Ventilated Suit Air Conditioning Controls**

8. The following controls are provided:

A DEFOG/FOOT HEAT control handle, outboard on the pilot's right console.

Two CABIN ALTitude indicators, one on the pilot's right console and the other on the navigator's left console.

An EMERG VENT control forward of the cabin altitude indicator in the pilot's cockpit.

A TEMP CONTrol panel on the right console in the pilot's cockpit.

Pre-mod 702 there is a SUIT VENT AIR control on the pilot's left console. Post-mod 702 the air ventilated suit pipework and valves are removed and the system is permanently off.

**Cockpit Air Conditioning Operation**

9. Reference to Fig 1 and Fig 2 is necessary to understand the operation of the air conditioning system.

10. The low temperature range produces inlet air temperatures from minus 20°F to plus 100°F. Cockpit temperature is determined by a combination of inlet air and environmental conditions. The low temperature curve is the governing schedule for all air entering the cockpit while in automatic temperature control with the DEFOG/FOOT HEAT lever set to FOOT HEAT. The demist port allows a small volume of air to enter the cockpit all the time. This volume of air increases as the DEFOG/FOOT HEAT lever is moved forward. Up to approximately mid travel towards DEFOG, all air enters on the low temperature schedule. Thus movement of the temperature control knob over its full range (from 8 o'clock to 4 o'clock) only produces minus 20°F to plus 100°F air temperature until the DEFOG/FOOT HEAT lever is moved forward of mid travel.

11. When the lever is forward of mid travel the temperature schedule of all air entering the cockpit changes to the high temperature curve. For example, with the temperature control knob set at 3 o'clock (250° of rotation) and with the lever in an aft position the temperature of incoming air would be 87°F, but when the change to high is made, the temperature changes to 137°F. Since switchover does not occur until 50% of lever movement, a considerable volume of defog air may be obtained without entering the high temperature range, thus aiding crew comfort at low altitudes. As the lever is moved forward through full travel, the foot heat butterfly valves for both cockpits are closing as the demist valve opens. The demisting air increases rapidly in volume and when the lever is fully forward the incoming air temperature is very hot.

**Manual Override — Cockpit Temperature Mixing Valve**

12. If the automatic temperature control malfunctions, the manual position of the TEMP CONT, AUTO/MANUAL switch can be used to select a full range of temperatures up to 230°F. The temperature changeover switch on the DEFOG/FOOT HEAT lever and auto rheostat switch is bypassed. Thus the entire temperature range for both foot heat and demist air is scheduled directly by the mixing valve position, which in turn is moved only when the temperature control AUTO/MANUAL switch is held to either HOT or COLD. The switch is spring-loaded to OFF from either MANUAL position and in the OFF position the mixing valve is held stationary.

**Cockpit Misting**

13. It is possible, through selection of cold temperature settings particularly on humid days, for the air conditioning system to deliver air at temperatures well below dew point, with resultant cockpit misting. This misting can be rapidly dissipated by selecting a slightly warmer temperature. When operating in high humidity conditions, warmer than normal temperatures should be selected prior to take-off, to preclude the possibility of cockpit misting as thrust is increased.

◆ **Air Ventilated Suit Operation (Pre-mod 702)** ◆

14. The air ventilated suit system is switched on when the front cockpit SUIT VENT VALVE is moved away from the OFF position. With the temperature control at AUTO, the air ventilated suit schedule is followed whether the DEFOG/FOOT HEAT lever is in the low or the high temperature range.

**Manual Override — Air Ventilated Suit Temperature Mixing Valve**

15. Manual override operation of the air ventilated suit mixing valve is actuated when the override switch is moved to HOT or COLD. The cockpit air mixing valve remains in its last automatic selected position. The relative volume of demist and foot heat air can be changed by the DEFOG/FOOT HEAT lever but its temperature is fixed when manual override is selected.

16. This characteristic can cause an undesirable situation if automatic temperature control becomes ◆ inoperative during flight. Pre-mod 702 with the air ◆ ventilated suit operating, cockpit air temperature is not normally at a high setting. When the manual override is selected the cockpit air mixing valve remains at its last automatic selected position which is likely to be at a moderate temperature. Therefore when higher temperature demist air is desired for letdown it is not available since manual override only controls air for ◆ the ventilated suit. However, pre-mod 702 when the ◆ SUIT VENT AIR lever in the front cockpit is moved to the OFF position the suit mixing valve becomes stationary at the cold position and the cockpit air mixing valve becomes operative again.

**Emergency Ventilation**

17. Operation of the EMERGency VENTilation control knob is the normal method of shutting off the cabin/air ventilated suit conditioning unit when an engine is operating. The unit may also be shut down by tripping circuit breaker X1 or Y1 on the No 2 circuit breaker panel in the rear cockpit.

18. The cockpits may be cleared of undesired smoke or fumes and the cabin/air ventilated suit air conditioning unit may be shut off by pulling up on the EMERGency VENTilation knob after first pushing in the button on top. When pulled up, three actions occur simultaneously:

a. All air conditioning and pressurisation air from the cabin/air ventilation suit air conditioning unit to the cockpits and pressure suits is shut off.

b. The cabin pressure regulator and safety (dump) valve is opened and the cockpit becomes completely depressurised.

c. A ram air shutoff valve is opened and atmospheric air is allowed to enter the cockpit through a port located just forward of the pilot's feet.

**Windscreen Demisting**

19. Conditioned air from the manifold along the lower surfaces of the side and centre windscreen panels prevents misting of the windscreen. The lever on the pilot's right console, outboard of the right utility panel, proportions the cabin airflow between the foot heaters and windscreen tubes such that in the full aft (FOOT HEAT) position approximately 90% of the total cockpit airflow is delivered to the pilot's and navigator's foot heat manifolds and 10% through the windscreen manifold. At the full forward (DEFOG) position approximately 20% of the total airflow is delivered through the foot heat manifold and 80% through the windscreen manifold.

**Windscreen Rain Removal**

20. Windscreen rain removal and the volume of bleed air pressure to the air conditioning system is controlled by the RAIN REM — ON/OFF LOW/NORM — CABIN AIR FLOW switch on the front cockpit right utility panel.

a. Placing the switch to ON provides a pressure of $40 \pm 5$ PSI for both rain removal and air conditioning. For rain removal, a valve opens allowing warm air to flow through nozzles directed up the outer surface of the windscreen centre panel. The air breaks up the rain drops, diverting the majority of them over the windscreen.

b. Placing the switch to OFF LOW shuts off the rain removal and limits pressure to the air conditioning system to 40 ± 5 PSI thereby greatly reducing cockpit noise.

c. With the switch at NORM, the rain removal is shut off and the air conditioning system operates at 62 ± 5 PSI.

21. A WINDSHIELD TEMP HIGH caption on the telelight panel comes on if the windscreen material approaches a temperature which could cause optical deterioration. If the caption comes on the system should be turned off immediately.

**Cockpit Pressure Altimeters**

22. The pressure altitude of each cockpit is indicated on an altimeter. The pilot's cabin altimeter is on the right console and the navigator's is in a panel on the left side of his cockpit. The altimeters are vented directly to cockpit pressure.

**Cockpit Pressurisation**

23. With the canopies closed, and with the cockpit conditioning system in operation, the cockpit automatically becomes pressurised at 8000 feet and above. The pressure in the cockpit is maintained by the cockpit pressure regulator which is on the cockpit floor aft of the navigator's seat and controls the outflow of air from the cockpit. Below 8000 feet the cockpit is unpressurised. Above 8000 feet the regulator relieves cockpit air as necessary to follow a definite cockpit pressure schedule. Operation of the pressure regulator is completely automatic. Small fluctuations in cockpit pressure and in noise level are noticeable during changes in engine power settings and in MIL power climbs. These fluctuations do not affect the safe operation of the system.

24. The cockpit safety (and dump) valve is used to prevent the cockpit pressure differential from exceeding the positive or negative differential pressure limit in case of malfunctioning of the cockpit pressure regulator, and to provide an emergency means of dumping the cockpit air. The dump feature of the safety valve is pneumatically connected to a dump feature on the cockpit pressure regulator. Both valves, which are operated pneumatically from the EMERG VENT control, have sufficient capacity to permit the cockpit differential pressure to be reduced from 5·5 PSI to 0·05 PSI within five seconds or less.

**WARNING:** Opening the canopy on the ground when the cockpit is pressurised may result in canopy hinge damage or canopy separation. Always dump cockpit pressure before opening either canopy.

**Equipment Air Conditioning System**

25. The equipment air conditioning system consists of an air-to-air heat exchanger, pressure regulating and shutoff valve, expansion turbine, mixing valve, and temperature controls. It also includes a liquid coolant heat exchanger, coolant pump, coolant reservoir, pressure and relief valves. The unit provides conditioned air to the nose radar package and radar unregulated power supply, the CNI equipment shelf aft of the nosewheel well, the electronic equipment shelf aft of the rear cockpit, and the liquid coolant heat exchanger. The conditioned air directed to the liquid coolant heat exchanger is used to cool the coolant which in turn cools the radar package in the nose.

26. The equipment air conditioning system also provides high pressure air (auxiliary air) for fuselage fuel tank pressurisation, wing fuel tank pressurisation and transfer, all external fuel tanks, anti g suits, electronic equipment pressurisation, high pressure pneumatic system air source, CADC, and canopy seal pressure. Operation of the system is entirely automatic with airflow initiated on engine start. Engine bleed air, after flowing through the heat exchanger and pressure regulating valve, is expanded through the cooling turbine and then mixed with warm bleed air as necessary to provide a delivery temperature of 85 °F from sea level to 25,000 feet, and 40 °F above 25,000 feet. If a system failure causes air temperatures to exceed 150 ± 10 °F, the air conditioning unit is automatically shut off and emergency ram air cooling is provided.

## BOUNDARY LAYER CONTROL SYSTEM

27. The Boundary Layer Control (BLC) system uses air bled from the 7th and 12th stages of the engine compressors. This air passes from four valves in each wing into ducts attached to the rigid part of the wing between the leading edge flaps and the spar and between the trailing edge flaps and the flap closure beam. Slots along the ducts behind the outboard and centre panel leading edge flaps and in front of the trailing edge flaps direct laminar flow air over the wings and flaps when the flaps have extended sufficiently to expose the slots. The high velocity laminar flow air directed over the wings and trailing edge flaps delays flow separation over the aerofoil and hence reduces turbulence and drag. Leading edge BLC is operative in the ½ or DN flap positions. Trailing edge BLC is operative only when the flaps are in the DN position.

28. With ½ flap selected air is bled from the 7th stage of the HP compressor and from the 12th stage when the flaps are in the DN position. However, to conserve engine turbine blade life, a pilot operated 2-position switch (NORMAL 12TH STAGE/ ISOLATE) is provided on the left console outboard engine control panel in the front cockpit. When this switch is in the ISOLATE position, air is bled from the 7th instead of from the 12th stage when flaps are fully down. Less air is therefore available to the systems supplied with bleed air. This reduction in air increases cabin temperature and reduces windscreen rain removal.

28A. When the switch is in the NORMAL 12TH STAGE position and the flaps are up, an automatic solenoid valve in the system directs 7th or 12th stage air to the bleed air systems, depending on demands (see Part 1, Chapter 6). When ISOLATE is selected, only 7th stage air is taken regardless of flap position or system demands. The two associated L or R ENG BLEED captions on the front cockpit telelight panel are electrically isolated when the flaps are up (but see the FRC for actions *should* they come on with flaps up). When the flaps are in the ½ position only 7th stage air should be taken and the captions come on if 12th stage air is being used (one caption if only one valve is incorrectly positioned). When the flaps are fully down the L or R ENG BLEED captions will come on if 12th stage air is not being tapped whether ISOLATE is selected or not; therefore, with ISOLATE selected, it is correct for the L and R ENG BLEED captions to be lit when flap is fully down, and incorrect with NORMAL 12TH STAGE selected. Momentary illumination of the captions is normal during flap travel. Illumination of either L or R ENG BLEED caption triggers the MASTER CAUTION light.

**WARNING:** Use of the 7th stage engine bleed/full flap configuration when landing in heavy rain, strong crosswind conditions or on a short runway may sometimes be operationally unacceptable. In these circumstances land in the 12th stage engine bleed/ ◆ full flap configuration. (See Part 3, Chapter 3, **Use of 7th Stage Engine Bleed/Full Flap Configuration**). ◆

## NORMAL MANAGEMENT OF THE SYSTEMS

### Control of Cockpit Temperature

29. Optimum cockpit environment can best be achieved by placing the temperature control override selector switch to AUTO and adjusting the temperature control knob to the desired temperature. Adjust the DEFOG control lever on the right utility panel for personal comfort and effective windscreen demisting. If the automatic temperature control system fails an adjustment may be obtained by 'blipping' the override selector switch to the HOT or COLD position.

### Control of Windscreen Demisting

30. Attempt to anticipate mist conditions so that, through proper management of temperature and airflow, it is not necessary to subject the windscreen and crew to the high temperatures and demist airflows which would be required to clear an already misted windscreen. To prevent windscreen misting during letdown into hot humid atmosphere, place the override selector switch to the AUTO position and have the DEFOG lever positioned about three quarters of the way forward. Then, five minutes before letdown, select the fully forward position and adjust the temperature control knob to the 2 o'clock (200 degrees of clockwise rotation) position, and maintain these settings throughout the letdown. If misting occurs, increase power to provide more engine bleed air to the mixing valves.

### Use of Windscreen Rain Removal

31. For a static ground check, the system is limited to operation with flaps fully down and engines running at or below 84% RPM.

32. Do not operate the rain removal system in flight with a dry windscreen or at airspeeds above 1·0M.

33. If the rain removal system cannot be shut down, pull up the cockpit EMERGency VENTilation knob. Engine bleed air is then shut off before entering the rain removal ducts.

## MALFUNCTIONING OF THE SYSTEMS

### Use of Manual Override Temperature Control

34. The manual override should be used only if the automatic temperature control system malfunctions. To change temperature by this means, the manual control switch should be held towards the desired position for short periods (0·5 second with a 3 second pause), until the desired temperature is reached. Actuating the switch for more extended periods does not allow the temperature limiter adequate time to function, and may result in excessive temperature. The presence of smoke in the cockpit after use of manual control is evidence of improper use of the switch and requires the selection of a colder valve position to avoid overheating of the cockpit distribution ducting.

◆ 35. Pre-mod 702 when operating in manual override, ◆ the SUIT VENTilation AIR must be OFF if manual control of cockpit temperatures is desired. SUIT VENT AIR can be turned on again after increasing demist air temperature. The navigator has no control over suit air temperature. He can control flow, but must accept the pilot-selected temperature. So, if the pilot turns SUIT VENT AIR to OFF driving the mixture valve to cold, the navigator receives full cold air, unless he elects to turn his OFF also.

Note: Post-STI/Phantom/437 the navigator's control knob is removed and the control left OFF.

**Cabin Turbine Overspeed Caption**

36. The CABIN TURB OVERSPEED caption is on the pilot's telelight panel and it comes on when the cooling turbine in the cockpit/air ventilation suit conditioning unit is being subjected to pressures and temperatures in excess of normal operation, and therefore subject to premature failure.

37. If possible, speed and engine power should be reduced until the light goes out. If the light fails to go out, the pilot should select ram air by pulling UP on the EMERGency VENT knob, to divert ram air into the cockpit and at the same time shut off bleed air to the conditioning unit, thereby stopping the cooling turbine.

**Use of the Equipment Emergency Air Conditioning System**

38. Malfunction of the equipment cooling turbine may be indicated by a high-pitched whine and/or vibration in the nose of the aircraft. To shut down the turbine, trip circuit breaker 9D (yellow colour code) on the No 2 circuit breaker panel. This shuts off equipment air conditioning (but not auxiliary air) and turns on ram air cooling.

39. RADAR CNI COOL OFF captions on the navigator's instrument panel and pilot's right vertical panel come on whenever ram air is being used for cooling. A COOLING RESET button is on the navigator's main instrument panel, and on the console below the pilot's right vertical panel. If the RADAR CNI COOL OFF caption comes on, attempt to restart the conditioning unit by reducing speed below that at which the light came on, waiting at least 15 seconds and then pressing the cooling reset button. If the conditioning unit fails to restart, no further restart attempt should be made. If the RADAR CNI COOL OFF caption remains on after the reset button has been used, set the radar to STBY and switch off all non-essential navigation and communication equipment.

40. When operating with emergency ram air cooling avoid high speed flight if possible. Maximum allowable cooling temperatures may be exceeded during high speed flight with the result that the following electronic equipment life and/or reliability may be affected:

Sparrow III Four Channel Tuning Drive

Radar Package

Tacan

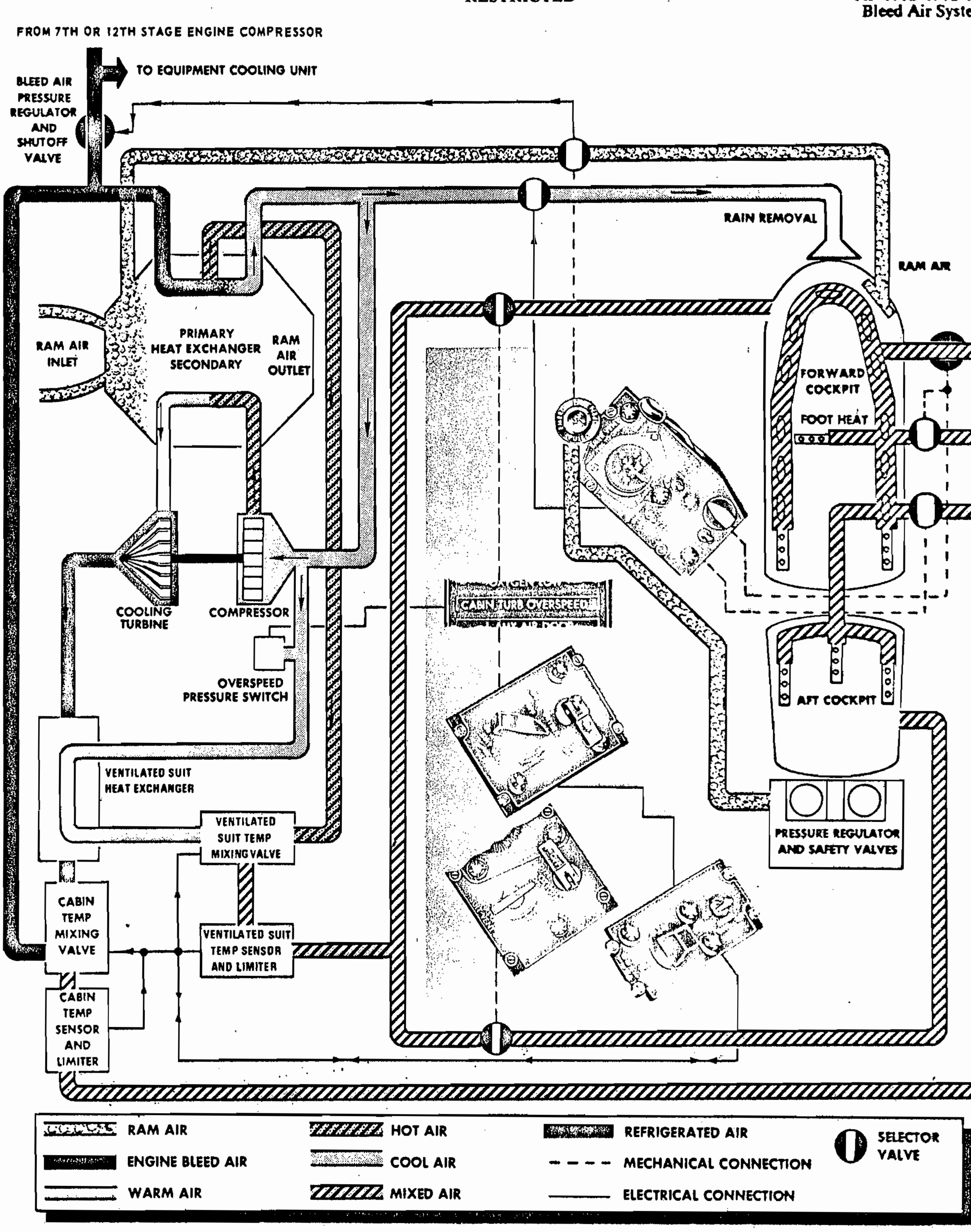
IFF/SSR

V/UHF Radio Transmitter/Receiver

**BLC Malfunction**

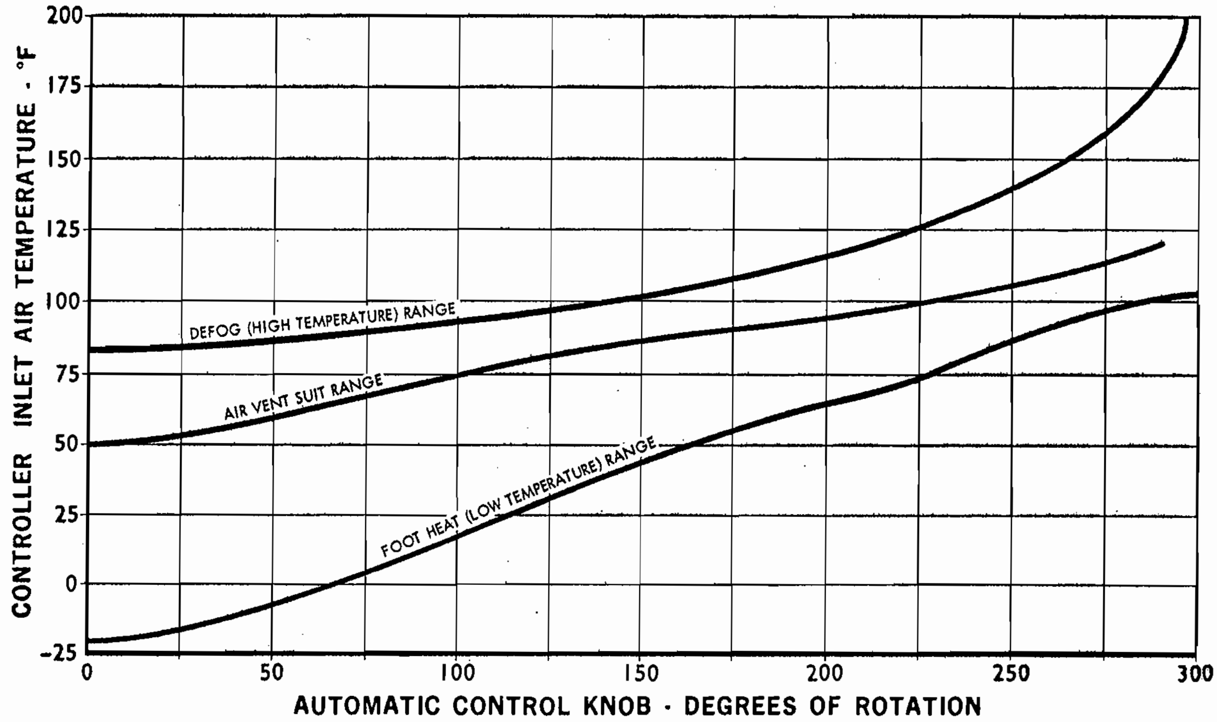
41. BLC MALFUNCTION caption is on the telelight panel and indicates a BLC valve malfunction in the ½ flap or flap up conditions. It comes on when any one of the BLC valves is not fully closed in the flap up condition, or when one of the trailing edge BLC valves is open in the ½ flap condition. No indication is provided for a completely inoperative system nor is there an indication provided for a BLC valve failing to open when in the ½ (leading edge BLC) and fully down (leading and trailing edge BLC) flap positions.

42. Operation at normal power settings in excess of 30 seconds with the flaps up and a BLC MALFUNCTION caption on may damage the warning light circuit and put out the warning light. Continued flight with the flaps up could damage the wing. If a BLC malfunction occurs complete the drill in the Flight Reference Cards.

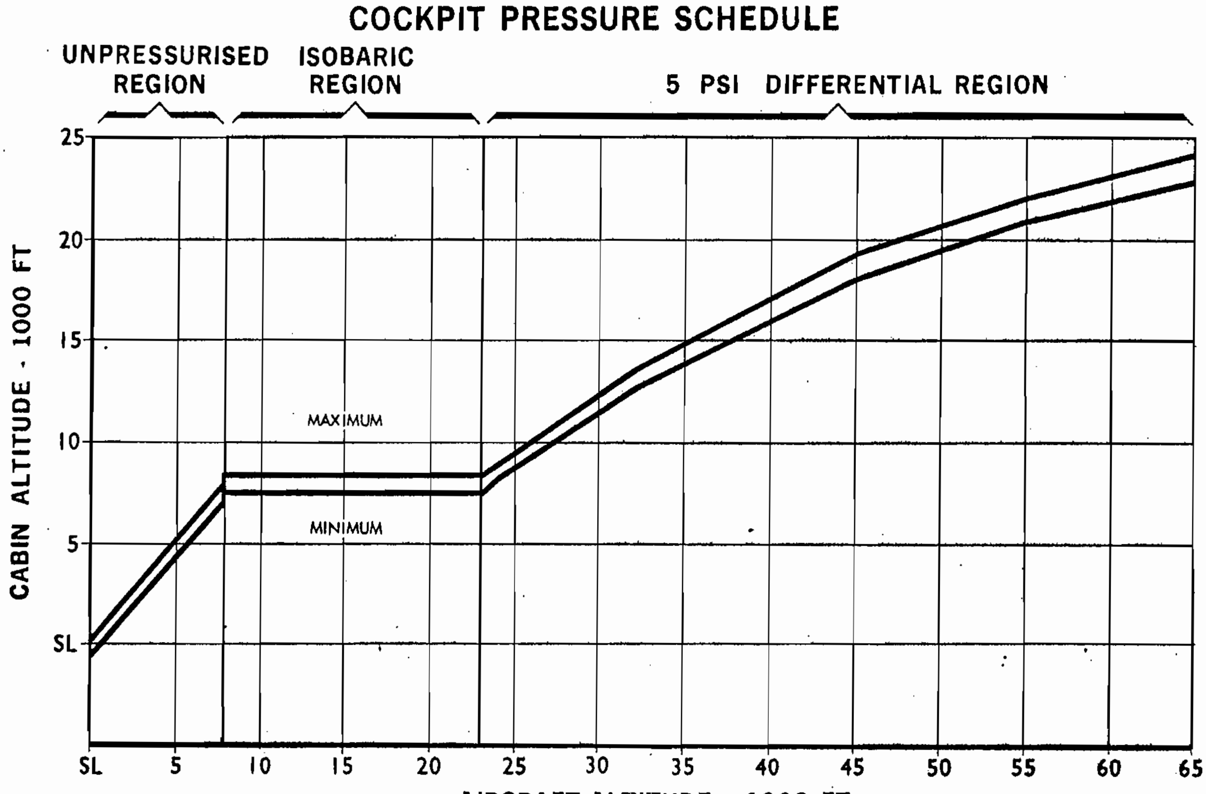



1—1 Fig·1 Cockpit Air Conditioning and Pressurisation System

## COCKPIT/AIR VENT. SUIT TEMPERATURE SCHEDULE




## COCKPIT PRESSURE SCHEDULE




CABIN PRESSURE REGULATOR

**NOTES**

1. THE MAXIMUM AND MINIMUM LINES SHOW THE TOLERANCES FOR THE OPERATION OF THE REGULATOR.
2. UNPRESSURISED REGION - A RANGE IN WHICH CABIN PRESSURE IS SLIGHTLY HIGHER THAN ATMOSPHERIC PRESSURE.
3. ISOBARIC REGION - A RANGE OF OPERATION IN WHICH CABIN PRESSURE IS MAINTAINED ESSENTIALLY CONSTANT.
4. 5 PSI DIFFERENTIAL REGION - A RANGE OF OPERATION IN WHICH AN ESSENTIALLY CONSTANT DIFFERENTIAL IS MAINTAINED BETWEEN CABIN PRESSURE AND ATMOSPHERIC PRESSURE.

**1—1 Fig 2 Cockpit Temperature and Pressure Schedules**

# PART 1

## CHAPTER 2 - ANGLE OF ATTACK SYSTEM AND CADC

### Contents



### ANGLE OF ATTACK SYSTEM

**Angle of Attack System**

1. Optimum angles of attack are not affected by gross weight, bank angle, load factor, airspeed, density, altitude, or flap position. For example, the optimum angle of attack for landing approach (19.2 units) is always the same irrespective of AUW. The approach airspeed automatically varies to compensate for the change in weight. The system consists of an angle of attack probe and transmitter, an angle of attack indicator, indexer lights, and a stall warning vibrator (rudder pedal shaker). Two electrical heaters are provided, one in the angle of attack probe to prevent the formation of ice, the other in the case housing the transmitter (adjacent to the fuselage skin) to prevent condensation. The case heater element is energised when the static pressure compensator switch is placed to CORR RESET, and the probe heater element is automatically energised when weight is off the landing gear. The probe heater and the case heater are both powered by the left Main 115V AC bus, through relays controlled by 28V DC.

**Angle of Attack (AOA) Indicator**

2. a. The AOA indicator measures the angle of attack by determining the direction of airflow relative to the fuselage. This is accomplished by means of a probe protruding through the fuselage skin. Airstream direction is sensed by two pairs of slots in the probe, 90° apart. When the direction of airflow changes, pressure becomes greater in one pair of slots than in the other and the probe rotates to equalise the pressure. Probe rotation moves potentiometer wiper arms, producing resistance variations which are sensed in the ◆ angle of attack indicator. The AOA indicator is mounted in a head-up position to the left of the LCOSS sight glass. The angle of attack indicator is ◆ calibrated from 0 to 30 in arbitrary units, equivalent to a range of minus 10 to plus 40 angular degrees of rotation of the probe. The indicator functions whenever it is supplied with DC power.

b. Four reference 'bugs', which can be adjusted on the ground, are provided on the scale of the instrument and are normally used as follows:

(1) *Stall or Stall Warning.* This 'bug' is striped black and white and can be set to either 30 units (stall) or 22.3 units (stall warning).

(2) *Approach.* This 'bug' is an oblong white indicator and is set for approach ('on speed') angle of attack at 19.2 units. Approach angle of attack values are only valid with the landing gear down. Gear up angle of attack values are 3 to 4 units lower because of a local flow difference caused by the nose gear door.

(3) *Cruise or Endurance.* A white triangle set to either 7.9 units (cruise) or 8.5 units (endurance).

(4) *Climb, 400 KCAS.* A white square set to 5.5 units if desired. Normally it is not used and is adjusted to be out of sight behind the approach 'bug'.

c. The AOA indicator also contains a switch which actuates the stall warning vibrator (rudder pedal shaker) at 22.3 units and above. When the indicator is inoperative the word OFF appears in a small window in the face of the dial.

**Angle of Attack Indexer**

◆3. An angle of attack indexer is located on the right of the windscreen in the front cockpit of single-stick aircraft and both sides of the windscreen in the rear cockpit of dual aircraft. The indexers present angle of attack information, which is derived from the angle of attack indicator, by illuminating three symbolic cut-outs either singly or in pairs (see Fig 1). ◆

4. *Indexer Lights Control.* Control knobs, marked INDEXER LIGHTS - DIM/BRT, are provided on the front cockpit right console and rear cockpit left console of dual control aircraft to control the intensity of their respective indexer lights. ◆◆ The front cockpit DIM/BRT control knob also varies the intensity of the MISSILE SELECTED and SEAM LOCK repeater lights (captioned RADAR and HEAT respectively, post-mod 723), mounted alongside the indexer lights on the pilot's command indicator, simultaneously with the indexer lights.

**Normal Operation of the AOA System**

5. a. There are no controls for the Angle of Attack system other than the indexer lights control knob and appropriate circuit breakers.

b. An OFF flag appears in the window on the face of the AOA indicator if there is no electrical power to the instrument. If the OFF flag appears in flight, the indicator freezes at the AOA shown at the moment of failure. The indexer lights come on as before but are frozen at the corresponding display. If the stall warning vibrator is operating at the moment of failure, it continues to shake the rudder pedal until the aircraft has landed or electrical power is restored to the AOA indicator. The appearance of the OFF flag does not necessarily mean that outputs from the CADC requiring AOA information are unreliable.

**Emergency Operation of the AOA System**

6. If double generator failure occurs, the system operates on RAT power. However, the AOA heaters do not work on RAT power.

## CENTRAL AIR DATA COMPUTER (CADC)

**Description of CADC**

7. The Central Air Data Computer (CADC) receives inputs of static pressure, pitot pressure, total temperature, and angle of attack. These inputs are supplied by two static ports on each side of the aft part of the radome, a total temperature sensor near the left air conditioning inlet duct, a pitot tube on the vertical fin, and an angle of attack probe on the left forward side of the fuselage. These inputs are corrected in the air data computer to compensate for errors in the sensing equipment installation. The corrected inputs are converted to usable outputs by the CADC and are displayed on the airspeed/Mach indicator, the altimeter, and the vertical speed indicator. Corrected signals are also taken by:

a. The induction air system to position the variable intake ramps.

b. The AFCS in autopilot attitude hold mode.

c. The INAS.

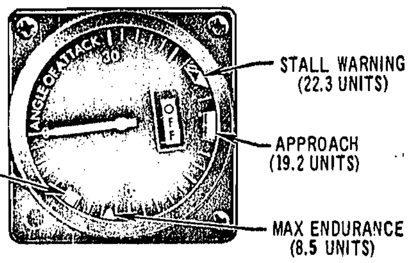
d. The missile control system in computing guidance signals and altitude compensation.

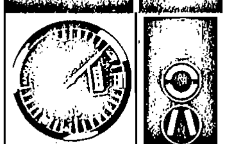
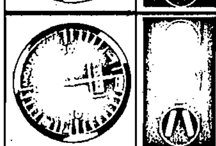
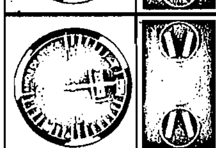
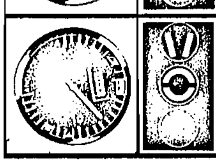
The instruments and/or systems using the outputs from the CADC are inoperative or in error if a failure or an interruption occurs in the Essential AC power supply, Essential DC power supply, or engine bleed air system. An interruption or failure in any of the above systems causes the STATIC CORR OFF caption to come on.

**Static Pressure Compensator**

8. One of the functions of the CADC is to supply all systems requiring static pressure inputs with a static source position error correction. This correction is accomplished through the static pressure compensator. When operating normally, the compensator uses the static air pressure as a balancing force only. The corrected static pressure output is actually auxiliary equipment air, corrected for the static error as dictated by the instantaneous flight situation. Should a malfunction occur in the compensator, a fail-safe solenoid is de-energised allowing static pressure to be routed directly to all systems requiring static pressure inputs. With a malfunction, overall accuracy suffers. However, no system dependent on static pressure becomes inoperative.

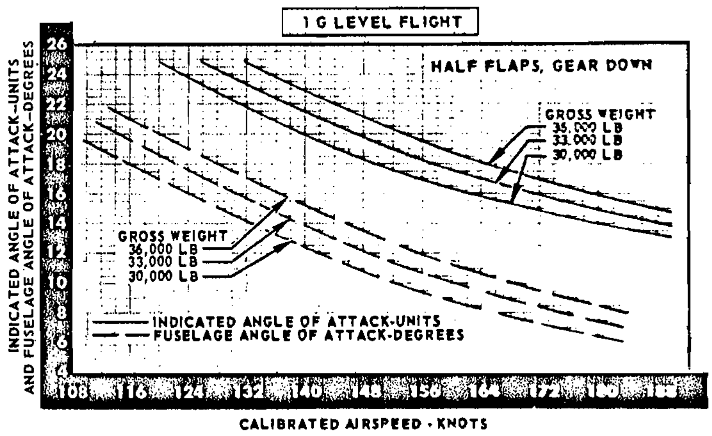
9. *Static Pressure Compensator Switch.* The pilot is alerted to a compensator malfunction by the STATIC CORR OFF caption on the telelight panel. It may be accompanied by a rapid change in altimeter reading. A static pressure compensator CADC switch on the inboard engine control panel is the only control associated with

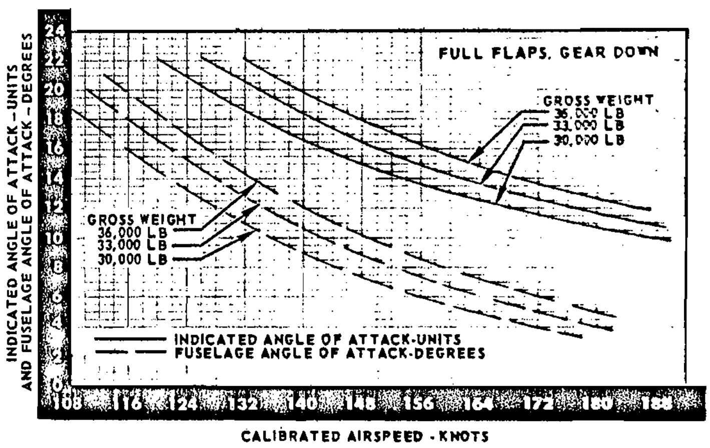



| INDICATOR | INDEXER | ANGLE OF ATTACK UNIT | AIRSPEED |
|---|---|---|---|
|  | | 20.3-30 | VERY SLOW |
|  | | 19.7-20.3 | SLIGHTLY SLOW |
|  | | 18.7-19.7 | ON SPEED |
|  | | 18.1-18.7 | SLIGHTLY FAST |
|  | | 0-18.1 | VERY FAST |

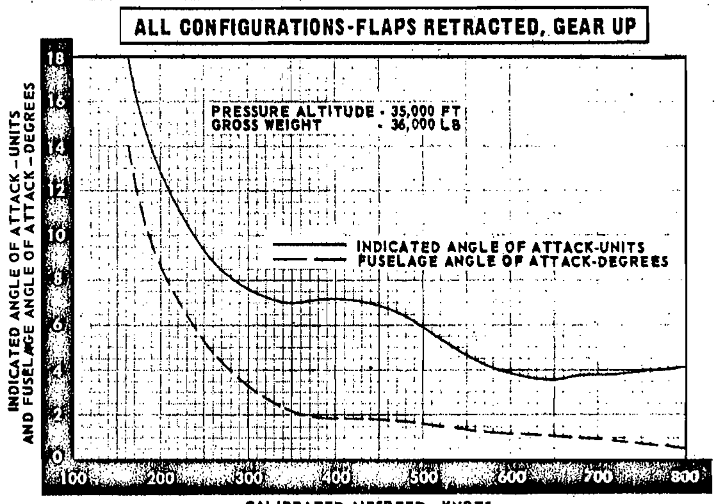
ALL CONFIGURATIONS-FLAPS AS NOTED, GEAR DOWN

1 G LEVEL FLIGHT

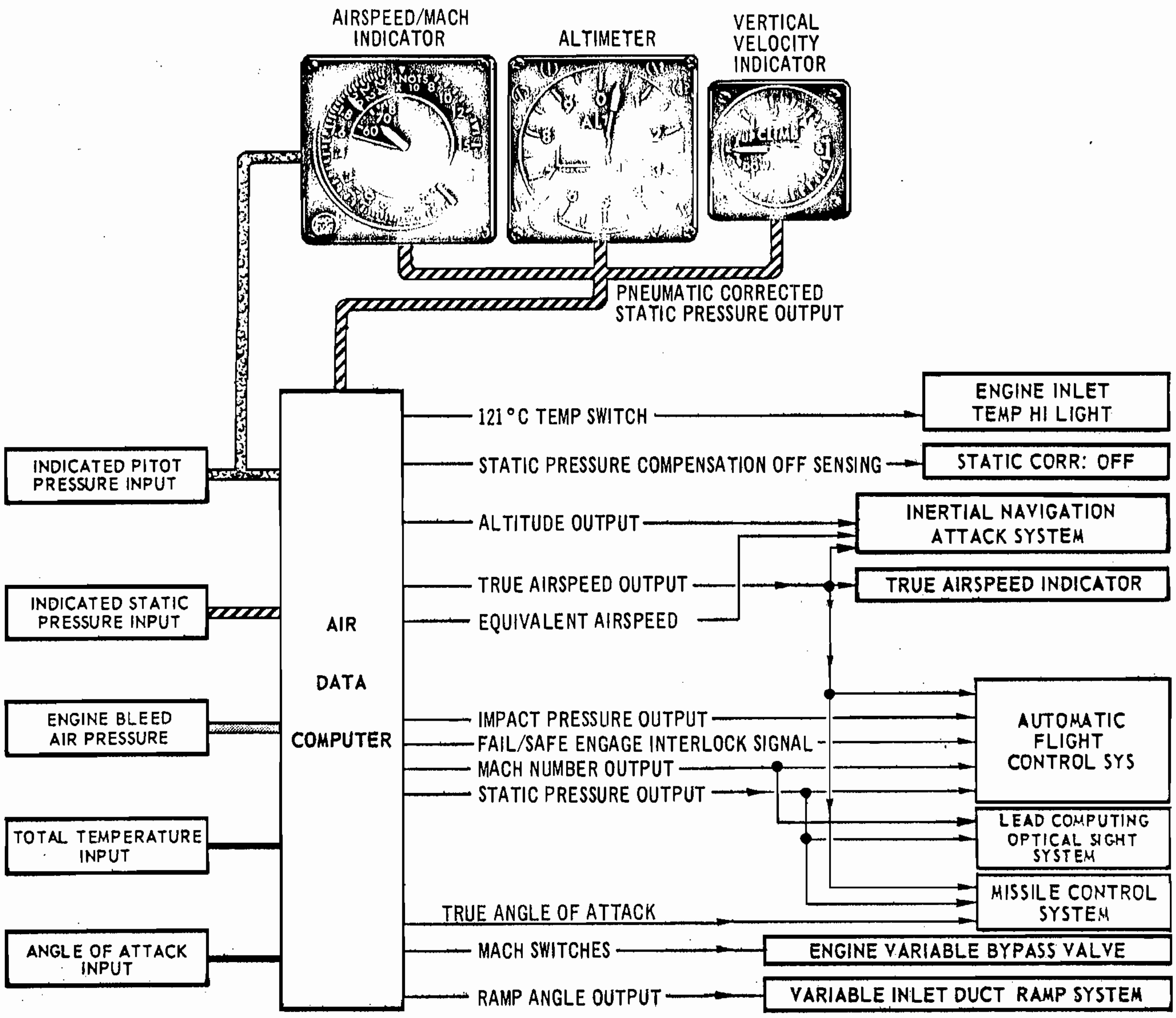



ALL CONFIGURATIONS-FLAPS RETRACTED, GEAR UP




**1—2 Fig. 1 Angle of Attack Conversion and Displays**




**1—2 Fig. 2 Air Data Computer**



RESTRICTED

the air data computer. The switch has positions of CORR RESET, NORM, and CORR OFF, which are used to reset or turn off the compensator. With the STATIC CORR OFF caption on, moving the compensator switch to the RESET position returns the compensator to normal operation and puts out the caption. The switch may then be released to return to the NORM position. If the compensator cannot be reset, as indicated by the caption coming on again when the switch returns to the NORM position, set the switch OFF. The pressure instruments are in error when the caption is on or the switch is in the OFF position. ◆

Note: The static pressure compensator must be reset after the engines are started. The altimeter jump after reset must not exceed 50 feet. This variation is an indication of the accuracy of the compensator and its effect on other instruments. It is possible to experience large errors in both altitude and airspeed if the altimeter jump exceeds 50 feet.

**Normal Operation of the CADC**

10. Normal operation of the air data computer consists of momentarily placing the static pressure compensator switch in the spring-loaded RESET position after an engine has been started. This action extinguishes the STATIC CORR OFF caption, and the CADC then operates with compensated static pressure. If the STATIC CORR OFF caption comes on in flight and cannot be reset, the AFCS, INAS, AMCS, and most flight instruments are in error. The air data computer system receives power from a 3-phase, Essential 115V AC bus, a 28V DC Essential bus, and a 28V AC Essential bus. The system is protected by CADC circuit breakers on the number one circuit breaker panel in the rear cockpit.

Note 1: Ensure that the variable area inlet ramps are fully retracted prior to take-off.

Note 2: If the CADC becomes suspect during flight, complete the **SPC/Altimeter Check** in the FRC.

Note 3: The CADC does not completely compensate for transonic jump but reduces it from approximately 5500 feet to approximately 1500 feet.

**Emergency Operation of the CADC**

11. There is no emergency operation of the system. If the STATIC CORR OFF caption comes on in flight and cannot be reset, the AFCS, INAS computer, AMCS, and most of the flight instruments are in error. Airspeed and altitude correction tables are in the FRC.

*Intentionally Blank*

# PART 1

## CHAPTER 3 — AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS)

### Contents



### General Description

1. The automatic flight control system is an electro-hydraulic system designed to provide stable and co-ordinated flight manoeuvres without interfering with manual control. The automatic flight control system is capable of performing two modes of operation: stability augmentation and AFCS (Autopilot). Stability augmentation (stab aug) operation provides stability in pitch, roll and yaw, in that it opposes any changes of attitude. It does not, however, return the aircraft to a given attitude or heading. Stability augmentation can be engaged individually or in any combination for pitch, roll, or yaw axis, but normally all three axes are engaged.

◆◆

2. All three channels must be engaged before complete autopilot operation is possible. This mode of operation maintains and corrects for deviation any aircraft heading and/or attitude selection within the AFCS limits. The altitude hold mode of operation holds the selected altitude when in the autopilot mode.

3. The AFCS components are the AFCS panel, the control amplifier, force transducer, accelerometers, and rate gyro sensors. Equipment used in connection with AFCS operation are the attitude reference computer set, the air data computer, and the control servos.

**AFCS Controls**

4. The AFCS panel is on the pilot's left console. This contains all the controls for the normal operation of the automatic flight control system.

5. *Stab Aug Switches.* There are three 2-position STAB AUG switches for pitch, roll, and yaw. Placing any one of these switches in the ENGAGE position establishes the stab aug mode for the axis selected.

6. *AFCS (AUTOPILOT) Switch.* This switch is a 2-position AFCS ENGAGE toggle switch. The switch can become energised only if the pitch stab aug switch or all three stab aug switches are energised. However, for the autopilot mode to be fully selected, all three stab aug switches must be energised.

7. *Altitude Hold Switch.* The altitude hold switch is a 2-position ALT ENGAGE toggle switch. The altitude hold feature functions only if autopilot is engaged. Placing the switch to the ENGAGE position energises an altitude sensor in the air data computer which is controlled by barometric altitude. As the altitude varies, an error signal is produced and fed to the pitch servo amplifier. The amplifier then transmits a signal to the stabilator actuator which deflects the stabilator as necessary to return the aircraft to its 'hold' altitude. The altitude sensor holds the aircraft within ±50 feet or ±0·3 per cent of the reference altitude at speeds up to 0·9M and at speeds greater than 1·0M. When using the altitude hold mode, the aircraft may experience pitch oscillations while accelerating through the transonic range (0·9 to 1·0M) due to fluctuations in the CADC airspeed system.

**Stability Augmentation Mode**

8. In the stab aug mode of operation, the system senses motion about the horizontal, vertical, and lateral axes, by means of rate gyro sensors. All attitude, heading and bank angle changes cause these sensing devices to transmit signals, representing the changing motion about their respective axes, to servo valves of the control surface power control cylinders. Therefore, any output signals from the rate gyro sensors indicating a roll, yaw, or pitching motion, or from the lateral accelerometer indicating side slip, cause the flight control system to position the appropriate control surfaces to oppose that motion. This action decreases any tendency of the aircraft to oscillate in roll, yaw, or pitch. The rate gyro sensors send signals to the control surfaces to oppose any deviations from selected flight attitude but do not return the aircraft back to its original heading or attitude.

**Autopilot Mode**

9. In the autopilot mode of operation, vertical gyro, directional gyro and accelerometer signals are used in addition to the rate gyro sensor signals, to maintain the aircraft in a desired attitude with pitch, roll, and yaw stability. The autopilot system can be engaged and hold manoeuvres and attitudes within a range of ±70° in bank and pitch, and 360° in azimuth, providing the g limits are not being exceeded. The attitude may be less than 70° roll when the mode disengages or the roll attitude may be more than 70° when the mode re-engages. This difference depends on the rate at which the roll manoeuvre is performed. Autopilot operation is interrupted when ±70° pitch or bank is exceeded. However, the AFCS ENGAGE switch remains engaged and the autopilot resumes normal operation when the aircraft is returned to within the ±70° limits. If a load factor of +4g or minus 1g is sensed by the g-limit accelerometer, the autopilot reverts to the stab aug mode and the AFCS ENGAGE switch must be re-engaged for autopilot operation.

**Control Amplifier**

10. The control amplifier is the key control of the entire automatic flight control system. It receives the signals from the various sensing elements in the system and supplies power to the flight control components.

**AN/AJB-7 Computer Set and INAS**

11. Attitude reference information is provided to the autopilot by the AN/AJB-7 attitude reference system (ARS). Directional reference information is provided by the ARS when STBY is selected on the COMPass system control panel, or by the INAS when PRIM is selected. With STBY and SLAVED selected, the autopilot receives magnetic heading from the ARS; with STBY and DG selected, the ARS uses as a directional reference any manually set heading. With PRIM selected, the autopilot receives true ground track information from the INAS irrespective of the selection on the mode selector knob. Autopilot disengagement occurs whenever selections are made between DG and SLAVED or PRIM and STBY. However, the autopilot can be re-engaged after switching is complete.

**Air Data Computer**

12. The CADC performs two functions for the autopilot. Firstly it provides all required gain changes necessary to maintain constant manoeuvring rates regardless of changes in airspeed and altitude.

Secondly, the CADC contains a clutched synchro which supplies the autopilot with a signal proportional to the deviation from the barometric altitude which existed when altitude hold was engaged. This signal is used by the autopilot to move the stabilator as necessary to maintain constant barometric altitude.

**Force Transducer**

13. The force transducer is part of the control column , having the control column grip mounted above. It contains pressure-sensitive switches which react to lateral and longitudinal stick forces, the forces required to close the switches being approximately 2.1 lb in roll, 3.75 lb of aft pressure and 2.55 lb of forward pressure.

14. In the stab aug mode, the force transducer is only in circuit for rolling plane control inputs. When sufficient lateral force is applied to the control column, the roll rate gyro signal is cancelled and the roll stab aug does not compensate for or oppose pilot–induced control movement.

15. When the autopilot is engaged, ie, when the AFCS switch is to ENGAGE, the force transducer is in circuit for both lateral and longitudinal control column movements: laterally the signals from the roll rate and attitude gyros are cancelled and the pilot has direct control of the ailerons and spoilers; fore and aft stick forces create error signals in the pitch autopilot system which reposition the aircraft in pitch. Therefore, with the autopilot engaged, the pilot has control of the aircraft without opposing inputs from the AFCS, the ailerons and spoilers being directly controlled and the stabilator being activated through the autopilot. This feature is known as control stick steering (CSS).

15A. During CSS the AFCS switch remains in the ENGAGE position even if the roll and pitch limits for AFCS operation (70°) are exceeded. If the ALT switch is also in the ENGAGE position however, it automatically disengages when longitudinal force is applied to the control column.

15B. After a CSS manoeuvre, when the stick forces are released, the autopilot holds the newly–selected attitude provided the aircraft is within the pitch and roll limits. If altitude hold is then required, it must be re–engaged.

**Accelerometers**

16. During autopilot operation two accelerometers are used to ensure proper functioning of the autopilot system. One of the accelermoters is of the g–limiting type which prevents excessive g loads from occurring as a result of autopilot operation. The other accelerometer is a lateral accelerometer which is used to perform co–ordinated manoeuvres while in autopilot operation.

17. *G–Limit Accelerometer.* The g–disengage feature of the AFCS is designed to inhibit the system from commanding excessive load factors on the aircraft. The system reverts automatically, from whichever mode is engaged, to the stab aug mode if plus 4 or minus 1g is sensed by the g–disengage accelerometer switch. The switch is mounted forward of the radar bulkhead so that if the aircraft is rotated rapidly into a manoeuvre, disengagement occurs at lower values of normal load factor due to the anticipation resulting from the forward location sensing a component of pitching acceleration. If in addition to the g switch being operated, the stab aug servo is hard over in a direction that tends to increase the magnitude of the existing load factor, the stab aug mode also disengages. It is possible to check the proper functioning of this feature in flight by engaging the stab aug and autopilot modes and gradually increasing load factor to approximately plus 4 or minus 1g. Autopilot should disengage; ◆ stab aug should not. If a stabilator hardover malfunction occurs, the system disengages at +2g or zero g, again reverting to the stab aug mode. The g–disengage feature is inoperative outside the ±70° limits of the autopilot. ◆

18. *Lateral Accelerometer.* This accelerometer detects aircraft skids or slips and produces error signals proportional to the lateral forces developed. These error signals cause the autopilot to take corrective action with the rudder to co–ordinate the manoeuvre being performed.

**Servos**

19. The automatic flight control system contains four control servos which function to operate the aircraft flight controls during stability augmentation and autopilot operation. Two lateral servos (one in each wing) operate the spoilers and ailerons and a directional series servo (on the rudder power control cylinder) operates the rudder. A longitudinal servo (on the stabilator power control cylinder) functions in a series mode to operate the stabilator during stability augmentation, the same servo functioning in a parellel mode to operate the stabilator during autopilot operation.

**Heading Hold Cutout**

20. When operating in the autopilot mode, roll attitude must be larger than 5° angle of bank in order to disengage the heading hold. Pressing and releasing the nose gear steering button provides the means of disengaging the heading hold to allow turns at an angle of bank of 5° or less. Heading hold may be re–established by again pressing and releasing the nose gear steering button.

**AFCS/ARI Emergency Disengage Switch**

21. A spring–loaded emergency disengage switch

(usually referred to as the 'paddle switch') is located on the control column. Depressing the lever causes the AFCS ENGAGE and ALT ENGAGE switches to disengage. The stability augmentation mode, ARI and anti-skid are disengaged as long as the lever is held depressed. When the lever is released, the stability augmentation and ARI again are in operation but the autopilot is no longer engaged. To disengage the stab aug mode permanently, the PITCH, ROLL and YAW stab aug switches must be placed off. To disengage the ARI permanently, the YAW stab aug switch must be off and the ARI circuit breaker (c/b), forward on the front cockpit left console, must be tripped; alternatively the RUDDER FEEL TRIM c/b (C4 No 2 panel) may be tripped but this c/b also controls the flap blow-up relay.

**Autopilot Pitch Trim**

22. The autopilot system includes an automatic pitch trim feature which attempts to keep the aircraft longitudinally trimmed to the flight conditions experienced while in autopilot mode. Thus an out-of-trim condition, which would not be sensed while in autopilot mode, is prevented, neutralising an excessive pitch transient when disengaging the autopilot.

23. The auto-pitch trim operates at approximately 40% of the speed of the normal trim system resulting in a slight delay, after changing flight conditions, before the aircraft is properly trimmed. During CSS manoeuvring, the auto-pitch trim in inoperative. Auto-pitch trim operation can be observed on the pitch trim indicator after changing flight conditions in the autopilot mode.

**Autopilot Pitch Trim Caption**

24. An A/P PITCH TRIM caption on the telelight panel illuminates during AFCS operation if the automatic pitch trim is inoperative or lagging sufficiently behind aircraft manoeuvring to cause an out-of-trim condition in the basic aircraft. This is because:

a. Auto-pitch trim rate is 40% of normal trim rate.

b. Auto-pitch trim is inoperative any time the force transducer switches are made (ie, during CSS manoeuvring). It is possible to develop an out-of-trim condition while manoeuvring in the autopilot mode. However, this out-of-trim condition must exist for approximately 10 seconds before the A/P PITCH TRIM caption illuminates, thus eliminating constant light flickering.

25. Momentary illumination of the light does not necessarily indicate a malfunction; however, if the light remains on and it is apparent from the pitch trim indication that the trim is not working, a pitch transient may be experienced when the autopilot mode is disengaged. Airspeed/pitch trim indicator relationship should provide an indication of the severity of the transient. If an out-of-trim condition is indicated by the steady illumination of the A/P PITCH TRIM caption, grasp the stick firmly before disengaging the autopilot mode in anticipation of a pitch 'bump'.

26. Before disengaging the autopilot following an automatic pitch trim malfunction, the out-of-trim condition can be alleviated by operating the manual trim button and observing the pitch trim indicator. If the out-of-trim condition is reduced to within five pounds of trim, the A/P PITCH TRIM caption goes out.

27. The A/P PITCH TRIM caption triggers the MASTER CAUTION captions. Pressing the RESET MASTER CAUTION button puts out only the MASTER CAUTION captions, leaving the A/P PITCH TRIM caption on.

**Autopilot Disengaged Caption**

28. With the autopilot engaged, the A/P DISENGAGED caption (on the telelight panel) and the MASTER CAUTION captions come on when the autopilot is disengaged by any means. All three captions are put out by pressing the RESET MASTER CAUTION button.

**Pitch Aug Off Caption**

29. The PITCH AUG OFF caption is on the telelight panel and remains lit unless pitch stab aug is engaged. After pitch stab aug engagement, disengagement also brings on the MASTER CAUTION captions.

## NORMAL MANAGEMENT OF THE SYSTEM

**AFCS Operation**

**WARNING 1:** Do not attempt to change the pitch attitude of the aircraft from the rear cockpit with AFCS engaged. As the rear cockpit control column has no force transducer, this causes the pitch trim to run up and down depending on the pressure applied. If the front cockpit pilot disengages the autopilot at this point, violent transients may occur.

**WARNING 2:** When engaging AFCS, hold the control column and be prepared to counter any abrupt control movements caused by an AFCS malfunction. The 'g' switch will not disengage the autopilot before the aircraft stalls under conditions of the lever is held depressed. When the lever is released, the stability augmentation and ARI again are in operation but the autopilot is no longer engaged. To permanently disengage the stab aug mode, the PITCH, ROLL and YAW stab aug switches must be placed off. To permanently disengage the ARI, the YAW stab aug switch must be off and the ARI circuit breaker, on the front cockpit left sub-panel, must be pulled, or alternatively the RUDDER FEEL TRIM CB on No 2 CB panel may be pulled.

AL 15

### Autopilot Pitch Trim

22. An automatic pitch trim feature is included in the autopilot system which attempts to keep the aircraft longitudinally trimmed to the flight conditions experienced while in autopilot mode. Thus, an out-of-trim condition, which would not be sensed while in autopilot mode, is prevented, insuring against an excessive pitch transient when disengaging the autopilot.

23. The auto-pitch trim operates at approximately 40% the speed of the normal trim system resulting in a slight delay, after changing flight conditions, before the aircraft is properly trimmed. During CSS manoeuvring, the auto-pitch trim is inoperative. Auto-pitch trim operation can be observed on the pitch trim indicator after changing flight conditions in the autopilot mode.

### Autopilot Pitch Trim Caption

24. An A/P PITCH TRIM caption on the telelight panel illuminates during AFCS operation if the automatic pitch trim is inoperative or lagging sufficiently behind aircraft manoeuvring to cause an out of trim condition in the basic aircraft. Since:

a. Auto-pitch trim rate is 40% of normal trim rate.

b. Auto-pitch trim is inoperative any time the force transducer switches are made (ie, during CSS manoeuvring), it is possible to develop an out-of-trim condition while manoeuvring in the autopilot mode. However, this out-of-trim condition must exist for approximately 10 seconds before the A/P PITCH TRIM caption illuminates, thus eliminating constant light flickering.

25. Momentary illumination of the light does not necessary indicate a malfunction, however, if the light remains on and it is apparent from the pitch trim indication that the trim is not working, a pitch transient may be experienced when the autopilot mode is disengaged. Airspeed/pitch trim indicator relationship should provide an indication of the severity of the transient. If an out-of-trim condition is indicated by the steady illumination of the A/P PITCH TRIM caption, grasp the stick firmly before disengaging the autopilot in anticipation of a pitch 'bump'.

26. Before disengaging the autopilot following an automatic pitch trim malfunction, the out-of-trim condition can be alleviated by operating the manual trim button and observing the pitch trim indicator. If the out-of-trim condition is reduced to within five pounds of trim, the A/P PITCH TRIM caption is extinguished.

27. Illumination of the A/P PITCH TRIM caption also illuminates the MASTER CAUTION caption. Depressing the master caution reset button only extinguishes the MASTER CAUTION, leaving the A/P PITCH TRIM illuminated.

### Autopilot Disengaged Caption

28. The A/P DISENGAGED caption is on the telelight panel. After initial engagement of autopilot, the A/P DISENGAGED and MASTER CAUTION captions illuminate when the mode is disengaged by any means. Both are extinguished by pressing the master caution reset button. They remain extinguished until the autopilot is again disengaged.

### Pitch Aug Off Caption

29. The PITCH AUG OFF caption is on the telelight panel and remains illuminated unless pitch stab aug is engaged. After pitch stab aug engagement, disengagement also illuminates the MASTER CAUTION caption.

## NORMAL MANAGEMENT OF THE SYSTEM

### AFCS Operation

**WARNING 1:** Do not attempt to change the pitch attitude of the aircraft from the rear cockpit with AFCS engaged. As the rear cockpit control column has no force transducer, this will cause the pitch trim to run up and down depending on the pressure applied; if the pilot attempts to take control at this point, violent transients may occur.

**WARNING 2:** When engaging AFCS, hold the control column and be prepared to counter any abrupt control movements due to an AFCS malfunction. The 'g' switch will not disengage the autopilot before the aircraft stalls under conditions of low airspeed or high AUW. If the autopilot remains engaged during a stall, it will apply pro-spin controls.

30. For complete autopilot operation all three STAB AUG switches must be engaged, the aircraft should be in trim, and an attitude within the autopilot limits must be established.

low airspeed or high AUW. If the autopilot remains engaged during a stall, it applies pro-spin controls.

30. For complete autopilot operation, all three STAB AUG switches must be engaged, the aircraft should be in trim, and an attitude within the autopilot limits must be established.

31. Autopilot operation is then achieved by engaging the AFCS switch. Manual trim during autopilot operation should not be used unless roll reversal is encountered, and then only a small amount of trim should be used to counteract the roll.

32. Autopilot disengagement is accomplished by placing the AFCS switch to off, but the aircraft remains in the stab aug mode.

33. Main power supplies for the autopilot system are from the three-phase Left Main 115/200V AC busbar; other supplies are fed from the Left Main 28 volt DC bus, the warning lights 28/14 volt DC bus and the Left Main 28 volt AC bus. The system is protected by five circuit breakers marked AUTOPILOT on the No 1 c/b panel in the rear cockpit.

**Operational Precautions**

34. *Generator Switching.* Power to the autopilot, CADC, and AN/AJB-7 may be momentarily interrupted during the starting and stopping of engines or generators. When the left engine or generator is started with the right generator already on line, the connection between the Right and Left Main buses is momentarily opened to allow the left generator to come on line. This momentary interruption allows the solenoid-held switches to disengage. This necessitates re-engaging the autopilot to bring back autopilot operation. The autopilot, CADC and AN/AJB-7 are not affected by starting or stopping the right engine or generator with the left generator on line. If failure of the left generator occurs, there may be a control transient as the left generator comes off line and the bus tie contactor closes. Stability augmentation may be left ON after a left generator failure providing the bus tie contactor closes (ie the BUS TIE OPEN caption is not lit).

35. *Autopilot Operation with Static Correction Off.* A malfunction of the static pressure compensator (indicated by the illumination of the STATIC CORR OFF caption) has no effect upon autopilot operation. The autopilot operates satisfactorily with the static pressure compensator out; however, the altitude hold mode may be affected. If the altitude hold mode is affected, the reference altitude changes when the static pressure compensator fails.

36. *Pitch Oscillations (Altitude Hold Mode).* When using the autopilot in altitude hold mode, pitch oscillations may be experienced in the transonic regions owing to fluctuations in the CADC airspeed system. The nature of these oscillations varies from 'stick pumping' to divergent pitch oscillations. If pitch oscillations occur at subsonic speeds, disengage the autopilot, place the CADC switch to CORR OFF, re-engage the autopilot and engage altitude hold. If the oscillations persist after taking corrective action, or if they are encountered at supersonic speeds, disengage the altitude hold mode. In any event divergent pitch oscillations must not be allowed to develop. If any divergence in pitch occurs, corrective action must be taken immediately.

**WARNING 1:** Because of electrical interference, AFCS engagement may not always be possible when the radar is transmitting in pulse doppler.

**WARNING 2:** When the autopilot is engaged, pressing the INAS ENTER button (when correcting a position error) may trip the autopilot off line. If a residual out-of-trim situation exists as the autopilot disengages, the result is an unexpected control input.

## MALFUNCTIONING OF THE SYSTEM

### AFCS Failures

37. In case of suspected flight control malfunction, immediately disengage the AFCS by depressing the paddle switch.

38. Any pitch oscillations which occur either as a result of the malfunction, or in subsequent unstabilised flight, are not to be chased with control inputs; either release the stick or apply a gentle back pressure. The malfunctioning channel should be disengaged and remain disengaged for the remainder of the flight.

39. If PC-1 hydraulic pressure is lost or drops below 500 PSI, pitch stab aug and AFCS are inoperative. However, the AUTOPILOT DISENGAGE and PITCH AUG OFF indicator lights do not come on.

40. If utility hydraulic pressure is lost or drops below 500 PSI, roll and yaw stab aug and AFCS are inoperative. The CHECK HYD GAUGES and MASTER CAUTION captions come on as pressure drops through 1500 PSI.

41. *Roll Reversal.* There is a possibility of roll reversal occurring when operating in the autopilot mode. This condition occurs infrequently and is apparent only when attempting small changes in bank angle. Roll reversal is associated with a small

out-of-trim condition in the lateral control system, and is apparent as a slow rolling of the aircraft in the opposite direction to the low lateral force. If, for instance, the aircraft is out of trim laterally to the left when the autopilot mode is engaged, roll reversal may occur when low right stick forces are applied. A roll reversal situation may also be caused by operating the lateral trim button while in the autopilot mode, followed by low lateral stick forces being applied opposite to the direction of the trim. There is also a possibility of roll reversal occurring even if the aircraft has been trimmed prior to engaging the autopilot mode, and the manual trim button has not been touched. This condition is brought about by changes in aircraft trim accompanying flight conditions.

**Effects of 3-Phase AC Failure**

42. Loss of 3-phase AC to the stab aug, AFCS and ARI without the loss of DC control voltage may cause the rudder, ailerons, spoilers, and stabilator to drift. These symptoms may also be caused by generator undervoltage.

43. If AC input power for the ARI and/or AFCS is lost these systems are unable to supply the electrical signals required to maintain control of the series hydraulic actuator servo valves. Without AC servo control signals, the mechanical/hydraulic imbalance within each of the control valves allows the series actuator to drift toward its extreme extended or retracted position. This could cause a rudder deflection of between 5° and 15° (depending on flap position), an aileron deflection of between +1° and minus 7·5°, a spoiler deflection of 11° maximum and a stabilator deflection of ±0·5°. The rate of actuator drift, as well as direction, is dependent upon the amount of imbalance and the side to which the imbalance occurs. Drift rates and direction of movement are unpredictable and they may be in any combination.

44. The correct drill to counter this type of failure is to depress the paddle switch, turn off all the stab aug switches and pull the ARI circuit breaker. The paddle switch may then be released. The aircraft does not return to normal flight immediately and in the case of rudder deflection it may take as long as 40 seconds to do so.

**Stab Aug Failures**

45. Failure of any stab aug degrades aircraft handling, although loss of the roll stab aug has very little effect. If the yaw stab aug fails, difficulty may be experienced on the approach owing to loss of ARI and care must be taken to control yaw with rudder. If the pitch stab aug fails, it is recommended that 350 knots/0·7M is not exceeded and the maximum height is limited to 10,000 feet. At higher speeds, pilot induced oscillations (PIO) can become uncontrollable.

**Effects of 3-Phase AC Failure**

42. Loss of 3-phase AC to the stab aug, AFCS and ARI without the loss of DC control voltage may cause the rudder, ailerons, spoilers, and stabilator to drift. These symptoms may also be caused by generator undervoltage.

43. If AC input power for the ARI and/or AFCS is lost these systems are unable to supply the electrical signals required to maintain control of the series hydraulic actuator servo valves. Without AC servo control signals, the mechanical/hydraulic imbalance within each of the control valves allows the series actuator to drift toward its extreme extended or retracted position. This could cause a rudder deflection of between 5° and 15° (depending on flap position), an aileron deflection of between +1° and minus 7·5°, a spoiler deflection of 11° maximum and a stabilator deflection of ±0·5°. The rate of actuator drift, as well as direction, is dependent upon the amount of imbalance and the side to which the imbalance occurs. Drift rates and direction of movement are unpredictable and they may be in any combination.

44. The correct drill to counter this type of failure is to depress the paddle lever, turn off all the stab aug switches and pull the ARI circuit breaker. The paddle lever may then be released. The aircraft will not return to normal flight immediately and in the case of rudder deflection it may take as long as 40 seconds to do so.

**Stab Aug Failures**

45. Failure of any stab aug will degrade aircraft handling, although loss of the roll stab aug has very little effect. If the yaw stab aug fails, difficulty will be experienced on the approach due to loss of ARI and care must be taken to control yaw with rudder. If the pitch stab aug fails, it is recommended that 350 knots/0·7M is not exceeded and the maximum height is limited to 10,000 feet. At higher speeds, pilot induced oscillations (PIO) can become uncontrollable.

# PART 1

## CHAPTER 4 — EJECTION SEATS

### Contents



### Illustrations



#### General Description

1. Rocket-assisted Type 7A/1 and 7A/2 Mk 3 ejection seats are fitted in the front and rear cockpits respectively to allow safe escape from the aircraft in an emergency. The seats have a gas-fired rocket initiator system with a remote breech and a leg-restraint system with single garters.

2. ▶◀ The Mk 3 seat with the simplified combined harness (SCH), is illustrated at Figures 1 to 3.

3. The seats are cleared for zero speed and zero altitude ejection. At speeds above 450 KCAS in unaccelerated level flight a minimum ejection height of 100 feet above ground level (AGL) is recommended. However, when the circumstances permit, the ejection conditions should be 250 to 300 KCAS at a minimum ejection height of 500 feet AGL. Speed and angle of bank/angle of dive have an effect upon the ideal terrain clearance required. Figures 4 and 5 illustrate these effects for a typical rocket assisted seat.

Note: These graphs do not present the complete picture of a dynamic situation. Other factors, such as crew reaction time, also have an effect.

**WARNING:** Normally the navigator ejects first if time and circumstances permit. However, in extreme situations, if the pilot decides that *immediate* ejection is necessary he should eject (without warning the navigator) and the navigator should follow on seeing the front seat leave the aircraft. The navigator may also decide to eject first if the situation demands. In this case he should, if possible, warn the pilot before ejecting so as to avoid the possibility of simultaneous or near-simultaneous ejections. ▶◀

4. The seat is equipped with two separate firing handles. Either handle jettisons the canopy and fires the ejection gun. These two handles are the face blind and seat pan ejection handles. The face blind is located above the head and the seat pan ejection handle between the occupant's knees.

5. The top of the seat provides a mounting for the drogue chutes, face screen, drogue chute restraining scissors and canopy interlock block. The drogue gun is on the left side of the seat near the top and the barostatic time release unit is near the top on the right side. Automatic operation of the seat is dependent upon these two units which are equipped with trip rods which in turn pull sears from these units during the ejection sequence.

6. An inertia reel and snubber unit, used for retaining the upper harness, is at shoulder level and provides free forward and aft shoulder movement or, when locked, shoulder restraint during crash or bale-out conditions. The inertia reel locks on ejection at whatever position the seat occupant is in when the firing handle is pulled; there is no automatic pull back into the seat.

7. Ejection through the canopy is *not* possible because of the interlock mechanism (see para 14).

8. When either seat is ejected, the IFF/SSR equipment is energised and the emergency coding signal automatically transmitted. This facility is triggered irrespective of the position of the IFF/SSR function selector knob, including the OFF position.

Note: The IFF/SSR requires a 50 second warm up period which starts when the equipment is either:

a. Selected STBY, NORM or EMGY

*or*

b. Triggered by the ejection seat when the IFF/SSR equipment is in the OFF position.

9. The drogue chutes, which are on the top of the seat, stabilise and decelerate the seat after ejection and deploy the personnel parachute.

10. A restraint line and snubbing unit is fitted on each side of the seat pan to restrain the occupant's legs during the ejection sequence.

11. In addition to the firing handle, the seat pan has five controls:

a. The manual separation handle which is used in manual separation procedures.

b. The shoulder harness go-forward lever which controls the upper harness.

c. The leg-restraint line release lever which releases the leg-restraint lines from the taper plug assemblies.

d. The knob which is used to select the emergency oxygen supply.

e. A lever on the inboard face of each snubber unit. When operated and held, this control releases the snubber and allows free movement of the leg-restraint line.

12. *Seat Position Switch*. A seat adjusting switch, on the forward right side of the seat pan, controls the seat height.

**Main Beam Assembly**

13. The main beam assembly is a strong lightweight structure built to withstand high g loads and is the main frame of the seat. It supports the:

Seat pan

Drogue chute container

Drogue shackle scissors

Drogue gun

Barostatic time release unit,

Personnel parachute.

The main beam consists of two vertical beams bridged by three cross-members. Each vertical beam has three slippers located on the inner side. Upon ejection, these slippers slide in the guide rails of the cylinder barrel which is secured to the aircraft structure. On the lower outboard side of each vertical beam are two seat pan guide tracks. The seat pan assembly rides in these tracks during seat height adjustment. The top latch mechanism is attached to the top of the left vertical beam and is used to secure the seat structure to the cylinder barrel.

**Canopy Interlock Mechanism**

14. The canopy interlock mechanism is mounted across the top of the aft corners of the main beam on the seat. The mechanism ensures correct sequencing between the canopy and ejection seat during the ejection sequence and also transmits the pull of the face screen handle or seat pan ejection handle to the canopy initiator and ejection gun firing mechanism. The interlock block of the mechanism is connected to the canopy by cable and is pulled from the interlock mechanism by the canopy during the ejection sequence. This block and various lever arrangements within the interlock mechanism, prevent firing of the ejection seat before the canopy has been jettisoned from the aircraft. A safety link connects the canopy interlock block to the ejection gun main sear safety pin. The safety pin remains inserted in the sear until it is pulled out by the interlock block as the canopy is jettisoned. This gives added protection against inadvertent ejection.

Note: If an ejection handle is inadvertently pulled, ejection cannot occur if the canopy is fully open. With the canopy actuator at the top limit of its travel, the canopy does not jettison to remove the interlock block, thus inhibiting the ejection gun.

**Ejection Gun**

15. The ejection gun is on the ejection seat between the vertical portion of main beam and is attached to the bulkhead of the cockpit by two mounting lugs. The gun is attached to the seat by the seat slippers and top latch mechanism. It is used to jettison the seat from the cockpit during the ejection sequence and is operated by three pyrotechnic cartridges. The gun is composed of four major assemblies:

a. The firing mechanism

b. The inner tube

c. The intermediate tube

d. The outer tube.

During the ejection sequence, gas pressure produced by the primary and auxiliary cartridges, causes the tubes of the gun to extend. When the inner and intermediate tubes are fully extended in the outer tube during upward travel of the seat, separation of the inner tube from the intermediate tube occurs. Separation of the tube is permitted by the incorporation of a shear rivet in the inner tube bushing which shears when the inner tube strikes the bushing.

**Rocket Motor**

16. Attached to the underside of the seat pan is a multi-tubed one inch rocket pack which sustains the thrust of the ejection gun giving a higher trajectory to enable ejection to be made under zero speed and zero altitude conditions. The rocket tubes contain a solid propellant which is ignited by a firing body. Two metal guards attached to the rocket tubes protect the occupant's legs against burns.

17. A gas operated firing unit is connected by a flexible hose to a remote rocket initiator bolted to the left side of the seat structure. The remote rocket initiator comprises a standard firing unit and a coiled static line. The upper end of the line is connected by a lever and shackle to the sear of the firing unit and the other end to a bracket attached to the drogue gun trip rod. A safety pin is provided for the sear of the firing unit and must be removed before flight.

18. After initiating ejection, as the seat leaves the aircraft under the influence of the ejection gun, the static line withdraws the sear from the remote rocket initiator firing unit. The firing unit generates gas pressure which is piped to the rocket motor firing unit where it forces the firing pin forward to initiate a cartridge which ignites the rocket motor.

**Pitch Control Unit**

19. On the front part of the left side of the seat pan is a pitch control unit. This unit enables the angle of incidence between the rocket pack and the seat to be varied, thus altering the direction of thrust of the rocket efflux nozzles to compensate for the occupant's weight effect on the centre of gravity of the seat. The unit is operated by a knurled knob which is turned clockwise to decrease weight compensation. Adjacent to the knob is a window which displays the weight in pounds. The unit covers weight range of 160 to 250 pounds. One click of the knob is equal to two and a half pounds. The occupant sets the pitch control unit so that the figure in the window agrees with his fully kitted weight.

**WARNING:** Should the weight set on the pitch control unit be grossly different from that of the occupant, it is possible that seat instability could be caused at ejection speeds below 140 knots.

**Drogue Gun**

20. The drogue gun is on the left side of the main beam assembly and is used to extract the controller drogue shute from its container 0.75 second after ejection. Upon ejection, a trip rod fixed to the aircraft structure pulls a sear from the drogue gun to initiate the time delay. After the time delay has elapsed, a cartridge is fired and the resultant gas pressures propel a piston out of the drogue gun barrel. Attached to this position is a lanyard which pulls the controller drogue chute from its container. When deployed, the controller drogue chute pulls the stabiliser drogue chute from its container.

**Drogue Chute Restraining Scissors**

21. The drogue chute restraining scissors are on the top of the seat, and are attached to the top cross-members of the main beam assembly. The scissors connect the drogue chutes to the top of the seat when they are deployed during ejection. A movable jaw of the scissors is used to release the drogue chutes from the seat when the barostatic time release mechanism actuates. The drogue chutes deploy the personnel parachute when actuation of the barostatic time release mechanism occurs.

**Barostatic Time Release Unit**

22. The barostatic time release unit is on the right side of the main beam assembly. It releases the drogue parachutes from the scissors shackle and frees the combined harness and leg-restraint lines thus releasing the occupant from the seat. The unit is cocked on ejection by a trip rod as the seat starts to rise. Below a pre-determined altitude the time release mechanism operates 2.25 seconds after initiation. When released from the scissor shackle, the drogue parachutes stream the personnel parachute and pull the occupant from the seat. Above the pre-determined altitude, the time release mechanism is prevented from operating by the barostatic capsule. The pre-determined altitude is set by use of either a 10,000 feet or a 15,000 feet capsule.

Note: The drogue gun and barostaic time release unit operate independently; the 0.75 second in para 20 and 2.25 seconds in para 22 are not additive.

**Sticker Clips**

23. The sticker clips, one on each inner side of the seat pan, are made of spring steel with a detent point to hold the harness sticker strap lugs. The sticker clips clamp on to the harness sticker strap lugs and retain the occupant in the seat until the personnel parachute deploys and pulls the occupant clear of the seat. This arrangement prevents a collision between seat and occupant.

**Face Blind Ejection Handle**

◆ 24. When pulled forwards and downwards, the face blind handle jettisons the canopy (see Part 1, Chapter 8, para 65). As the canopy leaves the aircraft the interlock block is removed and the main gun sear safety pin is also removed. A ◆ continued pull on the handle removes the sear from the ejection gun which fires the main charge and ejects the seat. The rear seat handle also actuates the withdrawal of locks to automatically stow the radar scope, the radar set controls, and the radar antenna hand control to provide ejection clearance. The canopy interlock block in the firing mechanism of both seats prevents seat ejection before canopy jettison.

**Seat Pan Ejection Handle**

25. The seat pan ejection handle is connected to a cable assembly which is routed under and behind the seat. The seat handle initiates the same jettison and firing functions as the face blind.

Note: The seat pan ejection handle remains attached to the seat after separation.

**Seat Positioning Switch**

26. The ejection seats may be adjusted vertically by actuating a spring-loaded contact switch on the right forward side of the seat pan. Each seat can be adjusted up or down through a total distance of six inches. It is not necessary to adjust the seat height before ejection. However, the seat should be lowered to afford adequate clearance between the helmet and face blind ejection handle if this handle is to be used. The seat positioning switch must not be used for more than 30 seconds in any ten minutes.

**Shoulder Harness Locking Mechanism**

27. The shoulder harness locking mechanism is part of the seat centre cross-member and is approximately at shoulder level. It is used to hold the occupant's upper torso against the back of the seat during all flight conditions and ejection. The mechanism consists of a strap wound on a spring-loaded reel, a snubbing unit, and an upper harness release pin. The strap wound around a spring-loaded retraction reel, passes through a snubbing unit, and then through the occupant's upper harness roller fitting. The eye of the strap, then returns back to the seat and through the rings to the two straps securing the personnel parachute to the seat, and is anchored by the upper harness release pin. The snubbing unit prevents any forward movement of the strap unless the unit is unlocked. During ejection upon actuation of the time release mechanism, the upper harness release pin releases the eye fitting,

thereby freeing the occupant's upper harness and the parachute securing straps.

28. A go-forward mechanism permits the occupant to lean forward when required. The mechanism is controlled by a 3-position spring-loaded lever on the left side of the seat pan. If the lever is pushed fully rearwards and then released to the centre position, the occupant can lean forward and backward at will. Movement of the lever to the forward position brings a snubbing unit into action preventing further forward movement and automatically locking the harness in the rearward position as the occupant leans back. When the lever is in the central position the functioning of the snubbing unit is determined by the previous position of the lever. If a crash landing or ejection occurs whilst the lever is in the central position, an automatic inertia device brings the snubbing unit into action to prevent the occupant being thrown forward.

**Leg-Restraint System**

29. The leg-restraint system consists of:

Two leg-restraint lines

Two taper plug assemblies

Two snubbing units

A leg-restraint garter for each leg

30. The garters are clipped to the legs just below the knees by a quick-release fastening. The lower end of each restraint line is attached to brackets on the cockpit floor by a fitting which incorporates a shear rivet. Each line is then routed upward through the rocket pack to beneath the seat pan, passed through the snubbing unit, through the garter D-rings and plugged into the lock-in hole of the taper plug assembly on the thigh guards. The snubbing units are designed to permit the leg-restraint lines to move freely down through the unit but lock the lines against any upward movement. When the seat is ejected, the upward movement of the seat pulls the leg-restraint lines taut and restrains the occupant's legs back, close to the seat pan; all forward movement is prevented by the snubbing units. As the load on the lines increases, the shear rivets fail and the leg-restraint lines are freed from the floor brackets. The legs are retained close to the seat pan until the taper plug assemblies are released by the harness release linkage. This linkage operates either automatically, or manually by the operation of the manual separation handle. A lever on the inboard face of each snubbing unit allows the seat occupant to adjust the leg-restraint lines to give comfortable leg movement in flight.

**Leg-Restraint Line Release Lever**

31. The leg-restraint line release lever is above the left thigh guard (Fig 2). When the lever is rotated to the aft position, the lock pins on the leg-restraint lines are released from the leg line lock mechanism. This allows the occupant to thread the leg lines back through the garter enabling him to leave the seat without removing the garters. The garters are each fitted with a quick-release box and buckle which, when operated by the two finger buttons, free the garters from the occupant thus enabling easy removal of the garters.

**Manual Separation Handle**

32. The manual separation handle is on the right side of the seat pan. The handle is used by the occupant to separate from the seat manually if the barostatic time release mechanism fails or in the event of ditching. The handle is protected by a trigger that must be squeezed before it can be rotated aft. When the handle is rotated aft a system of linkages releases the shoulder harness, lap belt, and leg-restraint lines, and the guillotine cartridge is fired. Gases from the guillotine cartridge are piped to the guillotine assembly which severs the line connecting the drogue chutes to the personnel parachute. When the handle is rotated fully aft a ratchet engages to hold the handle in the fully aft position.

**Guillotine Assembly**

33. The components of the guillotine assembly are on the right side of the seat pan and on the left side of the main beam assembly near the drogue gun. The guillotine is a pyrotechnically-operated device used to sever the personnel parachute withdrawal line during manual separation from the seat. The assembly consists of a firing mechanism gas line, and a guillotine blade assembly. The personnel parachute withdrawal line passes through a spring-loaded gate on the guillotine blade housing. Under normal ejection conditions, the parachute withdrawal line withdraws from the guillotine gate as the drogue chutes deploy the personnel parachute. During manual separation from the seat, guillotine actuation is accomplished when the manual separation handle is pulled; this action fires the guillotine cartridge which supplies gas pressure to the guillotine blade assembly. The gas pressure forces the blade assembly upwards, severs the withdrawal line and releases the personnel parachute from the drogue chutes.

**Harness**

34. *Simplified Combined Harness (SCH) Installation.* The SCH is a combined seat and parachute harness which

provides normal and negative-g restraint. The lower part of the harness comprises two lap straps, a lower harness seat pad, a quick release fitting (QRF) attached to a negative-g restraint strap, and a negative-g 'V'-strap through which is passed two crotch straps. The upper part of the harness comprises a pair of straps for normal restraint and parachute suspension; the shoulder straps have left and right connector lugs for strapping in. The left shoulder strap is used to mount the manual parachute ripcord handle. The upper and lower parts of the harness are connected by straps routed behind the padded back of the harness. When the occupant is correctly strapped in, the shoulder strap lugs connect the crotch and lap straps to the QRF. The personnel survival pack (PSP) is connected to the lower harness by a single suspension strap which is routed through two metal loops to the PSP side connectors on the harness; either side connector can ◆ be used to lower the PSP by releasing this strap. Post-mod SE161 an Automatic Deployment Unit (ADU) is fitted to the PSP. An ADU MANUAL/AUTO selector, set by ground servicing personnel, is viewed through a slot on the starboard side of the PSP shell. On seat/man separation with AUTO selected, a static line fires the ADU and, after a 4-second delay, the PSP falls away to be suspended by the lowering line. The harness is designed for use with◆ a life preserver on which is mounted an oxygen mini-regulator and a connection for the PSP lowering line. The upper harness is positioned prior to strapping in by two velcro fastener stowages for the shoulder straps.

**WARNING:** The post-ejection function of the QRF on the SCH is not the same as on the superseded torso harness. After ejection the torso harness QRF may be operated to lower the PSP; such action with an SCH would be catastrophic because it releases the parachute harness.

### Personal Equipment Connector (PEC)

35. The PEC is designed to connect aircraft oxygen, ventilating air (pre-mod 702), NBC air (post-mod 702), anti-g air and communications line to the crew member. The PEC assembly consists of an aircraft portion, seat portion, and a man portion. The seat portion is fastened to the left side of the seat pan. The PEC is so designed that the crew member, during normal aircraft entrance or departure, is capable of quickly attaching or detaching all hoses and electrical lines leading from the aircraft to the man. The aircraft portion contains check valves in the ventilating air (pre-mod 702), NBC air (post-mod 702), anti-g and oxygen ports, which are open when the three sections of the PEC are plugged in, and closed when either the man or aircraft portions are disconnected from the seat portion. The check valves prevent gas leakage in the normal direction of flow when the valves are closed. The aircraft portion is provided with a lanyard-operated locking device, the free ends of the lanyard being attached to the aircraft structure. As the seat is ejected, tension in the lanyard unlocks the device and separates the aircraft portion from the seat portion. In addition the seat portion of the PEC connects the emergency oxygen supply to the crew member. A lanyard from the disconnect handle of the man portion of the PEC is connected to the back of the life preserver to permit automatic separation of the man and seat portions of the PEC whenever the wearer leaves the seat.

36. A PEC dust cover stowage is provided on the left rear face of the personnel parachute container.

## NORMAL PROCEDURES

### Strapping-In Procedures

37. Complete the FRC **Ejection Seat Checks.** Strap in as follows:

a. Adjust the seat height and rudder pedals.

b. Adjust the garters to a position above the calf muscle and below the knee ensuring that the free end of the garter is not positioned closer than 25mm from the outer D-ring and does not obstruct the run of the leg-restraint line through the garter D-rings. The Martin Baker clip should be on the inside of the leg. Ensure that the garter is assembled such that the male portion of the Martin Baker clip is cranked inwards to follow the curvature of the leg. Check that the leg-restraint lines are not crossed; thread each line through the two rings on the garter around the front of the leg and insert the end lug into the corresponding leg line lock on the thigh guard. The length of the leg-restraint line should be adjusted to permit full leg movement and any excess pulled back through the snubbing unit.

c. Connect the PSP lanyard ensuring that the line is routed outside the left leg. Do not pull to extend the lowering line as this is safe-tied to the survival pack.

d. Connect the man portion of the PEC to the seat portion.

e. Bring down the shoulder straps and upper negative-g straps releasing the velcro fastener stowages with a sharp tug.

f. Bring the left crotch strap up inside the left thigh and pass it through the left strap D-ring from below, checking that the left lap strap is routed beneath the PEC supply tubes and outside the PSP lowering line. Bring up the QRF, ensuring that the strap does not foul the seat pan firing handle, and fold the end of the left crotch strap inboard towards the QRF. Pass the lug of the left shoulder strap down through the left crotch strap loop. Rotate the face of the QRF (yellow line towards dotted line) and insert the left shoulder strap lug in the upper left QRF slot ensuring that it locks into position; allow the QRF face to return to the normal locked position. Re-check that the lap strap is routed over the PSP lowering line and PSP/PLB lanyard, and under the PEC tubes.

g. Pull the oxygen tube and mic/tel lead through the restraint flap on the life preserver to minimise the surplus between the flap and the PEC.

h. Bring the right crotch strap up inside the right thigh, pass it through the right lap strap D-ring and insert the right shoulder strap lug through the crotch strap loop and into the right upper QRF slot in the same manner as for the left strap.

i. Fully tighten the lap straps, ensuring that the QRF remains central on the body. Roll up the free ends of the lap straps and secure with the velcro flaps. Check that the strap is not looped round the emergency oxygen knob.

j. Tighten the shoulder straps ensuring that they are clear of the lobes and beaded handle of the life preserver. Ensure that the ground crew pull any slack through the shoulder D-link buckles. Tuck excess shoulder strap ends under the harness.

Note: If at this stage the ripcord handle sits high and awkwardly on the left shoulder, operate the go-forward lever and tighten the shoulder straps sufficiently to rotate them forward over the shoulders and give a better position for the ripcord handle. When comfortable, release the go-forward lever and complete the tightening of the shoulder straps.

k. Move the go-forward lever fully rearwards and release it. Check that the shoulders are free to move forward. Move the go-forward lever fully forward and check that the mechanism locks correctly. Set the go-forward lever to the required position.

l. Don the helmet and oxygen mask. Route the helmet mic/tel lead over the left shoulder and connect it to the PEC portion. Route the lead over or around the left stole of the life preserver. Connect the mask oxygen hose to the mini-regulator.

m. Remove and stow all pins.

n. Oxygen checks are detailed in Part 1, Chapter 12.

### Normal Exit from the Seat

38. Make the **Aircraft Safe for Parking** in accordance with the FRC and proceed as follows:

a. Operate the leg-restraint release lever and withdraw the lines through the rings of the leg garter.

b. Rotate the face plate of the QRF fully (yellow line away from yellow dotted line) and depress it to release the combined harness.

c. Release the PSP lowering line.

d. Stand up, checking that the PEC man portion disconnects cleanly from the seat portion.

e. Fit the PEC dust cover.

## EMERGENCY PROCEDURES

### Ejection

39. The procedures for ejection are detailed in the FRC.

### Actions Following Ejection

**WARNING:** Do not release the QRF until after landing. Unlocking and releasing the QRF releases the parachute harness.

40. When the parachute is satisfactorily deployed proceed as follows:

a. If over water, inflate the life preserver.

b. Disconnect and discard the oxygen mask.

c. Confirm that the PSP lowering line is connected.

d. Lower the PSP. The PSP is lowered by releasing either of the side PSP connectors (preferably the right connector).

e. After landing release the parachute by operating the QRF to release the combined harness.

f. If appropriate, complete the recommended dinghy drill.

### Emergency Exit on the Ground

Note: External fire may dictate delaying canopy opening until fully released from the seat. The canopy jettison system may be used if necessary.

41. Proceed as follows:

a. Open the canopy.

b. Operate the leg-restraint release lever and withdraw the lines through the rings of the leg garter.

c. Operate the QRF.

d. Release the PSP lowering line.

e. Stand up, checking that the PEC man portion disconnects cleanly from the seat portion, and vacate the aircraft.

**Ejection Seat Failure to Eject**

42. If the canopy has failed to jettison complete the actions detailed in the FRC.

43. If the canopy has jettisoned but the seat has failed to fire, repeat the pull on the firing handle used. If this action is not successful, pull the other handle. If the seat still fails to fire, complete the **Manual Bale-Out Procedure** (below).

**Manual Bale-Out Procedure**

**WARNING:** Do not release the QRF until after landing.

44. Proceed as follows:

a. Reduce speed to 250 KCAS, if practicable.

b. Lower the helmet visor.

c. Disconnect the PEC.

d. Jettison the canopy.

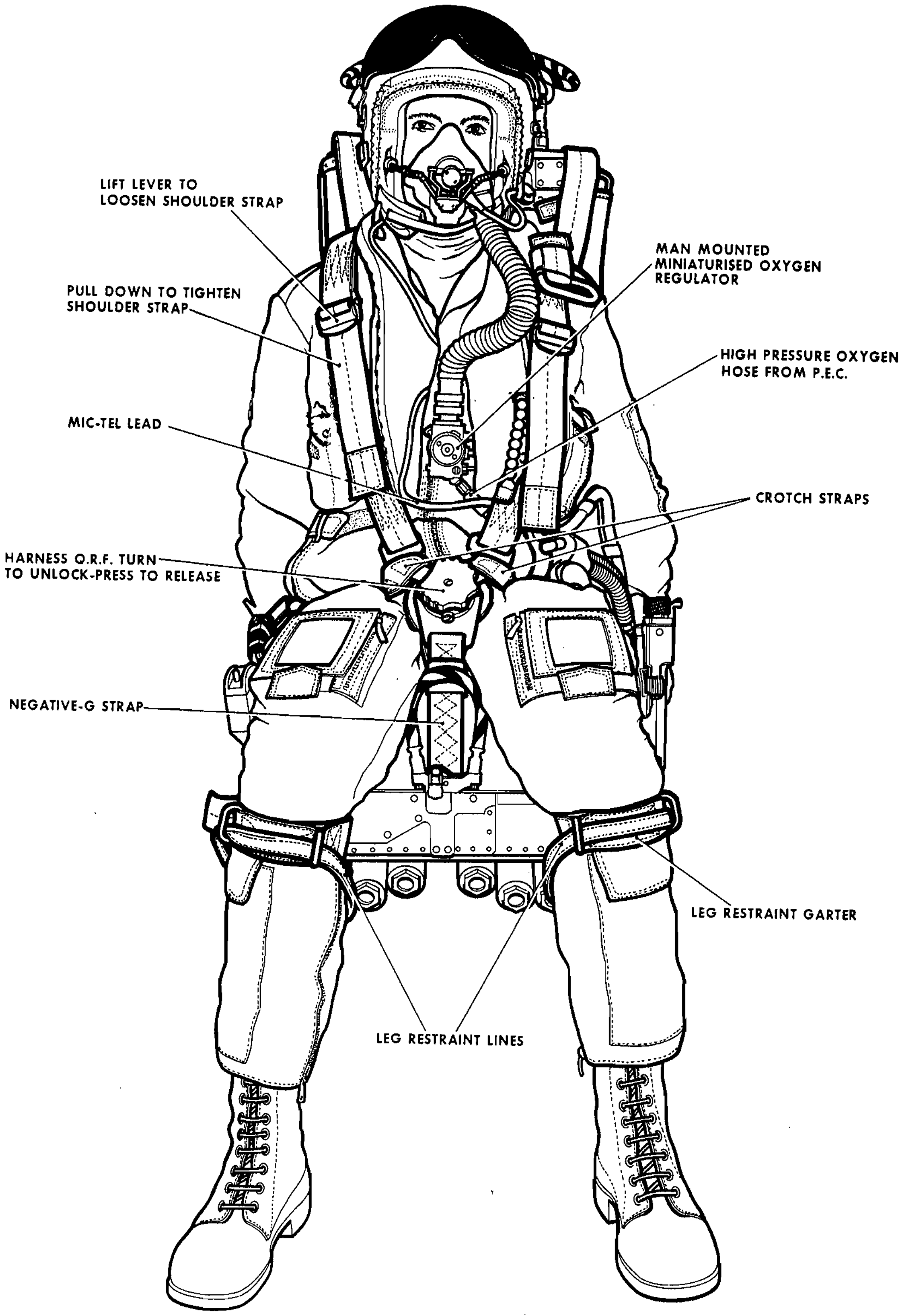
e. Operate the manual separation handle.

f. Hoist parachute onto shoulder.

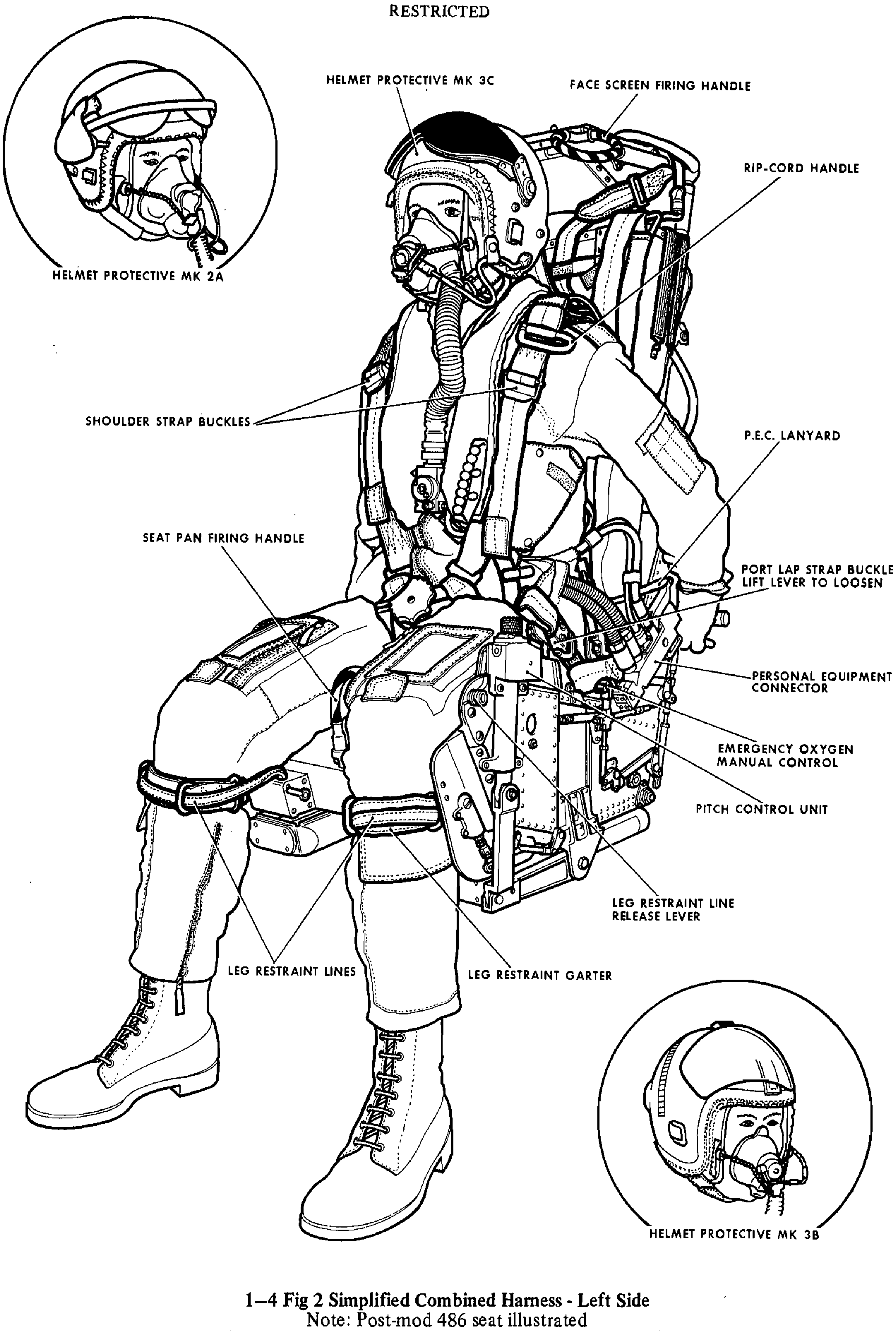
g. If practicable trim nose-own and invert the aircraft.

h. Release the stick and leave the aircraft.

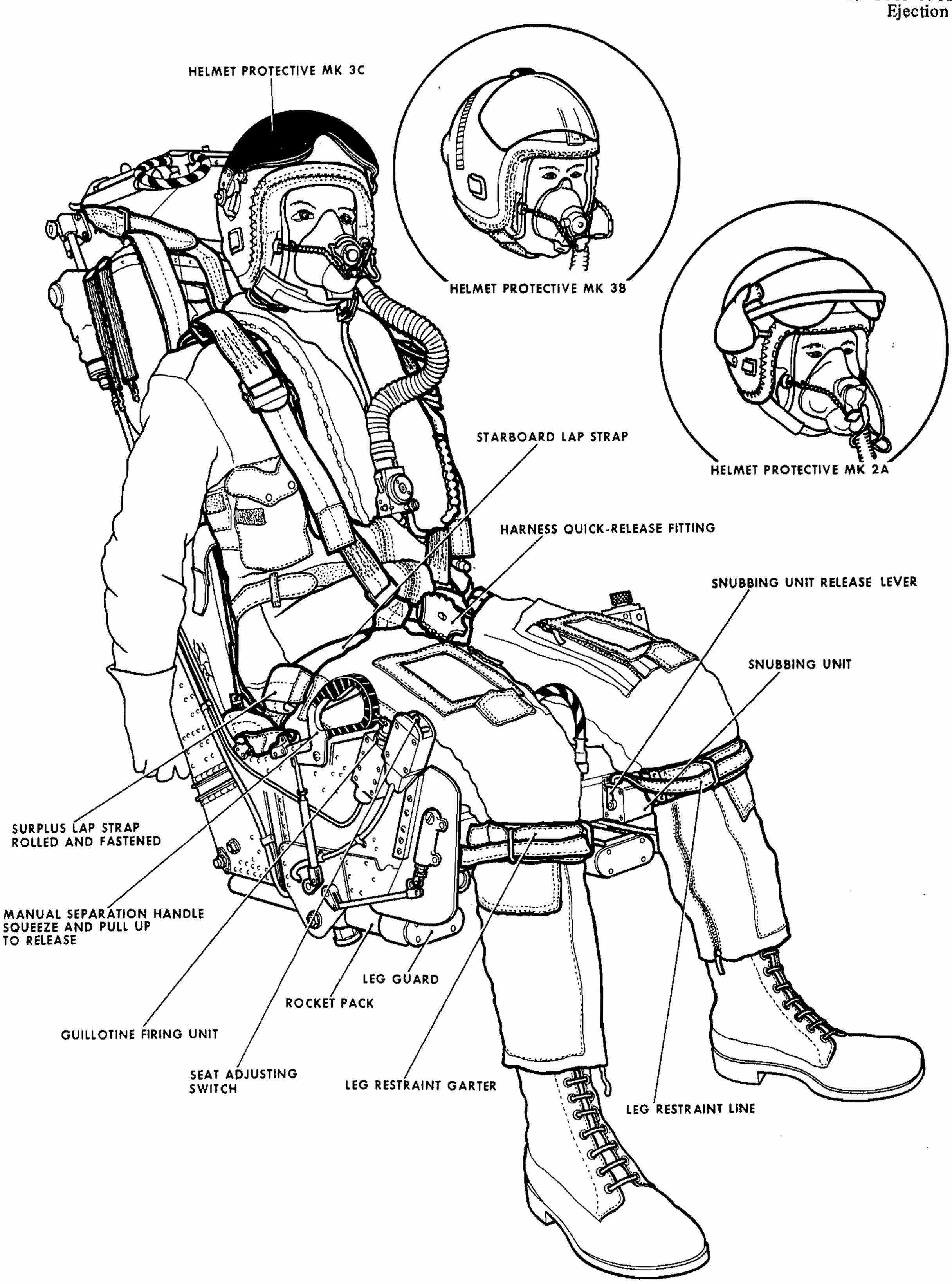
i. When clear pull the parachute ripcord handle. The shoulder riser may have to be pulled down to reach the D-ring which can then be pulled against the grip of the left hand on the riser.



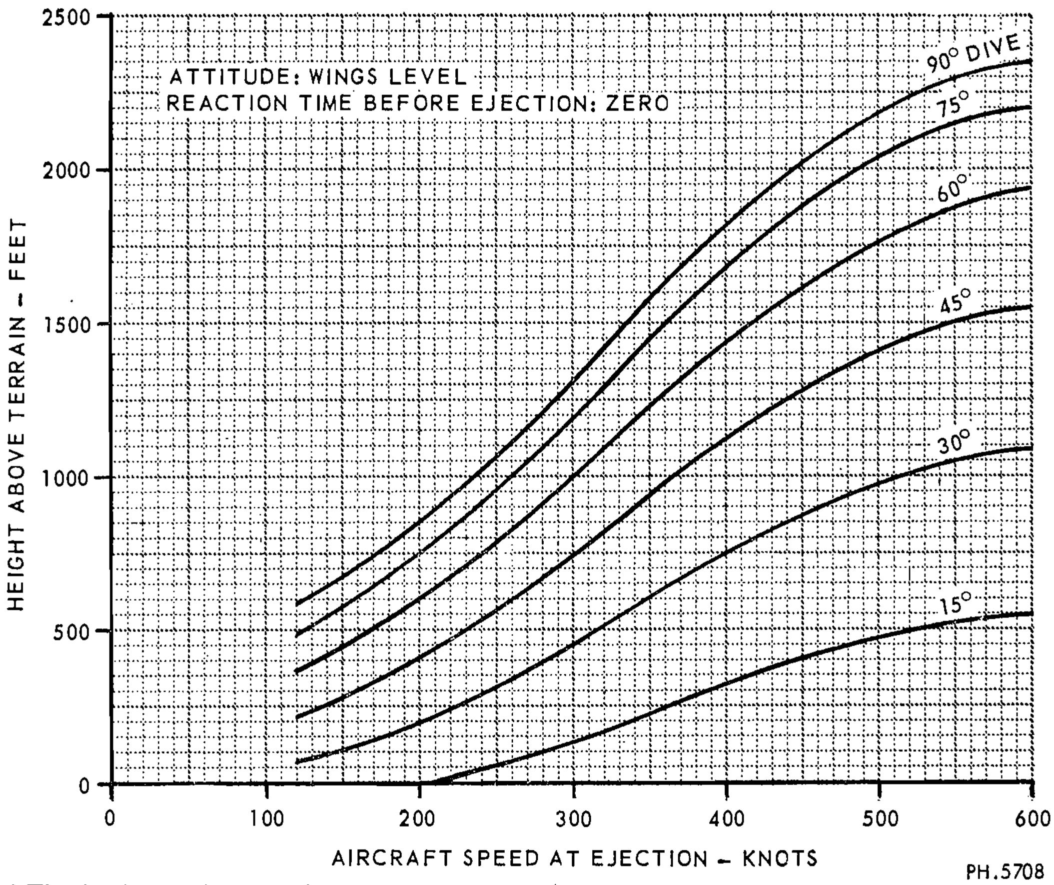

**1–4 Fig 1 Simplified Combined Harness - Forward View**
Note: Post-mod 486 seat illustrated
◀ *(Fig number changed; inner (blue) harness removed* ▶



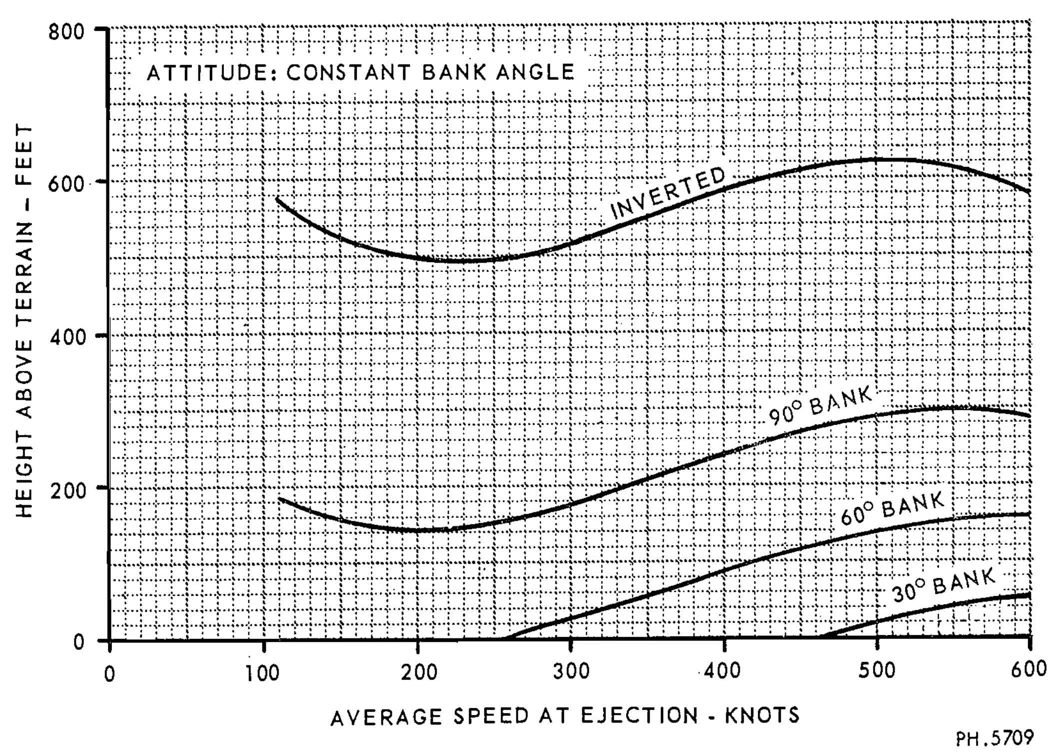

**1–4 Fig 2 Simplified Combined Harness - Left Side**
Note: Post-mod 486 seat illustrated
◀ *(Fig number changed; inner (blue) harness removed)* ▶




**1–4 Fig 3 Simplified Combined Harness - Right Side**
Note: Post-mod 486 seat illustrated
◀ *(Fig number changed; inner (blue) harness removed)* ▶




**1—4 Fig 4 Approximate Effects of Speed and Dive Angle on Terrain Clearance Required for Safe Ejection — Typical Rocket Assisted Seat**




**1—4 Fig 5 Approximate Effects of Speed and Bank Angle on Terrain Clearance Required for Safe Ejection — Typical Rocket Assisted Seat**

*(Fig numbers changed)*

# PART 1

## CHAPTER 5 — ELECTRICAL POWER SUPPLY SYSTEM AND TELELIGHTS

### Contents



### Illustrations

## CONTROLS AND INDICATORS

1. Details concerning the controls and indicators shown in Fig 1 are listed below:

| *Item No* | *Item* | *Location* | *Markings* | *Remarks* |
|---|---|---|---|---|
| 1 | Generator control panel | Front cockpit, right console | Captions: LH GEN OUT, RH GEN OUT, BUS TIE OPEN. Generator switches: L GEN, R GEN — ON/OFF/EXT ON. RESET MASTER CAUTION | Amber captions, 3-position switches, reset button |
| 2 | Circuit breaker panel | Front cockpit, right console | Seven circuit breakers: FLAPS, SPEED BRAKE, LG, STAB FEEL TRIM, AIL FEEL TRIM, RUD TRIM, TRIM CONT | — |
| 3 | No 3 circuit breaker panel | Front cockpit, right wall | AWG 12 | — |
| 4 | Essential DC test button and light | Rear cockpit, right wall | CHECK ESSENTIAL BUS TRANS–RECT PUSH TO TEST | — |
| 5 | No 2 circuit breaker panel | Rear cockpit, right wall | Refer to FRC | Colour-coded c/b marked |
| 6 | No 1 circuit breaker panel | Rear cockpit, left wall | Refer to FRC | Colour-coded c/b marked |
| 7 | RAT operating handle | Front cockpit, left wall | PUSH DOWN—RAT IN/ RAT OUT | — |
| 8 | RAT | Upper left fuselage | — | — |

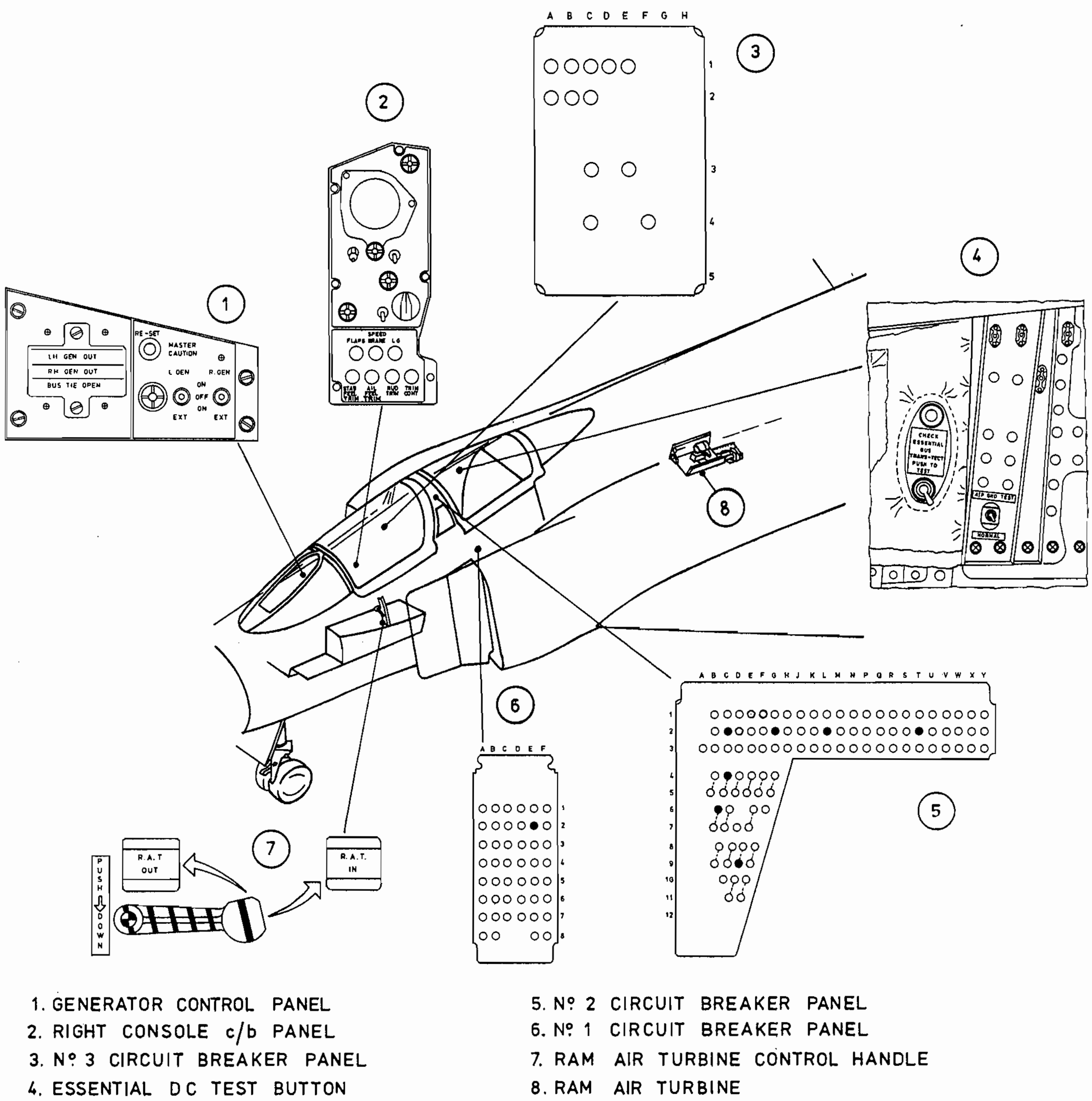
## DESCRIPTION OF THE SYSTEM

### General Description

2. The primary source of electrical power in the aircraft is provided by two 30 kVA AC generators, one being connected to each engine. In normal operation both generators are on line and each independently supplies Left and Right Main busbars with 115/200V AC, 400Hz, 3-phase current. If one generator should fail, or if one engine is shut down, the remaining generator is capable of carrying the total electrical load and it is automatically connected to both Main busbars through a bus tie system.

3. An emergency source of electrical power is provided by an emergency generator which is connected to a ram air turbine (RAT); this provides 115/200V AC, 400 Hz, 3-phase current at 3 kVA which can be fed to certain essential ◆ busbars. A 22.8 volt, 14 ampere-hour nickel cadmium battery provides potential for internal engine starting, the utility floodlights (wander lights) and INAS emergency power. ◆

4. All electrical services are protected by circuit breakers (c/b) which are located on panels in both cockpits and the nosewheel bay. The c/b in the front cockpit are clearly labelled with their functions; c/b location charts for the panels in the rear cockpit are to be found in the FRC. Certain important c/b in the rear cockpit are colour-coded to assist in their rapid identification. Tables 1 to 13 in this Chapter list the busbars in the system together with the function and location of every c/b.




**1–5 Fig 1 Controls and Indicators**

**AC Power Generation**

5. Each generator is mounted on a constant speed drive unit (CSDU), which in turn is mounted on the engine gearbox assembly. The CSDU has a self-contained mechanical/hydraulic system which maintains the drive to the generator at a constant 8000 RPM (corresponding to 400 Hz) at engine power settings between idle and 100% RPM. Each generator has a voltage regulator and supervisory panel (VRSP). The voltage regulator portion of the VRSP produces and varies the excitation to the generator to maintain a constant output voltage; the supervisory portion of the panel monitors the performance of the generation and AC distribution systems and takes the generator off line when a malfunction is detected. An oil-pressure-actuated underspeed switch prevents a generator from being connected to the aircraft electrical system when an unacceptable CSDU drive speed is present; post-mod 639 this underspeed switch is replaced by an underfrequency detection circuit in the VRSP which electronically provides the same protection.

6. Under maximum load a generator trips off line as the engine RPM decrease through approximately 53%. Since flight idle is always above this figure, the generators do not trip off line in flight. Under a typical normal load the generators come on line at 47% RPM which is below the normal ground idle of 51·5 to 56% RPM.

7. *Overvoltage.* If a generator's output should increase by more than 10 volts above normal, the associated VRSP takes that generator off line. To prevent 'nuisance' tripping of the system caused by transient faults, there is a time delay between the sensed overvoltage and the disconnection. If the overvoltage is of a short duration and can be controlled by the VRSP, the generator stays on line. When a permanent overvoltage is present the generator is tripped after a delay, the length of which is inversely proportional to the amount of overvoltage experienced.

8. *Undervoltage.* If a generator's output voltage should drop by more than 13 volts from normal, the generator is tripped off line by the VRSP after a time delay of 3·8 seconds. Should the voltage increase to within 8 volts of normal within the 3·8-second delay, the trip circuit resets and the generator remains on line. In the case of a sustained short circuit being sensed at either of the Main 115/200V AC busbars, the associated generator is tripped off line after 3·8 seconds and the bus tie closes, exposing the other generator to the short circuit. However, the VRSP of the second generator, whilst beginning its undervoltage trip cycle, senses that the bus tie is closed and acts to isolate its generator from the fault by opening the bus tie contactor after 2 seconds, giving a BUS TIE OPEN indication in addition to the tripped generator caption, but keeping the second generator on line.

**Generator Control Panel**

9. The generator control panel (Fig 1) contains the following controls and indicators:

a. *Control Switches.* Two 3-position generator control switches labelled L GEN and R GEN each have positions marked ON, OFF and EXT ON.

b. *Generator Captions.* Three telelight captions, LH GEN OUT, RH GEN OUT and BUS TIE OPEN are provided to indicate when the generators are on or off line and to confirm the position of the bus tie contactor. A generator caption comes on when the associated generator is off line; the bus tie caption comes on when the bus tie contactor is open but should be closed. The MASTER CAUTION lights are triggered when either generator caption comes on.

c. *Master Caution Reset Button.* When pressed, the master caution reset button, marked RESET MASTER CAUTION, puts out the master caution lights.

10. With the control switches to OFF, no power can be fed from the generators nor from an external AC source to the aircraft electrical system. When both engines are running and the switches are ON, power is supplied by the generators to the aircraft electrical system and all three captions are out. With external AC power applied and *both* the control switches to EXT ON, external power is applied to the aircraft electrical system but both the LH GEN OUT and RH GEN OUT captions are on; the BUS TIE OPEN caption goes out (the bus tie is closed during operation on external AC power).

11. The generator and bus tie warning captions are supplied from the Warning Lights 28/14V DC busbar (Fig 2). The Warning Lights busbar is fed either from the Essential 28V DC busbar (bright captions) or by a 14V DC TRU supply (dim captions) from the Right Main 115/200V AC busbar, depending upon the position of the INSTR PANEL rotary switch on the COCKPIT LIGHTS panel (right console, front cockpit). With the switch to OFF, Essential 28V DC is used and the captions come on bright. When the switch is away from OFF, the captions take the 14V DC supply and the captions are dimmed. Note that with the INSTR PANEL switch OFF, the left generator off line and the bus tie open, the captions are powered by the battery until the emergency generator comes on line. However, with the INSTR PANEL switch away from OFF (eg during night flying), the right generator off line

and the bus tie open, the captions to indicate this failure cannot come on because the Right Main 115/200V AC busbar is dead; this remains the case even with the emergency generator on line.

### Bus Tie Relay

12. The AC power supplies are arranged on a split busbar system with each generator supplying its own Main AC busbar and associated AC system. In normal operation, ie, with both generators on line, the bus tie contactor is open but the BUS TIE OPEN caption does not come on. When one generator comes off line the bus tie contactor, through the action of the appropriate VRSP, automatically closes and allows the remaining generator to supply both left and right systems and the bus tie caption is out; the caption comes on only if the bus tie contactor is open after a generator has failed.

### Power Distribution

13. The power distribution is shown at Fig 2. Under normal operation, with both engines running and the L GEN and R GEN switches ON, the generator line contactors are closed, the bus tie contactor is open and power is applied to the system. The Left Main 115/200V AC busbar supplies the Essential 115/200V AC busbar which in turn powers the Essential 28V AC and Essential 28V DC busbars; these supply services essential to the flying and safe recovery of the aircraft.

14. Three auto-transformers and three transformer-rectifier units (TRU) connected to the three 115/200V AC busbars convert generator output to AC and DC at 28V and 14V for the subsidiary busbars as shown in Fig 2. Two of these busbars require additional switching to receive power as follows:

a. *Armament 28V DC Busbar*. The Armament 28V DC busbar comes on line when the MASTER ARM switch is to ARM and the landing gear handle is up. On the ground, power may be applied to this busbar by selecting ARM and pressing in the ARMAMENT SAFETY OVERRIDE button (held in electrically) on the left wall of the front cockpit.

b. *Battery 24V DC Busbar*. The battery relay closes when either the L or R ENGINE MASTER is to ON or when the ground refuelling switch in the right wheelwell is to REFUEL or DEFUEL; it opens when the emergency generator is on line.

### DC Power System

15. Unlike the two AC power systems, which are completely separate under normal operation, the Left and Right Main 28V DC busbars operate in parallel through a 60 amp fuse, which is essentially a current limiter. If either the Essential TRU or the right TRU fails, the other unit takes the full 28V DC load. There is no cockpit indication of TRU failure. For this reason the correct operation of the Essential and Right TRU is checked in the rear cockpit before every flight.

16. *Essential DC Line Contactor*. The essential DC line contactor is held closed by power from the Left Main 115/200V AC busbar and therefore opens to isolate the Essential 28V DC busbar from the remainder of the 28V DC system when there is no power on the Left Main busbar. This automatic action reduces the DC load on the emergency generator after a double generator failure or a left generator plus bus tie open failure.

17. *Battery Power*. The battery is permanently connected to the Battery 24V DC busbar and therefore the two utility floodlights (wander lights) and emergency INAS power are always available. The battery relay is closed by switching either ENGINE MASTER switch to ON (enabling a DC internal start) or by moving the ground refuelling switch to REFUEL or DEFUEL; when the relay is closed, the battery is connected to the Essential 28V DC busbar and is charged in normal operation. The battery relay is automatically opened to isolate the battery from the DC system when the emergency generator is on line.

### Ram Air Turbine (RAT)

18. The RAT is positioned on the upper left side of the fuselage. It is extended and retracted pneumatically by operating the RAT control handle above the left console in the front cockpit; moving the handle down through approximately 180° extends the RAT and the marking then visible on the RAT handle reads RAT OUT. From selection it can take from 5 to 8 seconds for the RAT to extend and produce the required frequency and voltage from the emergency generator. Moving the handle up retracts the RAT and RAT IN is then visible on the handle. The pneumatic system pressure is reduced by approximately 1000 PSI when the RAT is moved in or out, but the pressure recovers as the pneumatic pump replenishes the system. No attempt must be made to retract the RAT unless the pneumatic gauge is indicating at least 2000 PSI. There is no cockpit indication of RAT extension apart from the handle position and the drop in pneumatic pressure; extension can be viewed in the rear cockpit mirror and the recovery of lost electrical services confirms that the emergency generator is working.

19. The RAT has two variable-pitch blades which are controlled by a constant speed unit to maintain 12,000 RPM at the output shaft (corresponding to 400 Hz) which

drives the gearbox attached to the emergency generator. The maximum speed for RAT operation is 515 KCAS/ 1.1M. Full output is maintained down to 180 KCAS; no output is produced below approximately 90 KCAS.

**Emergency Generator**

20. The emergency generator operates automatically when the RAT is extended. If the left line contactor and the bus tie contactor are both open and the emergency generator is producing power, the emergency generator line contactor closes to connect the output to the Essential 115/200V AC busbar. If the left generator comes back on line, or the bus tie contactor closes, the emergency generator line contactor opens to isolate the emergency generator output. The emergency generator is capable of delivering its fully rated output for a period of at least 3 hours. However, report any use of the emergency generator after landing since it is inspected after every 15 minutes of operation.

21. A test of the emergency generator output can be made in flight, without the need to switch off both aircraft generators, by attaching a test set in the rear cockpit and extending the RAT.

**External Power**

22. There are two sockets under the left engine intake for the connection of external power:

a. *External AC Power.* The 6-pin AC socket accepts 115/200V AC, 400 Hz, 3-phase current which supplies all connected busbars with power providing both generator switches are to EXT ON. However, certain services are isolated when the external power source ◆ is in use; pre-mod 721, for the main V/UHF radio to ◆ be in operation during engine starting, the CNI GROUND POWER switch in the left wheelwell must be moved to ON; if AJB-7 operation is required while on external AC power, the AN AJB-7 VERT REF GRD PWR TEST SWitch, above the left console in the rear cockpit is moved from NORMAL to TEST. Both these switches return to their normal positions when either aircraft generator is brought on line; CNI services and the AJB-7 then remain in operation on internal power.

b. *External DC Power.* The 3-pin DC socket accepts 24 to 28V DC to power only the services connected to the Essential 28V DC busbar. When external DC power is connected, neither internal nor external AC power can be accepted by the aircraft electrical system owing to the isolating action of the AC power cut-off relay while the external DC contactor is closed. However, when 28V DC ground power is connected via a special adaptor, the AC cutoff relay is bypassed and only the telebrief system and the INAS fine heaters are energised, but external AC power can be used.

## NORMAL MANAGEMENT OF THE SYSTEM

**Essential DC Checks**

23. Prior to starting, complete the essential TRU and right TRU tests as follows:

a. *Essential TRU Test.* With external AC power on line, the L GEN and R GEN switches to EXT ON, the ENGINE MASTER switches OFF and the ground refuelling switch OFF, press the ESSENTIAL BUS TRANS-RECT button to open the essential DC line contactor thus allowing only current produced by the Essential TRU to reach the essential DC test light, adjacent to the button. If the light comes on the Essential TRU is functioning. The light has an integral press-to-test facility to check the filament.

Note: The test is not valid on either internal AC or external DC power because the battery is on line.

b. *Right 28V TRU Test.* In the same pre-start conditions, the correct operation of the right 28V TRU is checked by operating the WARNING LIGHTS test switch while keeping the ESSENTIAL BUS TRANS-RECT button pressed. If the telelight captions come on, the right TRU is serviceable.

**Starting**

24. External AC power is normally used for the engine starting cycle because some important services, such as fire and overheat warnings, require AC power. If starting on DC power either from an external source or the battery, connect internal AC power as soon as possible after starting the first engine to energise the fire detection and other AC systems. When starting on external DC power, the external source must be disconnected before an engine generator can be brought on line. The full drills are given in the FRC.

**Engine Shutdown**

25. If an engine is to be shut down in flight as a premeditated action, first switch OFF the stab augs and the radar in case transients occur as the bus tie closes, and extend the RAT as a precaution against bus tie failure or failure of the second generator. Then switch OFF the associated generator before shutting down the engine. However, when shutting down the engines on the ground, leave the generator switches to ON to check the correct operation of the underspeed/underfrequency protection circuits as the engine RPM decrease.

## MALFUNCTIONS OF THE SYSTEM

### Control Transients

26. The Left Main 115/200V AC busbar supplies power to the radar, INAS, AFCS and the stab aug systems. A transient high or low voltage on this busbar may give control transients through the AFCS or stab aug systems. In addition, if a sustained short circuit exists (eg caused by the radar), control transients may be experienced as the voltage drops and the left generator is tripped, followed by further transients which continue until the right generator's VRSP opens the bus tie contactor a total of 5·8 seconds after the onset of the undervoltage condition. The drill for electrical transients is given in the FRC and the subject is discussed further in Part 4, Chapter 2.

### Single Generator Failure

27. The failure of one generator is indicated by either the LH GEN OUT or RH GEN OUT caption coming on and by the MASTER CAUTION lights. The bus tie closes and the other generator takes the full electrical load. Extend the RAT as a precaution against the failure of the on-line generator, switch OFF the failed generator's control switch and land as soon as practicable. Do not attempt to reset a single failed generator in case a bus tie open failure is induced; with the bus tie closed, no electrical services are lost.

### LH GEN OUT/BUS TIE OPEN Captions

28. *Implications.* If a BUS TIE OPEN caption follows a LH GEN OUT warning, it can be assumed either that the right VRSP has acted properly to protect the right generator from a short circuit in the left AC system or that a transient VRSP fault caused the opening of the bus tie relay after the failure of the left generator. In this situation, with the emergency generator connected to the Essential 115/200V AC busbar, the Left Main 115/200V and the Left Main 28V AC busbars are lost (see Tables 3 and 5: the major items lost are also listed in the FRC). In view of the importance of some of the services lost (eg stab aug, ARI and nose-wheel steering), an attempt must be made either to reset the tripped left generator or to close the bus tie.

29. *Actions.* Having extended the RAT to allow the emergency generator to supply the Essential AC services, switch OFF the stab augs to prevent control transients, and the radar to isolate a possible cause of a sustained short circuit; since the INAS is lost in this situation, primary attitude and true heading information are also lost but there is an automatic changeover to AJB-7 information; however, select STBY and SLAVED on the compass control panel. Cycle the left generator switch OFF and ON. If this is unsuccessful, the right generator switch is cycled OFF and ON with the left generator switch OFF in an effort to reset the VRSP and close the bus tie contactor. This last action is only effective in correcting a transient fault and may provoke double generator failure. The full drill is in the FRC.

Note: When the right generator switch is cycled to OFF, a double generator failure is induced, but with the RAT extended and the emergency generator on line, essential services are maintained.

30. *Recovery and Landing.* The following significant services are inoperative when recovering with a left generator plus bus tie open failures with the emergency generator on line:

| | |
|---|---|
| Stab aug | INAS |
| AOA probe heater | ARI |
| TACAN | Nosewheel steering |

Make an approach-end cable engagement.

### RH GEN OUT/BUS TIE OPEN Captions

**WARNING:** If the front cockpit INSTR PANEL switch is not at the OFF position, the generator warning panel captions are inoperative after a right generator failure with the bus tie open, *whether the emergency generator is on line or not.*

31. *Implications.* With the right generator off line and the bus tie open, the left generator supplies power to the Essential busbars, the Left Main 115/200V AC busbar and the Left Main 28V AC busbar. Full DC services are available since the essential DC line contactor remains closed. Extending the RAT does not bring the emergency generator on line because it is isolated by the emergency generator line contactor whilst the left line contactor is closed. The services lost in this situation are listed in Tables 4, 6 and 7; the FRC also lists major items lost.

32. *Indications.* If this failure occurs with the INSTR PANEL switch away from the OFF position (eg during night flying), the RH GEN OUT caption comes on for approximately two seconds and then goes out as the bus tie contactor opens. The following relatively inconspicuous cockpit failures also occur:

BAI OFF flag

Radio altimeter OFF flag (indication freezes)

Mk 30 altimeter OFF flag (rear cockpit)

Console lights go out

Console flood lights go out (if MED selected)

Red console floods go out (if DIM or MED selected)

Instrument emergency floods go out (if DIM selected)

E2 compass light goes out

Selecting the INSTR PANEL switch to OFF connects the Warning Lights 28/14V DC busbar to the Essential 28V DC busbar and power is restored to the captions on the generator warning panel.

◆ Note: Post-mod 848, a relay is energised to bypass the INSTR PANEL switch ensuring that in the event of a RH GEN OUT/BUS TIE OPEN failure, the cockpit warning lights come on at full brilliance with no dimming facility. ◆

33. *Actions.* First extend the RAT as a precaution against further electrical failures and then cycle the R GEN switch to OFF and ON. If this is not successful, the further resetting procedure of switching OFF the operating generator (as described in para 28) is not attempted since any advantage gained by restoring the less-important right AC busbar services is not worth even the minimal risk of losing the left generator and inducing a double generator failure. The full drill is in the FRC.

34. *Recovery and Landing.* When recovering to land with a right generator plus bus tie open failure, avoid icing conditions (ASI pitot heater inoperative) and, at night, select the red floodlights to BRT. Note that the radio altimeter and the Mk 30 altimeter are inoperative and that the Mk 29 altimeter (front cockpit) vibrator is not working. The anti-skid system is inoperative but normal braking is available. The full drill is given in the FRC.

**Double Generator Failure**

**WARNING 1:** If the aircraft is flown without a battery, the generator captions do not come on after a double generator failure until the RAT is extended and the emergency generator is on line.

**WARNING 2:** All normal cockpit lighting is lost after double generator failure. Therefore familiarity with the positions of the INSTR PANEL EMERG FLOOD switch (right wall, front cockpit) and the RAT handle is essential. Setting the switch to the BRT (uppermost) position illuminates the instrument panel; the utility floodlight may also be used. When the emergency generator is on line the instrument panel lights are regained.

Note: If double generator failure occurs after a double flame-out in a spin, it is unlikely that the RAT will receive a workable airflow until the spin is broken.

35. *Implications.* A double generator failure is indicated by the LH GEN OUT, RH GEN OUT and BUS TIE OPEN captions together with the MASTER CAUTION lights (and telelight captions such as WINDSHIELD TEMP HIGH and IGV MALFUNCTION). Until the RAT is extended and the emergency generator is on line, all AC services are lost and only those DC items powered by the Essential 28V DC and Battery busbars are available, the Warning Lights 28/14V DC busbar being automatically connected to the Essential 28V DC supply irrespective of the INSTR PANEL switch position (see Tables 8, 12 and 13 for operative items). However, once the emergency generator is on line, all Essential busbar services are restored. The FRC lists the *major* items lost when on RAT and battery power alone, and the services available can be found in Tables 1, 2, 8, 12 and 13. Note that the battery is isolated from the Essential 28V DC busbar when the RAT is in operation, but the Battery 24V DC busbar is still powered by the battery.

36. *Actions.* A double generator failure calls for RAT extension, the restoration of cockpit lighting (at night), stab augs and radar OFF, a reduction in speed to less than 350 KCAS/0·7M and the selection of STBY and SLAVED on the compass control panel. Both L GEN and R GEN switches are moved to OFF and then cycled individually to ON in an attempt to regain one or both generators.

Note: A double generator failure may be caused by an incorrectly seated AC test plug socket. If the generators do not reset after cycling, the AC power test receptacle cover in the rear cockpit is to be checked to ensure it is fully in the detent.

**Recovery Using RAT Power Only**

37. The following considerations apply during recovery and landing on RAT power alone:

a. Stab aug, pitot and AOA probe heaters, engine anti-icing, the BAI, radio altimeter, Mk 30 altimeter and the vibrator for the Mk 29 altimeter are all inoperative.

b. External lighting is not available.

c. Navigation aids are not available; main and standby radios are operative but without ADF.

d. Fuel cannot be dumped.

e. For the landing the gear and flaps are lowered on the emergency pneumatic system; the ARI and rain removal systems are inoperative; and the nosewheel steering and anti-skid systems do not work, making an approach-end cable engagement advisable.

Note: If the flaps were lowered on the normal system before double generator failure, they blow up to a low drag position until lowered pneumatically.

**Total Electrical Failure**

38. If the RAT should fail to extend or the emergency generator fail to come on line, battery power is available to the Battery 24V DC busbar, and to the Essential 28V DC busbar providing either ENGINE

MASTER switch is ON. The BAI provides attitude information for 3 to 5 minutes as it runs down with its OFF flag showing; thereafter the only instruments available are the turn needle and slip ball, ASI, VSI and the Mk 29 altimeter (uncorrected). The engine relight system, the radio and the jettison circuits still operate. The engine RPM and TGT must be controlled within limits manually and only stabilator trimming is available. The gear and flap indicators still operate until the battery fails.

39. Should the battery subsequently fail, all electrical services are lost and fuel cannot transfer from external or internal wing tanks (see Part 1. Chapter 7, **Total Electrics Failure** for details regarding fuel availability). However, if the aircraft can be recovered to an airfield visually, the gear and flap can be lowered on the emergency pneumatic system, and the hook selected down (without confirmatory indications), for an approach-end cable engagement.

## CIRCUIT BREAKERS

### Colour Coding

40. Certain emergency procedures in the FRC call for the tripping of circuit breakers (c/b). Important c/b in the rear cockpit are colour-coded to assist in their rapid identification. The colour-coded c/b are:

a. *No 1 Panel*

| *Location* | *Description* | *Colour* |
|---|---|---|
| 2E | Refuel Probe | Yellow |

b. *No 2 Panel*

| *Location* | *Description* | *Colour* |
|---|---|---|
| 2L | R Booster Pump | Yellow |
| 2G | L Booster Pump | Yellow |
| 2C | L Booster Pump Emerg | Yellow |
| 4C | Rudder Feel Trim | Blue |
| 2T | Arresting Hook Control | Blue |
| 9D | Equipment Cooling | Yellow |
| 6B | Gun/Missile Firing | Red |

## TELELIGHT CAPTIONS

### Description — Front Cockpit

41. A comprehensive warning and status lights indicator system is provided in the front cockpit. The telelight panel is on the right vertical panel; other status or warning lights are elsewhere in the cockpit adjacent to associated switches or systems. A list of these captions and a brief description of their meanings is at Fig 4.

42. A telelight remains lit until its cause is removed or corrected with the exception of the AUTO PILOT DISENGAGE caption which is extinguished by pressing the RESET MASTER CAUTION button. The following captions are coloured red for emphasis:

L IGV MALFUNCTION
R IGV MALFUNCTION
BLC MALFUNCTION
CHECK HYD GAUGES
◆NBC FAN (post-mod 702)◆

### Master Caution Lights

43. A MASTER CAUTION light is fitted to the instrument panels in both cockpits. They operate as amber 'attention-getters' in conjunction with the generator warning panel captions and critical telelights in the front cockpit. The captions on the telelight panel which do not trigger the MASTER CAUTION lights are:

| | |
|---|---|
| SPEED BRAKE OUT | IFF FAIL |
| L EXT FUEL | ACC FAIL (post-mod 607) |
| R EXT FUEL | |
| CTR EXT FUEL | STRIKE CAMERA |
| REFUEL READY | L ANTI ICE ON |
| TANK 7 (pre-mod 677) | R ANTI ICE ON |

Note: The FIRE, OVHT and ENG captions also do not trigger the MASTER CAUTION lights.

44. The MASTER CAUTION captions are extinguished by pressing the RESET MASTER CAUTION button on the generator warning panel; the captions are then available if a further emergency condition occurs. The captions go out automatically when the associated telelight caption extinguishes if the RESET button has not been pressed.

### Warning Lights Test

45. A spring-loaded WARNING LIGHTS—NORMAL/TEST switch is on the COCKPIT LIGHTS panel. Moving the switch to TEST against the spring provides a filament test for all lights in the warning and indicator lights circuit except for the L and R ANTI ICE ON captions. This test does not provide an operational check of the warning systems. The L and R ANTI ICE ON captions may be checked with the engines running by selecting the ENGINE ANTI ICE switch (outboard of the throttles) from NORMAL to DE-ICE.

**WARNING:** Operating the WARNING LIGHTS switch to TEST disturbs the fire warning system integrity; therefore, a test of the warning lights should always be followed by a test of the fire warning system (see Part 1, Chapter 6).

**Rear Cockpit**

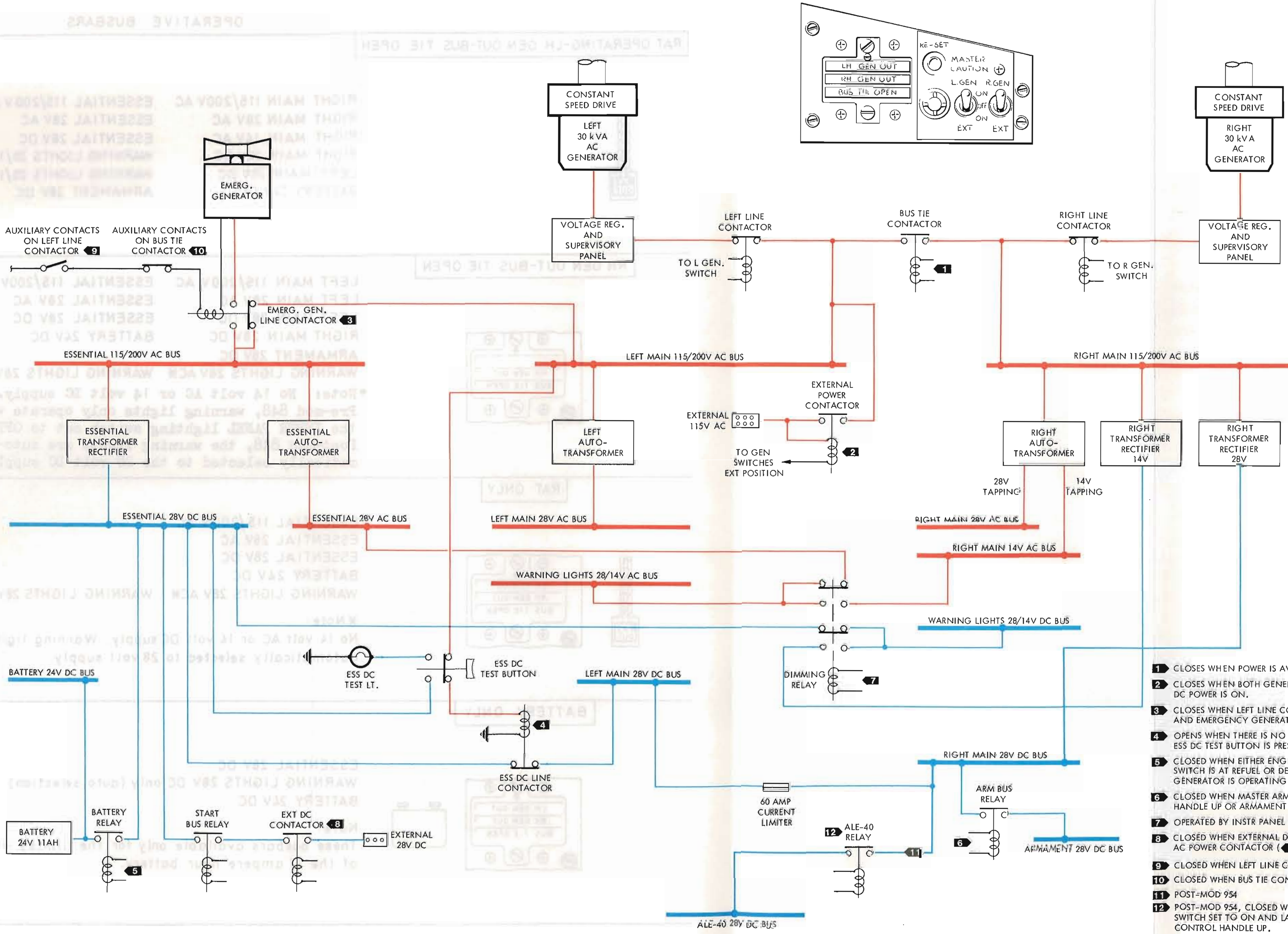
46. The rear cockpit telelight panel provides captions relevant to rear cockpit operation. The main telelight panel is on the right instrument panel; other status or warning lights are elsewhere in the cockpit adjacent to the associated switches or systems. Descriptions of the weapons captions are to be found in the Aircrew Manual, Book 2 (AP-101B-0902-15B). The following captions/light are common to both cockpits:

MASTER CAUTION
INERTIAL NAV SYS OUT
FUEL LEVEL LOW
CANOPY UNLOCKED
RADAR CNI COOL OFF
SEAM LOCK (post-mod 657)
ACC FAIL (post-mod 607)
NBC FAN (post-mod 702)
Low altitude warning light

47. A spring-loaded WARNING LIGHTS — NORMAL/TEST switch is on the COCKPIT LIGHTS panel on the left console. Selecting TEST against the spring checks the filaments of all the rear cockpit captions except the EJECT caption.

**Eject Light**

48. Located in a tube on the left wall of the front cockpit (outboard of the throttles) is a button marked EJECT LT. Pressing the button to its hold-in position brings on the integral light in the button and the EJECT caption in the rear cockpit (at the bottom of the instrument panel). Pressing the button again puts out the integral light and the caption. The rear cockpit caption has a press-to-test function to check the filament. The facility is completely independent of the aircraft electrical system, power being provided by a separate dry cell battery.




## NOTES

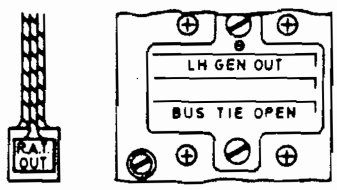
1. CLOSES WHEN POWER IS AVAILABLE TO ONE SIDE BUT NOT THE OTHER.
2. CLOSES WHEN BOTH GENERATOR SWITCHES ARE AT EXT AND NO EXTERNAL DC POWER IS ON.
3. CLOSES WHEN LEFT LINE CONTACTOR AND BUS TIE CONTACTOR ARE OPEN AND EMERGENCY GENERATOR IS GIVING AN OUTPUT.
4. OPENS WHEN THERE IS NO POWER ON LEFT MAIN 115V AC BUS OR WHEN ESS DC TEST BUTTON IS PRESSED.
5. CLOSED WHEN EITHER ENGINE MASTER SWITCH IS ON OR GROUND REFUELLING SWITCH IS AT REFUEL OR DEFUEL POSITION. OPENS WHEN EMERGENCY GENERATOR IS OPERATING.
6. CLOSED WHEN MASTER ARM SWITCH IS AT ARM AND EITHER LANDING GEAR HANDLE UP OR ARMAMENT SAFETY OVERRIDE SWITCH PRESSED.
7. OPERATED BY INSTR PANEL LIGHTING SWITCH.
8. CLOSED WHEN EXTERNAL DC POWER CONNECTED. THIS CAUSES THE EXTERNAL AC POWER CONTACTOR (2) AND BOTH GENERATOR CONTACTORS TO OPEN.
9. CLOSED WHEN LEFT LINE CONTACTOR IS OPEN
10. CLOSED WHEN BUS TIE CONTACTOR IS OPEN
11. POST-MOD 954
12. POST-MOD 954, CLOSED WHEN ALE-40 ENABLE SWITCH SET TO ON AND LANDING GEAR CONTROL HANDLE UP.

PH.6049/1

1-5 Fig 2 Electrical System

OPERATIVE BUSBARS

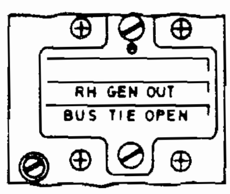
**RAT OPERATING-LH GEN OUT-BUS TIE OPEN**




RIGHT MAIN 115/200V AC
RIGHT MAIN 28V AC
RIGHT MAIN 14V AC
RIGHT MAIN 28V DC
LEFT MAIN 28V DC
BATTERY 24V DC

ESSENTIAL 115/200V AC
ESSENTIAL 28V AC
ESSENTIAL 28V DC
WARNING LIGHTS 28/14V AC
WARNING LIGHTS 28/14V DC
ARMAMENT 28V DC

**RH GEN OUT-BUS TIE OPEN**

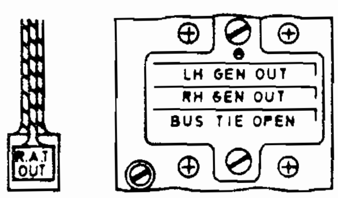



LEFT MAIN 115/200V AC
LEFT MAIN 28V AC
LEFT MAIN 28V DC
RIGHT MAIN 28V DC
ARMAMENT 28V DC
WARNING LIGHTS 28V AC*

ESSENTIAL 115/200V AC
ESSENTIAL 28V AC
ESSENTIAL 28V DC
BATTERY 24V DC
WARNING LIGHTS 28V DC*

*Note: No 14 volt AC or 14 volt DC supply. Pre-mod 848, warning lights only operate with the INSTR PANEL lighting switch set to OFF. Post-mod 848, the warning lights are automatically selected to the 28 volt DC supply.

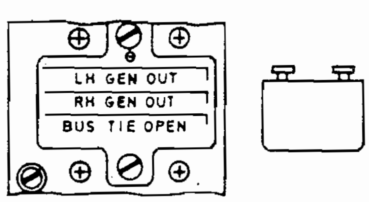
**RAT ONLY**




ESSENTIAL 115/200V AC
ESSENTIAL 28V AC
ESSENTIAL 28V DC
BATTERY 24V DC
WARNING LIGHTS 28V AC*
WARNING LIGHTS 28V DC*

*Note:
No 14 volt AC or 14 volt DC supply. Warning lights automatically selected to 28 volt supply.

**BATTERY ONLY**




ESSENTIAL 28V DC
WARNING LIGHTS 28V DC only (auto selection)
BATTERY 24V DC

Note:
These busbars available only for the limited life of the 11 ampere hour battery.

**1-5 Fig 3 Emergency Power Distribution**

## CAPTIONS ON INSTRUMENT PANELS/CONSOLES

| *Caption* | *Cause* |
|---|---|
| **WHEELS** ... ... ... ... | Flaps down and gear up |
| **ENG** ... ... ... ... ... | Temperature of LP cooling air excessive |
| **FIRE/OVHT** ... ... ... | Fire or overheat condition exists in indicated engine compartment |
| **TK** (missile status panel) ... ... | Centreline tank being carried |
| **ANTI-SKID OFF** ... ... ... | Wheelbrakes anti-skid units inoperative |
| **LH GEN OUT**<br>**RH GEN OUT** ... ... ... | Appropriate generator off-line |
| **BUS TIE OPEN** ... ... ... | Bus tie relay has opened |
| **TELEBRIEF** ... ... ... | External landline connected |

## TELELIGHT PANEL CAPTIONS

| *Caption* | *Cause* |
|---|---|
| **†L IGV MALFUNCTION**<br>**†R IGV MALFUNCTION** | Temperature amplifier has tripped or has lost electrical power |
| **L ENG OIL PRESS LOW**<br>**R ENG OIL PRESS LOW** | Low oil pressure in indicated engine oil system |
| **L ENG BLEED**<br>**R ENG BLEED** | 7th or 12th stage bleed malfunction or ISOLATE selected with flaps fully down |
| **CHECK FUEL FILTERS** ... | One or both fuel filters are partially clogged |
| **ENG BLEED OVERPRESS** | Bleed air pressure exceeds 242±12 PSI |
| **†BLC MALFUNCTION** ... | Flaps are up and at least one BLC valve is stuck open.<br>Flaps are ½ down and trailing edge BLC valve is open |
| **STRIKE CAMERA** ... ... | Stalled drive motor<br>Broken film<br>Exhausted film supply<br>Camera power supply failure |
| **FUEL LEVEL LOW** ... ... | 1800±200 lb total fuel remaining in cells 1 and 2 |
| **ENG INLET TEMP HIGH** | Total temperature output signal from CADC is above allowable temperature (122°C) limit for steady state engine operation |
| **PITCH AUG OFF** ... ... | Pitch stability augmentation is disengaged |
| **L AUX AIR DOOR**<br>**R AUX AIR DOOR** | Engine compartment pressure high<br>Doors out of phase with airspeed switch<br>Engine inlet control switch in OVERRIDE position<br>Aux air door switch in EMERG OPEN position |
| **STATIC CORR OFF** ... ... | CADC malfunction |
| **L ANTI-ICE ON**<br>**R ANTI-ICE ON** | Switch on — normal indication<br>Switch off — system fault |
| **INERTIAL NAV SYS OUT** | INAS malfunction |
| **OXYGEN LOW** ... ... ... | Supply depleted to 1 litre |
| **IFF FAIL** ... ... ... ... | IFF system malfunction |
| **ACC FAIL (post-mod 607)** ... | ACC unit failure, code erasure or starvation, ACC battery failure, removal/ejection of either ejection seat |
| **IFR PROBE UNLOCKED** | Normal indication with probe extended<br>Probe is not fully retracted |
| **AUTO PILOT PITCH TRIM** | Automatic pitch trim is not functioning with AFCS engaged |
| **L EXT FUEL**<br>**R EXT FUEL**<br>**CTR EXT FUEL** | Fuel flow has stopped<br>Tank is full (during AAR) |
| **RADAR CNI COOL OFF** | Equipment cooling turbine has shut-down |
| **AUTO PILOT DISENGAGE** | Autopilot has disengaged |
| **L WING PIN UNLOCKED**<br>**R WING PIN UNLOCKED** | Wing(s) unlocked (Blocks 31 to 34) |
| **REFUEL READY** ... ... ... | Fuselage pressurisation and vacuum relief valve open |
| **†CHECK HYD GAUGES** | Pressure below 1500±100 PSI in any system<br>A Utility pump has failed |
| **W'SHIELD TEMP HIGH** ... | Windshield is overheated |
| **SPEED BRAKE OUT** ... ... | Either or both speedbrakes are not closed |
| **CABIN TURB OVERSPEED** | Turbine subjected to extreme pressure and/or temperature |
| **CANOPY UNLOCKED** ... ... | Front, rear or both canopies are unlocked |
| ◆ † **NBC FAN (Post-mod 702)** ... ... ... | Pilot's NBC blower motor failed |
| **NBC FAN (Post-mod 702)** ... ... ... | Navigator's NBC blower motor failed ◆ |

†Red captions

**1—5 Fig 4 Warning Indicator Lights Analysis**

*Intentionally Blank*

Table 1 — Essential 115/200 volt AC Bus Services

| *Services* | *Circuit Breakers* *Annotation* | *Panel* | *Location* |
|---|---|---|---|
| ADI | ADI | 1 | C7 |
| Rear cockpit instrument and console lights | AFT CKPT INST & CSL LIGHT | 2 | P3 |
| ADI<br>RAI<br>Turn needle<br>Magnetic heading | AJB7<br>AJB7<br>AJB7 | 1<br>1<br>1 | D7<br>D8<br>D4 |
| Air data computer | CADC<br>CADC<br>CADC | 1<br>1<br>1 | E7<br>E6<br>E4 |
| ADI steering bars<br>V/UHF radio<br>IFF | CNI<br>CNI<br>CNI | 1<br>1<br>1 | B7<br>B8<br>C4 |
| Essential 28 volt AC Bus | ESSENTIAL AUTO XFMR | 2 | E8 |
| FIRE & OVHT detection | FIRE DETECTOR | 2 | B1 |
| Fuel gauge | FUEL QUANTITY | 2 | A3 |
| Front cockpit instrument panel lights | FWD CKPT INST LT XFMR | 2 | L3 |
| Left engine control amp | LEFT ENGINE CONTROL | 2 | C1 |
| Right engine control amp | RIGHT ENGINE CONTROL | 2 | D1 |
| Essential 28 volt DC Bus | LH ESSENTIAL XFMR RECT<br>LH ESSENTIAL XFMR RECT<br>LH ESSENTIAL XFMR RECT | 2<br>2<br>2 | D8<br>C8<br>B8 |
| Left fuel booster pump (low speed) | LH BOOST PUMP EMERGENCY<br>LH BOOST PUMP EMERGENCY<br>LH BOOST PUMP EMERGENCY | 2<br>2<br>2 | D2<br>E2<br>F2 |
| Windshield temperature sensor | WSHLD TEMP SENSOR | 1 | F7 |

**Table 2 — Essential 28 volt AC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Rear cockpit floods (BRT) | AFT CKPT FLOOD LT BRIGHT | 2 | N3 |
| Turn needle | AJB 7 | 1 | D5 |
| BIT programmer<br>Air data computer | CADC | 1 | E5 |
| Radar scope lights | RADAR SCOPE LIGHTS | 1 | F4 |
| ADI (PRIM)<br>V/UHF antenna switching<br>TACAN<br>BDHI No 1 & 2 needles<br>HSI deviation bar | CNI | 1 | C5 |
| Front cockpit red console floods (bright) | FWD CKPT RED CSL FLOOD LT | 2 | M3 |
| PC 1 gauge | HYD PRESS IND No 1 | 2 | F4 |
| PC 2 gauge | HYD PRESS IND No 2 | 2 | G4 |
| Utility hyd press guage | HYD PRESS UTILITY INDICATOR | 2 | U2 |
| Pneumatic press gauge | PNEUMATIC PRESSURE INDICATOR | 2 | E4 |
| Fire overheat test relays ◆ (Post-SEM/065/STC) | FIRE & OVERHEAT CONTROL | 2 | B2 ◆ |

**Table 3 — Left Main 115/200 volt AC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| AOA case and probe heater | — | Nosewheel | 13B |
| ARI | — | Nosewheel | 11F |
| Autopilot control stick steering | AUTO PILOT<br>AUTO PILOT<br>AUTO PILOT | 1<br>1<br>1 | A4<br>A8<br>A7 |
| Bellmouth pitot heater | BELLMOUTH PITOT HEATER | 2 | V1 |

*(continued)*

**Table 3** — *continued*

| *Services* | *Annotation* | *Circuit Breakers* Panel | Location |
|---|---|---|---|
| TACAN range readouts<br>Comms/ADF relays | CNI | 1 | B4 |
| INAS power | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 2E<br>4E<br>6E |
| INAS | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 8E<br>10E<br>12E |
| Left engine ramp control | RAMP CONTROL L ENGINE | 2 | U1 |
| Right engine ramp control | RAMP CONTROL R ENGINE | 2 | T1 |
| Left main 28 volt AC Bus | — | Nosewheel | 10G |
| Left fuel booster pump | LH FUEL BOOST PUMP<br>LH FUEL BOOST PUMP<br>LH FUEL BOOST PUMP | 2<br>2<br>2 | H2<br>J2<br>K2 |
| Nosewheel steering | — | Nosewheel | 19B |
| LCOSS | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 4G<br>6G<br>8G |
| Radar power (pre-mod 402)<br>Radar power (post-mod 402) | RADAR PWR<br>RADAR PWR | FCP utility panel<br>FCP No 3 | A1<br>F4 |
| Radar scope camera<br>IFR probe light (post-mod 378) | RADAR SCOPE CAMERA | 2 | X2 |
| Ejection seat pan raising/lowering | — | Nosewheel | 13D |
| Utility receptacle | — | Nosewheel | 11D |
| Airborne interrogator<br>Azimuth processor | AIR-TO-AIR IFF | 3 | B2 |

**Table 4 — Right Main 115/200 volt AC Bus Services**

| | | *Circuit Breakers* | |
|---|---|---|---|
| *Services* | *Annotation* | *Panel* | *Location* |
| Aileron feel trim | AIL FEEL TRIM | FCP right console | D2 |
| ASI pitot heater | AIRSPEED PITOT HEATER | 2 | W1 |
| Altimeter vibrator (pre-mod 4) | — | Nosewheel | 5F |
| Height encoding altimeter (post-mod 4) | — | FCP No 3 | — |
| Anti-skid | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 14A<br>16A<br>18A |
| AN/AWW-1 bomb fuzing | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 10A<br>9B<br>10C |
| Cockpit temp control panel power | COCKPIT HEAT & VENT | 2 | X1 |
| Equipment cooling temp control unit | EQUIPMENT COOLING | 2 | E9 |
| Fuel flow indicators | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 21D<br>22C<br>23D |
| Front cockpit console lights | FORWARD CONSOLE LT XFMR | 2 | R2 |
| Gun pod power | GUN POWER<br>GUN POWER<br>GUN POWER | 2<br>2<br>2 | B7<br>C7<br>D7 |
| HF radio | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 17H<br>19H<br>21H |
| IFR probe light (pre-mod 378) | INFLIGHT REFUEL PROBE LT | 2 | Q2 |
| Left radar missiles | —<br>—<br>— | Nosewheel<br>Nosewheel<br>Nosewheel | 2A<br>1B<br>2C |

*(continued)*

**Table 4** - *continued*

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Right radar missiles | - | Nosewheel | 4A |
| | - | Nosewheel | 3B |
| | - | Nosewheel | 4C |
| No 4 fuel trans pump | NO 4 FUEL TRANS PUMP | 1 | B1 |
| | NO 4 FUEL TRANS PUMP | 1 | C1 |
| | NO 4 FUEL TRANS PUMP | 1 | D1 |
| No 6 fuel trans pump | NO 6 FUEL TRANS PUMP | 1 | B2 |
| | NO 6 FUEL TRANS PUMP | 1 | C2 |
| | NO 6 FUEL TRANS PUMP | 1 | D2 |
| Oxygen gauge | - | Nosewheel | 7F |
| Passive warning receiver ◆◆ | - | FCP No 3 | C1 |
| Radio altimeter | - | Nosewheel | 3F |
| Right main 28V AC bus<br>Right main 14V AC bus | - | Nosewheel | 12G |
| Right fuel booster pump | RH FUEL BOOST PUMP | 2 | M2 |
| | RH FUEL BOOST PUMP | 2 | N2 |
| | RH FUEL BOOST PUMP | 2 | P2 |
| Right main 28V DC bus | - | Nosewheel | 18G |
| Warning lights 28/14V DC bus | - | Nosewheel | 14G |
| (14 volt supply) | - | Nosewheel | 16G |
| Sidewinder | - | Nosewheel | 6A |
| | - | Nosewheel | 8A |
| | - | Nosewheel | 5B |
| | - | Nosewheel | 7B |
| | - | Nosewheel | 6C |
| | - | Nosewheel | 8C |
| BAI (post-mod 378) | - | 2 | Q2 |
| Strike camera | - | Nosewheel | 11H |
| | - | Nosewheel | 13H |
| | - | Nosewheel | 15H |

**Table 5 - Left Main 28 Volt AC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| One anti-collision light | ANTI-COLLISION LIGHTS | 2 | Y2 |
| ARI | - | Nosewheel | 9F |
| Compass adapter compensator<br>INAS rack | AUTO PILOT | 1 | A6 |
| White floodlights<br>Wing and tail lights (bright) | WHITE FLOOD LIGHTS<br>WING & TAIL LIGHTS BRIGHT | 2<br>2 | W3<br>U3 |

**Table 6 - Right Main 28 Volt AC Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Booster pumps gauge | FUEL PRESS INDICATOR | 1 | E1 |
| Aileron position indicator<br>Rudder position indicator | AILERON POS IND<br>RUDDER POSITION INDICATOR | 1<br>2 | F5<br>D4 |
| Taxy light | TAXI LIGHT | 2 | V3 |
| Fuselage and one anti-collision light | - | Nosewheel | 19F |

**Table 7 - Right Main 14 Volt AC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Front cockpit red<br>console flood lights (dim) | FWD CKPT RED CSL FLOOD LT | 2 | S3 |
| Front cockpit red<br>instrument flood lights (dim) | FWD CKPT RED INST FLOOD LT | 2 | R3 |
| Rear cockpit flood<br>lights (dim) | AFT CKPT FLOOD LT DIM | 2 | Q3 |
| Wing and tail lights (dim) | WING & TAIL LIGHTS DIM | 2 | T3 |

**Table 8 - Essential 28 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Trim control | TRIM CONT | FCP right console | D2 |
| Stabilator feel trim | STAB FEEL TRIM | FCP right console | A2 |
| Fuel transfer pressure relay | MAIN FUEL CONT | 1 | A3 |
| Refuel probe normal | REFUEL PROBE | 1 | E2 |
| Refuel probe emerg extend | REFUEL PROBE EMER EXT | 1 | F1 |
| Internal wing fuel transfer control | INT WING FUEL CONT | 1 | F3 |
| External wing fuel transfer control | EXTERNAL FUEL CONT | 1 | E3 |
| Fuel valve power | FUEL VALVE POWER | 1 | D3 |
| Left engine fuel shut-off | L ENGINE FUEL SOV | 1 | C3 |
| Right engine fuel shut-off | R ENGINE FUEL SOV | 1 | B3 |
| Gear and flap indicators | LG & FLAP POS IND | 1 | F6 |
| Turn needle<br>RAI power fail flag | AJB-7 | 1 | D5 |
| NAV & COMM CMD control<br>Transit key function<br>Standby radio<br>V/UHF radio | CNI | 1 | B6 |
| Intercom | INTERCOM | 1 | C6 |
| Air data computer | CADC | 1 | E6 |
| Left engine ignition | IGNITION L ENGINE | 2 | G1 |
| Right engine ignition | IGNITION R ENGINE | 2 | H1 |
| Nozzle position indicators<br>LP RPM indicators | NOZZLE POSITION INDICATOR | 2 | M1 |
| Left engine bleed control | L ENGINE BLEED CONTROL | 2 | E1 |
| Right engine bleed control | R ENGINE BLEED CONTROL | 2 | F1 |
| Engine start circuits | ENGINE START | 2 | J1 |
| Left booster pump emerg control | LH BOOST PUMP EMERGENCY | 2 | C2 |
| FUEL LEVEL LOW caption | FUEL LOW WARN LT | 2 | B3 |
| Rudder feel trim<br>Flap blow-up relay | RUDDER FEEL TRIM | 2 | C4 |
| Front cockpit inst panel floods (bright) | FWD CKPT RED INST FLOOD LT | 2 | K3 |

*continued*

**Table 8** - *continued*

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Master caution reset | MASTER CAUTION LT RESET | 2 | J3 |
| Pneumatic system control | PNEUMATIC SYSTEM CONTROL | 2 | B4 |
| Special weapon select relay<br>Special weapon release<br>Jettison relays | STORES<br>EMERGENCY<br>JETTISON | 2 | E5 |
| Special weapon power relay | CENTRE STORES POWER | 2 | D10 |
| Special weapon control panel | CENTRE STORES POWER | 2 | B10 |
| Outboard jettison secondary | OUTBD JETTISON SECONDARY | 2 | D5 |
| Aux air door emerg | AUXILIARY AIR DOOR EMERGENCY | 2 | K1 |
| Radar missile jettison | RADAR MISSILE JETTISON | 2 | C5 |
| ACC control and display | AIR-TO-AIR IFF | 3 | C2 |
| Nav's NBC power/warning ◆◆ | NBC WARNING OBSVR | 3 | G3 |
| Pilot's NBC power/warning ◆◆ | NBC WARNING PILOT | 3 | H3 |

**Table 9 - Left Main 28 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| ARI 10° servo actuator shut-off valve | ARI | FCP left console | B1 |
| Autopilot control amp | AUTO PILOT | 1 | A5 |
| TACAN | CNI | 1 | B5 |
| Left fuel booster pump normal control | LH FUEL BOOST PUMP | 2 | G2 |
| Rain removal control | RAIN REMOVAL | 2 | V2 |
| Outboard jettison primary | OUTBD JETTISON PRIMARY | 2 | E7 |
| Radar scope camera | RADAR SCOPE CAMERA | 2 | W2 |
| Stabilator trim indicator | - | Nosewheel | 13F |
| Wing fold control (Blk 31 to 34) | - | Nosewheel | 17F |
| Static accel | - | Nosewheel | 15F |
| ARI/ANTI-SKID | - | Nosewheel | 22A |
| LCOSS | - | Nosewheel | 2G |
| Radar | ◆◆ AWG-12 | FCP No 3 | C3 |
| Airborne interrogator Azimuth processor | AIR-TO-AIR IFF | 3 | A2 |

**Table 10 - Right Main 28 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Landing gear control | LG | FCP right console | C1 |
| Flaps control | FLAPS | FCP right console | A1 |
| Airbrakes control | SPEED BRAKE | FCP right console | B1 |
| Rudder trim control | RUD TRIM | FCP right console | C2 |
| Wing dump | INT WING FUEL DUMP | 1 | F2 |
| No 4 fuel transfer relay<br>No 5 fuel tank sensor | NO 4 FUEL TRANS PUMP | 1 | A1 |
| No 6 fuel transfer pump relay | NO 6 FUEL TRANS PUMP | 1 | A2 |
| Armament safety override | ARM BUS CONTROL | 2 | F5 |
| Right fuel booster pump control | RH FUEL BOOST PUMP | 2 | L2 |
| Fire and overheat test relays (pre-SEM/065/STC) | FIRE & OVERHEAT CONTROL | 2 | B2 |
| FIRE, OVHT & ENG lights test | WARNING LIGHT CONTROL | 2 | S2 |
| Hook control | ARRESTING HOOK CONTROL | 2 | T2 |
| AOA indexer lights (pre-mod 723) | INDEXER LT POWER | 2 | Y3 |
| Oxygen flow indicator | OXYGEN FLOW | 2 | L1 |
| BRSL control | BRSL CONT | 2 | D11 |
| Air vent suit mixing valve<br>Cabin temp mixing valve<br>Nosewheel steering | COCKPIT HEAT & VENT | 2 | Y1 |
| Special weapon control panel | CENTRE STORES POWER | 2 | C10 |
| Left engine anti-ice control | LEFT ENGINE ANTI-ICE | 2 | N1 |
| Right engine anti-ice control | RIGHT ENGINE ANTI-ICE | 2 | P1 |
| Equipment cooling turbine | EQUIPMENT COOLING | 2 | D9 |

*continued*

**Table 10** - *continued*

| *Services* | *Annotation* | *Circuit Breakers* *Panel* | *Location* |
|---|---|---|---|
| Left engine aux air control<br>Left variable duct solenoid | L ENGINE AUX<br>AIR CONTROL | 2 | R1 |
| Right engine aux air control<br>Right variable duct solenoid | R ENGINE AUX<br>AIR CONTROL | 2 | R1 |
| Both ramp override solenoids<br>Aux air door relay | AIR INDUCTION CONTROL | 2 | Q1 |
| Sidewinder | SIDEWINDER<br>SIDEWINDER | 2<br>2 | B9<br>C9 |
| Utility receptacle | - | Nosewheel | 9D |
| Turn and slip indicator<br>(Blk 31 to 33) | - | Nosewheel | 20D |
| External light control | - | Nosewheel | 20C |
| AOA probe heater control | - | Nosewheel | 15B |
| Nosewheel steering<br>◆Primary weapons◆ | - | Nosewheel | 17B |
| Gun and missile select | - | Nosewheel | 12A |
| Radar altimeter | - | Nosewheel | 1F |
| Bomb and rocket release control | - | Nosewheel | 12C |
| Weapon power | - | Nosewheel | 11B |
| INAS heater | -<br>- | Nosewheel<br>Nosewheel | 14E<br>16E |
| INAS mode select | - | Nosewheel | 18E |
| Height encoding altimeter | - | FCP No 3 | B1 |
| Passive warning receiver<br>(post-mod 404 or 429) | - | FCP No 3 | D1 |
| ILS power (post-mod 402) | ILS | FCP No 3 | E1 |

**Table 11 - Armament 28 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* Panel | *Circuit Breakers* Location |
|---|---|---|---|
| Special weapon release<br>Stores release dual timer | STORES RELEASE CONTROL | 2 | E6 |
| Gun and missile firing | GUN & MISSILE FIRING | 2 | B6 |
| Bomb/rocket intervalometer | BOMB & RKT REL POWER | 2 | C6 |
| AN/ALE 40 chaff/flare dispenser<br>◆ (post-mod 855, pre-mod 954) | LEPUS FLARE PWR & CONT | 2 | F6 |
| AN/ALE 40 chaff/flare dispenser<br>(pre-mod 954) | AN/ALE 40 28V DC PWR<br>AN/ALE 40 28V DC PWR | 2<br>2 | C12<br>B12 ◆ |

**Table 12 - Warning Lights 28/14 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* Panel | *Circuit Breakers* Location |
|---|---|---|---|
| ENG BLEED captions | ENG BLEED WARN LT | 2 | E3 |
| Various front cockpit warning lights | FORWARD COCKPIT WARN LT | 2 | G3 |
| Various rear cockpit warning lights | AFT CKPT WARN LT | 2 | H3 |
| OXYGEN LOW caption<br>AUX AIR DOOR captions<br>CANOPY UNLOCKED caption | OXYGEN LOW WARN LT<br>AUX AIR DOORS CAUTION LT<br>- | 2<br>2<br>Nosewheel | D3<br>F3<br>21B |
| AOA indexer lights<br>(post-mod 723) | INDEXER LT PWR | 2 | Y3 |

**Table 13 - Battery 24 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* Panel | *Circuit Breakers* Location |
|---|---|---|---|
| Wander lights | UTILITY FLOOD LIGHTS | 2 | X3 |
| INAS emergency power | INAS EMERGENCY POWER | 2 | G5 |

◆ **Table 14 - AN/ALE 40 28 Volt DC Bus Services**

| *Services* | *Annotation* | *Circuit Breakers* Panel | *Circuit Breakers* Location |
|---|---|---|---|
| Lepus flare power and control AN/ALE 40 | LEPUS FLARE PWR & CONT | 2 | F6 |
| AN/ALE 40 Chaff flare dispenser | AN/ALE 40 28V DC PWR<br>AN/ALE 40 28V DC PWR | 2<br>2 | C12<br>B12 ◆ |

# PART 1

# CHAPTER 6 - ENGINES

## Contents



**General Description**

1. The aircraft is powered by two Spey 202 engines. At military power each engine develops a nominal thrust of 12,250 pounds and with full reheat the total nominal thrust is 20,515 pounds. The engine is an axial flow, by-pass turbofan engine incorporating two compressors driven by separate turbines through coaxial shafts. The air delivered by the low pressure compressor is divided into two paths, one passing through the high pressure compressor, and the other ducted around the engine to re-enter the main airflow in the exhaust mixer. This arrangement results in improved specific fuel consumption and overall engine efficiency, coupled with lower jet pipe temperatures.

2. The compressors consist of a 5-stage low pressure compressor and a 12-stage high pressure compressor. Each compressor is coupled to its respective turbine assembly by a shaft, with the low pressure compressor shaft rotating inside the high pressure shaft. The HP shaft drives most of the ancillary units necessary for the operation of the engine; the only drives taken from the LP shaft are those for the LP RPM tachometer and the LP governor. The high pressure compressor is provided with variable inlet guide vanes (IGV) and a bleed valve at the 7th stage to ensure smooth operation at all RPM.

3. Two manifolds, one around the 7th stage of the high pressure compressor (bleed valve manifold) and the other around the 12th stage of the high pressure compressor (diffuser case manifold) supply air to the boundary layer control, air conditioning, rain removal, fuel tank pressurisation, and pneumatic systems. The diffuser case manifold also supplies hot air for anti-icing purposes.

4. The combustion section is of the tubo-annular type and contains ten inter-connected liners. Each liner has a fuel spray nozzle mounted in its head. Two of the liners, numbers four and eight, contain igniter plugs.

5. The turbine section consists of a nozzle case, a 2-stage high pressure turbine, a 2-stage low pressure turbine, nozzle guide vanes (NGV) and an exhaust mixer. The exhaust mixer removes the swirl from the gas stream before it enters the exhaust collector and nozzle. This ensures an efficient mixing of the by-pass air with the hot gas from the turbines.

◆6. Fuel is supplied from the aircraft fuel system to an engine-driven LP fuel pump which feeds two separate fuel systems: the main fuel system and the reheat fuel ◆ system. The two systems are independent except that the main fuel system supplies the servo pressure for initiating operation of reheat and also provides the LP supply to the reheat fuel pump.

7. The engine has four independent associated oil systems which are the engine lubrication system, the reheat nozzle control system, the constant speed drive system and the starter oil system.

**Engine Air Induction and Controls**

8. Each engine has two independent air induction systems. The primary system consists of the fixed and variable duct ramps and variable inlet guide vanes (IGV) and the secondary system consists of the auxiliary air doors and variable by-pass valve.

9. *Variable Duct Ramps.* The variable duct ramps provide primary air at optimum subsonic airflow to the compressor face throughout the range of aircraft speeds. The ramp assembly consists of a fixed forward ramp with a ramp angle of 10° and two variable ramps with a travel of 0° to 16° relative to the fixed forward ramp. The forward variable ramp is perforated to allow boundary layer air to be bled off and exhausted overboard. The aft ramp moves as a function of free stream total temperature and positions the forward variable ramp through a system of mechanical linkage.

10. *ENG INLET CONTROL Switch (NORM Position).* Operation of the variable ramps is controlled by the ENG INLET CONTROL switch on the auxiliary armament control panel. This is a 3-position switch, OVERRIDE/RAMP RETRACT/NORM. In the NORM position the aft variable ramp receives signals from the CADC and positions the ramps for optimum engine operation. The variable ramps must be in their retracted or zero degree position (open) for all take-offs or landings. This is normally accomplished through an airspeed switch which opens the ramp circuit at 195 ±5 KCAS while decelerating and closes it approximately 15 knots above this airspeed while accelerating.

11. *ENG INLET CONTROL Switch (OVERRIDE and RAMP RETRACT Positions).* The OVERRIDE position is used to counteract an airspeed switch failure by breaking the electrical circuit to the ramp, by-pass valve, and auxiliary air door solenoid. The RAMP RETRACT position is used to counteract an electronic failure in the CADC by de-energising the ramp servo solenoid valve. This position is selected whenever it is desired to retract the ramps without opening the auxiliary air doors and by-pass valve. This allows stall-free engine operation at subsonic speeds.

12. *ENG INLET TEMP HIGH Indicator Light.* The ENG INLET TEMP HIGH caption is on the telelight panel. The caption comes on when the total temperature output signal from the CADC is beyond allowable temperature limits for steady state engine operation. The light also comes on during sub-sonic and ground operation if a CADC failure occurs. The maximum steady state operation of the engine is limited to 122°C (equivalent to 2.0M at 36,000 feet in ISA conditions) and if exceeded, affects the creep life of the HP compressor components.

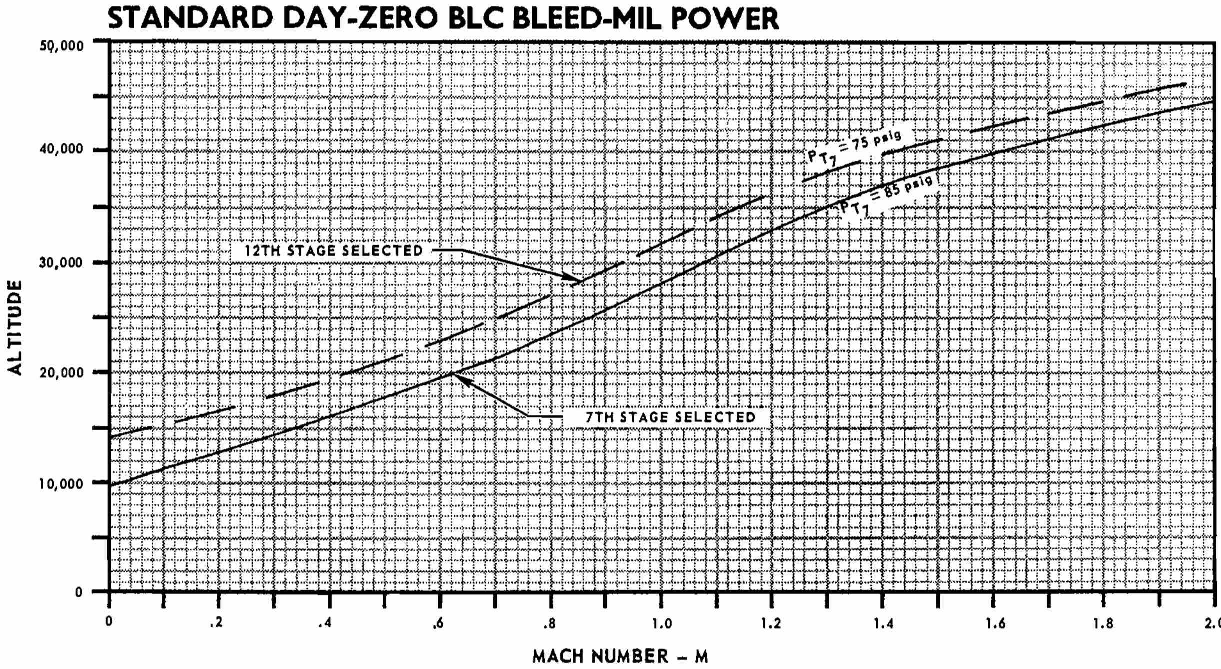
**WARNING:** If the ENG INLET TEMP HIGH caption comes on prior to take-off, abort the flight because faulty CADC output signals may cause incorrect scheduling of the ramps after take-off (when above the airspeed switch speed).

13. *Variable By-pass Valve.* The variable by-pass valve is an automatic unit which allows additional air to be drawn into the engine during low speed flight or ground operation, and for excess air to be bled off into the engine bay during high speed flight. The unit is essentially a large rotary valve between the inlet duct and the engine compressor inlet. The position of the by-pass valve is controlled by an airspeed switch. The switch opens the valve at 195 ±5 KCAS during deceleration and closes it at approximately 15 knots above this airspeed during acceleration. Air drawn through the open auxiliary air door passes through the by-pass valve to the engine. At speeds above 210 KCAS the valve is positioned as a function of Mach number signals from the CADC and inlet pressures to the by-pass controller by utility hydraulic pressure. Since it is essential that the valve is open during low speed flight, a spring opening device is provided to cater for utility hydraulic or electrical failure.

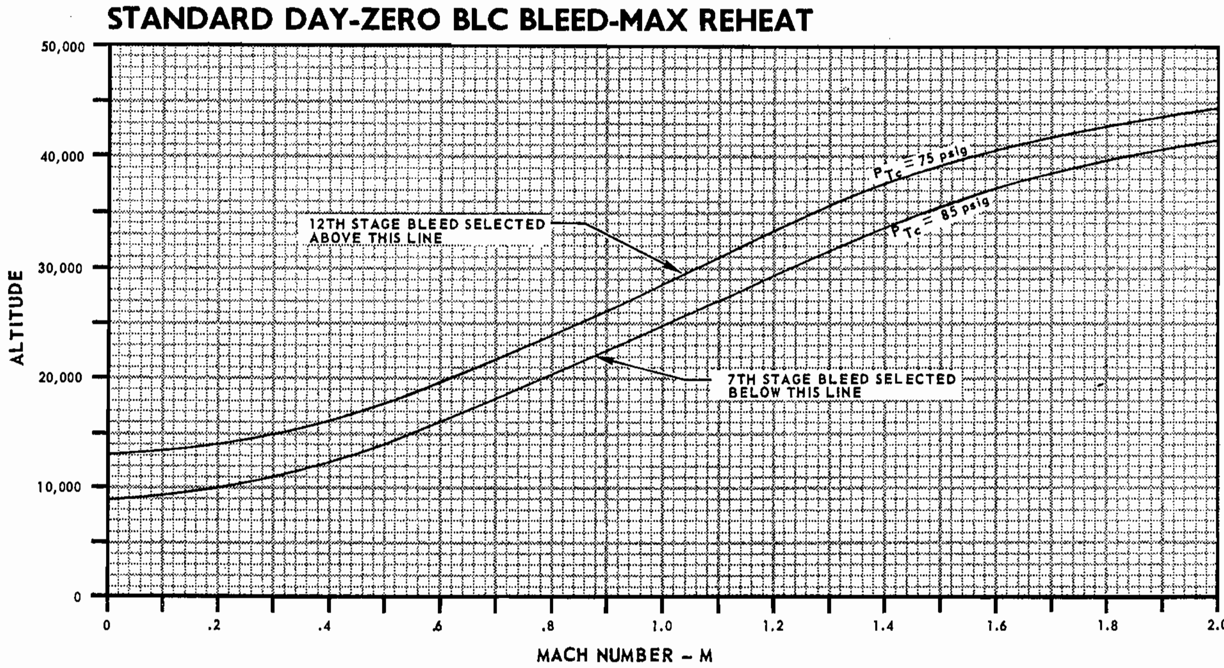
14. *Auxiliary Air Doors.* Each engine is provided with two auxiliary air doors. The doors located on the bottom of the aircraft are the forward auxiliary doors and the doors located on the side of the aircraft are the aft auxiliary doors or ejector doors. Each door is operated by individual hydraulic actuators. These doors normally open at speeds below 210 KCAS and close above 210 KCAS. The doors also open momentarily to bleed off engine compartment pressure over 10 PSI.

15. *Auxiliary Air Door Indicator Lights.* The auxiliary air door captions on the telelight panel, L AUX AIR DOOR and R AUX AIR DOOR, come on if the auxiliary air doors open above 210 KCAS or are closed below 195 KCAS. The captions also come on momentarily when engine compartment overpressure is relieved. The MASTER CAUTION caption comes on at the same time as the L and R AUX AIR DOOR captions. Post-mod 74 the captions come on if the doors are open above 240 KCAS or closed below 170 KCAS.

## STANDARD DAY-ZERO BLC BLEED-MIL POWER




## STANDARD DAY-ZERO BLC BLEED-MAX REHEAT




**1—6 Fig 1 Bleed Air Stage Selection**

16. *Auxiliary Air Door Switch.* A 2-position AUX AIR DOORS—NORM/EMERG OPEN switch is on the left console, front cockpit. After a utility hydraulic failure, EMERG OPEN is selected prior to landing to open the doors pneumatically. If the doors fail to open below 170 KCAS when utility pressure is available, first select the ENG INLET CONTROL switch to OVERRIDE; if the caption remains on, the AUX AIR DOORS switch is then selected to EMERG OPEN to open the doors pneumatically.

**WARNING:** If, when utility pressure is available the AUX AIR DOORS switch is selected from EMERG OPEN back to NORM, a utility failure may be induced.

**Variable Inlet Guide Vane System**

17. The high pressure compressor is designed to give a high compression ratio with optimum efficiency in the high RPM range in which the engine normally operates and each stage of the compressor is matched to the airflow characteristics in that range. When the engine is operated in the lower speed range, however, the change in the airflow characteristics causes the air to approach the compressor rotor blades at an unsuitable angle. This tends to cause two detrimental effects: stalling of the front stages and choking of the rear stages of the compressor with resultant high blade stresses and the possibility of compressor surge. Stalling is prevented by using variable angle inlet guide vanes (IGV) to correct the approach angle of the airflow to the first stage rotor blades. The inlet guide vanes are positioned by a guide vane hydraulic ram; the ram movement is controlled by an IGV governor. With the engine stationary, the vanes are positioned closed (40°); as engine speed increases the vanes position toward the open position (0°). Therefore, the airflow approaches the compressor rotor blades at a suitable angle and gives a high compression ratio with optimum efficiency in the high RPM range.

18. *Engine Temperature Control Amplifier.* The function of the engine amplifier is to transmit electrical signals to the IGV (and bleed valve control) governor and the fuel flow regulator. These signals modify the output of the IGV governor for variations in engine inlet total temperature and control the fuel flow from the fuel flow regulator to keep TGT within limits.

19. L and R IGV MALFUNCTION captions on the telelight panel come on if a malfunction occurs in the associated engine amplifier. A malfunction results in a reduction in engine handling capability (reduced surge margin) or a loss of thrust. When a caption comes on it should be assumed that both have occurred and the associated throttle handled with care; set and leave 80% RPM on the engine if practicable. In the worst case there could be a thrust loss of approximately 30%. An IGV MALFUNCTION caption can also indicate a loss of automatic TGT control, therefore the TGT must be monitored carefully and kept manually within limits. With a caption on, the IGV continue to operate, but the scheduling may be incorrect since the engine amplifier supplies temperature information. Apart from engine surge, there is no cockpit indication of mechanical failure of the IGV.

**Compressor 7th Stage Air Bleed Valves**

20. To prevent choking of the rear stages during starting and low speed operation, each engine has a compressor bleed valve installed in the air manifold surrounding the HP compressor 7th stage and positioned by the IGV governor. During starting and low speed operation the valve is open, exhausting excess 7th stage air into the bypass duct. As engine speed increases, the valve progressively closes reaching the fully closed position midway through the IGV range.

**Compressor Bleed Air Extraction System**

21. To supply the cabin heat exchanger unit, the equipment heat exchanger unit, the boundary layer control system, windscreen rain removal, anti-icing, pneumatic system and fuel tank pressurisation, air is bled from the 7th or 12th stage of the HP compressor. Selection is automatic or manual and depends on the position of the 12th stage solenoid valve. This valve is controlled either by the trailing edge flap limit swtches, the 7th stage pressure switch, or the NORMAL 12TH STAGE/ISOLATE switch.

22. In normal flight, ie with NORMAL 12TH STAGE selected, bleed air is ducted from the 7th stage unless the pressure drops below 75 PSI, when the 12th stage solenoid valve opens. 7th stage air is restored when the 7th stage pressure exceeds 85 PSI. With full flap and NORMAL 12TH STAGE selected, the 12th stage solenoid opens to give a high rate of flow to the BLC which permits a lower 'on speed' for landing. With ISOLATE and full flap selected, or when the flaps are in the ½ position, the 12th stage solenoid is held closed to give a higher maximum engine thrust, a reduced rate of flow to the BLC and a slightly higher landing speed (see Part 3, Chapter 3, **Use of 7th Stage Bleed/Full Flap Configuration).**

Note: In normal flight, with the flaps up and ISOLATE selected, 12th stage bleed is not available to the bleed air services via the 75 PSI switch.

23. When transfer from one bleed source to another occurs, a slight increase or decrease in thrust and a pulsing of the cockpit pressurisation are noticeable. With NORMAL 12TH STAGE selected, incorrect operation of the 12th stage solenoid valve in the ½ or full flap configurations is shown by the L and R ENGINE BLEED captions on the tele-

light panel. The captions come on when the valve is open with the flaps at ½, or closed with the flaps fully down. Momentary illumination of the captions during flap travel is acceptable. It is normal for the captions to come on when ISOLATE is selected and the flaps are fully down.

**Engine Fuel Control System**

24. An integral fuel control system is fitted to each engine to ensure correct fuel combustion in all engine operating conditions. The reheat fuel control system is described separately.

25. *Throttles*. The thrust output of each engine is controlled by a throttle lever on the left console of the forward cockpit. Each throttle is mechanically connected to the fuel flow regulator, the high pressure shut–off valve, and the reheat fuel control unit of its associated engine through the cam box. Advancing the throttle from the OFF to IDLE electrically opens the mains fuel shut–off valve, mechanically opens the high pressure shut–off valve, and mechanically selects idle operation on the fuel flow regulator. To move the throttles from OFF to IDLE, push forward and then shift the throttle inboard. Further advancement selects power settings up to and including military thrust (MIL). After reaching MIL, the throttle may be shifted outboard and then advanced further forward to achieve reheat operation. Once the outboard shift is made, movement from minimum to maximum reheat requires straight line advancement. Noticeable cam actions are felt due to the opening or closing of the fuel shut–off valve and moving on or off IDLE, MIL or MAX reheat. Throttle slams against the idle stop may produce momentary closure of the high pressure shut–off valve, resulting in engine flame–out. Finger–operated latches on the throttles prevent throttle movement aft of the IDLE stop, thus obviating inadvertent movement of the throttles into the OFF position. The latches must be raised to move the throttles from IDLE to OFF but need not be operated to move for OFF to IDLE.

**WARNING 1:** It is possible to flame out the engines by slam decelerations because of linkage backlash, despite the action of the latches.

◆ **WARNING 2:** As throttle quadrants become worn, it is possible for an outward pressure, applied when the throttles are at IDLE, to move the throttles into the OFF detent. If this occurs, the throttles can only be moved forward after a correcting inboard pressure.

26. *Dual Control Aircraft Throttles*. On aircraft up to and including Block 33, the aft cockpit is also equipped with a pair of throttles which are mounted on the left console. Each throttle is mechanically connected to its corresponding throttle in the forward cockpit by a series of teleflex cables and telescopic rods. Normal control from the aft cockpit is limited to IDLE through the MIL power settings. The rear cockpit throttles cannot be used to initiate reheat, or start and stop the engines. Should it become necessary to override the throttles in the rear, or if the aft throttle(s) become jammed, a sufficient force applied to the forward throttle(s) will cause the forward and aft throttle(s) to become disconnected at the telescopic rod(s), once they have been disconnected, it is only necessary to set the aft throttle(s) in the same position as the forward throttle(s).

27. *Throttle Linkage Disconnection*. No provision is made on the fuel flow regulator for stabilised RPM should the throttle linkage become disconnected, so the regulator may hunt due to vibration, depending on the breakaway force required. If a throttle linkage disconnect occurs, the engine may be shut down by moving the throttle or ENGINE MASTER switch to the OFF position. Either action shuts off fuel to the engine by electrically closing the main fuel shut–off valve.

**WARNING:** Use of the ENGINE MASTER switch to shut down the engine must be reported since it results in high stresses occuring in certain fuel tubes and necessitates their replacement. This warning also applies to engine flame–out owing to fuel starvation.

28. *Low Pressure Fuel Pump*. The centrifugal–type low pressure fuel pump, driven from the high speed gear box, receives fuel from the booster pumps and delivers it through the low pressure filter to the high pressure fuel pump. Its purpose is to maintain sufficient pressure at the inlet to the high pressure pump to prevent cavitation under normal operating conditions or should booster pump failure occur; it also supplies fuel to the reheat fuel pump via a velocity cleaned filter.

29. *High Pressure Fuel Pump*. The variable–stroke piston–type high pressure fuel pump, on the rear face of the high speed gear box, receives fuel from the low pressure filter and delivers it at sufficiently high pressure to the fuel flow regulator. To protect the fuel system from excessive pressure, a relief valve opens and bleeds excessive pressure back to the low pressure side of the system.

◆ 30. *Engine Fuel Flow Regulator*. The fuel flow regulator is mounted on the rear face of the high speed gear box. Since the thrust of the engine is mainly a function of the mass of air flowing through it and the temperature of the gases at the turbine inlet, the thrust developed can be controlled by varying the amount of fuel supplied to the combustion section. The fuel flow regulator controls the amount of fuel supplied to the spray nozzles and thus controls the thrust output. Basic control is by the throttle which is mechanically linked to the regulator. As the throttle is moved, the shaft RPM of the high pressure compressor increase with a change in TGT. The thrust then increases accordingly. Additional automatic control inputs to the fuel flow regulator compensate for changes in altitude and atmosphere. Protection measures are also incorporated to guard against engine overspeed, overtemperature and overpressure.

31. *Low Pressure Fuel Filter.* The low pressure filter contains a replaceable paper filter element in the low pressure line. A pressure switch senses differential pressure between the filter inlet and the filter outlet. When a predetermined differential pressure is exceeded, the switch brings on the CHK FUEL FILTERS caption on the telelight panel and the MASTER CAUTION light(s), indicating that the fuel filter on either engine is blocked (either by dirt or ice). As there is only one warning caption for both filters, power is reduced on each engine in turn to extinguish the light. If the caption does not go out, do not use reheat, use cruise power settings only, and land as soon as practicable. A possible reduction in power should be anticipated.

32. *Fuel Cooled Air Cooler.* The assembly contains a central tube passing through an outer case. Air from the compressor passes through the central tube and is cooled by the fuel passing through the outer case. This arrangement ensures that the air from the compressor is reduced to an acceptable level prior to entering the P-3 limiter in the fuel flow regulator.

33. *Low Pressure Shaft Governor.* The LP governor, on the low speed gear box, consists of a pressure limiter, a TGT controller, and a governor reset. The governor overrides the throttle lever and trims the fuel flow to prevent excessive LP RPM.

34. *High Pressure Fuel Shut-Off Valve.* The high pressure shut-off valve is a plunger type valve connected by linkage to the throttle lever and is either open or closed. In the open position, the fuel is routed to the primary and main manifolds of the spray nozzles. When the throttles are OFF, fuel flow is routed to the drain manifolds to provide drainage during engine rundown.

35. *Fuel Spray Nozzles.* The fuel spray nozzles, one for each burner, supply metered fuel from the fuel flow regulator to the burner for combustion. The fuel is divided into primary and main fuel streams, and each stream is delivered through separate internal passages within the nozzle. The purpose of the stream division is to ensure optimum fuel atomisation over the entire engine operating range.

36. *Flowmeters.* Two flowmeters on the right of the pilot's instrument panel indicate engine fuel flow in pounds per minute by a pointer over a scale calibrated from 2 to 20 with readings multiplied by 10. This flow is measured by transmitters on the engines. Reheat fuel bypasses the transmitters and is therefore not indicated.

37. *Turbine Gas Temperature (TGT) Indicators.* The TGT indicators are on the forward main instrument panel. They indicate the temperature of the gas as it leaves the turbine. The scale range is from 0 to 10 with readings multiplied by 100°C. The scale is expanded from 500 to 800°C.

**Ignition System**

38. The main ignition system consists of a fuel cooled ignition assembly containing a dual, high energy ignition unit on the engine, two surface discharge igniter plugs in liners 4 and 8, and the necessary wiring. For ground starting, once the start switch is engaged, the ignition cycle is automatic and requires no further attention by the pilot. For relighting, the ignition system is energised when the ignition buttons on the throttle grips are pressed. In either case once the ignition system is energised, the igniter plugs fire and ignite the fuel spray in liners 4 and 8. Interconnecting tubes lead the flame into the remaining eight liners.

39. *Relight Ignition Buttons.* The relight ignition buttons are spring-loaded, pushbutton switches, one on each throttle directly below the throttle grips. Pressing either button causes the igniter plugs in the corresponding engine to fire. They are used only during relighting in flight. Once the relight button is pressed initially it is then automatically held on for 20 seconds, during which time the igniter plugs operate.

**Starting System**

40. For ground starting, a gas-turbine is provided and is mounted on the front case of the high speed gear box. Normally, power for starting is obtained from an external AC source via the Essential 28 volt DC bus. However, an alternate DC source or the battery, may be used in lieu.

41. *ENGINE MASTER Switches.* Two toggle-lock type, 2-position ENGINE MASTER ON/OFF switches are on the left console in the pilot's cockpit on the inboard engine control panel. Placing a switch to the ON position directs power to the fuel booster pumps and fuel transfer pumps. The circuits for the fuel shut-off valves, which are normally operated by the throttles, are such that either valve is closed when its corresponding ENGINE MASTER switch is OFF, *irrespective of throttle position.*

42. *ENGINE START Switches.* The ENGINE START switches, on the left console in the front cockpit just inboard of the throttles, are marked L and R ON/OFF and receive power from the Essential 28V DC busbar. Setting a switch to ON activates the gas turbine starter fuel valve and ignition, energises the engine igniter and engages the starter. The start switch, once engaged, remains in its engaged position until the engine accelerates to approximately 38% RPM. When this speed is attained, the starter automatically returns to the OFF position.

43. *Tachometers.* Two electric tachometers on the pilot's instrument panel and a further two on the navigator's instrument panel (Blocks 31 to 33) are operated by engine-driven tachometer generators, one on each engine. The system is completely self-contained in that it requires no external source of power. The tachometer generator develops a polyphase alternating current which is used to indicate percentage of maximum engine RPM. The indicator dials are calibrated from 0 to 110. Each indicator has two pointers, a large one operating on the 0 to 100 scale and a small one operating on a separate scale calibrated from 0 to 10. An LP/HP switch, spring-loaded to HP, is on the forward face of the left throttle handgrip and enables either LP RPM or HP RPM to be read on the ◆tachometer. Post-mod 855, the LP/HP switch is replaced ◆ by a flare/chaff dispense button.

**Reheat System**

44. *Reheat System.* The reheat system is comprised of the exhaust collector and variable nozzle, the nozzle operating and control system, and the reheat fuel control system. The function of the system is to provide the increase in thrust necessary to achieve high speed flight.

45. *Reheat Fuel System.* Fuel for the reheat system is taken downstream of the low pressure engine-driven fuel pump after the fuel has passed through the velocity-cleaned filter and oil coolers. It enters the reheat fuel control unit which contains the shut-off valve, pump and throttle.

46. *Reheat Fuel Pump.* The reheat fuel pump is of the centrifugal, vapour-core type. The output of the pump is regulated by an inlet throttle which is controlled by differential fuel pressure within the reheat fuel control unit. The pump is driven from the high-speed gear box.

47. *Reheat Fuel Control System.* The fuel control system provides a means of selecting, igniting and shutting down reheat. It also controls fuel flow according to throttle position and changes in flight conditions, and keeps the manifolds free of fuel when reheat is not selected. When reheat is selected, several simultaneous actions take place. The pilot's selection and shut-off valve is opened. This valve is a dual unit comprising a mechanically-operated high-pressure fuel valve and an 82% speed valve. Each of these valves acts as an override for the other. If reheat is selected while the engine is under 82% RPM, the 82% speed valve remains closed, blocking fuel flow initiation. If the engine is operating at or above 82% RPM the 82% speed valve opens but fuel is blocked until the throttle is moved to the reheat range. Once these two valves are open, a high pressure fuel signal is directed to the low pressure fuel shut-off valve, causing it to open. As this low pressure valve opens, fuel is directed to a catalytic igniter, where ignition takes place and fuel from the engine low-pressure fuel pump is admitted to the reheat fuel pump. The selection and shut-off valve also directs fuel pressure signals to the pressure ratio rams in the reheat nozzle control system to activate the exhaust nozzle, and to the nozzle trip valve to set the nozzle mechanism in motion. Metered fuel from the reheat pump is then directed to the vapour gutters. This fuel is ignited by the burning fuel from a catalytic igniter. Once ignited, the vapour gutters continue to burn until reheat is cancelled. The catalytic igniter shuts down after approximately 3 seconds. During this period a spill valve in the fuel line to the reheat fuel manifolds prevents fuel from being supplied to the manifolds. After the 3 seconds the spill valve is released allowing metered fuel to be supplied. The rate of release is controlled to prevent overfuelling.

48. *Reheat Fuel Distribution.* The main fuel manifolds with the vapour gutters, supply metered fuel at all stages of reheat.

49. *Reheat Ignition System.* The ignition system consists of a catalyst fuel flow control unit, a fuel injector, and a catalytic igniter. The catalytic fuel flow control unit is mounted on the exhaust collector case adjacent to the high energy ignition unit. Its function is to provide a controlled fuel flow through an injector which is integral with the catalytic igniter fuel in the vapour gutters upon reheat selection. A clockwork mechanism within the unit provides a predetermined operation time. The fuel is ignited by a rhodium platinum catalyst element which maintains fuel ignition temperature by virtue of its location in the main turbine exhaust stream. Fuel is sprayed from the catalytic fuel injector into the forward end of the catalytic igniter where it is ignited by the hot catalyst and then ignites the fuel being discharged from the vapour nozzles.

### Variable Area Exhaust Nozzle System

50. The exit area of the nozzle is variable so that the engine may develop optimum thrust for any throttle position. At start and idle, the nozzle area as indicated on the cockpit gauge is approximately $^1/_8$ open. As the throttle is advanced the area remains constant until 82% RPM is reached. From this point to MIL power, the nozzle is closed. When decelerating, nozzle changeover occurs at about 85% and can be as low as 65% RPM. When reheat is selected, the nozzle is pre-opened to ¼ for light-up. Nozzle area is then automatically varied by engine pressures to maintain scheduled pressure ratios. When the maximum power throttle position is reached, the nozzle position indication is ½ to $^7/_8$.

51. *Exhaust Nozzle Position Indicators.* Exhaust nozzle position indicators, which show the exit area of the exhaust nozzle, are on the pilot's instrument panel. The instruments are calibrated from CLOSE to OPEN in ¼ increments.

52. *Nozzle Control System.* The variable area nozzle system is positioned by hydraulic pressure from the reheat nozzle control system.

### Oil Systems

53. There are four separate oil systems associated with each engine. They are the engine oil system, the reheat nozzle control system, the constant speed drive unit (CSDU) and the starter system.

54. *Engine Oil System.* Each engine is equipped with a 10-pint capacity oil tank on the lower left side of the engine, on the anti-icing air manifold. The oil in the system is circulated by one pressure pump, a metering pump, and seven scavenge pumps. The pressure pump and five of the scavenge pumps form the main oil pump assembly. Each pump is protected by a wire-mesh strainer, and the main feed flow is filtered by a single wire-wound filter. The filter is equipped with a by-pass valve to prevent oil starvation should the filter become clogged. The pumps distribute the oil in the system to the bearings, gears, shafts, and splines in the engine. The pressure pump draws oil from the engine oil tank and passes it through the air-cooled oil cooler which is cooled by ram air from the air inlet. The oil then passes to the fuel-cooled cooler assembly, which contains five separate cooler units. The entire oil flow passes through the cooler assembly and is cooled by the engine main fuel flow. When the oil viscosity is high (ie, low temperature), the oil by-passes the cooler. After the oil is circulated throughout the engine, five scavenge pumps return the oil to the tank from the bearings, internal gear box and high speed gear box. Metallic deposits in the oil are indicated by magnetic chip detectors in the return lines before entering the reservoir. In addition to oil, various bearings are also cooled by air. To separate the air from the oil, a de-aerator tray is incorporated in the reservoir. A relief valve in the system maintains the oil supply at a satisfactory pressure. The L ENG OIL PRESS LOW or R ENG OIL PRESS LOW caption on the telelight panel in the forward cockpit comes on if the oil pressure falls below 15 PSI between the pressure line and the return line.

55. *Reheat Nozzle Control System.* The reheat nozzle control system consists of a high and a low pressure oil system. The high pressure oil system is used to position the variable area nozzle system. The high pressure oil is passed through the pistons of the nozzle operating jacks and then through a fuel-cooled oil cooler. Any oil leakage from around the piston stems is returned to the oil tank. The low pressure oil system supplies the high pressure system with oil from the 6-pint capacity reheat oil tank mounted on the engine intercase. There are three oil coolers in the low pressure line which dissipate any heat generated in the system.

56. *Constant Speed Drive System.* Oil for the lubrication of the CSDU and lubrication and cooling of the AC generator is supplied from a 13-pint capacity oil tank integral with the unit. A charge pump draws oil from the tank and pumps it to the hydraulic unit inlet manifold, the mechanical governors, and the servo piston. A scavenge pump returns the oil through the fuel-cooled oil coolers and air-cooled oil cooler to the tank. The AC generator is cooled by oil circulated around the stator and through the rotor by a pump. The oil is returned directly to the tank, where it mixes with the scavenge oil. Some of the cooling oil is used to lubricate the generator tail-end bearing and drains back to the CSDU to be returned to the oil tank by the scavenge pump.

57. *Gas Turbine Starter System.* A self-contained oil system is provided for the gas turbine starter. Oil, pressurised by starter compressor air, feeds the gas generator bearings and splash oil lubricates the reduction gearbox.

58. *Fuel/Air Coolers.* Five fuel-cooled and two air-cooled oil coolers are used for all oil systems. Three of the fuel-cooled oil coolers are in the main fuel line downstream of the low pressure pump. The oil coolers transfer heat from the reheat oil, engine oil, and constant speed drive oil to the fuel. The two air-cooled oil coolers are in the engine air intake. Engine and constant speed drive oils are cooled by both engine and reheat fuel and by the air-cooled oil coolers. Nozzle oil is cooled by engine fuel only. The transfer of heat from the oil to the fuel assists in the prevention of ice formation in the fuel system.

## Engine Anti-Icing

59. Engine anti-icing is affected by hot air from the HP compressor and is controlled by an electrically-energised pressure-operated regulating valve. The supply of hot air is from a number of equally spaced points round the diffuser casing to a manifold surrounding the casing. The air is circulated through the inlet guide vanes and the nose fairing and exhausted into the compressor entry. The system is designed to prevent ice forming and not for de-icing purposes.

60. Selection of anti-icing to both engines is by a single ENGINE ANTI-ICING DE-ICE/NORMAL switch outboard of the throttle levers. A pressure switch on each engine operates a L ANTI-ICE ON and R ANTI-ICE ON caption on the telelight panel to indicate that the system is in operation.

Note: When accelerating through 450 KCAS, the L and R ANTI-ICE ON captions may illuminate.

## FIRE, OVHT and ENG Warning Systems

61. *FIRE/OVHT/ENG Captions.* Two FIRE, OVHT and ENG caption panels, one for each engine, are on the upper left and upper right of the instrument panel to provide warnings for the left and right engines respectively. There is also an arrow pointing outboard on each panel to assist in the correct identification of a malfunctioning engine. These captions *do not* trigger the MASTER CAUTION captions.

62. *FIRE Caption.* Each engine has a fire warning system which consists of a warning caption, a control unit and a continuous type sensing element. The element is routed through the engine compartment and monitors the bay temperatures external to the engine. The light comes on when the temperature of the forward engine bay increases above 302°C or when the temperature of the aft engine bay increases above 407°C.

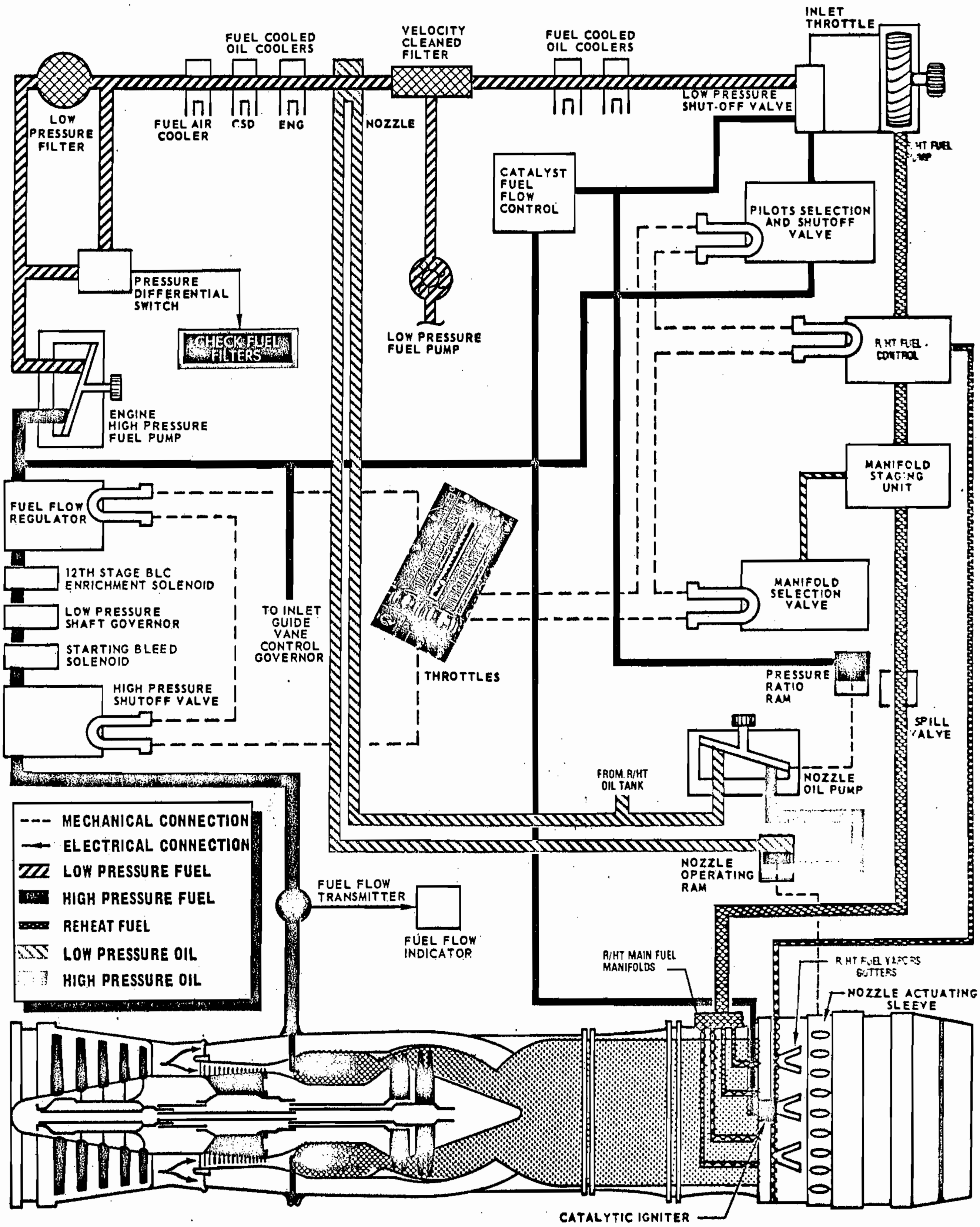
63. *OVHT Caption.* Each engine bay has an OVHT warning system which is similar in construction and mode of operation to the FIRE warning system but is completely separate from it. The sensing element is routed vertically in recesses in the skin fairing of the keel. These recesses are located opposite the aft end of the engine nozzle. The energising temperature for the OVHT warning system is approximately 566°C. Because of the high ventilation flow rate in the engine bay it is possible for leaking fuel not to ignite until it reaches the jet pipe nozzle area and thus bring on the OVHT warning. Reheat must not be used again on an engine that has exhibited an OVHT warning.

64. *ENG Caption.* Each engine has an ENG caption which warns of internal engine malfunction. The system consists of a warning caption, and a temperature switch situated in the LP cooling air outlet duct of each engine. The warning light is illuminated whenever the temperature of the LP cooling air rises above 529°C. The temperature increase is a warning of mechanical failure in the engine which could very soon develop into an internal fire. The most likely malfunction is an internal mechanical failure in the engine, which leads to the deterioration of internal air seals and allows hot air to mix with the LP cooling air, or oil to be fed into the air system and ignite. The ENG caption warns the pilot to shut down the engine immediately before a more serious condition develops from over-heating of rotating internal components.

65. *FIRE, OVHT and ENG Systems Check.* In common with all other warning light filaments the FIRE, OVHT and ENG caption filaments come on when the WARNING LIGHTS switch on the starboard console is placed in the TEST position. All six warning lights also come on if the FIRE TEST switch, which is adjacent to the right FIRE, OVHT and ENG lights , is pressed. When the FIRE TEST switch is pressed a circuit is completed to the FIRE, OVHT and ENG test relays. In the case of the FIRE and OVHT systems this causes the closed sensing loops to 'open' and connect the centre conductor of the detection element to ground; this simulates the effect of a fire on the element, checks the complete loop for continuity, and also the operation of the control unit. The captions come on to indicate that the circuits are operating correctly. If a caption does not come on, it must be assumed that the sensing element has been severed. In the case of the ENG caption, the test relay causes the engine overheat detector switch to be short circuited and hence completes and checks the remainder of the circuit. The ENG warning comes on to indicate a successful circuit check and in no way checks the actual overheat detector switch. ◆ Pre-SEM/065/STC, the ENG warning system and the FIRE TEST circuits use power from the Right Main 28 volt DC bus, whereas the FIRE and OVHT *detection* circuits take power from the Essential 115/200 volt AC bus. Therefore, in the event of failure of the Right Main 28 volt DC bus (double generator failure) neither the ENG warning system nor the FIRE TEST facility is available. However, the FIRE and OVHT warning systems are still operative. ◆ Post-SEM/065/STC, the ENG warning system and FIRE TEST circuits use power from the Essential 28 volt DC bus and thus are available in the event of a double generator failure.

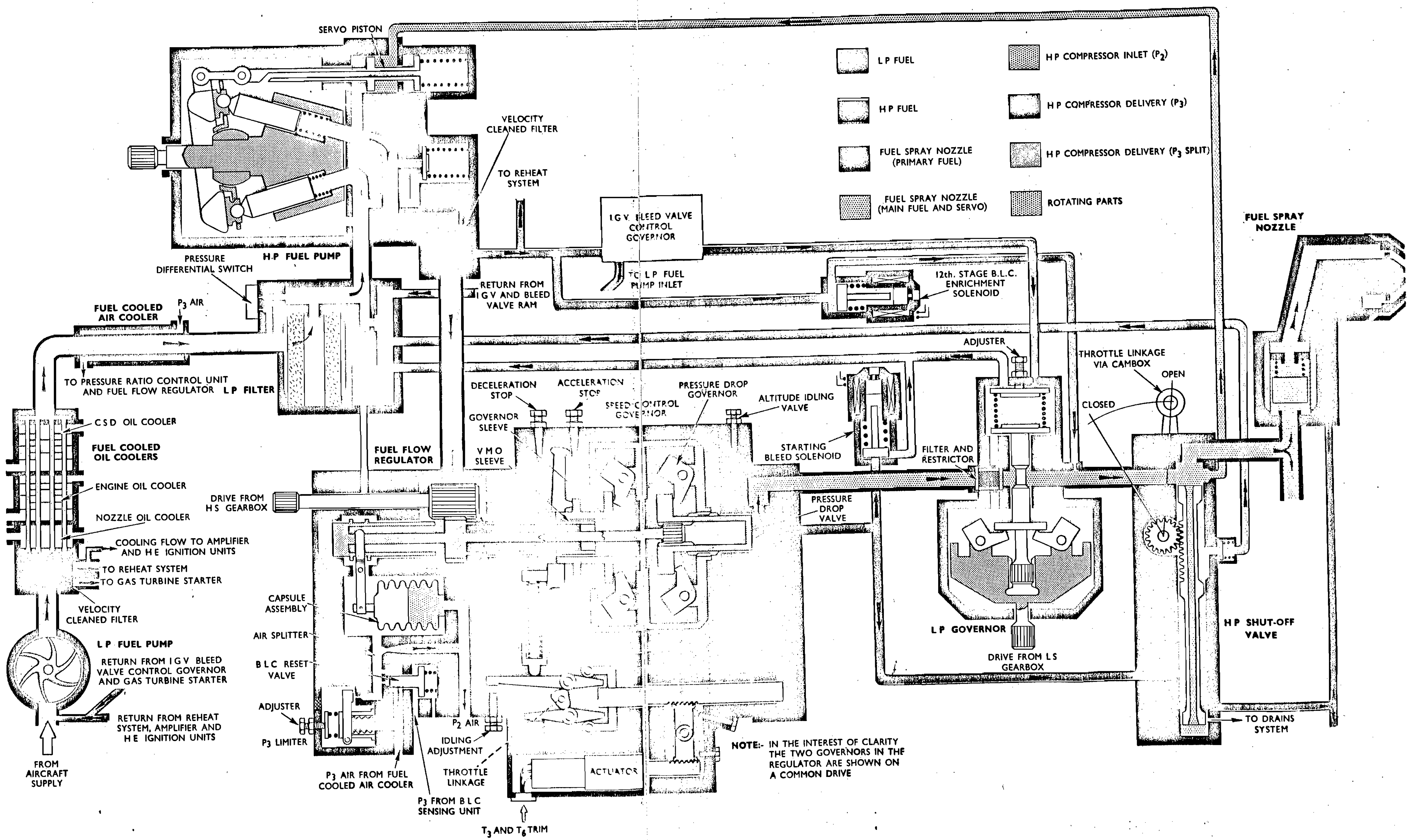
66. Further information on fires and engine malfunction is contained in Part 4 of this Manual.

*Intentionally Blank*



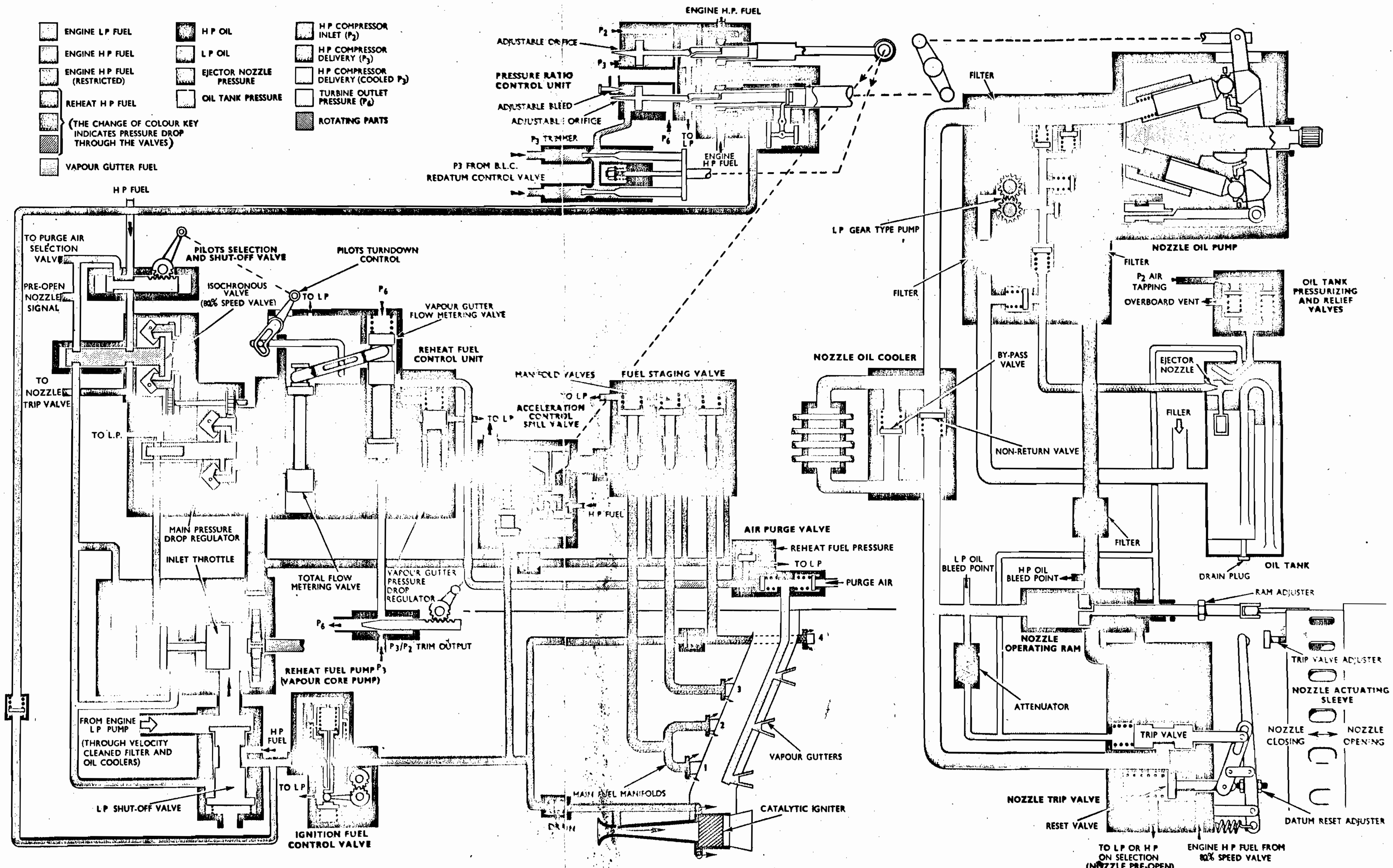

**1—6 Fig 2 Engine Fuel Systems — General Layout**

*Intentionally Blank*




1—6 Fig 3 Main Fuel System

*Intentionally Blank*




1—6 Fig 4 Reheat Fuel and Nozzle Control System

*Intentionally Blank*

# PART 1

# CHAPTER 7 - FUEL SYSTEM

## Contents



### General Description

1. The fuel system consists of seven interconnected fuel cells in the fuselage and two integral wing cells, one in each wing torque box. Two externally mounted wing drop tanks and a fuselage centreline drop tank may be carried. There is also an air-to-air refuelling system. Fuel tank contents are given in Fig 1.

Note: No 7 fuel cell is isolated and inoperative.

2. An air pressure system transfers wing and external tank fuel to the fuselage cells. Hydraulic and electric transfer pumps, plus gravity feed, transfer fuel from fuselage cells 2, 3, 4, 5 and 6 to number one cell which is the engine feed tank.

3. Single-point ground pressure fuelling at the rate of approximately 1700 lb per minute may be accomplished. Simultaneous 2-point ground pressure refuelling is available by using both the in-flight refuelling probe and the

normal ground refuelling point. There is no provision for gravity fuelling or defuelling the internal fuel system. However, the external tanks may be gravity fuelled or defuelled as necessary. Single-point defuelling of both internal and external fuel systems is normally accomplished by using the ground refuelling point.

4. All internal fuel cells incorporate capacitance fuel gauging units which continuously indicate the total fuel quantity in pounds in all internal cells.

Note: Unless stated otherwise all fuel quantities quoted in this chapter are based on an SG of 7.7 (AVTAG).

5. The fuel system is equipped with refuelling level float valves which shut off the pressure fuelling when predetermined fuel levels are reached.

6. All internal and external fuel tanks are pressurised in flight by regulated engine bleed air which is also used to transfer wing or external fuel to the fuselage cells or to jettison wing fuel. The internal cells and external centreline tank are all vented to a common manifold which exhausts overboard from the fuel vent mast immediately below the rudder. The external wing tanks are vented to the internal wing fuel dump lines.

**Fuel Transfer System**

7. Electric transfer pumps in fuselage cells 4 and 6 start transferring fuel to the engine feed tank (cell 1) and cell 2 when either ENGINE MASTER switch is selected to ON, provided AC power is supplied to the system (see Fig 2). The hydraulic transfer pumps in cells 4 and 6 run when reheat is selected, when the FUEL LEVEL LOW light is on, when double generator failure occurs (ie, no power on Right Main 28V DC bus) or when the PROBE switch is in the REFUEL position.

8. The transfer pump level control valves open to allow fuel from the transfer pump to enter cells 1 and 2 when the fuel level in these cells drops below the level of the control valves. Fuel is transferred solely by gravity feed from cell 2 to cell 1, cell 3 to cell 4 and cell 5 to cell 6.

9. All internal and external tanks and cells are pressurised when the landing gear control handle is in the UP position or the TRANS PRESS switch is ON and an engine is running. Wing fuel may now be transferred by regulated air pressure to fuselage cells I and 3. Wing fuel does not normally enter cell 1 unless the fuel level in the cell drops sufficiently to allow the refuelling level control valve to open. Wing fuel is transferred to fuselage cell 3 when the FUEL TRANS switch on the fuel control panel on the left console is set to INT WING; transfer to cell 5 is prevented by a transfer level control valve which closes off the inlet pipe when INT WING is selected.

10. With an engine running, fuel from the external tanks starts transferring once the FUEL TRANS switch is selected to either OUTBD or CENTER, providing the landing gear control is in the UP position or the transfer pressure switch is in the ON position. When operating on RAT power only, all fuel can be transferred.

◆ Note: The wing fuel transfer pitch limits are illustrated in Fig 1. ◆

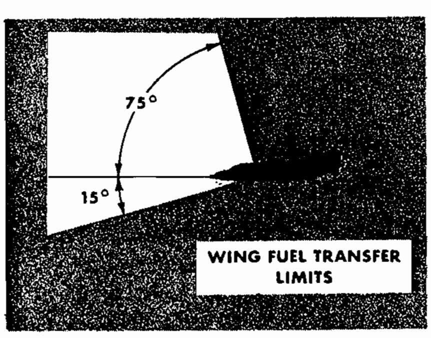
**Fuel Transfer Switch**

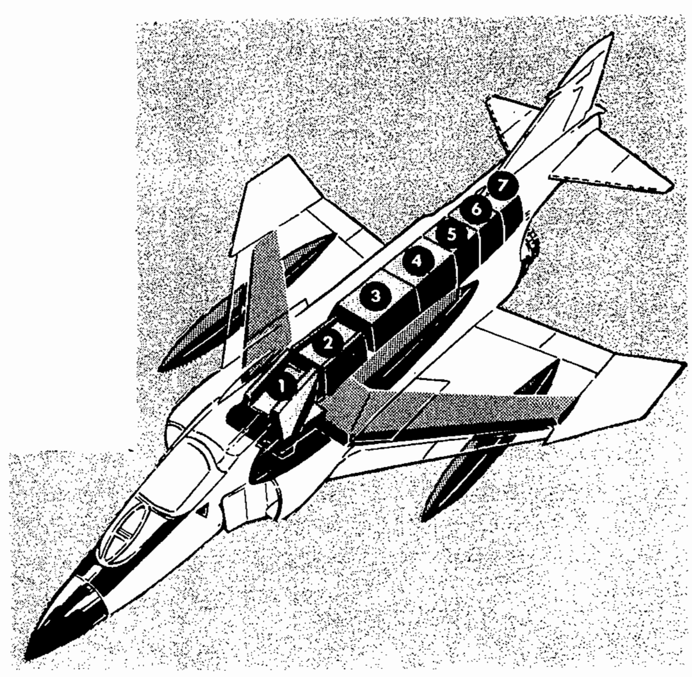
11. The FUEL TRANSfer switch is a 4-position rotary switch marked STOP, OUTBD, INT WING and CENTER and enables transfer only from the selected cells.

12. Upon the selection of CENTER, the internal wing tank shut-off valves close, the centreline drop tank fuel shut-off and refuel shut-off valves are opened and fuel starts to transfer. Placing the switch to OUTBD closes the centreline shut-off valves, opens the drop tanks shut-off valves and fuel begins to transfer, in each case, to cells 3 and 5 and to cell 1 if space is available.

| TANKS | FULLY SERVICED | | | | USUABLE FUEL | | | |
|---|---|---|---|---|---|---|---|---|
| | *IMPERIAL GALLONS* | *AVCAT POUNDS* | *AVTUR POUNDS* | *AVTAG POUNDS* | *IMPERIAL GALLONS* | *AVCAT POUNDS* | *AVTUR POUNDS* | *AVTAG POUNDS* |
| FUSELAGE CELL 1 | 204 | 1674 | 1613 | 1572 | 192 | 1579 | 1521 | 1482 |
| FUSELAGE CELL 2 | 184 | 1510 | 1455 | 1418 | 178 | 1462 | 1409 | 1373 |
| FUSELAGE CELL 3 | 143 | 1175 | 1132 | 1103 | 137 | 1121 | 1080 | 1053 |
| FUSELAGE CELL 4 | 190 | 1558 | 1501 | 1463 | 184 | 1510 | 1455 | 1418 |
| FUSELAGE CELL 5 | 172 | 1408 | 1356 | 1322 | 168 | 1374 | 1323 | 1290 |
| FUSELAGE CELL 6 | 200 | 1640 | 1580 | 1540 | 196 | 1606 | 1547 | 1508 |
| TOTAL FUSELAGE FUEL | 1093 | 8965 | 8637 | 8418 | 1055 | 8652 | 8335 | 8124 |
| INTERNAL WING TANK | 537 | 4401 | 4240 | 4133 | 525 | 4305 | 4148 | 4043 |
| TOTAL INTERNAL FUEL | 1630 | 13366 | 12877 | 12551 | 1580 | 12957 | 12483 | 12167 |
| EXTERNAL WING TANKS | 620 | 5084 | 4898 | 4774 | 617 | 5057 | 4872 | 4749 |
| TOTAL INTERNAL FUEL PLUS EXTERNAL WING TANKS | 2250 | 18450 | 17775 | 17325 | 2197 | 18014 | 17355 | 16916 |
| EXTERNAL CENTRELINE TANK | 502 | 4114 | 3963 | 3863 | 500 | 4100 | 3950 | 3850 |
| TOTAL INTERNAL FUEL PLUS EXTERNAL CENTRELINE TANK | 2132 | 17480 | 16840 | 16414 | 2080 | 17057 | 16433 | 16017 |
| TOTAL INTERNAL FUEL PLUS ALL EXTERNAL TANKS | 2752 | 22564 | 21738 | 21188 | 2697 | 22114 | 21305 | 20766 |

Fuel weights are based on 8·2 lb per gallon for AVCAT, 7·9 lb per gallon for AVTUR and 7·7 lb per gallon for AVTAG.




**1—7 Fig 1 Fuel Contents Table**
◆ *(Mod 677 incorporated)* ◆

*Intentionally Blank*

13. With the switch in the STOP position only fuselage fuel is available. With no external tanks fitted, internal wing fuel transfers into the fuselage cells irrespective of the position of the fuel transfer switch, with the exception of the STOP position.

14. With the switch in the INT WING position, internal wing fuel is transferred to fuselage cell 3 as soon as the internal wing tanks are pressurised and the refuelling level valve in cell 3 opens. Fuel also transfers to cell 1 if space is available.

Note: If the FUEL TRANS switch is selected to OUTBD or CENTER with no tank(s) fitted to the selected station, internal wing fuel transfers.

**Transfer Pressure Switch**

15. The TRANSfer PRESSure switch is a two-position ON/NORMAL switch on the fuel control panel. When the landing gear handle is in the UP position and the transfer switch is in the NORMAL position, all internal and external tanks become pressurised by the pressure regulator valves being opened and the pressure relief valve closed. This maintains 14·5 to 16 PSI air-pressure in the wing and external tanks and 2±0·5 PSI in the fuselage tanks. Placing the switch to ON performs the same function as the landing gear handle switch.

**Buddy Tank Fill Switch**

16. A BUDDY TANK switch, marked FILL/STOP FILL, is intended for use only if a 'buddy' in-flight refuelling centreline tank is fitted. It should be at the STOP FILL position at all times. Selecting FILL opens the defuelling shut-off valve, opens the centreline shut-off valve, opens the centreline pressure relief valve and closes the centreline pressure regulator, allowing engine supply fuel under booster pump pressure to be fed to the centreline tank (when fitted).

**Pressurisation and Vent System**

17. The pressurisation and vent system provides regulated bleed air pressure to all internal and external tanks for pressurisation, fuel transfer, and wing fuel jettison. The system also provides for venting of external tanks to prevent collapse during fast descents.

18. *Wing Tank Pressurisation and Vent.* The wing cells and external tanks pressurisation system uses pressure regulators and pressure/vacuum relief valves, set respectively at 14·5 to 16 PSI and 18 PSI. The wing cell pressure/vacuum relief valves, which provide fuel tank pressure and vacuum relief, exhaust into a common manifold which is vented overboard under the rudder. The external wing tanks are vented through their pressure relief valves to the internal wing dump lines. The wing cells and external wing tanks are vented to the atmosphere when the landing gear handle is DOWN and the TRANS PRESS switch is set to NORMAL.

19. *Fuselage Tank Pressurisation and Vent.* The fuselage tank pressure regulator, in conjunction with the flow limiter and pressure relief vent valve, maintains regulated air pressure at 2±0·5 PSI and pressure relief at 4 PSI. The fuselage tank cells and the centreline external tank are vented to the common fuel vent manifold and then exhausted overboard through the fuselage pressure relief valve. When the landing gear handle is DOWN and the TRANS PRESS switch is set to NORMAL all pressure relief valves are open, venting all tanks to atmosphere.

**Fuel Dump System**

20. Internal wing fuel may be dumped at any time regardless of any other transfer position by selecting the DUMP position on the NORMAL/DUMP switch on the fuel control panel. This position momentarily depressurises the wing tanks, opens the left and right wing dump shutoff valves and closes the wing transfer and vent valves. The wing air regulator then maintains the wing tank pressurisation to force fuel out at the wing fold trailing edge. The dump shutoff valves return to their original positions when the DUMP switch is returned to NORMAL.

**WARNING 1:** The fuel dump system is inoperative when operating on RAT power only.

**WARNING 2:** The WING DUMP switch must be selected to NORMAL *prior to engine shutdown.* If the switch is left at DUMP, fuel spillage will occur during refuelling. Be prepared to stop a refuelling operation if fuel spillage occurs; this can happen momentarily if the WING DUMP switch was selected to NORMAL with no electrical power available.

**Fuel Booster Pumps**

21. Fuel is supplied to the engine during all flight attitudes by two submerged electric motor-driven centrifugal type booster pumps in the engine feed (No 1 cell) tank. The left pump is a 2-speed unit. During normal operation the left and right pumps operate at high speed, taking their power from the Left and Right Main 115/200V AC busbars respectively. After a double generator failure, extending the RAT to bring the emergency generator on line automatically switches the left pump from high to low speed, power being taken from the Essential 115/200V AC busbar. The right pump is inoperative when on emergency generator power. Thus the electrical demand is reduced but positive fuel pressure for the engines is maintained.

22. Both pumps are mounted at the bottom of the tank but they provide pressure during limited negative-g flight through a system of tank baffling

and check valves which trap approximately 900 lb of fuel in the lower one-third of the tank. The booster pumps operate when either engine master switch is ON, provided that AC power is supplied to the system. A non-return valve between the engine feed tank and the booster pump manifold allows fuel to flow by gravity to the engines in the event of a double booster pump failure.

23. *Booster Pumps Pressure Gauge.* A single pressure gauge, calibrated from 1 to 5 (x 10) is on the oxygen panel forward on the left console. A pressure transmitter between the booster pump manifold and the individual shutoff valves measures booster pump pressure as it enters the engine fuel pumps. With the tank pressurisation off the pump limits are 28 to 50 PSI, increasing by 4 PSI to 32 to 54 PSI with the tank pressurisation system on. Single pump failure is difficult to detect on the gauge, since only a slight drop in pressure occurs (approx 2 PSI). The gauge uses power from the Right Main 28V AC bus and is inoperative when using RAT power only and with the RH GEN OUT and BUS TIE OPEN captions on.

24. *Booster Pumps Check Switch.* A three-position BOOST PUMP, L/R, CHECK switch, spring-loaded to the central (off) position, is provided forward on the left console to check the operation of the booster pumps. The check is operable only when both engine master switches are off and external AC power is available. Setting the switch to L or R causes the appropriate pump to run and the pressure to be shown on the pressure gauge.

**Fuel System Indicators**

25. The fuel quantity indicating system is of the capacitance type and provides a reading in pounds of total *internal* fuel. The system components include the fuel quantity gauge, fuel tank check switch and a fuel level low caption. There are thirteen fuel gauging units located throughout the internal tanks which register at the one cockpit fuel quantity gauge.

26. *Fuel Quantity Gauge.* A combination tape/counter fuel quantity gauge is on the upper right corner of the front cockpit instrument panel. The tape portion at the top of the gauge indicates the total usable fuel quantity in fuselage cells 1 to 6 only, with reading multiplied by 1000. Internal wing fuel quantities are not indicated by the tape. The counter unit in the centre of the gauge continuously indicates the total usable fuel quantity (with readings multiplied by 10) in all internal wing and fuselage tanks. An auto temperature compensator is incorporated to minimise gauge errors caused by temperature variations; the capacitance fuel gauging units compensate for the variations in SG of different fuels.

27. At a fuel state of 2500 lb, the tape portion of the fuel gauge has a tolerance of ±150 lb, and the counter portion has a tolerance of ±200 lb, giving a maximum tolerance between tape and counter readings of ±350 lb. If the FUEL LEVEL LOW caption illuminates above an indicated 2000 lb, this should be used as the primary indication of a low fuel state, since it is independent and does not reflect errors in the basic quantity indicating system. At the full end of the scale the tape tolerance is ±280 lb and counter tolerance is ±420 lb.

28. After all wing fuel has transferred the counter ◆ and tape should read within ±350 lb of each other, ◆ although this may be masked by fuel consumption occurring during the transfer.

29. There is a possibility of transient decreases and increases occurring on the fuel gauge during aircraft accelerations and decelerations respectively. Optimum fuel quantity indication is achieved with the aircraft in a straight and level attitude in conjunction with moderate stabilised power settings. Large discrepancies may also occur after climbs or descents, with the fuel gauge under-reading at the top of a climb and vice versa.

30. During sustained transmissions on certain HF frequencies both the fuel tape and counter readings can drift, returning to the correct readings within approximately 30 seconds of cessation of transmissions, consequently fuel readings should not be taken during or up to 30 seconds after an HF transmission.

31. *Feed Tank Check Switch.* The two-position feed tank CHECK/NORMAL check switch enables a check to be made of the fuel quantity in the No 1 cell. When the switch is placed to the spring-loaded CHECK position, the tape and counter of the fuel gauge both read only No 1 cell fuel quantity (both show 1500 lb). It is also an indication that the gauge is functioning correctly and that there is power to the fuel quantity circuits.

32. *Fuel Level Low Caption.* The FUEL LEVEL LOW caption on the telelight panel, comes on when the combined fuel in cells 1 and 2 is reduced to approximately 1800±200 lb with the aircraft in a perfectly level attitude and moderate stabilised power settings being used.

◆◆

33. *Left and Right External Fuel Captions.* The L EXT FUEL or R EXT FUEL captions on the telelight panel indicate an empty left or right outboard external tank, with OUTBD position selected on the FUEL TRANS switch. Each caption comes on when the fuel flow from its associated tank ceases, either because it is empty or flow is interrupted. Since external fuel transfer is intermittent rather than continuous, the captions come on during a temporary halt of fuel flow (approximately 10 to 30 seconds). Intermittent external fuel transfer is desirable since this means the transfer rate is greater than engine consumption and fuselage fuel is being maintained at its highest possible level. The L EXT FUEL or R EXT FUEL captions also come on during refuelling to indicate lack of fuel transfer or that the fuselage tanks are full. A steady caption allied to a decreasing fuel gauge reading indicates that either the tanks have finished feeding or that transfer has stopped.

34. *Centreline External Tank Fuel Caption.* The CTR EXT FUEL caption is provided to indicate an empty centreline tank, with CENTER position selected on the FUEL TRANS switch. It comes on when fuel flow ceases and also when the tank is full during refuelling.

35. *TK Light.* A TK light on the missile status panel should come on when a centreline tank is carried and the jettison safety switch is set to READY. If the TK light fails to come on in these conditions, the centreline tank may not feed in flight and may not be jettisonable.

## EXTERNAL STORES JETTISON

**Jettison Safety Switch**

36. The jettison safety switch, marked INBD-OUTBD PYLONS & MISSILE JETTISON SAFETY SWITCH with READY/SAFE positions, is mounted in the rear cockpit on the right console. The switch must be set to READY before any stores, except centreline stores, can be jettisoned (see Part 4, Chapter 2, Fig 1).

**Outboard Stores**

37. Stores on stations 1 and 9 (normally wing tanks) can be jettisoned by lifting the red guard on the OUTBD STORES JETTISON switch on the fuel control panel and selecting the jettison position, provided the jettison safety switch is to READY.

**Centre Jettison Switch**

38. External stores carried on the aircraft centreline can be jettisoned by lifting the red guard on the CTR JETTISON switch on the fuel control panel and moving the switch to the jettison position. Once the aircraft is airborne, the CTR JETTISON switch is live, since electrical power is available with either the main landing gear fully extended or the gear handle up. The jettison safety switch does not affect centreline stores jettison.

**External Stores Emergency Release Button**

39. The external stores emergency release button is on the front cockpit left vertical panel. When this button is pressed all external stores are jettisoned in flight (including missiles and pylons) provided that ◆electrical power is available, the weight is off the main landing gear and the jettison safety switch is set to ◆ READY.

## AIR-TO-AIR REFUELLING

**Description**

40. The AAR probe is on the starboard side of the fuselage above the engine air inlet duct. The probe is equipped with an MA-2 refuelling nozzle which is capable of receiving fuel from any drogue type refuelling system. The refuelling operation is actuated by the refuel PROBE—REFUEL, EXTEND and RETR switch on the fuel control panel.

41. The REFUEL position makes ready the fuel system for air-to-air refuelling of all tanks and extends the probe. The EXTEND position retains the probe in the extended position, but returns the aircraft fuel system to normal operation with the exception that fuselage cells 1, 3 and 5 (unless INT WING selected when cells 1 and 3 only can be filled) can be filled up and maintained full by fuel flow from the tanker. This position is used when it is necessary to replenish the fuel in the engine feed tank, either by normal fuel transfer or from the tanker, should the contents have become low when in the refuel position. It is also used if the probe is damaged and cannot be retracted. The RETR position returns the fuel system to normal transfer operation and retracts the probe.

42. The probe can be extended in an emergency by pneumatic pressure from the canopy air bottle by placing the PROBE—NORMAL/EMER EXT switch to EMER EXT. Once the switch has been so used it must be left at that position to prevent loss of utility pressure. The PROBE switch is on the engine control panel.

43. When the PROBE switch is placed in the REFUEL position, a REFUEL READY caption, on the telelight panel, comes on if the fuselage pressurisation and vacuum relief valve open properly. This ensures that the fuselage tanks are properly vented for refuelling. Wing transfer is discontinued.

44. A guarded ALL TANKS/INT ONLY switch on the fuel control panel controls the selection of tanks to be refuelled. The ALL TANKS position opens the external tank fuel shut-off valves when refuelling. The INT ONLY position closes the external tank fuel shut-off valves and allows only the internal tanks to be refuelled during air refuelling.

45. *IFR Probe Unlock Caption.* The IFR PROBE UNLOCK caption is on the telelight panel, and comes on when the probe is not fully retracted. The illumination of the caption also energises the MASTER CAUTION. The light circuit is completed through a limit switch within the probe latching actuator.

46. *Refuelling Probe Light.* A red light on the right side of the fuselage forward of the refuelling probe is used during night air refuelling operations to illuminate the refuelling probe and the drogue. The light is controlled by a 2-position OFF/ON switch on the exterior lights control panel. Variable intensity control is provided by a rotary IFR PROBE—DIM/BRIGHT switch on the same panel.

## NORMAL MANAGEMENT OF THE SYSTEM

### Fuel Supply System Operation

47. a. Operation of the fuel system is normally controlled through the fuel control panel. With no drop tanks carried the fuel transfer switch should be set to INT WING and the transfer pressure switch at NORMAL.

b. If drop tanks are carried set the fuel transfer switch to an appropriate external tank position. When the fuel in the selected drop tanks is depleted select the next position required on the rotary transfer switch. The L EXT FUEL, R EXT FUEL and CTR FUEL captions come on when the flow from the selected tanks is interrupted; therefore, the only indication of completed external transfer is the illumination of these captions accompanied by a decrease in internal fuel. When the external tanks are empty, the fuselage cells continue to supply fuel to the engine feed tank; however, internal wing fuel does not commence transferring until the transfer switch is turned to INT WING.

### Booster Pump Checks

48. Set the switch to L or R to check the appropriate pump. Any pressure outside the limits 28 to 50 PSI when checking a booster pump with the tank pressurisation off indicates a malfunction. If the tank pressurisation system is on, this pressure is increased by 4 PSI to 32 to 54 PSI. When operating at low speed the left pump pressure is approximately 8 PSI.

## MALFUNCTIONING OF THE SYSTEM

### Booster Pump Failure

49. a. Normally the indicated pump pressure exceeds 30 PSI with both engines at any power setting including maximum reheat. The gauge is powered by the Right Main 28 volt AC bus and is therefore inoperative on RAT power or with RH GEN OUT and BUS TIE OPEN captions on. The gauge falls to zero in the event of a failure.

b. *Single Pump Failure.* A single pump failure in the air is unlikely to be detected by reference to the pressure gauge. However, if the indicated pressure falls to below 20 PSI or it is known that a pump has stopped (eg either generator failed with BUS TIE OPEN caption on) then the following restrictions must be observed. Reheat may be used at any time except at speeds above 1·0M when below 10,000 feet or during negative-g manoeuvres. MIL power operation is not restricted.

c. *Double Pump Failure.* If both pumps fail or if pump pressure above 10 PSI cannot be obtained, reduce power to stabilise RPM and descend to 20,000 feet or below if practicable. Do not use reheat and do not exceed 1·0M. Switch the TRANS PRESS switch to ON to ensure that the tanks remain pressurised when the undercarriage is lowered. Engine malfunction or flameout is likely under negative-g conditions. Avoid sudden attitude changes and throttle movements.

50. *Operation of RAT Power.* If extended operation on RAT power is necessary, observe the double booster pump failure procedure and limitations.

### Transfer System Failures.

51. *Fuel Transfer Failures.* Fuel transfer failures may be caused by fuel system pressurisation failure or the failure of an associated shut off or transfer valve. Fuselage tank transfer failure is unlikely since both electric and hydraulic transfer pumps are provided. If fuel transfer to the fuselage fails, the tape and counter indications decrease and the difference between the two readings remains constant. The FUEL TRANSfer selector switch should be recycled and the fuel

TRANSfer PRESSure switch selected to ON. If the failure is rectified, the tape indication increases as fuel transfers to the fuselage tanks.

52. *Internal Wing Transfer Failure.* If one or both internal wing tanks fail to transfer it may be necessary to dump fuel to reduce AUW for landing. If the wing tanks fail to pressurise with DUMP selected the rate of fuel dumping is reduced.

53. *External Wing Tank Transfer Failure.* If one or both external wing tanks fail to transfer, the weight of fuel remaining in the tanks should be estimated when calculating the AUW for landing. The failure of only one tank to transfer presents an asymmetric wing loading which is apparent if the aircraft is manoeuvred. High g or AOA should be avoided. Part 2, Chapter 2 contains asymmetric load limitations. Part 3, Chapter 7 gives advice on flying with asymmetric loads.

54. *Centreline Tank Transfer Failure.* If the centreline tank fails to transfer, the weight of fuel remaining in the tank should be estimated when calculating the AUW for landing. It should be noted that failure of the TK light to illuminate may be caused by an incorrectly secured centreline tank electrical connection, in which case the centreline tank does not feed and is not jettisonable.

55. *Reverse Fuel Transfer.* Reverse fuel transfer is indicated by a rapidly decreasing tape indication. If the reverse transfer is to the internal wings the counter indicates steady or decreases at the normal rate. If the reverse transfer is to the external tanks the counter decreases at the same rate as the tape: The causes of reverse transfer are as follows:

a. *Reverse Transfer to the Centreline Tank.* Reverse transfer to the centreline tank may be initiated by the BUDDY FILL switch or by an open defuel valve. Booster pump pressure forces fuel from the engine fuel manifold through the open defuel valve to the centreline tank.

b. *Reverse Transfer to the Internal Wing Tanks.* Reverse transfer to the internal wing tanks may be caused by an open defuel valve and a failed open internal wing fuel level control valve. Booster pump pressure forces fuel from the engine fuel manifold through the open defuel valve to the internal wing tanks.

c. *Reverse Transfer to the External Wing Tanks.* Reverse transfer to the external wing tanks may occur if external wing tank pressurisation is lost (for example from combat damage). The pressure differential on the refuel/transfer fuel level control valves caused by fuselage tank pressure opens the valves and allows fuselage fuel to reverse transfer to the external wing tanks. A relief valve is provided in the refuel/transfer fuel level control valve to prevent a pressure differential from occurring, thus preventing reverse transfer.

56. *Actions in the Event of Reverse Transfer.* If reverse fuel transfer is suspected the immediate and subsequent actions listed in the FRC should be taken. These actions require both booster pumps to be shut down. The high speed pumps can be rapidly stopped by reverting to RAT power, if practicable, whilst the relevant booster pump circuit breakers are located and pulled.

57. *Air-to-Air Refuelling After Reverse Fuel Transfer.* If it is essential to refuel following a reverse fuel transfer malfunction, the recommended actions listed in the FRC should be complied with. These actions recommend initial refuelling with the FUEL TRANSfer selector set to STOP, the REFUEL selector set to INT ONLY, and the PROBE switch set to EXTEND. This allows the fuselage cells to fill and the internal wing tanks to accept fuel by reverse transfer if the refuelling level control valves are failed open. After filling the fuselage tanks, the internal wing tanks can be filled, if required, by use of the REFUEL position on the PROBE switch. If it is necessary to fill the external tanks, this can be accomplished after filling the internal tanks by use of the ALL TANKS position on the REFUEL selector.

### ◆ AAR Probe Malfunction

58. If the AAR probe does not transit smoothly out or in, it is possible that the mechancial linkage between the probe and the AAR probe door is faulty. In this situation avoid cycling the probe unless essential.

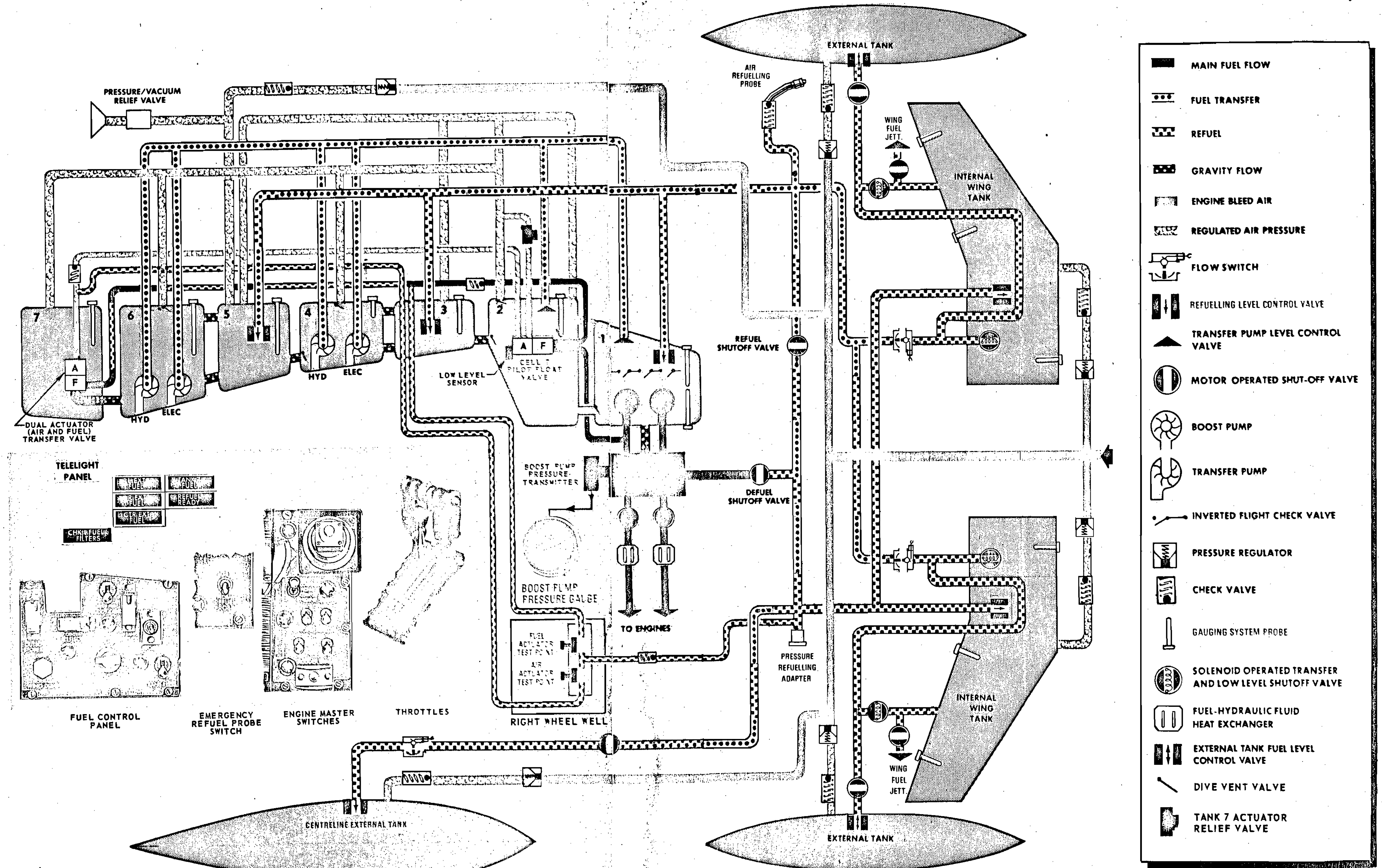
59. If the AAR probe door becomes detached in flight, leave the probe in the selected position. If the probe is out, select EXTEND on the PROBE switch to return the aircraft fuel system to normal operation. A probe door which becomes detached in flight is likely to damage spine panels and the stabilator or fin. ◆

### Total Electrical Failure

60. In the event of a double generator failure, a ram air turbine or emergency generator failure and a battery failure, neither external fuel tank transfer nor internal wing fuel transfer will be available irrespective of fuel control panel switch positions prior to the total electrical failure. External fuel tanks cannot be jettisoned nor can internal wing fuel be dumped. Usable fuel at the time of the complete electrical failure will be indicated by the tape on the fuel quantity gauge, therefore the pilot should time his remaining fuel to adjust gross weight for landing. The only available method for internal fuel transfer is the hydraulic transfer pumps. In the event of a subsequent Utility hydraulic system failure approximately 1500 lb of remaining fuselage tank fuel will not be available.

◆◆

*Intentionally Blank*




1—7 Fig. 2 Aircraft Fuel System, ~~pre-mod. 84~~

AL19

# PART 1

## CHAPTER 8 — HYDRAULIC, PNEUMATIC AND RELATED SYSTEMS

### Contents

## Illustrations



## HYDRAULIC SYSTEM

### General Description

1. Hydraulic power is supplied by three completely independent hydraulic systems. They are power control system one (PC1), power control system two (PC2), and the utility system. The systems have operating pressures of approximately 3000 PSI at any time the engines are running. The PC systems and utility system supply hydraulic pressure to the dual power control cylinders of the ailerons and spoilers. The stabilator is supplied by the PC systems.

2. Each PC system is completely independent of the other. The systems normally operate in tandem. However either system, operating alone, supplies sufficient power to control the aircraft.

3. The utility system supplies hydraulic pressure to the rudder power control cylinder, and to all other hydraulically-operated systems. Each system can be pressurised by an external hydraulic power source.

**Hydraulic System Caption and Pressure Gauges**

4. Hydraulic system pressure is shown on three gauges situated at the base of the pedestal panel; PC1 and PC2 pressures are registered on separate gauges, with the combined utility pumps pressure on a single gauge. A CHECK HYD GAUGES caption on the telelight panel is used by both PC systems and the utility system to indicate loss of hydraulic system pressure and to direct attention to the three hydraulic pressure gauges. The caption comes on when either:

a. Pressure in any one of the systems drops below 1500 ± 100 PSI and/or

b. Immediately either utility pump fails.

5. In all cases a loss of system pressure is shown on the applicable hydraulic pressure gauge. However, a failed utility hydraulic pump may not register a significant pressure drop on the utility pressure gauge.

6. Normally, if the caption illuminates but no noticeable pressure drop is apparent on the gauges, it can be concluded that the left utility pump has failed. If it illuminates in conjunction with a utility hydraulic pressure drop of 200 PSI the right utility pump has failed.

7. The MASTER CAUTION light comes on in conjunction with the CHECK HYD GAUGES caption and may be extinguished by pressing the reset button. The CHECK HYD GAUGES caption remains on until the pressure in the faulty system increases beyond 1750 PSI. Should a failure occur in one of the remaining hydraulic systems while the CHECK HYD GAUGES caption is already on, the MASTER CAUTION light does not come on again and the pilot is not alerted to the second failure.

8. The MASTER CAUTION light, and CHECK HYD GAUGES caption may come on momentarily when the landing gear is being lowered, due to high system demands.

**Utility Hydraulic Supply System**

9. Fluid is supplied to the utility pumps by an airless, pressure-loaded, piston type hydraulic reservoir that has a usable capacity of 1·53 gallons. The reservoir ensures positive hydraulic pressures and fluid supply at the suction ports of the pumps regardless of aircraft altitude or attitude.

10. The utility hydraulic system supplies hydraulic pressure to the:

Aileron Power Control Cylinders

Aileron Dampers

Aileron-Rudder Interconnect

Air-to-Air Refuelling Probe

Anti-skid

Arrester Hook (retraction)

Auxiliary Air Doors

Flaps (leading and trailing edge)

Fuel Transfer Pumps (hydraulic)

Landing Gear

Lateral Control Servo (Autopilot)

Nose Gear Steering

Pneumatic System Air Compressor

Radar Antenna Drive

Rudder Damper

Rudder Power Control Cylinder

Speed Brakes

Spoiler Power Control Cylinders

Variable Bypass Valve

Variable Engine Intake Duct Ramps

Wheel Brakes

Wing Fold (early aircraft only)

**Utility Hydraulic Pressure System**

11. The utility hydraulic system is pressurised to 3000 ± 250 PSI by two variable-volume, constant-pressure hydraulic pumps, one on each engine. To prevent the utility hydraulic pumps from resonating, check valves with different opening pressures are installed on the pump output lines. As a result, the left engine utility hydraulic pump delivers 2775 ± 225 PSI at idle RPM, while the right engine utility hydraulic pump delivers 3000 ± 250 PSI at idle RPM. A 50 cubic inch accumulator, pre-charged to 1000 PSI, operates as a pump surge suppressor and as a

limited source of hydraulic fluid and pressure when system demands exceed the output of the pumps. A pressure relief valve protects the system from pump surges, and limits pressure build-up to 3850 PSI by starting to relieve at 3250 PSI and becoming fully open at 3850 PSI. A pressure transmitter, for the utility hydraulic pressure gauge, is in a main pressure line. If either pump fails, the CHECK HYD GAUGES caption and MASTER CAUTION light come on. The hydraulic fluid is maintained at a usable temperature by two fuel-hydraulic fluid heat exchangers.

12. *Utility Hydraulic Pressure Gauge.* The UTILITY hydraulic pressure gauge is on the pedestal panel in the front cockpit. The gauge is calibrated within the range 0 to 5000 PSI and is marked 0 to 5 multiplied by 1000.

### Flight Control Hydraulic Systems

13. Hydraulic power for the flight control systems is provided by PC1, PC2 and utility hydraulic systems as described in Part 1, Chapter 9.

14. PC1 and PC2 systems are each supplied with fluid by independent airless, pressure-loaded, piston-type hydraulic reservoirs that have a usable capacity of 0·7 gallons. Each reservoir ensures positive hydraulic pressure and fluid supply to the associated pump suction port, regardless of aircraft altitude or attitude.

15. Each system is pressurised to 3000±250 PSI by a variable-volume, constant-pressure hydraulic pump driven by its associated engine. Each system supplies hydraulic pressure to one side of the dual power control cylinders of the ailerons, spoilers, and stabilator. A 50 cubic inch accumulator, precharged to 1000 PSI, operates as a pump surge suppressor and as a limited source of hydraulic fluid and pressure when system demands exceed pump output. A pressure relief valve protects each system from pressure surges, and limits pressure build-up by ◀starting to relieve at 3250 PSI and becoming fully▶ open at 3850 PSI. A pressure transmitter for the gauge is in a main pressure line. In the event of a loss of system pressure, the CHECK HYD GAUGES caption and MASTER CAUTION light illuminate. The hydraulic fluid is maintained at a usable temperature by a fuel-hydraulic fluid heat exchanger.

16. *Flight Control Hydraulic Pressure Gauges.* Two gauges, No 1 CONT and No 2 CONT, are on the pedestal panel in the front cockpit. Pressure transmitters, one for each system, convert pressure into electrical signals to the gauges, which are identical, and cover a pressure range of 0 to 5000 PSI (marked from 0 to 5 with readings multiplied by 1000).

## WING FLAP SYSTEM

### General Description

17. The wing flap system comprises 2-position leading edge flaps and 3-position trailing edge flaps. The system is operated by the utility hydraulic system. The leading edge flaps are on the centre and outer wing panels. Trailing edge flaps are on the inboard portion of the wing adjacent to the fuselage. Each flap has its own hydraulic actuator. The leading edge flaps are locked in the retracted position by overcentre linkages. Trailing edge flaps are locked in the retracted position by internal locks in the cylinders. A check valve is provided as an integral part of the selector valve to prevent unlocking of overcentre mechanisms and internal locks by back pressure in the return lines. A flow divider is provided to synchronise the trailing edge flaps. There is no synchronisation between leading edge flaps or between leading and trailing edge flaps.

### Wing Flap Switch

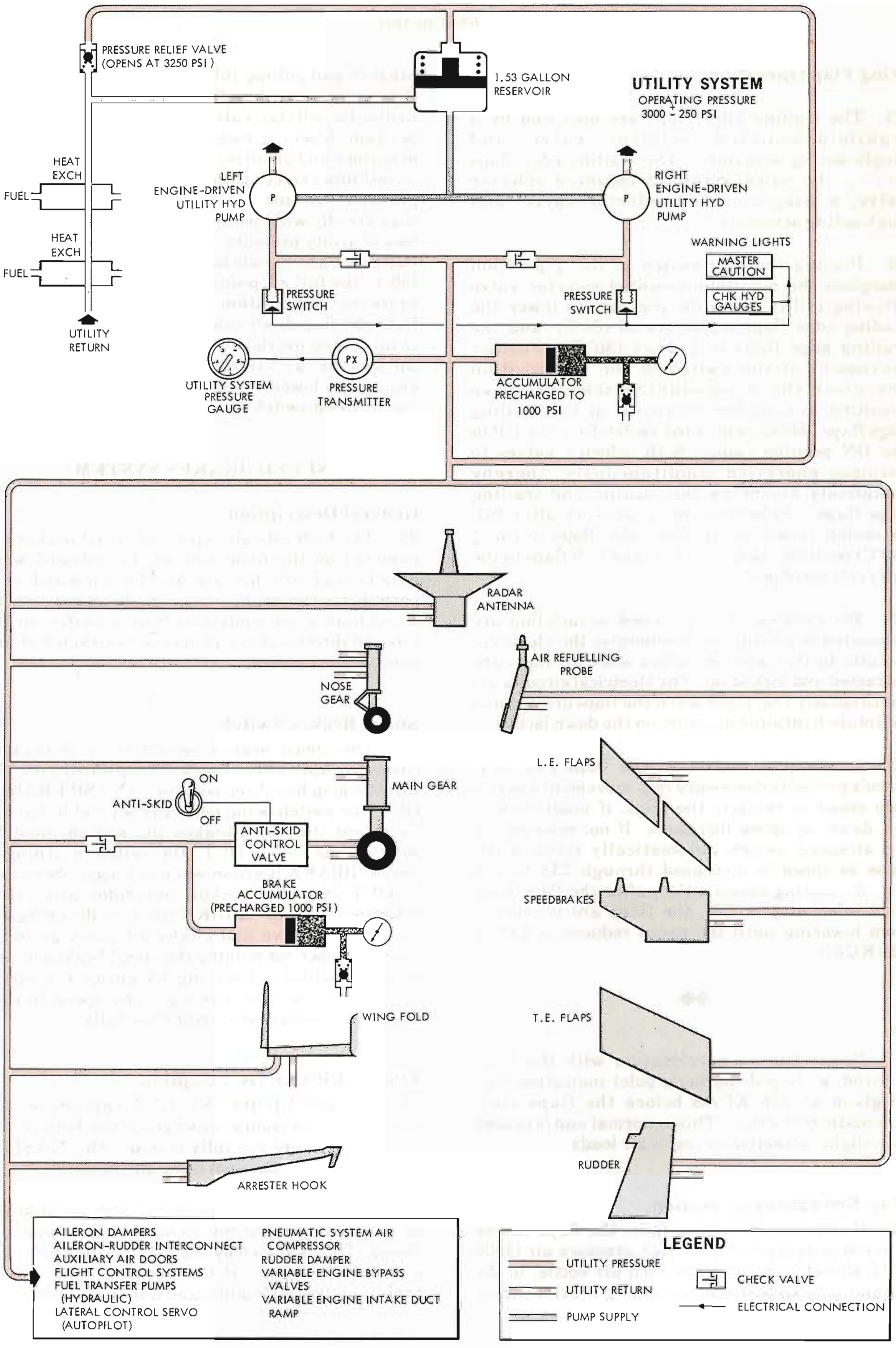
18. The leading and trailing edge flap switch is on the wing flap control panel, above the left console outboard of the throttles. The 3-position toggle switch is marked UP, ½ and DN and is shaped like an aerofoil for ease of identification. (See para 21 to 23.)

### Flap Position Indicator

19. The leading edge and trailing edge flap indicators are on the left vertical panels in both cockpits (dual control aircraft) or in the front cockpit (single control). The indicators operate in conjunction with position switches on the leading and trailing edge flaps. The position of the flaps is indicated by drum dials viewed through cutouts in the instrument panel. With flaps up, the word UP appears on the indicators; flaps in transit is indicated by stripes; half flaps is indicated by the fraction ½ appearing on the drum for the trailing edge flaps and DOWN for the leading edge flaps; with the flaps fully down the letters DWN appear for the trailing edge flaps, DOWN remaining on the other indicator.

### ◀WHEELS Caption ▶

20. The WHEELS caption on the upper left corner of the main instrument panel flashes any time the flaps are not fully up and the landing gear handle is in the UP position. An additional light in the landing gear handle comes on at any time the gear is unlocked or out of sequence with the handle.




1—8 Fig 1 Utility Hydraulic System

**Wing Flap Operation**

21. The leading edge flaps are operated by a manifold-mounted selector valve and single-acting actuators. The trailing edge flaps employ the same manifold-mounted selector valve, a wing-mounted selector valve, and dual-acting actuators.

22. Placing the flap switch to the ½ position energises the manifold-mounted selector valve allowing utility hydraulic pressure to lower the leading edge flaps to full travel (60°C), and the trailing edge flaps to ½ down (30°C). Further movement of the switch to the DN position energises the wingmounted selector valve resulting in complete extension of the trailing edge flaps. Movement of the switch from the UP to the DN position causes both selector valves to becomes energised simultaneously, thereby completely extending the leading and trailing edge flaps. Selecting the ½ position after full extension raises the trailing edge flaps to the ½ (30°C) position. Selecting Up raises all flaps to the fully retracted position.

23. The limit switches, provided on each flap, are connected in parallel to de-energise the electrical circuits to the selector valves after all flaps are retracted and locked up. The electrical circuits are continuously energised when the flaps are down to maintain hydraulic pressure on the down jacks.

23A. An airspeed switch in the flaps electrical circuit prevents downward flap movement above a safe speed or retracts the flaps, if inadvertently left down, as speed increases. If not selected up, the airspeed switch automatically retracts the flaps as speed is increased through 235 to 242 KCAS. During deceleration, after the flaps have been selected ½ or DN, the flaps are prevented from lowering until the speed reduces to 230 to 225 KCAS.

◆◆

Note: During acceleration with the flaps lowered, a striped (barber's pole) indication may be given at 235 KCAS before the flaps start automatic retraction. This is normal and is caused by a slight retraction owing to air loads.

**Flap Emergency Extension**

24. If the normal system fails, the flaps can be lowered pneumatically by high pressure air (3000 PSI), stored in a 300 cubic inch air bottle, to the normal ½ down position by tripping FLAPS circuit breaker and pulling full aft and down on the wing flap emergency handle. This causes the flap hydraulic selector valve to return to its full trail position, blocking hydraulic pressure to the flap actuators and ensuring that hydraulic fluid is not forced into the actuators on top of the pneumatic pressure. Should this occur, system hammering may result, with possible eventual rupture and loss of utility pressure. Once the emergency wing flap extension handle has been pulled, it should be left in the full aft position. Returning the handle to its normal position allows the compressed air from the flap down side of the actuating cylinder to be vented overboard, and the flaps to be blown up by the air-stream. During and after emergency lowering, the flaps are *not* protected by the airspeed switch.

## SPEED BRAKES SYSTEM

**General Description**

25. The hydraulically operated speed brakes are mounted on the underside of the inboard wing panels and are hinged on the forward side permitting the brakes to open downward. The speed brakes are controlled from a switch on the inboard throttle grip and may be positioned at any point of their travel.

**Speed Brakes Switch**

26. The speed brakes switch in each cockpit (front cockpit only, Block 34 upwards) on the throttle grip has three position: IN / SP BRAKE / OUT, the switch being normally set and left at IN. To extent the speed brakes the switch must be selected and held to OUT, the switch returning to the SP BRAKE position when released. Selection to OUT in either cockpit overrides any other selection. The SP BRAKE position de-energises the selector valve and blocks all ports giving a hydraulic lock for holding the speed brakes in any desired position. Selecting IN closes the speed brakes flush with the swing. The speed brakes take 2 to 3 seconds to open or close fully.

**SPEED BRAKE OUT Caption**

27. The SPEED BRAKE OUT caption on the telelight panel comes on when either both of the speed brakes are not fully closed. The MASTER CAUTION light does not come on.

28. The SP BRAKE position of the speed brake switch may not hold the speed brakes completely closed. This is shown by the SPEED BRAKE OUT caption coming on. If this occurs, set the speed brakes switch to IN and leave it in that position.

### Speed Brakes Emergency Closure

29. In the event of a hydraulic failure, air loads close the speed brakes to a low drag trail position. If a failure occurs in the throttle mounted switch, the speed brakes can be closed by tripping the SPEED BRAKE circuit breaker on the essential circuit breaker panel (front cockpit, right console). The speed brakes close automatically in the event of an electrical failure.

## LANDING GEAR SYSTEM

### General Description

30. A fully retractable tricycle landing gear, completely covered by flush doors when retracted, is provided. The gear is electrically controlled by the Right Main 28 volt DC busbar and hydraulically actuated by the utility hydraulic system. There is no tail bumper. Accidental retraction of the landing gear when the aircraft is on the ground is prevented by safety switches on the main gear torque scissors, and by ground safety locks.

### Main Gear

31. Each main gear is hydraulically extended and retracted. As the main gear retracts, the oleos are mechanically compressed and the wheels are automatically braked by the anti-spin system, which is relieved when the wheels lock up. Since the indicator microswitches are operated by the main landing gear doors, the D-doors must be closed to obtain a main gear UP indication. When the main gear is selected down, the oleos are mechanically extended by the time the gear is fully down. The main gear is held up by hydraulic pressure and mechanical locks, and is locked down by an integral hydraulic lock mechanism within the hydraulic jack. All main gear doors remain open when the gear is down.

### Nose Gear

32. The nose gear is hydraulically retracted and extended. The gear is locked in the down position by an integral down lock mechanism within the hydraulic jack. A hydraulically operated nose gear up-lock cylinder is located in the nose gear wheel well, and is employed in the system as part of the nose gear up-latch mechanism. The nose gear retracts aft into the fuselage and is covered by mechanically-operated doors which close flush with the underside of the fuselage, the indicator microswitch in this instance being operated by the nose gear leg. The forward door is attached to the nose gear strut, and closes with retraction; the aft door is operated and latched closed by the gear up-latch mechanism. The nose gear is equipped with dual nose wheels, a combination shimmy damper steering actuator and a self-centring mechanism. The nose gear can be steered by differential braking if nosewheel steering is not used.

### Landing Gear Control Handle

33. Operation of the landing gear is controlled by a handle at the left side of the front cockpit main instrument panel. The handle has a wheel-shaped knob for ease of identification. In the UP or down position it energises a solenoid valve to connect system pressure to the landing gear. Placing the handle in the gear up position operates switches in the fuel tank vent and pressurisation, jettison and armament circuits. A red warning light in the landing gear control handle comes on whenever the control handle is moved to retract or extend the gear and it remains on until the gear completes its cycle and locks.

### Emergency Control

34. Two 100 cubic inch air bottles provide sufficient compressed air to extend the gear pneumatically in the event of a hydraulic system failure. Pulling the landing gear control handle fully *aft* operates an air valve which directs 3000 PSI compressed air to open all gear doors, release the uplocks, and extend all gear.

### Landing Gear Position Indicators

35. The landing gear position indicators are on the left vertical panel in each cockpit (front cockpit only, Block 34 upwards), and operate in conjunction with position switches on the landing gear. The position of the landing gear is indicated by drum dials viewed through cutouts in the indicator. With gear up, the word UP appears on the three indicators; gear in transit is indicated by stripes; and with gear down a picture of a wheel is seen through the cutouts. The main gear D doors must be closed before an UP indication is obtained; nose gear position indication is not dependent on nose gear door position.

## NOSEWHEEL STEERING SYSTEM

36. An electrically-controlled, hydraulically-operated nosewheel steering system is provided. The steering actuator is on the nosewheel strut and geared to the strut torque collar; it is used for both steering and damping. The system is operated by utility hydraulic pressure and electrically controlled by the nose gear steering button on the control column grip. When this button is held down, with the main gear strut compressed and the nose gear down and locked, the system is energised and steering is effected by rudder pedal movement. The nosewheel steering system is limited to 70° each side of centre; the nosewheel casters through a greater angle, but the steering gear disengages. The steering response rate is a constant 12°/sec up to the limits of the steering system.

Note: The lower UHF antenna must not be used when it is intended to use nosewheel steering.

**WARNING:** The nosewheel steering system is to be used with caution and pilots are to disengage the system immediately if any unscheduled steering commands are detected. If the nosewheel steering system is found to be unserviceable, it is not to be re-engaged.

## WHEELBRAKES SYSTEM

### General Description

37. The main wheelbrakes are operated hydraulically for normal use and pneumatically for emergency use. Two power brake valves in the nosewheel well are operated by a linkage attached to the rudder pedals. The brake control valves are power-operated. Excessive pedal travel and pumping of the brakes in order to obtain a firm pedal is eliminated since the fluid supply to the wheel cylinders is virtually unlimited. The nosewheel is not fitted with brakes.

### Hydraulic Wheelbrake Systems

38. Normal wheel braking is initiated by pressing the toes of the rudder pedals. This action is mechanically transmitted to the brake control valves, compression of which results in utility system fluid being passed via the de-energised anti-skid control valve to the brakes at a pressure proportional to the force applied. The system provides progressive differential braking.

39. If utility pressure is lost, emergency braking is provided by:

a. A 25-cubic-inch hydraulic accumulator which provides pressure for approximately seven normal brake applications.

b. Utilising the brake control valves as master cylinders. Considerable movement of the brake pedals is necessary before the manual system becomes effective. Braking is proportional to the force applied, this force being greater than that required for normal braking. The manual system provides differential braking and should be capable of stopping the aircraft on a standard runway, provided the brake parachute is used.

c. The emergency pneumatic system, completely independent of the hydraulic system, which provides non-differential braking.

40. When landing gear is retracted, with the weight of the aircraft off the gear, utility hydraulic pressure at 1300 PSI is applied to the wheelbrakes to stop wheel spin. Pressure is released when the landing gear is fully locked up.

41. Each main landing wheel contains three fuse plugs to protect against tyre explosion. If the brakes are used excessively, causing overheating of the wheels and tyres, the fuse plugs melt and deflate the tyre before a tyre explosion occurs.

### Emergency Pneumatic Wheelbrake System

42. An emergency pneumatic brake system is provided and is entirely separate from the hydraulic brake system. A 100-cubic-inch air bottle is charged to 3000 PSI by the pneumatic system and permits up to ten full applications by the EMERgency BRAKE handle just inboard of the right console in the front cockpit. It is spring-loaded to the off, or brake release, position. The EMERgency BRAKE handle when operated, meters compressed air to the pneumatic brake cylinders in proportion to the handle movement. Operation of the handle applies braking equally to both wheels, and there is no differential braking. Use of the emergency pneumatic system does not introduce air into the hydraulic system. Post-mod 54, a pressure gauge is provided adjacent to the right vertical panel to indicate residual air bottle pressure during ground handling.

Note: There is a delay of about 2 seconds from the operation of the EMERgency BRAKE handle to effective wheel braking.

### Anti-Skid System

43. The anti-skid system detects the rate of wheel deceleration during braking and then adjusts the hydraulic pressure to the brakes, through the action of the anti-skid control valve, before the wheel becomes ◆ locked. The anti-skid system takes effect when a wheel deceleration greater than 20ft/sec$^2$ is detected provided that the ground speed is greater than 15 knots. With the anti-skid in operation, the brake pedals pressed and wheel deceleration below 20ft/sec$^2$, the control valve allows normal braking (as described in para 38). When a rate of deceleration greater than 20ft/sec$^2$ is detected at *either* wheel, the control valve reduces pressure at *both* wheelbrakes. As the wheel deceleration returns to normal, the control valve restores brake pressure at a reduced level. This cycle continues, giving maximum ◆ braking action for the runway conditions, until the brake pedals are released. The system also has a locked-wheel memory circuit which has 2 functions:

a. It completely removes brake pressure from both wheels when one wheel is locked, thus allowing the wheel to spin again and become subject to anti-skid protection.

b. If the wheel remains static after the removal of all brake pressure, as it could in a severe aquaplaning situation, brake authority is restored to the pilot, at the expiry of locked-wheel memory time, without anti-skid protection. (See Part 3, Chapter 3 for advice in aquaplaning situations.)

Locked wheel memory time is dependent upon aircraft groundspeed. The faster the wheel was rotating immediately before it stopped, the longer the pressure is removed from the wheel to allow it to spin up again.

44. The anti-skid system is controlled by a 2-position ANTI-SKID switch, marked ON and OFF, which is located on the pilot's left console. Adjacent to the switch is an ANTI-SKID OFF caption. For the anti-skid to operate, the following conditions need to be satisfied:

a. ANTI-SKID switch ON.

b. ANTI-SKID OFF caption out.

c. Groundspeed greater than 15 knots.

◆ d. Either wheel decelerating at more than 20ft/sec². ◆

Unless all these conditions are met, the anti-skid system does not operate and normal braking is available without anti-skid protection. Therefore, if the aircraft is accelerating or is at a constant velocity when the brakes are applied, there is no anti-skid ◆protection until either wheel is decelerating at◆ 20 ft/sec² or more. Similarly, as the speed reduces through 15 knots during landing roll, the anti-skid protection cuts out and pressure is applied in proportion to the pilot's effort on the brake pedals: apply brakes carefully in this region to avoid skidding.

45. *Anti-Skid Testing.* When the ANTI-SKID switch is ON and the landing gear is lowered, or when the switch is moved to ON when the gear is down, the system carries out an automatic self test. This test includes, in part, the application of a simulated skid signal to both wheel sensors which interrupts, momentarily, any brake pressure the pilot may be applying, eg when stationary and the switch is put ON. As the gear is lowered, or when the switch is selected ON with the gear down, the ANTI-SKID OFF caption flashes momentarily as the self test is carried out. In addition, failure detection circuitry constantly monitors the operating voltages in the control valve. If the system fails either the self test or the continuous check, the ANTI-SKID OFF caption comes on and only normal braking is available.

46. *ANTI-SKID OFF Caption.* The ANTI-SKID OFF caption cannot come on unless the landing gear is down. With the ANTI-SKID switch ON, the caption comes on when the system has a malfunction. It does not come on when the system is inoper-◆ative because groundspeed is below 15 knots or when wheel deceleration is not as great as 20 ft/sec². The anti-◆ skid system is normally switched OFF for taxying since cycling of the system at 15 knots may cause a malfunction, bringing on the caption. Normally, however, with the system selected ON and serviceable, the caption remains out when stationary and at all taxying speeds.

47. *Emergency Disengage Lever (Paddle Switch).* The paddle switch, when held pressed, disengages the anti-skid system as well as AFCS and ARI. The ANTI-SKID OFF caption comes on but the light goes out and the anti-skid system re-engages if the paddle switch is released.

## WING FOLD SYSTEM

Note: Early aircraft, up to and including XV 417 (Blocks 31 to 34) have a hydraulic wing fold system. On later aircraft, XV 418 to 501, inclusive, the wings are folded mechanically.

### Description

48. On aircraft with hydraulic wing fold, each outer wing panel is folded upward and inboard by a conventional hydraulic actuator which receives hydraulic pressure from the Utility hydraulic system. A mechanical locking system is installed in the aircraft to lock wing pins in hinge fittings when wings are spread. A flush mounted control shaft on the lower surface of each wing inboard of the wing fold line, is connected to a pin locking device in the wing fold area. A hole in the lower wing surface provides access to the control shaft, which is rotated by a screwdriver. Turning the lever anti-clockwise unlocks wing pins, extends red warning indicators in the upper wing surfaces, brings on the L and R WING PIN UNLOCKED captions and operates a microswitch to complete the circuit for the electrical folding operation.

49. Folding is accomplished by operating a 2-position toggle switch in the left wheel well. The switch is marked FOLD and SPREAD. As an added safety precaution, the wing fold hydraulic circuit receives its hydraulic pressure from the landing gear down pressure line; this prevents pressurisation of the wing fold circuit when the landing gear is up.

50. On aircraft without hydraulic wing fold, once the wings have been unlocked they have to be manually folded. The wing fold switch and hydraulic jacks are deleted. WING PIN UNLOCKED telelight captions are not provided.

**WARNING:** On aircraft without hydraulic wing fold the indicator pins in the upper wing surfaces are the *only* positive indication of wing status. The warning indicator(s) are flush with the wing surface when the wing(s) are locked and are proud of the wing(s) upper surface when the wing(s) are unlocked.

## ARRESTER HOOK SYSTEM

### Description

51. The arrester hook system consists of an arrester hook, a combination hydraulic jack and dashpot, a mechanical uplatch, and a control handle. The forward end of the arrester hook is pivoted in a manner which not only permits up and down movement, but left and right motion as well. Coil springs keep the hook centred for retraction. It is retracted by a hydraulic jack, and is caught and held by a mechanical uplatch. It is extended by the pneumatic action of the dashpot and its own weight. The hook is controlled by a handle on the right side of the front cockpit instrument panel. The handle and the uplatch mechanisms are joined by a control cable. In the event of a cable failure, the hook lowers.

### Arrester Hook Operation

52. When the handle is pushed down the uplatch is released and the arrester hook is extended. Placing the handle in the up position energises a solenoid valve which directs utility hydraulic pressure to the cylinder. A red warning light inside the handle comes on when the hook is not fully locked up and remains lit until the hook is fully retracted; it is not a positive indication that the hook has lowered fully.

## BRAKING PARACHUTE SYSTEM

### Description

53. A 16-foot ring slot parachute provides braking after touchdown to reduce landing distances. It may also be used for spin recovery. The chute is controlled by means of a control handle inboard of the front cockpit left console; when pulled to its full extent the handle engages in a detent. A cable joins the handle, the release and jettison mechanism and the door latch mechanism. There is a braking parachute release button beneath the control handle which allows the handle to be returned to its normal position. The chute is carried in a compartment at the base of the fin.

### Operation

54. To deploy the brake chute, rotate the control handle fully aft, ensuring the release button is not pressed and that the handle engages in its detent. This releases the door latch mechanism and a spring-loaded actuator opens the braking parachute door. At the same time a hook lock is positioned over the chute attaching ring. The opening of the braking parachute door allows the spring-loaded pilot chute to open and pull the braking parachute from its housing. To jettison the chute, pull aft on the control handle to clear the detent, press the release button and lower the handle. The release and jettison mechanism then returns to the normal position, allowing the chute to fall free. When deploying the chute, care must be taken not to release the handle before it is engaged in its detent, otherwise the chute will be released and pull free. Similarly, pressing the release button during the deployment action will not allow the mechanism to engage in the detent and the chute will drop away when the handle is released. If the compartment door should open without control handle authority, the chute will stream and fall away.

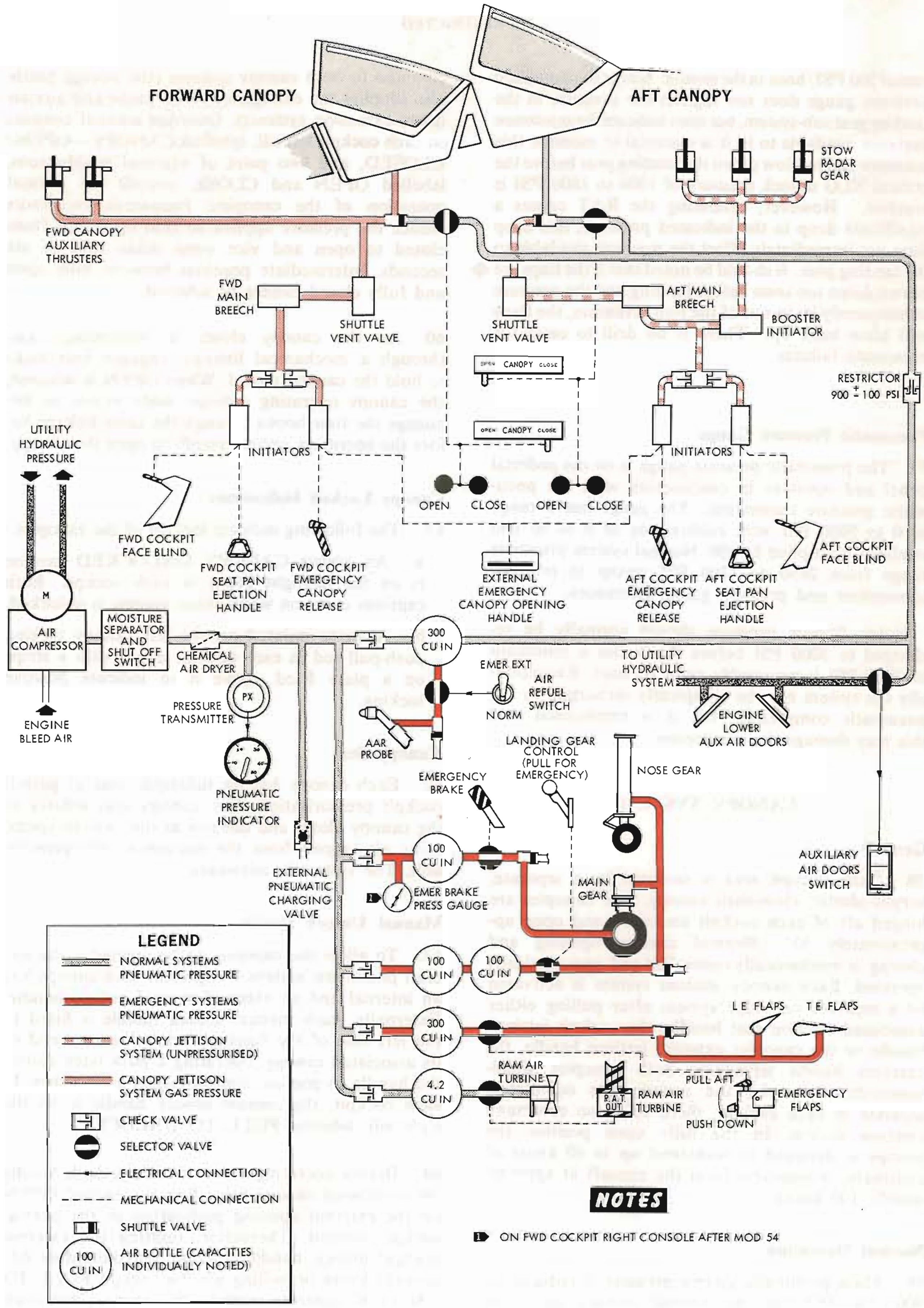
## PNEUMATIC SYSTEM

### General Description

55. The pneumatic system (see Fig 2) provides high pressure air for the normal operation of the canopies and the ram air turbine (out and in), and also provides for the emergency operation of the landing gear (down only), the flaps (to $\frac{1}{2}$), the wheel brakes, the forward aux-air doors (open) and the AAR probe (extension). Air for the pneumatic system is tapped from the engine bleed air supply, via the electronic equipment air conditioning system, and is compressed to approximately 3000 PSI by an air compressor which is driven by a hydraulic motor. A pneumatic pressure sensor in the system moisture separator opens a hydraulic shutoff valve, to operate the air compressor, when the system pressure falls below approximately 2750 PSI. When the pneumatic system pressure builds to 3100 $^{+100}_{-50}$ PSI the pneumatic pressure sensor closes the hydraulic shutoff valve which shuts down the air compressor. The air compressor discharges through a moisture separator and chemical air dryer to the pneumatic system air bottles. Check valves prevent the air bottles from discharging back to the air compressor. Shutoff valves isolate the air bottles from their component systems until they are manually discharged. A pressure transmitter, for the pneumatic pressure indicator, is in a main pressure line.

**WARNING:** Use of the emergency pneumatic system with a serviceable utility hydraulic system could lead to a complete utilities failure if shuttle valves within the utilities system fail to operate correctly.

56. Following a complete utility hydraulic system failure the pneumatic system ceases to be continuously 'topped up'. There is a maximum acceptable leak ◆




PH 4884

**1 – 8 Fig 2 Pneumatic System**

◆ rate of 500 PSI/hour in the system. Since the pneumatic pressure gauge does not register the pressure in the landing gear sub-system, but does indicate the *minimum* pressure available to it, it is essential to monitor this pressure and to blow down the landing gear before the critical NLG unlock pressure of 1500 to 1800 PSI is reached. However, extending the RAT causes a significant drop in the indicated pressure; this drop does not immediately affect the pressure available to the landing gear. It should be noted that if the flaps are ◆ blown down too soon before landing and the pressure subsequently leaks out of the flap actuators, the flaps will blow back up. There is no drill to cater for pneumatic failures.

**Pneumatic Pressure Gauge**

57. The pneumatic pressure gauge is on the pedestal panel and operates in conjunction with the pneumatic pressure transmitter. The gauge has a range of 0 to 5000 PSI with calibrations of 0 to 50 and readings multiplied by 100. Normal system pressures range from 2650 to 3300 PSI owing to pressure transmitter and pressure gauge tolerances.

Note: System pressure should normally be recharged to 3000 PSI before flight, but a minimum of 2000 PSI is acceptable prior to start. Exceptionally the system may be completely recharged by the pneumatic compressor, but it is emphasised that this may damage the compressor.

## CANOPY SYSTEM

**General**

58. Each cockpit area is enclosed by a separate, acrylic-plastic, clam-shell canopy. The canopies are hinged aft of each cockpit enclosure and open approximately 53°. Normal canopy opening and closing is mechanically controlled and pneumatically operated. Each canopy jettison system is activated by a separate cartridge system after pulling either associated ejection seat handle, the cockpit jettison handle or the canopies external jettison handle, the external handle jettisoning both canopies simultaneously. Otherwise the systems are completely separate in each cockpit, there being no command ejection system. In the fully open position the canopy is designed to withstand up to 60 knots of airstream; it separates from the aircraft at approximately 100 knots.

**Normal Operation**

59. Main pneumatic system pressure is reduced to 900 ± 100 PSI for the normal canopy operating system, and is stored in a 300 cu in storage bottle common to both canopy systems (the storage bottle also supplies the emergency AAR probe and aux-air doors extension systems). Guarded manual controls on each cockpit left sill, labelled CANOPY—OPEN/CLOSED, and two pairs of external pushbuttons, labelled OPEN and CLOSE, control the normal operation of the canopies. Pneumatic restrictors reduce the pressure applied so that operation from closed to open and vice versa takes four to six seconds. Intermediate positions between fully open and fully closed cannot be selected.

60. As the canopy closes, a sequencing cam, through a mechanical linkage, engages four locks to hold the canopy closed. When OPEN is selected, the canopy operating cylinder body moves to disengage the four hooks through the same linkage before the operating piston extends to open the canopy.

**Canopy Locked Indications**

61. The following indicate locking of the canopies:

a. An amber CANOPY UNLOCKED caption is on the telelight panel in each cockpit. Both captions come on when either canopy is unlocked.

b. A stripe painted on the left canopy locking push-pull rod in each cockpit aligns with a stripe on a plate fixed above it to indicate positive locking.

**Canopy Seal**

62. Each canopy has an inflatable seal to permit cockpit pressurisation. The canopy seal inflates as the canopy closes and deflates as the canopy opens, using air tapped from the equipment refrigeration unit. The system is automatic.

**Manual Unlock System**

63. To allow the canopies to be opened if the aircraft pneumatic system is depleted, each canopy has an internal and an external manual unlock handle. Externally, each manual unlock handle is fitted to the left side of the fuselage below the rear end of its associated canopy; operating a push latch causes the handle to pop out approximately 1·75 inches. In each cockpit, the manual unlock handle is on the *right* sill, labelled PULL TO UNLOCK.

64. Before operating either manual unlock handle the associated canopy must first be selected OPEN on the external opening pushbutton or the normal cockpit control. Thereafter, rotating the external manual unlock handle through approximately 63° anti-clockwise or pulling aft the cockpit PULL TO UNLOCK control, releases the canopy downlock mechanism and allows for canopy to be lifted open

manually. If there is no pressure in the pneumatic system, the canopy does not remain open without manual restraint.

### Canopy Jettison

65. Each cockpit has an independent, self-contained emergency system for jettisoning its canopy. The two systems are identical except that, in the front cockpit, there are two auxiliary thrusters which lift the canopy from its sills to ensure jettison under any conditions of speed, altitude and attitude; in the rear cockpit the jettison system also operates the cockpit equipment stowage system.

66. Operating either ejection seat handle through the first part of its travel, or pulling aft the yellow and black striped canopy jettison lever on the *left* sill (labelled PULL TO JETTISON), fires either a seat-mounted or cockpit initiator. Either initiator fires a main cartridge and the resultant gas pressure, after passing through a shuttle vent valve and a shuttle valve, acts on the normal canopy. In the front cockpit the auxiliary thrusters also push the canopy up approximately two inches; in the rear cockpit, the cockpit equipment stowage system operates. As the canopy opens beyond its normal 53° under gas and slipstream pressure, the hinge pins and piston-rod-end pin all shear and the canopy is free of the aircraft structure.

67. *Equipment Stowage System.* The rear cockpit canopy jettison system retracts the radar scope, radar set controls and hand controller to provide adequate space for ejection from the cockpit.

68. *Canopies External Jettison.* The canopies external jettison system is activated by a lanyard underneath an access panel on the lower left side of the fuselage, just forward of the nosewheel door. Pulling the lanyard operates both cockpit initiators and both canopies are jettisoned simultaneously.

## NORMAL MANAGEMENT OF THE SYSTEMS

### Landing Gear Operation

69. To lower the landing gear, push the handle down. A red warning light in the control handle knob comes on and stays on until all three legs are fully extended and locked. To raise the gear, lift the landing gear handle; the warning light again comes on until the landing gear is up and locked. Once a selection has been made, an opposite selection is not to be made until the cycle is complete. Maximum permissible airspeed for flight with the landing gear lowered and for operation of the landing gear is 250 KCAS.

Note: It is important to maintain a forward pressure on the handle when it is used to prevent inadvertent operation of the emergency pneumatic system.

### Wheelbrake Operation With Anti-Skid

70. With the ANTI-SKID switch ON, the ANTI-SKID OFF caption out, a groundspeed greater than 15 knots and a wheel deceleration greater than 20 ft/sec$^2$, the anti-skid unit prevents the wheels from locking when excessive pressure is applied at the brake pedals. Therefore, with the anti-skid system in operation and the groundspeed below the limit for maximum continuous braking, the pilot is at liberty to apply as much brake pedal force as he wishes during a landing run, irrespective of runway conditions (but see Part 3, Chapter 3 for advice concerning extreme runway conditions). However, unless the shortest possible runway landing run is required, a more gentle application of braking effort is recommended. Bear in mind that below 15 knots the anti-skid system becomes inoperative and direct brake pressure, proportional to pedal force, is transmitted to the wheels. If the ANTI-SKID OFF caption comes on during the landing ◆roll, or there is no braking felt, release the brakes, switch ◆ OFF the anti-system and revert to braking without anti-skid.

Note 1: Switch OFF the anti-skid for taxying to avoid cycling of the system as the groundspeed passes through 15 knots.

Note 2: With the anti-skid system serviceable and switched ON, anti-skid protection is not provided until either wheel is decelerating at more than 20 ft/sec$^2$. It is therefore possible, for instance in an aborted take-off situation, to apply brakes hastily and powerfully before anti-skid protection is available, causing excessive wear or flats on the tyres and a danger of tyre burst before anti-skid control comes into operation.

### Wheelbrakes Operation Without Anti-Skid

71. For all conditions, the most desirable braking technique is a single, smooth application of the brakes with a constantly increasing pedal or handle application as the aircraft decelerates. In the event of a reduction in retardation being felt while exercising maximum braking, pedal force must be fully released in order to allow the skidding wheels to regain full rolling speed before further application of brakes.

72. Rough runways tend to emphasise the skid or bounce characteristics of the aircraft which are caused by relatively stiff struts. To preclude the possibility of locking a wheel while momentarily off the ground, use light braking until the aircraft is solidly on the ground and all skipping has ceased.

73. Peak temperatures occur in the wheel brake assembly from 5 to 15 minutes after maximum braking. To prevent brake fire and possible tyre explosion, it is recommended that a minimum of 15 minutes elapses between landings where the landing gear remains extended in the airstream, and a minimum of 30 minutes between landings where the landing gear has been retracted, to allow sufficient time for cooling. Additional time should be allowed for cooling if brakes are used for steering, crosswind taxying operation, or a series of landings.

**Wing Fold System Operation**

74. Whenever the aircraft is parked or towed with wings folded, jury struts must be installed. Taxying with wings folded and jury struts not installed must be kept to a minimum. Normal operation is accomplished through the wing fold panel in the left wheel well.

75. To fold the wings, turn the manual pin lock control shaft in each wing anti-clockwise and place the wing fold switch in the FOLD position. To spread the wings, remove the jury struts and place wing fold switch in the SPREAD position. After the wings have spread and pins have extended, turn the manual pin lock shafts clockwise. Red warning indicators which are attached to the wing pin locks are flush with the wing skin if the wing pin locks are fully inserted. The indicators extend above the wing surface, inboard of the wing fold line, when the wing pin locks are not inserted. When the wing pin locks are fully inserted the L WING PIN UNLOCK and R WING PIN UNLOCK captions are out. On aircraft with manual wing fold, care must be taken to avoid folding the wings too far and caution must be exercised when removing the jury struts from folded wings, in both cases to avoid structural damage.

Note: The wings must not be folded or spread in winds over 60 knots or in the jet blast of other aircraft.

**Arrester Hook Operation**

76. To lower the hook, put the control handle down. The warning light comes on when the hook is unlocked, and remains on even in the fully down position. To retract the hook, raise the handle and observe the warning light which goes out when the arrester hook is fully retracted. Lowering should be complete within five seconds and raising within 13 seconds.

**Braking Parachute Operation**

77. The braking parachute is deployed by rotating the control handle aft until the detent is reached. Maximum airspeed for deployment is 200 KCAS. To jettison the chute, rotate the handle further aft to clear detent, press the thumb button and then rotate the handle fully forward.

**Canopy Operation**

78. Normal operation of the canopies is accomplished by either the external or internal controls.

**WARNING:** After landing, the canopy must not be opened if a loose article is suspected. In this case a thorough inspection of the ejection seat and canopy activating mechanism is to be carried out by qualified personnel prior to opening the canopy. Aircrew must remain fully strapped in until the aircraft is at rest and the canopy fully open.

79. When closing the canopy the EMERG VENT knob must be out until the canopies are closed and locked. Attempted canopy closure with the EMERG VENT knob in, especially with the RPM above idle, may result in the canopy not locking fully owing to the back pressure caused by the cockpit pressurisation system.

**WARNING:** If the canopy closing time exceeds 9 seconds the canopy rigging must be inspected by the groundcrew before flight.

Note: The canopies must be either fully open or fully closed during taxying. Although the canopies are cleared to remain fully open at speeds up to 60 knots, taxy speed should be kept well below this figure. Surface wind speed must be allowed for when taxying with the canopy open.

## MALFUNCTIONING OF THE SYSTEMS

**Emergency Lowering of the Flaps**

80. The emergency flap lowering drill is contained in the FRC. Some loss of lateral control may occur if the flaps lower asymmetrically, but lateral control is restored once the flaps have extended. For this reason, if a double utilities and single PC failure occurs, only blow down the flaps when no approach-end cable is available, ensuring that the emergency selection is made at a safe height (above 5000 feet AGL).

**Landing Gear Emergency Lowering**

81. If normal operation fails, the landing gear can be lowered by pushing the landing gear handle down, tripping the landing gear circuit breaker and then pulling aft on the landing gear handle. The landing gear circuit breaker must be tripped prior to lowering the gear by the emergency system.

82. Hold the handle aft until the gear indicates down and locked. Do not retract the landing gear following an emergency extension. If the landing gear is inadvertently extended in flight by emergency pneumatic pressure, it must be left in the extended position until post-flight servicing. If retraction in flight is attempted, rupture of the utility reservoir will probably occur with subsequent loss of the utility hydraulic system.

83. After operation, leave the landing gear handle in the full aft position. Returning the handle to its normal position allows the compressed air from the gear down side of the actuating cylinder to be vented overboard. In this condition the main landing gear hydraulic jack mechanical latch is the only device preventing the landing gear from collapsing upon landing.

**Use of the Wheelbrakes Emergency Pneumatic System**

84. After a utility hydraulic system failure, anti-skid protection and nosewheel steering are lost and an approach-end cable engagement is normally made. However, the aircraft can be stopped after landing by using brake accumulator pressure if no arresting gear is available. There are approximately seven full brake applications available from the accumulator. Apply the brakes progressively to reduce speed and differentially, as necessary, to keep straight. Avoid a pumping action which rapidly depletes the accumulator. Should the brake accumulator be exhausted before the landing run is complete, use pneumatic brakes to stop the aircraft and manual hydraulic braking to steer (see para 39). It is emphasised that there is a time lag between easing back the pneumatic brake handle and resultant braking action; having applied pneumatic brake pressure, wait and assess the braking ◆action before applying more pneumatic brake. ◆

**Emergency Operation of the Arrester Hook**

85. If the hook fails to extend when the control handle is placed in the down position, the hook-up limit switch has probably failed to de-energised the solenoid-operated selector valve. To de-energise the solenoid selector valve, trip the hook control circuit breaker T-2 (blue) on the No 2 circuit breaker panel. Utility hydraulic pressure is then removed from the up side of the hook hydraulic jack and the hook extends. There are no provisions for arrester hook retraction in the event of a utility hydraulic failure or double generator failure. See Part 4, Chapter 2 under **Cable Engagement** for further advice on emergency lowering of the arrester hook.

**Landing With Anti-Skid Failure**

86. If the ANTI-SKID INOPERATIVE caption fails to go out when the ANTI SKID switch is selected to ON during the **Checks Before Landing,** check that the ARI circuit breaker is made and recycle the ANTI SKID switch. If the caption remains on, switch OFF the ANTI SKID switch and consider an approach-end engagement. Avoid heavy braking.

*Intentionally Blank*

# PART 1

# CHAPTER 9 — FLIGHT CONTROL SYSTEM

## List of Contents



## Illustrations



## FLIGHT CONTROL SYSTEM

### General Description

1. The flight control system is hydraulically operated, the control surfaces being moved by irreversible hydraulic power cylinders to provide control effectiveness throughout the entire speed range. The flight controls are supplied with hydraulic pressure as follows:

| | |
|---|---|
| Left spoiler, left aileron | PC1 and Utility Systems |
| Right spoiler, right aileron | PC2 and Utility Systems |
| Stabilator | PC1 and PC2 |
| Rudder | Utility System |

## Lateral Control System

2. The lateral control system, an aileron/spoiler combination, consists basically of:

Control column
Left and right push–pull rods
Left and right override spring cartridges
Left and right walking beam bellcranks
Aileron dual power cylinders and control valves
Spoiler dual control valves
Left and right aileron dampers
Autopilot series servos
Lateral feel trim actuators

3. The ailerons travel downwards 30 degrees from the full trail position. Upward travel is limited to 1 degree. The spoilers travel upwards 45 degrees from a flush contour position in the upper wing surface. Lateral movement of the control column is transmitted mechanically by the push–pull rods through the walking beam bellcranks to the spoiler dual control valves and the servo valve section of the aileron power cylinders. The spoilers travel upwards 45 degrees from a flush contour position in the upper wing surface. Lateral movement of the control column is transmitted mechanically by the push–pull rods through the walking beam bellcranks to the spoiler dual control valves and the servo valve section of the aileron power cylinders. The servo valves meter hydraulic fluid to their respective dual power control actuators in proportion to the mechanical displacement. An override spring cartridge is incorporated into the left and right push–pull rod systems. If one side becomes jammed, the override spring may be deflected by applying a considerable force through the control column, allowing operation of the other lateral control surfaces. The walking beam bell–cranks receive control surface movement inputs from three sources:

The control column

The lateral trim system

The autopilot series servos

4. A hydraulic damper, attached to the aileron backup structure, operates as an up-stop for the aileron as well as a flutter damper. The control system uses dual power cylinders to allow simultaneous use of all three hydraulic systems. In the event of a single hydraulic system failure, the other two systems supply adequate power for control.

## Aileron Control

5. The ailerons are controlled by dual, irreversible, power cylinders which receive metered hydraulic fluid from dual integrated control valves. The control valves, in turn, are controlled by the push–pull rods, through the walking beam bellcranks and control column.

6. Each power cylinder contains four parallel inner cylinders with rods and pistons. The piston rods are joined at one end by a yoke which is attached to the aircraft structure. The cylinder portion of the power cylinder is attached to the aileron. For the right aileron, the inner cylinders are powered by utility pressure and the outer cylinders by PC2. For the left aileron, the inner cylinders are powered by PC1 and the outers by utility pressure. This arrangement provides symmetrical loading of the yoke should one of the power control systems fail.

## Spoiler Control

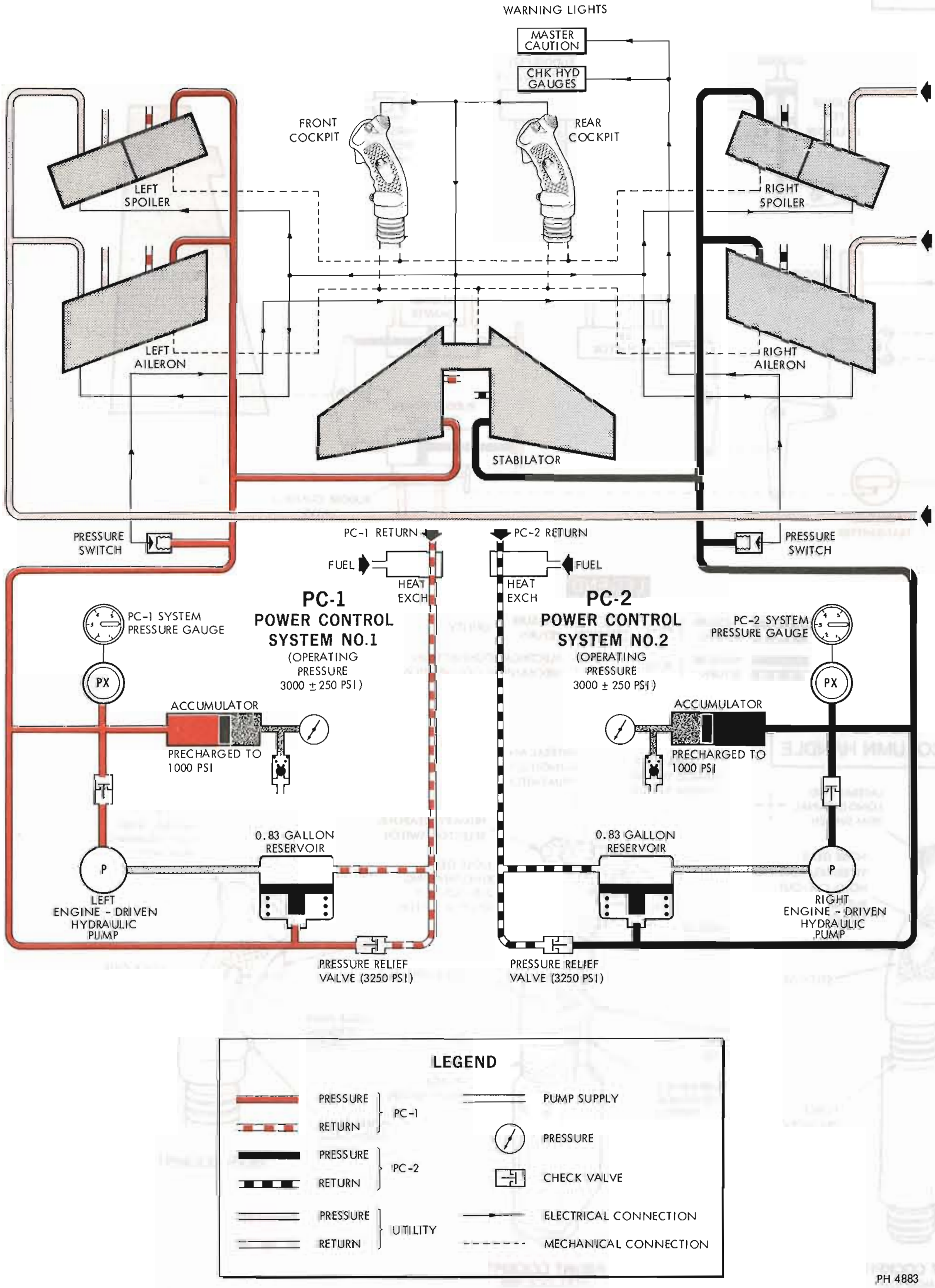
7. Each wing contains two spoiler surfaces. Each surface has a dual, irreversible power cylinder, with a feedback linkage to a dual spoiler control valve. The spoiler control valve divides each power control system input into equal parts which is then distributed to each spoiler dual power cylinder. One portion of the right spoiler power cylinder receives PC2 pressure and one portion of the left cylinder receives PC1 pressure. The remaining portions of the cylinders receive utility pressure.

## Lateral Control Feel and Trim System

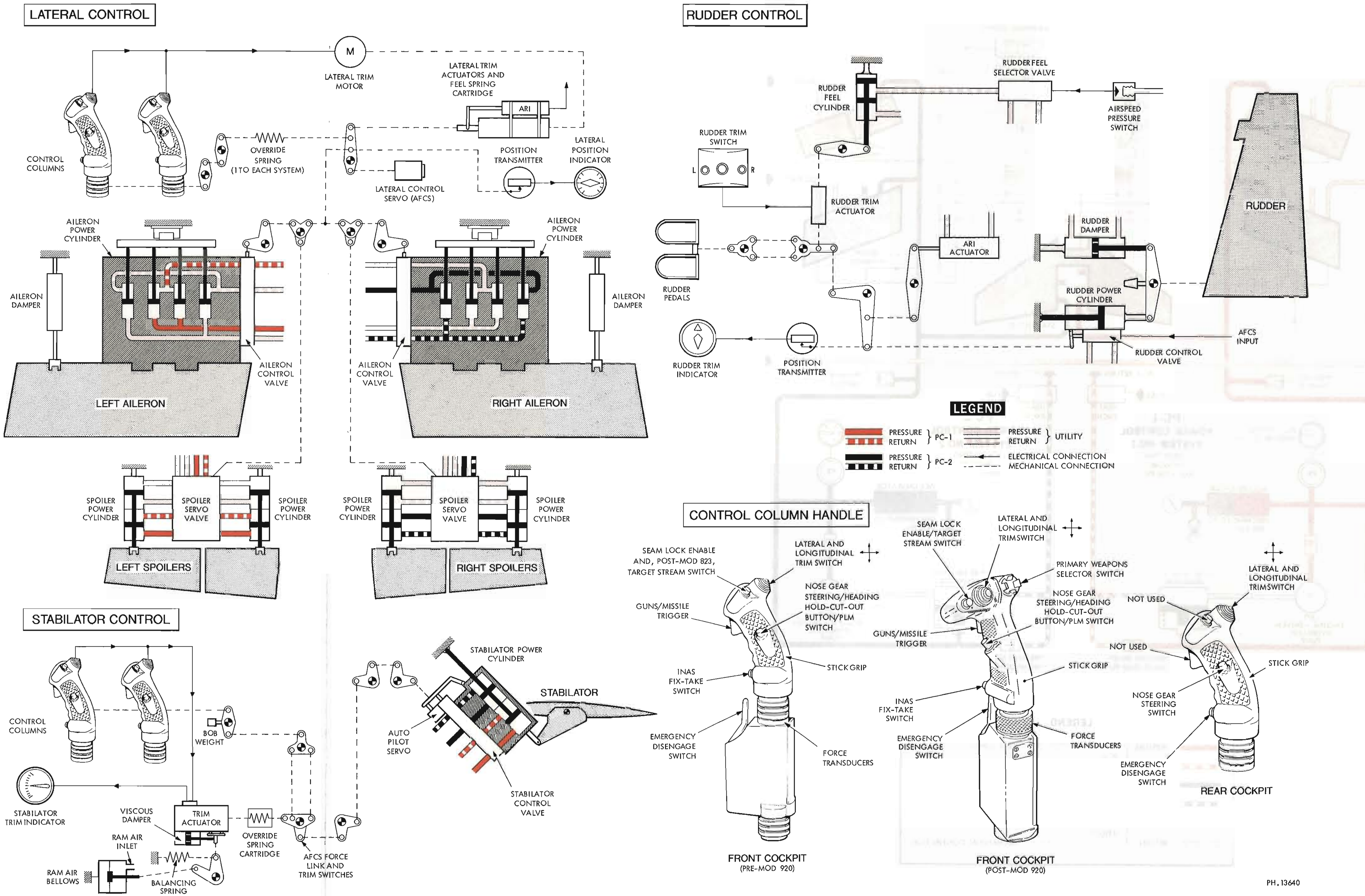
8. The lateral trim system consists of the trim switch on the control column grip, a rotary power unit, two flexible drive shafts, and two screw–jack actuators. When the trim switch is operated, the rotary power unit and flexible drive shafts position the screwjack actuators. The screwjack actuators are connected to the aircraft structure on one end, and the walking beam bellcranks on the other end. As the crewjack actuators extend and retract, the lateral controls are repositioned and the control column follows the trim movements. Lateral control artificial feel is provided by double–action spring cartridges connected in tandem with the screwjack actuators. When the control column is moved from neutral, the springs are compressed. The further the control column is moved from neutral, the greater the force required to compress the springs. The spring cartridges return the control column to neutral when the force on it is removed.

## Aileron Position Indicator

9. An aileron position indicator is on the left vertical panel in the front cockpit. A transmitter is mechanically connected to the lateral control linkage in the left wing. As the control linkage moves, the mechanical input is converted into electrical impulses which are signalled to the position indicator. The indicator, marked in units of percent of system travel, represents actual control surface position. A wings level indication is zero trim, and a full down left or right indication is maximum control travel. The maximum lateral trim indication is 33% of total control travel.




1-9 Fig 1 Flight Control Hydraulic Systems




**1-9 Fig 2 Flight Controls**
◆ *(Illustration Up-Dated)* ◆

**Rudder Control System**

10. The rudder control system consists of the rudder pedals, push-pull rods, cable assemblies, bellcranks, a rudder feel trim system, an aileron-rudder interconnect actuator, a rudder damper, and an irreversible power cylinder with integral control valve. When the rudder pedals are moved, the motion is transmitted by the push-pull rods, bellcranks and cable assemblies to the control valve of the power cylinder. The control valve meters utility system hydraulic fluid to the power cylinder which positions the rudder.

11. It is possible to have limited mechanical authority over the rudder in the event of a utility hydraulic system failure. A bypass valve in the power cylinders opens when system pressure is lost, allowing fluid to pass from one side of the cylinder to the other. Total amount of rudder deflection available is then a function of air loads on the rudder; however, under all speed conditions it requires a considerable amount of effort to deflect the rudder.

12. A hydraulic servo for yaw damping and AFCS operation is incorporated into the control valve of the power cylinder. Operation of the AFCS however, does not move the rudder pedals.

13. *Rudder Feel Trim System.* Artificial feel is supplied to the rudder pedals by an artificial feel trim system. A hydraulic cylinder with utility system hydraulic pressure on both sides of a differential area piston, provides a pedal force of approximately 2.6 pounds per degree of rudder defection on the low gradient and 11.5 pounds per degree of rudder deflection on the high gradient. Switching between gradients is accomplished through an airspeed pressure switch. The switch is set to limit the maximum speed for switching from low to high at approximately 235 KCAS. The minimum speed for switching from high to low is approximately 225 KCAS. On any particular aircraft, changeover from low-to-high and high-to-low gradient occurs within a 10-knot speed range.

14. *Rudder Trim Switch.* The rudder trim switch is in the front cockpit on the inboard engine control panel on the left console. This switch controls the trim actuator in the rudder feel and trim system to trim the aircraft directionally. Normal trim range is 7.5 ±1° of rudder defection, left and right.

15. *Rudder Position Indicator.* A rudder position indicator is on the left vertical panel in the front cockpit. A transmitter is mechanically connected to the rudder control linkage. As the control linkage moves, the mechanical input is converted into electrical impulses which are sent to the indicator. The indicator is only marked for take-off trim, which is the neutral position.

16. *Rudder Pedals.* The rudder pedals are conventional type suspended units which are coupled to the rudder push-pull rod system by individual screwjacks. The screwjacks provide adjustment of the rudder pedals for comfort and are adjusted simultaneously by turning a crank on the pedestal panel. The pedals are coupled to the power brake valves so that toe pressure on the pedal applies the brakes. They are also used to control the nose gear steering unit when the nose gear steering switch on the control column grip is pressed.

**Stall Warning Vibrator**

17. A stall warning vibrator is fitted to the front cockpit left rudder pedal to warn of approaching stall conditions. The vibrator is electrically connected to a switch in the angle of attack indicator, which is set it 22.3 units. The stall warning vibrator motor is powered from the right main 28 volt DC bus through the angle of attack probe heater circuit breaker. The circuit breaker 15B is in the nosewheel well.

**Aileron-Rudder Interconnect (ARI)**

18. The aileron-rudder interconnect system causes rudder displacement proportional to aileron displacement to provide co-ordinated turns at low airspeeds. The limits of the system are 15° of rudder displacement when the automatic flight control system is in the stab aug or autopilot mode, and 10° rudder displacement when the YAW STAB AUG switch is disengaged, or 5° with Stab Aug or AFCS engaged and the ARI CB tripped.

19. Components of the system include the control amplifier, the 10° servo actuator, acting through a walking beam, an airspeed pressure switch and two aileron transducers. The ARI circuit is completed through the airspeed pressure switch and the flap control switch. When the FLAPS switch is set to DWN and airspeed is below 230 ±7 KCAS, 28 volts DC is applied to the engage relay solenoids of the ARI system. When the flaps reach the ½ down position, a second parallel electrical circuit is completed through a trailing edge limit switch. However, with the FLAPS control set to ½ the ARI circuit is only completed once the limit switch is energised. Completion of the circuit allows the hydraulic 10° servo actuator to move the control linkage (if aileron displacement is present) and cause rudder displacement. Whenever the flaps move above the trailing edge ½ down limit switch operating position, the ARI system is disengaged. The system can be disengaged by pressing the emergency disengage switch on the control column; this disengages the ARI only as long as it is held pressed. For permanent disengagement of the system, the circuit breaker on the left utility panel must be tripped, and the YAW STAB AUG switch disengaged. Tripping the circuit breaker

only, and keeping the stab aug yaw switch engaged, still provides 5° of ARI rudder authority. The system may also be disengaged by pulling the rudder feel trim c/b (C4 on the No 2 c/b panel).

**Stabilator Control System**

◆ Note: Some Phantom FG Mk 1 slotted stabilators are fitted to FGR Mk 2 aircraft. This has no effect on aircraft handling. ◆

20. Longitudinal control is provided by a single unit horizontal tail surface (stabilator), actuated by an irreversible dual power cylinder.

21. The stabilator control system components include the control column, push-pull rods, cables, bellcranks, integrated control valve, and an irreversible dual power cylinder. Additional components include a ram air bellows for system artificial feel, a trim actuator, and an AFCS servo integral with the control valve.

22. When the control column is moved longitudinally, the motion is transmitted by push-pull rods to a bellcrank. It is then transmitted by a cable assembly to another push-pull rod set. The second push-pull rod set actuates the control valve which meters hydraulic fluid to the dual power cylinder. Hydraulic pressure to the stabilator power cylinder is supplied by both power control hydraulic systems. If one of the power control hydraulic systems fails, the remaining system provides adequate control response.

23. A hydraulic AFCS servo is integrated into the stabilator dual servo valve. It positions the dual servo valve in the same manner as control column inputs. As a result, when the autopilot signals for a pitch attitude change, the control column follows the movement. A bob weight is included in the control linkage to increase stick forces in proportion to increases in g force.

24. *Stabilator Control Feel and Trim System.* Artificial feel is provided by a dynamic (ram air) pressure bellows acting through a variable bellcrank on the stabilator trim actuator and a 5 pound/g bob weight. When the aircraft is in trim, the ram air force on the bellows is balanced by the bob weight. As airspeed changes, the pressure on the bellows changes causing the variable bellcrank assembly to become off balance. The off balance condition is then transmitted through the control cables and push-pull rods back to the control column. Actuating the trim switch causes the stabilator trim actuator to move, balancing the forces between the bellows and bob weight and thereby eliminating force on the control column.

25. A viscous damper, attached to the trim actuator, limits abrupt control surface movements by increasing stick forces with rapid stick movements. An override spring cartridge allows the feel and trim portion of the stabilator control system to be by-passed in the event of a runaway nose-up trim malfunction.

26. A heater is installed in the bellows ram air inlet probe and the venturi to prevent freezing. The heaters are controlled by the PITOT HEAT switch on the right console in the front cockpit.

27. *Stabilator Trim Position Indicator.* The stabilator trim indicator is on the left vertical panel in the front cockpit. It is directly controlled by a transmitter which is integral with the stabilator feel trim actuator. The indicator, marked in units of percent of trim, represents trim actuator position.

**Control Column**

28. *Front Cockpit.* The control column, which consists of a grip and force transducer (see Chapter 3), is mounted in a yoke to permit left, right, fore and aft movement. The ◆grip contains six controls (pre-mod 920), or seven controls (post-mod 920): ◆

A four-way trim switch

◆◆

An INAS fix-take switch

A nose gear steering switch

A guns/missile trigger

An emergency disengage switch

◆ A primary weapons selector switch (post-mod 920)

A SEAM lock enable button or, post-mod 823 or 920, a SEAM lock enable/target stream button. ◆

29. The force transducer is used in conjunction with the automatic flight control system to provide control stick steering (see Chapter 3).

30. The nose gear steering switch has the following additional functions:

a. Acts as heading hold cut-out switch for the automatic flight control system (Chapter 3).

b. PLM selector.

31. *Rear Cockpit.* The control column in the rear cockpit (connected by direct mechanical linkage to that in the front), incorporates the following functions only:

a. A 4-way trim switch

b. A nose gear steering switch

c. An emergency disengage switch

## MALFUNCTIONING OF THE FLIGHT CONTROL SYSTEM

### Utility Hydraulic System Failure

32. Failure of the Utility system prevents or degrades the hydraulic operation of components of the Flight Control System as listed in Part 1, Chapter 8, para 10.

33. Back-up or alternate operation is provided for the ailerons, spoilers and rudder. The rudder can be manually operated; however, the amount of deflection possible is entirely dependent upon air loads on the rudder surface.

### Flight Control Hydraulic System Emergency Operation

34. The loss of a hydraulic pump in either power control system, or in the utility hydraulic system, is shown by the CHECK HYD GAUGES caption coming on. PC1 and PC2 are independent of each other, but each system satisfactorily functions as an emergency system for the other. The utility system also supplies pressure to the ailerons and spoilers; if simultaneous loss of utility system occurs the operable aileron and spoiler provide adequate, but reduced, lateral control for landing.

### Complete Flight Control Hydraulic System Failure

35. On initial detection of hydraulic power loss, note whether or not the gauges show a definite steady drop, or gauge fluctuation. It has been found that failure of the essential auto-transformers can cause false readings on the PC1, PC2, utility and pneumatic gauges. For this reason if both PC1 and PC2 gauges indicate a complete flight control system failure, make certain that the warnings are not spurious by confirming the CHECK HYD GAUGES caption is on. If both flight control hydraulic systems fail, the aircraft is uncontrollable and will probably pitch nose-up.

### Stabilator Feel Trim Failure

36. In order to detect these insidious failures, the stabilator trim gauge must be periodically monitored during flight. The normal trim settings vary from 0° to 4° nose down. Therefore, if the trim gauge reads outside the range 0° to 4° nose down, a bellows failure must be suspected and the actions given in the FRC carried out.

37. *Bellows Vent Blockage.* Blockage of the bellows vent is recognised by a light nose-up feel force at the control column, proportional to airspeed. This force cannot be trimmed out and attempts to do so would result in full nose-down trim being applied. When a blockage of the bellows vent is recognised, reduce speed quickly to 250 to 300 KCAS, trim the stabilator to 2° nose down and disengage the autopilot. While the vent remains blocked there is a nose-up feel force at the control column. Avoid abrupt fore-and-aft stick movements and, if the symptoms persist, land as soon as practicable.

**WARNING:** At high KCAS, if the blockage of the bellows vent suddenly clears or the bellows rupture, *an uncontrollable PIO in pitch* may occur owing to the lack of sufficient control column feel.

38. *Partial Bellows Failure.* Partial bellows failure is recognised by a mild nose-down stick force proportional to airspeed, unless the failure occurs during manoeuvring flight at which time it may not be noticeable. Reduction of stick centring and pitch stability results. If this failure occurs, reduce speed to 250 to 300 KCAS, trim stabilator to 2° nose down, avoid abrupt fore-and-aft stick movements and land as soon as practicable.

39. *Complete Bellows Failure.* A complete bellows failure is recognised by a light nose-down feel force at the control column. The maximum amount that this stick force can attain is 5 pounds dependent on the trim position. Ice or water blockage of the artificial feel bellows ram air line results in conditions similar to a complete bellows failure. Longitudinal trim should not be applied to relieve the control stick force since if the failure is caused by ice or water blockage the intermittent nature of this condition and the suddenness of the return to normal can cause violent pitch transients. When the ram air line is blocked, no stick force is felt by the pilot should a change in stick position be required. In the event of a complete bellows failure or suspected ice or water blockage, reduce speed to 250 to 300 KCAS, trim stabilator to 2° nose down, disengage the autopilot, maintain attitude by pilot effort, ensure the PITOT HEAT switch is ON and, if practicable, descent to warmer air. Avoid abrupt fore-and-aft stick movements and if the symptoms remain, land as soon as practicable.

### Runaway Stabilator Trim

40. If stabilator trim appears to be running away, it may possibly be arrested if the stab trim circuit breaker is tripped immediately upon detection of the runaway trim. Provided that the trim runaway is either nose-up or not more than 2.5 units nose-down and airspeed is reduced below 300 KCAS, the auto-pilot can be engaged to hold the stick load.

41. When the autopilot is used to alleviate a runaway trim condition, and excessive out-of-trim forces are present (full nose-down runaway trim), the autopilot alternately disengages and re-engages. If this occurs, discontinue ◆ use of the autopilot and land as soon a practicable; the aircraft can be landed safely in a full runaway trim condition. ◆

Note: It may be possible to regain control of the trim if it is lost due to an electrical malfunction by using the auto pitch trim in the autopilot.

*Intentionally Blank*

# PART 1

## CHAPTER 10 — INSTRUMENTS

### Contents



*Only the instruments which are not covered under another system are described in this Chapter.*

**True Airspeed Indicator**

1. The true airspeed indicator on the rear cockpit instrument panel, displays TAS by means of small rotating counters on the face of the instrument. The range of the indicator is from 0 to 1500 knots. However, the TAS calibrated range is from 150 to 1500 knots and readings below 150 knots TAS are unreliable. The true airspeed indicator may indicate between 60 and 180 knots while the aircraft is motionless on the ground. The true airspeed outputs are produced from the total temperature sensor signal of the CADC by routing this signal through a potentiometer driven by one of the mach number function cams. Thus, mach number is translated into true airspeed. The system is accurate to ±5 knots in steady flight conditions and ±10 knots during linear accelerations and decelerations.

▶◀

**Mk 29 and 30 Altimeters**

2. A Mk 29 altimeter is fitted in the front cockpit and a Mk 30 in the rear cockpit.

3. *Mk 30 Altimeter*

a. A Mk 30 altimeter is in the rear cockpit. The altimeter is the master instrument of the automatic height encoding system; it provides an electrical output to operate the Mk 29 altimeter when that instrument is in the servo mode and an encoded altitude output to the IFF/SSR transponder for altitude reporting on Mode C. It is powered from the Right Main 115 volt AC and Right Main 28 volt DC busbars, and is protected by two circuit breakers on the No 3 circuit breaker panel in the front cockpit.

b. The altimeter dial is marked from 0 to 1000 feet in 50 feet intervals; it is swept by a single pointer. Inset on the left of centre are three counters which indicate altitude in 100 feet intervals over the range minus 1000 to +60,000 feet. The 10,000 feet counter is marked with diagonal black/white hatching at altitudes below 10,000 feet and with red/white hatching at negative altitudes. A setting knob, on the bottom left of the instrument, enables altitude to be displayed relative to the selected barometric pressure which is displayed on a millibar counter, behind a window in the dial. The millibar (mb) scale setting range is from 850 to 1050 mb. If a servo malfunction or power failure occurs, a failure flag, marked with diagonal red/black hatching, drops over the altitude counters.

c. A reference datum pressure of 1013·2 mb is used for the outputs to the pilot's Mk 29 altimeter and the IFF/SSR transponder; this will not be affected by changes to the millibar counter setting.

d. The instrument tolerance at sea level is ±20 feet.

Note 1: If the millibar setting is adjusted with AC power off, the altitude counters and pointer do not move. If the millibar setting is increased more than 90 mb with AC power off, a travel limit switch within the instrument opens and prevents AC power being connected to the instrument. If the failure flag does not clear when the AC power to the instrument is switched on, wind the millibar setting towards the lower end of the scale until the flag clears. Normally the millibar setting should only be adjusted with AC power on.

Note 2: As the Mk 30 altimeter is powered from the Right Main 115 volt AC busbar, it will not operate on RAT power.

4. *Mk 29 Altimeter*

a. A Mk 29 altimeter is in the front cockpit. The altimeter is servo-operated by electrical outputs from the Mk 30 altimeter with reversion to pressure capsule operation either automatically or by selection.

b. The altimeter dial is marked from 0 to 1000 feet in 50 feet intervals; it is swept by a single pointer. Inset on the left of centre are three counters which indicate altitude in 100 feet intervals over the range minus 1000 to +60,500 feet. The 10,000 feet counter is marked with diagonal black/white hatching at altitudes below 10,000 feet and with red/white hatching at negative altitudes. A setting knob, on the bottom left of the instrument, enables altitude to be displayed relative to the selected barometric pressure which is displayed on a millibar counter, behind a window in the dial. The millibar (mb) scale setting range is from 950 to 1050 mb.

c. A RESET/STBY rotary switch on the bottom right of the instrument, provides for manual selection of the standby (STBY) or servo (RESET) mode of operation; the knob is spring-loaded to the central position. When STBY is selected for about 3 seconds, the altimeter functions as a conventional pressure capsule instrument connected to corrected static pressure from the air data computer, an integral vibrator starts to operate and a flag marked STBY appears in the window above the altitude counters. When RESET is selected momentarily, with system power supplies available, the altimeter resets to servo operation and is slaved to the Mk 30 altimeter in the rear cockpit, the flag clears and the vibrator stops working.

d. Automatic reversion to standby occurs as a result of any of the following malfunctions:

(1) Failure of the power input to the altimeters.

(2) Servo amplifier failure.

(3) Servo motor failure.

(4) Failure in the servo error detection circuitry.

(5) Differences greater than 4000 feet at sea level between indicated servo and standby altitudes; this difference increases with altitude.

e. The instrument tolerance at sea level, in the standby mode, is ±30 feet. In the servo mode, the Mk 29 altimeter should read within ±20 feet of the Mk 30 altimeter at all altitudes (with the same mb settings on both altimeters).

**Airspeed/Mach Number Indicators**

5. The combined airspeed and mach number indicator on each cockpit instrument panel shows airspeed readings at low speeds and additionally mach number readings at high speeds. Both readings are provided by a single pointer moving over a fixed airspeed scale, graduated from 80 to 850 knots, and a rotatable mach number scale graduated from 0·4M to 2·5M. A movable 'bug' is included as a landing speed reference and can be positioned by a knob on the face of the instrument. The same knob when pressed, can be rotated to operate another 'bug' on the mach number scale. The airspeed indicator pointer and the mach number scale are synchronised so that a proper relationship between the two is assured throughout all altitude changes. Thus, at sea level and under standard conditions, the pointer indicates 1·0M at approximately 660 KCAS. Under the same conditions, but at 50,000 feet, if the same true airspeed is maintained the pointer indicates approximately 292 KCAS and 1·15M. The indicator uses corrected static pressure from the CADC which eliminates the need for instrument position error correction. Therefore, the airspeed and mach number indicator displays calibrated airspeed (CAS) and true mach number (TMN) when the static pressure correction portion of the CADC is operative. If the static correction source is lost the airspeed and mach number indicators revert to displaying indicated airspeed (IAS) and indicated mach number (IMN).

**Vertical Speed Indicator**

6. A vertical speed indicator on the pilot's instrument panel (also on the rear instrument panel of dual control aircraft) shows the rate of ascent or descent of the aircraft and is so sensitive that it can register a rate of gain or loss of altitude which would be too small to cause a noticeable change in the altimeter reading. Both halves of the indicator face are graduated in units of 500 feet from 0 to 6000 feet with scale divisions of 100 feet from 0 to 1000 feet. The upper half of the instrument indicates rate of climb and the lower half indicates rate of descent, both in thousands of feet per minute. The indicator is connected to the corrected static pressure system of the aircraft and measures the change in atmospheric pressure as the aircraft climbs or descends. Since the indicator uses corrected static pressure, a

failure of the corrected static pressure source may result in slightly erroneous indications.

**Turn-and-Slip Indicator**

7. a. A slip indicator and rate of turn needle are incorporated into the attitude director indicator on the front cockpit instrument panel. The indicator displays turn rate about the normal axis of the aircraft and, as a result, does not provide an accurate indication of actual rate of turn. When the bank angle is increased, the rate of turn needle shows increased turn rate up to a point beyond which the rate of turn around the normal axis decreases. This characteristic normally precludes obtaining a full needle width deflection at high altitudes and/or high airspeeds. Therefore, the rate of turn needle should not be used as a primary turn rate instrument. At low airspeeds, however, a single needle width deflection is approximately equivalent to a rate one turn. The turn needle is deflected electronically, and electrical failure renders the needle immediately inoperative, despite the fact that the gyro is still spinning.

b. A needle-and-ball type turn-and-slip indicator is on the rear cockpit instrument panel (dual control aircraft only).

**Accelerometer**

8. An accelerometer, to measure and record positive and negative acceleration (g) loads, is on the front instrument panel; there is also one on the rear cockpit instrument panel in dual control aircraft. The indicator has three movable pointers. One pointer moves in the direction of the g load being applied, while the other two (one for positive g and one for negative g), follow the indicator pointer to its maximum travel. These recording pointers remain at their respective maximum travel position of the g load being applied. Pressing a PUSH TO SET button, in the lower left corner of the instrument, allows the recording pointers to return to the 1g position.

Note: Accelerometers may underread by approximately 0.5g up to +4g and by 1g above +4g.

**Backup Attitude Indicator**

9. A Backup Attitude Indicator (BAI) is on the pilot's instrument panel. It is powered by the Right Main 115/200V AC busbar via circuit breaker Q2 on No 2 circuit breaker panel and erects as soon as power is applied to the aircraft. The instrument incorporates a self-contained gyro and is completely independent of the AN/AJB-7 and INAS systems. The instrument gives reliable attitude information as long as power is supplied to the Right Main AC busbar. In the event of a double generator failure the instrument continues to provide accurate attitude information for a limited period, allowing time for the RAT to be extended to restore the ADI to normal operation. A fast erection pushbutton is on the bottom right corner of the instrument front cover. An OFF flag at the bottom of the display indicates power failure only and is deflected from view whenever power is applied.

Note 1: The fast erection pushbutton must not be operated unless the instrument has been running for at least 90 seconds. In flight the switch must only be used in level unaccelerated conditions and for not more than 60 seconds in any 3-minute period.

Note 2: The BAI cannot be powered from the RAT.

**Standby Compass**

10. A conventional magnetic compass on the cockpit windscreen frame is provided for navigation in the event of instrument or electrical malfunction. Compass cards are above the canopy sill on the right side of the cockpit.

**Radio Altimeter STR-70P**

**WARNING 1:** High frequency radar waves can penetrate snow and ice fields. When operating in areas covered by snow and ice, the radio altimeter may indicate a greater terrain clearance than actually exists.

**WARNING 2:** Spurious low level and associated visual warnings may be seen on some radio altimeters when flying above 5000 feet.

11. The Radio Altimeter STR-70P indicates the height of the aircraft above the earth's surface. The cockpit equipment consists of a height indicator, which incorporates a function control knob, and three low height warning lights. When the system is operating a reliability signal must be generated before the height can be displayed. Loss of the reliability signal indicates loss of power, system malfunction or insufficient signal return and a fail flag is then displayed on the indicator. The system takes power from the Right Main 115/200V AC busbar and from the Right Main 28V DC busbar.

12. *Height Indicator.* The height indicator (on the front cockpit instrument panel) displays height by a single pointer traversing a non-linear scale of zero to 5000 feet. The scale is expanded at the lower heights to allow accurate interpretation. A mask over the dial covers the pointer when above a height of 5000 feet, when there has been a failure in the system, or when the system is switched off. A striped fail flag is displayed in a window below the axis of the height pointer. A low height index pointer traverses the outside edge of the scale.

13. *Function Control Knob.* The function control knob (lower left side of the height indicator) is the only control for the system. By rotating the knob clockwise past the detent, power is applied to the system. Rotating the knob further clockwise moves the low height index pointer clockwise round the height indicator. The knob also has a press-to-test function.

14. *Built-In Test (BIT).* The system indicates approximately zero feet when on the ground; pressing the function knob in the air or on the ground initiates a BIT, during which the pointer reads 20 to 30 feet to indicate a serviceable system.

15. *Low Height Warning Lights.* The three low height warning lights in the aircraft are positioned as follows:

a. Above and to the left of the height indicator in the front cockpit.

b. On the front cockpit windscreen pillar.

c. At the bottom of the main instrument panel in the rear cockpit.

The lights all come on simultaneously when the height pointer indicates a height below that set on the low height index. The lights are dimmed by rotating their outer covers to operate the built-in masks, but the lights cannot be completely masked. The filaments are tested by pressing in the lights.

**Normal Operation of the Radio Altimeter**

16. Rotate the function control knob out of the detent ◆position. The system starts operating after a short warm-up period when the fail flag retracts. Position the low height index as desired, checking that the low height warning lights come on when the height indicated is below the index set. ◆

# PART 1

## CHAPTER 11 - LIGHTING EQUIPMENT

### Contents



### Exterior Lighting

1. The exterior lights consist of the navigation lights (wing and tail), formation lights (wing only), fuselage lights, AAR probe lamp, taxylight and anti-collision light. The exterior lights control panel in the front cockpit right console contains all the manual controls for these lights.

2. *Navigation and Formation Lights.* The navigation lights are red and green wing tip leading edge lights and a white tail light. The formation lights are red and green wing tip trailing edge lights. All wing lights are controlled by the same 3-position OFF/DIM/BRT toggle switch. The tail navigation light is controlled by a separate 3-position OFF/DIM/BRT toggle switch. When either switch is put in the BRT position, the respective lights come on at full brilliance. Placing the switch in the DIM position reduces the brilliance. The dim circuit of the lights is powered by the Right Main 14V AC bus. The bright lights circuit is powered by the Left Main 28V AC bus.

**WARNING:** ◆◆ The tail light on the drag chute door may be obscured when the drag chute door is open.

3. *Fuselage and Anti-Collision Lights.* Three semi-flush white fuselage lights are installed, one above the number two fuel cell and one below each of the engine air inlet ducts. In addition to the fuselage lights, one red anti-collision light is in the leading edge of the fin. The three fuselage lights and the anti-collision light are controlled by the FUS - DIM/BRT/MAN switch. The anti-collision light is on only when the fuselage lights switch is in the BRT position and the exterior lights flasher switch is in the FLASH position. The MAN position of the switch allows the fuselage lights to be energised by the manual key button. The fuselage lights are powered by the Right Main 28V AC bus. One of the two lamps in the anti-collision light is powered by the Right Main 28V AC bus, and the other from the Left Main 28V AC bus.

4. *Exterior Lights Flasher Switch.* The exterior lights switch, annotated FLASH/OFF/STEADY, operates the flasher unit of the fuselage lights and tail light. The anti-collision light only operates when the switch is in the FLASH position. The flasher unit and relay is powered by the Right Main 28V DC bus. In the OFF position, the switch acts as the exterior lights master switch.

5. *Manual Key Button.* The MAN KEY button is used to energise the fuselage lights when the fuselage lights switch is in the MAN position and the exterior lights flasher switch is in the STEADY position. An indicator light on the exterior lights panel glows when the manual key button is pressed. The manual key button receives its power from the Right Main 28V AC bus.

6. *Air-to-Air Refuelling Probe Lamp.* The air-to air refuelling probe lamp is on the right side of the fuselage forward of the air refuelling probe. It is used during night air refuelling operations to light the refuelling probe and the drogue from the refuelling aircraft. The lamp is controlled by the IFR PROBE - ON/OFF switch and its intensity adjusted by the rotary DIM/BRT switch.

7. *Taxylight.* The taxylight is on the nose gear door and is controlled by the TAXI LT switch. Power to the light is supplied by the Right Main 28V AC bus.

### Interior Lighting

8. The interior lights are powered by the AC and DC buses. Only the utility floodlight is powered by the Battery busbar.

### Front Cockpit Lighting

9. Most of the cockpit lighting controls are on the COCKPIT LIGHTS control panel. An INST PANEL EMERG FLOOD - BRT (up)/OFF/DIM (down), switch is on the right cockpit wall. In the BRT position it takes power from the Essential 28V DC busbar; in the DIM

position, Right Main 14V AC busbar power is used.

10. *Cockpit Lights Control Panel.* Front cockpit lighting is controlled by the following switches on the COCKPIT LIGHTS panel:

a. *INSTR PANEL.* The INSTR PANEL - OFF/BRT (bright) rotary switch controls the instrument panel lighting and the intensity of the warning lights. In the OFF position the instrument panel lighting is off but the warning lights are fully bright. When selected out of the OFF detent, the intensity of the instrument panel lights is varied by the switch position. However, the warning lights are dimmed to a constant level irrespective of the switch position once the switch is out of the OFF detent. The switch controls the intensity of the warning lights in both cockpits.

b. *CONSOLE.* A square-topped rotary switch controls the edge lighting on the left and right consoles, the pedestal panel and the armament panel. In any position but OFF, it also switches on the red console floodlights, the intensity of which are controlled by the CONSOLE FLOODS - BRT/MED/DIM switch.

c. *WHITE FLOOD.* Two white floodlights, one above each side console, are controlled by a lever-lock WHITE FLOOD - ON/OFF switch. There is no dimmer.

d. *Standby Compass.* The STBY COMP - ON/OFF switch is operative when the CONSOLE lights switch is turned on.

◆ e. *WARNING LIGHTS.* The WARNING LIGHTS test switch is spring-loaded to NORMAL. To test the warning lights, hold the switch to TEST; the missile status panel SEAM-LOCK and SEAM OUT captions, and the head-up SEAMLOCK and MISSILE SELECTED repeater captions, are also lit during test. ◆ The switch does not, however, test the BRSL, LOW ALTITUDE WARNING, ILS MARKER, or R and L ANTI-ICE ON lights. Post-mod 723, the SEAMLOCK and MISSILE SELECTED lights are re-captioned HEAT and RADAR respectively.

f. *INDEXER LIGHTS.* The intensity of the indexer lights is controlled from DIM to BRT by a rotary switch on the COCKPIT LIGHTS control panel.

g. *AOA Indicator Light.* ◆◆ The intensity of the AOA indicator lighting is controlled by the normal INSTR PANEL switch, but the AOA light can be switched off by means of an ON/OFF switch beside the AOA gauge.

11. *Utility Floodlight.* A utility floodlight is under the right canopy sill. The light has its own pushbutton on/off switch and dimmer, and may be changed from red to white by pressing the latch button and rotating the lens housing. The light is powered from the Battery 24V DC bus.

12. *Spare Edge Lamps.* Spare edge lamps are in a spring-loaded cylindrical container on the aft right console.

**Rear Cockpit Lighting**

13. All the controls for the rear cockpit lighting are at the aft end of the left console. The following controls are provided:

a. *CONSOLE.* A square-topped rotary switch marked OFF to BRT controls the intensity of the console lights.

b. *INSTR PANEL.* A round-topped rotary switch marked OFF to BRT controls the intensity of the instrument lighting.

c. *CONSOLE FLOODS.* Six red floodlights (eight, Block 34 and upwards) are controlled by a CONSOLE FLOOD switch marked BRT, MED and DIM.

d. *WARNING LIGHTS.* The WARNING LIGHT test switch is spring-loaded to NORMAL. When held at TEST, all aft cockpit warning lights come on.

e. *INDEXER LIGHTS.* The intensity of the indexer lights is controlled from DIM to BRT by a rotary switch (dual aircraft).

14. *Utility Floodlight.* A utility floodlight is forward of the right console. The light has its own pushbutton on/off switch and dimmer, and may be changed from red to white by pressing the latch button and rotating the lens housing. The light is powered by the Battery 24V DC bus.

15. *Spare Edge Lamps.* Spare edge lamps are in a spring-loaded cylindrical container under a panel aft of the lights control panel.

# PART 1

# CHAPTER 12 — OXYGEN SYSTEM

## Contents



## DESCRIPTION

### General

1. The liquid oxygen (LOX) system basically consists of a ten litre capacity container, ON/OFF levers, and cockpit quantity gauges. The system is designed to deliver gaseous oxygen to the crew at a continuous rate of up to 120 litres per minute at 60 to 120 PSI. A relief valve operates if the pressure exceeds 120 PSI and if this fails to work, a patch on the LOX container should blow out. Electrical capacitance-type gauges indicate to the pilot and navigator the amount of LOX remaining at any time. An OXYGEN LOW caption operated by the indicator circuit alerts the pilot when the LOX supply is reduced to one litre or below.

### Oxygen Supply Levers

2. A 2-position ON-OFF oxygen supply lever is on the left console in each cockpit.

### Oxygen Contents Gauge

3. In each cockpit is an oxygen contents gauge which indicates ten litres maximum and is powered from the right-main 115/200 volt AC bus. Each gauge also contains a red power OFF flag. The flag appears in a window in the centre of the gauge whenever there is no AC power to the gauge. On the pilot's left utility panel is a pushbutton OXY TEST switch which, when held depressed, causes the pointers of both gauges to rotate to zero or below. The OXYGEN LOW caption on the front cockpit telelight panel comes on when the pointers reach the one litre mark. On releasing the switch the pointers return to their original positions, and the caption goes out as the needles pass the one litre mark.

### Oxygen Flow Indicators and Pressure Gauge

4. An OXY FLOW magnetic indicator (MI) is on the front cockpit left utility panel and on the rear cockpit main instrument panel. Each indicator alternates black/white. It shows black when there is no oxygen flow to the user and white when oxygen is flowing. Additionally, an OXYGEN PRESS indicator on the front cockpit left utility panel measures system supply pressure which should normally be between 60 and 120 PSI. This gauge is pressure-operated.

### Oxygen Regulator and Limitations

5. The oxygen system is designed to be used with a miniaturised man-mounted regulator. The regulator (stage 3) is limited to 50,000 feet and has the following features:

a. A choice of air-mix or 100% oxygen by means of a toggle lever on the regulator.

b. Safety pressure at all altitudes if 100% is selected; on air-mix the safety pressure is automatically applied when above approximately 16,000 feet.

c. Automatic pressure breathing above 40,000 feet.

d. Emergency bypass; this is a press, turn and release knob on the regulator and, if used, bypasses the main regulator and supplies the user with a continuous flow of oxygen. Normally if bypass is required, the user should also select air-mix to ease resistance to breathing in.

e. Ground test facility.

f. V1 (large or small) masks must be worn with the regulator. These masks have an anti-suffocation valve fitted.

◆6. Post-mod 702, airframe provision is made for the protection of aircrew against NBC agents. The PEC is modified to supply both oxygen and filtered air allowing aircrew respirator NBC No 5 (AR5) to be worn. See Chapter 14 for NBC protection details. ◆

**Emergency Oxygen Supply**

7. Emergency oxygen is stored in a seat-mounted cylinder and thus remains with the seat after separation ◆following ejection. Normally the emergency supply lasts for approximately 10 to 12 minutes, however, post-mod 702 when emergency demist is selected on the AR5, the emergency supply lasts for approximately 3½ minutes. When actuated, the emergency supply◆ flows at a pressure of 50 PSI through the PEC to the regulator and then to the user. If emergency oxygen is operated because of faults in the main LOX supply, it will not get through to the user unless the main oxygen supply is less than 50 PSI.

**Emergency Knob**

8. An Emergency oxygen knob is just forward of the PEC. When emergency oxygen is needed for breathing, the knob must be pulled to actuate the emergency supply. Although the knob can be manually re-set, this does not turn off the emergency oxygen supply. On ejection the supply is automatically turned on.

**Emergency Oxygen Contents Gauge**

9. The Emergency oxygen contents gauge is a miniaturised gauge on top of the emergency oxygen bottle. It has two sectors. The first is marked in red and labelled REFILL, and the second is marked in white and labelled FULL. Providing the needle is in the white sector, there is sufficient emergency oxygen for flight.

## NORMAL MANAGEMENT OF THE SYSTEM

**Functional Checks**

10. After Strapping in and with external AC electrical power applied, turn on the oxygen ON-OFF supply lever and then complete the following functional checks on the system/regulator.

a. Check that the OFF flag on the oxygen contents gauge is retracted and that there is sufficient oxygen for the flight.

b. Check oxygen pressure gauge indicates at least 60 PSI.

c. Depress the OXY TEST button and check that the needles in the contents gauges rotate to zero or below, and that the OXYGEN LOW light on the front cockpit telelight panel illuminates as the needles pass the one litre mark. On releasing the button check that the needles return to their original positions and that the OXYGEN LOW caption extinguishes as the needles pass the one litre mark.

d. On air-mix and then on 100%, check that the magnetic indicator shows white when breathing in and black when breathing out or when holding the breath. With 100% selected, lift the edge of the mask off the face and check that the magnetic indicator shows steady white.

e. Set the mask toggle down and then, with the fingers, occlude the two press-to-test holes on the regulator. Check that the regulator provides pressure breathing and that the MI shows steady black when the breath is held. This check ensures that a correct connection between the mask hose and regulator has been achieved.

f. Remove the fingers from the two holes and the pressure should automatically release. Return the mask toggle to the up (normal) position.

## MALFUNCTIONING OF THE SYSTEM

**System Malfunctions**

11. The FRC give the actions to be taken in the event of hypoxia or system malfunctions. Following most oxygen emergencies, the FRC recommend a descent to a cabin altitude of 10,000 feet or lower. A cabin altitude of 10,000 feet normally coincides with an aircraft altitude of approximately 26,000 feet. Obviously, unless range requirements are paramount, it is prudent to descend to an *aircraft* altitude of 10,000 feet following oxygen emergencies.

**Contaminated Oxygen Supply**

12. If the LOX supply becomes contaminated, pull the emergency oxygen knob, turn OFF the main oxygen supply and descend to a cabin altitude of 10,000 feet or lower if practicable.

Procurement Executive
Ministry of Defence
September 1983

AP101B-0902-15A

# PHANTOM FGR MK 2 AIRCRAFT

## AIRCREW MANUAL - FLIGHT SYSTEMS

## ADVANCE INFORMATION LEAFLET No 2/83

This leaflet supersedes and cancels AIL 1/79 which is to be removed from its position facing page 2 of Part 1, Chapter 12 and destroyed.

Insert this leaflet in AP101B-0902-15A to face page 2 of Part 1, Chapter 12.

---

Aircrew NBC equipment is in use as specified by user Commands. Fitting and instruction on use is carried out at aeromedical training units. The equipment includes the Aircrew Respirator NBC No5 Mk 1 (AR5). This AIL gives brief details of the AR5, its use on the ground and in the air, its limitations, and the normal operating procedures; emergency procedures are given in the FRC. The air/gas supply system to the AR5 as described is an interim measure: action is in hand to modify the aircraft to provide a system which has a higher performance and imposes a lower demand on the oxygen supply. Read this AIL in conjunction with the detailed information and procedures given in AP 3456E, Part 1, Section 2, Chapter 8.

---

## AIRCREW RESPIRATOR NBC No5 MK 1 - INTERIM SUPPLY SYSTEM

### General

1. The AR5 assembly for the Phantom is illustrated at Fig 1. The edge of the mask seals to the wearer's face and the hood seals round the neck. Air or oxygen supplies are fed to each compartment through a manifold mounted on the wearer's life preserver. When outside the aircraft, gas supply into the manifold is from a portable ventilator, the hose of which is connected to the air inlet hose. In the aircraft, the wearer connects the PEC to feed aircraft oxygen into the manifold and disconnects the air inlet hose from the portable ventilator and reconnects the air inlet hose to the hose of the S6 NBC filter canister, also attached to the life preserver. It is important to ensure a continuous supply of air or oxygen through

the hood otherwise misting of the optical area of the hood occurs within a few seconds.

Oxygen Consumption

2. The rate of LOX consumption is increased considerably above the rate when using the normal mask and man-mounted regulator. Comparative rates are:

| (a) Aircraft Altitude (feet) | (b) Both Crew Using Man-Mounted Regulator - Airmix (litres/hour) | (c) One Crew Member Using AR5 and Safety Pilot Using Man-Mounted Regulator - Airmix (litres/hour) |
|---|---|---|
| 0 | 0.7 | 2.6 |
| 10,000 | 0.7 | 2.5 |
| 25,000 | 0.7 | 2.4 |

3. Thus the total LOX supply of 10 litres is consumed in approximately 3.8 hours under column c conditions. The LOX converter must therefore be fully replenished before each sortie when AR5 is used. If the normal oxygen supply fails, the emergency supply can be selected but, because of the increased consumption, it lasts for only 3 to 4 minutes after which the optical area of the hood rapidly mists over.

Limitations

4. ACAS(OPs) has authorised the use of AR5 for routine flying training subject to the following limitations:

a. Maximum Altitude. The maximum aircraft altitude is not to exceed 35,000 feet.

b. Temperature. The ambient temperature limits on the ground for normal use are minus 15°C to +25°C. Below minus 15°C the equipment is not to be worn for more than 5 minutes.

c. Crew. With this interim system, only one crew member is permitted to fly wearing the AR5; the other crew member acts as safety pilot. Therefore, when a pilot is wearing AR5, a dual controlled aircraft is to be used and a safety pilot wearing normal oxygen equipment is to man the other cockpit.

d. Time.

(1) The maximum time that AR5 may be worn is 6 hours.

(2) The maximum time that the AR5 is worn during cockpit alert is not to exceed 2 hours.

(3) The total time that AR5 may be worn on the ground, either pre-flight and/or during cockpit alert, should not normally exceed 2 hours.

5. Additional limitations or restrictions may be imposed at the discretion of the relevant Operating Authority.

## Cockpit Entry and Pre-Flight Checks

6. Enter the cockpit with the AR5 supplied by the portable ventilator, which is hung from the cockpit sill. Turn ON the aircraft oxygen supply. Remove the seat PEC cover and the cover over the man portion of the PEC. Connect the man portion to the seat portion. Whilst temporarily holding the breath, disconnect the air inlet hose from the portable ventilator and connect the S6 canister, inserting the blanking plug into the hose of the portable ventilator.

7. Make the following checks of the AR5 and its supply system as part of the pre-flight cockpit checks:

a. Man portion PEC locked to seat portion PEC.

b. Oxygen supply hose connected to oxygen inlet hose of AR5 manifold.

c. S6 canister hose connected to the air inlet hose.

d. EMERGENCY DEMIST control in the open position.

e. Oxygen supply ON.

f. Oxygen contents at least $\frac{7}{8}$ full.

g. Oxygen pressure at least 60 PSI.

h. Oxygen flow MI indicating continuous white.

i. Oxygen flow to mask and hood compartment checked by noting increase of noise on inspiration (mask flow) and flow of gas across the face (hood flow).

j. No detectable leakage through seal of mask to face. Re-adjust fit if necessary.

## In-Flight Checks

8. Carry out the following checks at regular intervals in flight:

a. Oxygen contents adequate.

b. Oxygen pressure greater than 60 PSI.

c. Oxygen flow MI showing continuous white.

d. Oxygen connections at PEC, in hose to AR5 manifold and at mask hose to faceplate intact.

e. Confirm seal of mask to face (especially if rate of oxygen consumption appears high); adjust fit if necessary.

## In-Flight Emergencies

9. Drills for emergencies and malfunctions while wearing the AR5 are given in the FRC. If the wearer of the AR5 is in control of the aircraft when the emergency or malfunction occurs, he is immediately to pass control to the safety pilot.

## Fogging of AR5 on Cessation of Ventilation

10. In any situation where there is a cessation of gas flow from the oxygen system in normal flight, following ejection or after emergency ground egress (or from the portable ventilator on the ground), it is very likely that the internal surface of the AR5 visor will fog up rapidly. The rapidity and intensity of this fogging depends on the degree of sweating from the face of the wearer and the local ambient temperature. Cessation of the ventilation to the hood is therefore a serious emergency. In flight, the selection of emergency oxygen provides ventilation of the hood compartment for approximately 3 to 4 minutes after main system oxygen failure. Vision may also be impaired following man/seat separation in the ejection sequence or following emergency ground egress.

## Routine Cockpit Exit

11. The portable ventilator is hung from the cockpit sill by the groundcrew. Release the harness, leg restraints and PSP lowering line in the normal way. Hold the end of the portable ventilator hose beside the air inlet hose. Turn on the portable ventilator and remove its plug. While holding the breath, disconnect the S6 canister from the air inlet hose and reconnect the air inlet hose to the portable ventilator. Resume breathing and insert the blanking plug into the S6 canister hose. Locate the covers for the man and seat portions of the PEC; disconnect the man portion of the PEC and fit both covers appropriately. Turn OFF the aircraft oxygen supply and vacate the aircraft.

Emergency Ground Egress

12. In situations where rapid ground egress is necessary, there is not usually sufficient time to locate and fit a portable ventilator. In these circumstances, use the standard emergency egress drill. The AR5 visor fogs up rapidly once ventilation of the hood compartment ceases.

---

Note: If, after receipt of this leaflet, an amendment list with a prior date and conflicting information is received, the information in this leaflet is to take precedence.

---

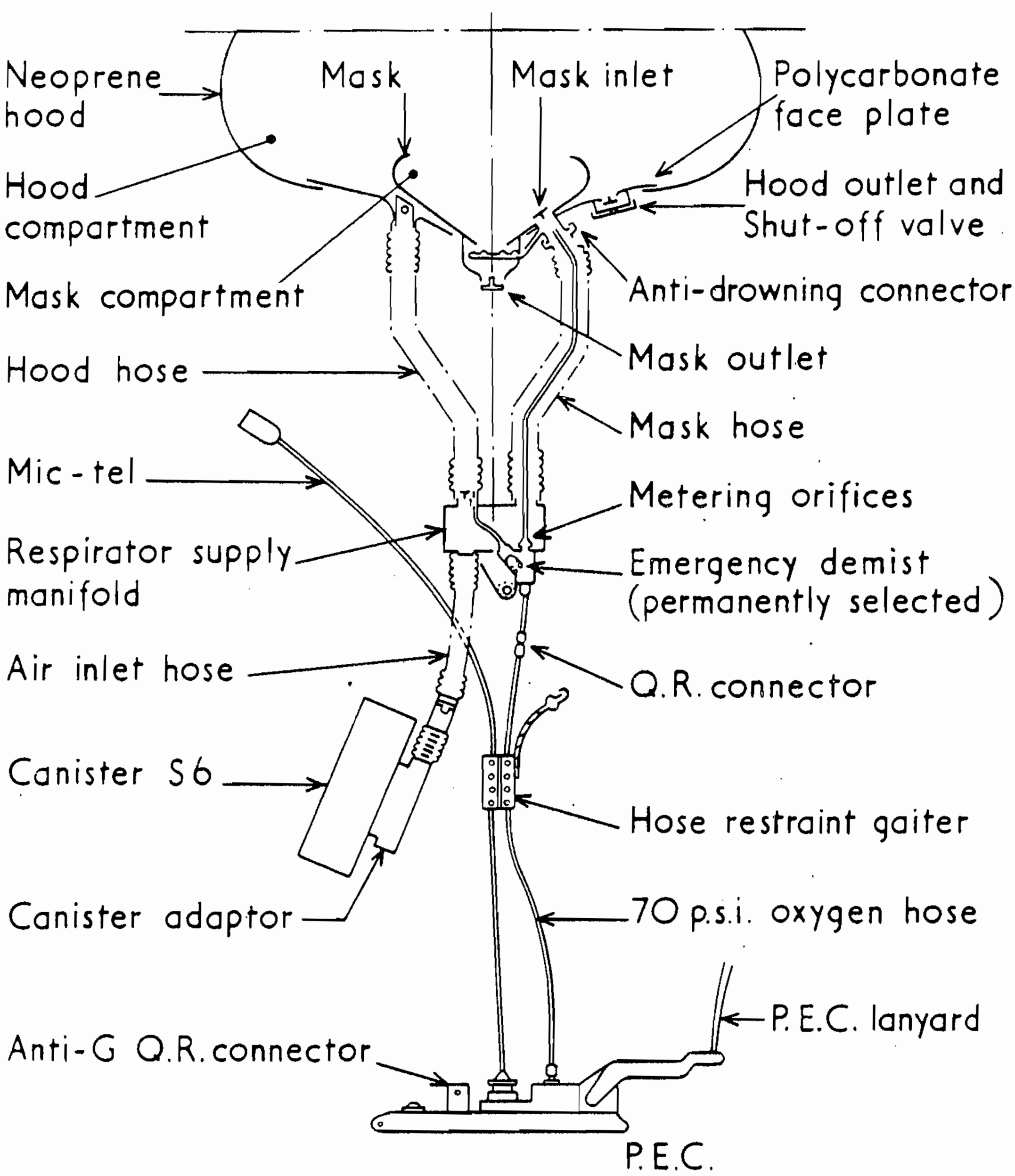



Fig 1 - Aircrew Respirator NBC No 5 Mk 1 - Interim Supply System

M.No. 2198

# PART 1

## CHAPTER 13—COMMUNICATIONS AND NAVIGATIONAL EQUIPMENT

### Contents



*continued*

**Contents** — *continued*

## Illustrations



## COMMUNICATIONS EQUIPMENT

### General Description

1. The functions and locations of the communications equipment are listed in Table 1.

**Table 1 — Communications Equipment**

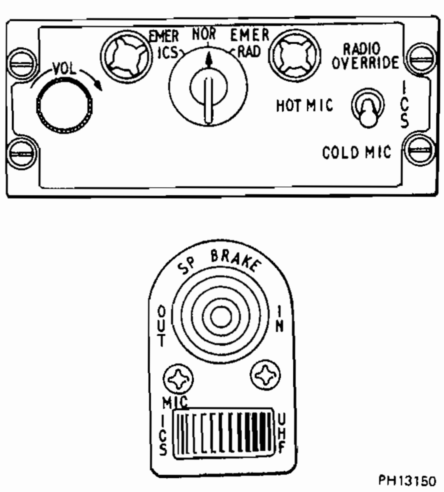
| *Item* | *Function* | *Control Location* |
|---|---|---|
| Intercom and telebrief system | Intercom between cockpits, between cockpits and ground crew, and telebrief/radio amplification | Front cockpit, left console. rear cockpit, left console |
| Main UHF/VHF radio | Multi-channel UHF/VHF voice communication | Front cockpit, right console, Rear cock, left console |
| Standby radio | 2-channel UHF voice communication | Controls incorporated in main UHF/VHF panel |
| Automatic direction finder | Indicates relative bearing and allows homing on UHF radio signal sources | Main UHF/VHF panels and: Front cockpit, navigation function selector; rear cockpit, CNI/NAV COMP switch |
| HF radio | Long range voice communication | Rear cockpit, left console |
| ILS | Approach aid | Front cockpit, right console |
| Voice recorder | To record selected transmissions and reception | Front cockpit, pedestal panel |
| IFF/SSR | IFF transponder allows coded identification when challenged by an air or ground interrogator. Other modes provide emergency, height and selective identification responses | Front cockpit, right console |
| Airborne interrogator system (post-mod 651) | Allows the aircraft to challenge and identify other aircraft in which IFF/SSR transponders are fitted | Front cockpit, right console. Rear cockpit, antenna hand control |
| Sonar locating beacon | To assist in the location of ditched aircraft | — |

## INTERCOM AND TELEBRIEF SYSTEM

### General Description

2. In addition to permitting voice communication between cockpits, the intercom system also amplifies audio frequency signals from various sources. V/UHF and HF transmissions may be made through the system from either cockpit. Post-mod 404/429, PWR audio signals are amplified. A telebrief facility is installed, and voice communication with groundcrew is possible through a connector in the left wheel well. A continuous tone of 400 Hz is normally heard over the system.

3. *Intercom and Telebrief Controls.* The intercom controls in both cockpits consist of volume controls, function selector switches, emergency amplifier selection knobs and intercom/microphone buttons. The intercom control panel is shown at Fig. 1.




1—13 Fig 1 Intercom Control Panel and Microphone Button

a. *Volume Controls.* The intercom volume control knobs are on the left side of the intercom panels. The input level of the intercom signals to the headsets is increased by rotating the respective volume control knobs in a clockwise direction. The level of signal from the radio receivers is not affected by these controls, the level being varied for each radio receiver by its own volume control. The control is marked VOL.

b. *Function Selector Switches.* A 3-position ICS toggle switch, with positions marked RADIO OVERRIDE, HOT MIC and COLD MIC, is on the right side of each intercom control panel. The switch is spring-loaded away from the RADIO OVERRIDE position to the central HOT MIC position. The switches have the following functions:

(1) *HOT MIC.* In the HOT MIC position the intercom system is continuously live. If either crew member has HOT MIC selected the amplifiers go into HOT MIC operation.

(2) *RADIO OVERRIDE.* When RADIO OVERRIDE is selected, intercom and PWR (post-mod 404/429) audio signals remain normal but all other radio gain is reduced, allowing easier communication between cockpits, or between cockpits and groundcrew, when external radio transmissions are loud.

(3) *COLD MIC.* In the COLD MIC position, normal radio reception and transmission is still available but intercom and, therefore, cockpit background noise are completely muted. With COLD MIC selected, intercom can be achieved by moving the microphone button to the ICS position in the front cockpit or by pressing down the ICS floor button in the rear cockpit.

Note: With both switches to COLD MIC, there is a 1.5 second delay before the microphones becomes operative on keying either ICS button.

c. *Emergency Amplifier Selector Knobs.* The emergency amplifier selector knobs are 3-position rotary switches in the centre of both intercom control panels. These controls are used to bypass an amplifier should it malfunction. There are three possible settings for each control. The NOR position is used when both amplifying stages in the respective intercom control panels are functioning properly. The other two positions, EMER RAD and EMER ICS, are used to bypass a faulty amplifier. In certain cases of amplifier failure it may be necessary for both cockpit controls to be turned to an emergency position. In this case a loud squeal may be heard in the headsets unless one of the volume control knobs is turned down to a position less than 75% of the volume range.

4. *Telebrief Facility.* When using the telebrief, the function selector switches should be in the HOT MIC position. The normal microphone buttons are used to transmit. A TELEBRIEF caption above the front cockpit left console comes on when the landline is connected to the telebrief receptacle in the left wheel well. The caption has a 'press-to-test' facility to check the serviceability of the bulb. With external 28 volt DC applied via a special adapter, the Essential busbar is isolated and only the telebrief system and the INAS fine heaters are energised, keeping the inertial

platform above 35°C and thus avoiding unwanted errors during quick-reaction alignment.

5. *Microphone Buttons.* The microphone buttons are used to key V/UHF/HF radio and telebrief transmissions, or to obtain intercom when COLD MIC is selected. In dual control aircraft the microphone buttons, marked with ICS and UHF positions, are mounted on the inboard side of the right throttle in both cockpits. In single-stick aircraft, two foot-operated switches are provided in the rear cockpit; the left switch triggers the ICS/telebrief transmit and the right, radio transmissions. The selection of ICS reduces the volume of radio reception, transmits on telebrief and keys the microphone is COLD MIC is in use. A role equipment panel may be fitted to the rear cockpit; the left switch triggers the ICS/telebrief transmit and the right, radio transmissions. The selection of ICS reduces the volume of radio reception, transmits on telebrief and keys the microphone if COLD MIC is in use. A role equipment panel may be fitted to the rear cockpit left console to provide a 0.5 second UHF tone transmission on trigger press.

**Normal Operation of the Intercom and Telebrief System**

6. *Intercom System — Normal Operation.* The intercom system is operative as soon as electrical power is available. The controls in each cockpit should be set in the following manner in order to check the equipment before take-off:

| *Switch* | *Position* |
|---|---|
| Function Selector Switch | HOT MIC |
| Emergency Amplifier | |
| Selector Switch | NOR |
| Volume | Rotate Clockwise |

Then check the operation of all the intercom amplifiers by talking into the microphones. Rotate the VOL controls to ensure that they are operating properly. Switch to each of the EMER ICS-NOR-EMER RAD positions in turn to make sure they are functioning. The radio override functions of the intercom should be checked by each operator. In order to check the equipment properly, care should be taken to avoid simultaneous selection of RADIO OVERRIDE, since reduction in radio receiver volume is accomplished in both headsets when only one selection is made. Having proved the system, the operators should place the function selector switches as desired, select the NOR position on both panels and set the volume as desired. The system is turned off when aircraft electrical power is removed.

7. *Telebrief System — Normal Operation.* When the telebrief connection is properly made in the port wheel well, the TELEBRIEF caption above the pilot's left console illuminates and the aircraft intercom system is connected to the telebrief centre. It is possible to listen out on V/UHF and telebrief at the same time. The HOT MIC position should be selected on the function selector switches. To transmit on telebrief, either move the microphone button on the inboard throttle aft to the ICS position or, in single-stick aircraft, depress the ICS button on the left floor of the rear cockpit, Care should be taken when connected to the telebrief centre not to use the ICS position as a mute switch since all cockpit intercom would then be transmitted and the telebrief centre jammed.

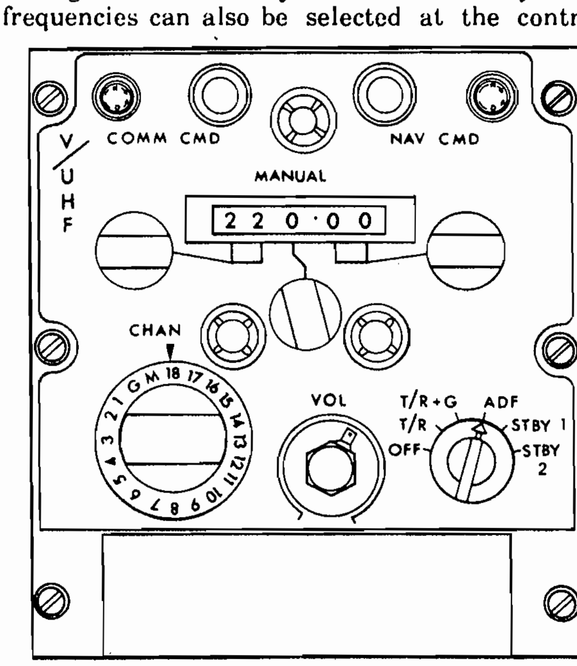
**Emergency Operation of the Intercom System**

8. Each cockpit's intercom unit is equipped with two amplifiers, both of which are used in normal operation (ie with NOR selected). Selection of EMER ICS or EMER RAD on the emergency amplifier selector switch enables an operator to bypass a faulty or dead amplifier.

## UHF/VHF RADIO

◆ **Description of the Equipment (Pre-mod 721)** ◆

9. *General.* The main UHF/VHF transmitter/receiver provides the primary voice communication system in the aircraft. The pilot's control panel is on his right console, and the navigator's control panel on his left console. Both panels control the operation of the main transmitter/receiver on 18 pre-set channels plus a guard channel, and manual selection of 3500 channels at 50 kHz intervals on UHF and 370 channels at 50 kHz intervals on UHF. Audio inputs and outputs on the main U/VHF are through the intercom system. Two standby UHF frequencies can also be selected at the control




**1—13 Fig 2 Main UHF/VHF Control Panel (Pre-mod 721)**

panel. A radio control panel is shown at Fig 2. The panels are identical in each cockpit.

10. *Radio Control Panels.* The radio control panels operate the main U/VHF set, the UHF standby set and ADF. At any time either the front cockpit panel or rear cockpit panel controls which frequency is in use. This is referred to as communications command (COMM CMD). Either the pilot or navigator may take or relinquish COMM CMD by operating a pushbutton at the top left of the control panel. An associated green light beside the pushbutton is lit when that control panel has COMM CMD and, therefore, the frequency set on that panel is the one in use in both cockpits. Other controls on the panel consist of the channel selector, the UHF/VHF volume control and the manual frequency control knobs. There is also a NAV CMD pushbutton and indicator light which is discussed in the Tacan section of this Chapter. The controls consist of:

a. *Channel Selector.* The channel selector is a rotary switch with positions 1 to 18, G and M. Positions 1 to 18 permit the selection of preset frequency channels. Position M selects the frequency set by the manual frequency control knobs as shown on the manual counters. Position G permits the main transmitter to operate on guard frequency (243.0MHz) independently of the standby set. When the channel selector is turned fully in either direction it stops in the G position.

b. *Mode Selector.* The mode selector is a 6-position rotary switch which has the following positions:

(1) OFF: all UHF/VHF communications and the ADF system inoperative.

(2) T/R: power on: equipment set to transmit and receive

(3) TR+G: normal transmit/receive facilities on the selected channel are maintained and the guard *receiver* is switched on.

(4) ADF: automatic direction finding system operates in conjunction with the main UHF system and normal UHF communications are retained.

(5) STBY 1: standby UHF set operating on 243.0 MHz.

(6) STBY 2: standby UHF set operating on 243.8 MHz.

c. *UHF/VHF Volume Control.* The volume control knob increases the incoming UHF/VHF signals of the main set when it is rotated clockwise. It is marked VOL.

d. *Manual Frequency Control Knobs.* There are three manual frequency control knobs which are used to set the manual UHF/VHF frequency shown by the MANUAL counters. The knob on the left of the panel is the hundreds and tens selector, the centre knob the units selector, and the knob on the right the decimals selector. Clockwise rotation of the knobs increases the figures.

11. *Remote Channel Indicator.* A remote channel indicator is on the forward cockpit instrument panel. It provides a secondary means of indicating which preset channel is in use. M or G is indicated when either Manual or Guard is selected.

12. *Standby UHF Transmitter/Receiver.* The UHF standby transmitter/receiver provides a standby communications source on 243.0 MHz (STBY 1 position) or 243.8 MHz (STBY 2 position). The STBY 2 position is normally used to check the serviceability of the standby set. Volume of reception cannot be adjusted in either cockpit. Both controllers must be set to STBY 1 or STBY 2 together for operation. The set also operates from RAT power or from the battery.

Note: When the standby radio is in use, turn down the volume control of the main set to minimum to prevent interference from the main set jamming the intercom.

13. *Automatic Direction Finding (ADF).* When operating with the ADF mode selected, associated controls should be positioned so that ADF information is displayed. In the front cockpit, the bearing/distance selector switch on the navigation function selector panel should be set to the ADF position so that ADF information is displayed on the horizontal situation indicator (HSI). In the rear cockpit, the CNI/NAV COMP switch should be placed in the CNI position for ADF information to be displayed on needle 1 of the bearing distance heading indicator (BDHI). A low level 155 cycle buzz is heard in the headsets while the ADF antenna is searching. The buzz diminishes as the ADF locks on to a bearing. The system works only on UHF frequencies.

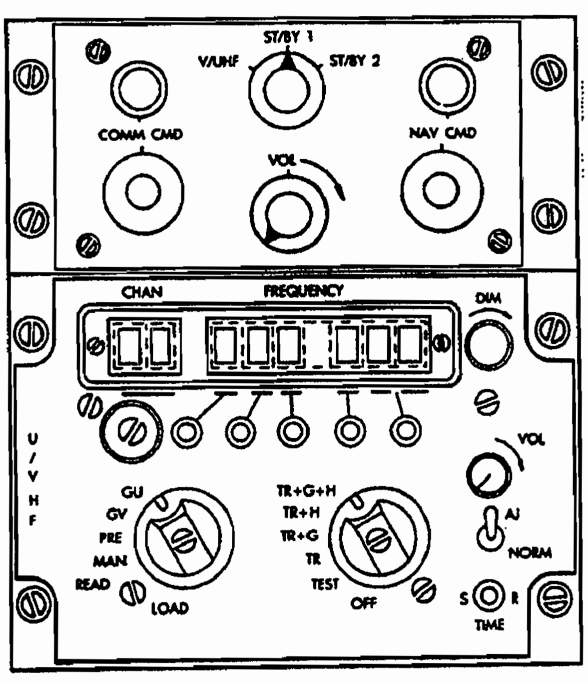
14. *Antenna Selector Switches.* There is a 2-position antenna selection switch in each cockpit. The pilot's antenna switch is on the left console outboard of the throttles, and the navigator's antenna switch is on his instrument panel. The switch positions are upper (UPR) and lower (LWR) and are used with the COMM CMD radio set. Which ever cockpit has COMM CMD controls the antenna in use for UHF. When VHF is selected, the upper antenna is used irrespective of antenna switch position. The standby UHF automatically uses the antenna not being used by the main UHF set.

**WARNING:** Before transmitting on the standby radio while taxying, the position of the appropriate antenna selector switch should be checked to ensure that the standby radio transmits through the upper aerial to avoid interference with nosewheel steering.

**Description of Equipment (Post-Mod 721)**

14A. *General.* The V/UHF transmitter/receiver provides the primary external voice communication system. The pilot's command and control unit is on his right console and the navigator's on his left console. The two units are identical and are shown in Fig 2A. The upper portion of the unit comprises the command panel and the lower portion the V/UHF control panel. The system allows operation on 24 pre-set channels or manual selection of 3500 channels on UHF at 50 KHz intervals ◆ (post-mod 1005, 7000 channels at 25 KHz intervals) (225 to 399.975 MHz) and 720 channels on VHF at 25 KHz intervals (118 to 135.975 MHz). Audio inputs ◆ and outputs on the main V/UHF are through the intercom system. Two standby UHF frequencies can also be selected on the command panel.

14B. *Command Panel.* Command panel selections determine which cockpit V/UHF controller or which standby UHF frequency is in use. The controls and indications on the command panel are as follows:




**1-13 Fig 2A V/UHF Command and Control Panel (Post-Mod 721)**

a. *Communications Push-Button and Light.* Either the pilot or navigator can take or relinquish communications command by operating the COMM CMD push-button. The green light above the push-button is lit in the cockpit which has COMM CMD and reference to the mode switch shows whether the main V/UHF system or one of the standby UHF frequencies is in use.

b. *Navigation Push-Button and Light.* Either the pilot or navigator can take or relinquish navigation command by operating the NAV CMD push-button. The green light above the push-button is lit in the cockpit which has NAV CMD, indicating which cockpit Tacan selection is in use.

c. *Mode Switch.* The 3-position mode switch has the following selections and functions:

(1) *V/UHF.* Main V/UHF transmitter/receiver in use.

(2) *ST/BY 1.* UHF standby set operational on 243.0 MHz.

(3) *ST/BY 2.* UHF standby set operational on 243.8 MHz.

d. *Volume Control Switch.* The rotary VOL control switch provides independent adjustment of the V/UHF and intercom audio levels.

14C. *V/UHF Control Panel.* The V/UHF control panel operates as follows:

a. *Volume Control Switch.* Clockwise rotation of the VOL control increases the audio level of incoming V/UHF signals.

b. *Manual Frequency Selection and Display.* The five manually-operated switches below the FREQUENCY display select any required manual frequency. Upward movement of the first four switches increases the reading in the associated FREQUENCY window by one digit; downward movement decreases the indicated digit. In the case of the right-hand switch, which controls the selections for the two right-hand windows, each movement of the switch changes the display by 25 KHz, ie, the display shows only 25, 50, 75 or 00.

c. *Channel Selector.* The rotary pre-set channel selector controls the selection and indication of the channel number, between 1 and 24, shown in the CHAN display above the selector.

**Table 1A - Command Panel Selections**

| *Mode* | *Function* | *Operation* |
|---|---|---|
| OFF | Any | System inoperative. |
| TEST | MAN | CHAN and FREQUENCY displays all show 8. |
| | PRE | Pre-set frequency displayed. UHF test tone or VHF hash audible. Pre-set channels may be checked. |
| | GV | FREQUENCY display shows 121.500. VHF hash audible. |
| | GU | FREQUENCY display shows 243.000. UHF test tone. |
| TR | MAN | Manually set frequency in use. |
| | PRE | CHAN displays frequency in use. |
| | GV | 121.5 MHz in use. FREQUENCY display shows last manually-set frequency. UHF inhibited. |
| | GU | 243.0 in use. FREQUENCY display shows last manually-set frequency. VHF inhibited. |
| TR+G | As above | UHF guard receiver operative. |
| TR+H | As above | ADF system operative. |
| TR+G+H | As above | UHF guard receiver and ADF system both operative. |
| Any except OFF | READ and LOAD | To load a new frequency into a pre-set channel, set the new frequency with READ selected, select the required channel number and rotate switch to LOAD. The new frequency can be checked in TEST/PRE. |

d. *AJ-NORM and TIME-S/R Switches.* These switches are not operational. The AJ-NORM switch must be set to NORM or the first digit on the FREQUENCY display shows 'A'.

e. *Mode and Function Selectors.* Two rotary 6-position switches control the mode and function as shown in Table 1A.

14D. *Remote Frequency Channel Indicator (RFCI).* An RFCI is located on the front cockpit instrument panel. When a pre-set channel is in use, the channel number is displayed. When MAN or a guard frequency is selected via the function switch, the channel number LED display goes blank and an M or G indication is lit on the RFCI.

14E. *Standby UHF Transmitter/Receiver.* The UHF transmitter/receiver provides a standby communications system operating on 243.0 MHz (ST/BY 1) or 243.8 MHz (ST/BY 2). The ST/BY 2 position is normally used to check the serviceability of the standby set. Volume of reception cannot be adjusted in either cockpit. When using the standby set, the mode switches in each cockpit are normally set to ST/BY 1 or ST/BY 2 together. The standby set works from RAT power in an emergency.

Note: When the standby set is in use, turn down the volume of the main set to prevent interference from the main set disrupting standby set audio.

14F. *Automatic Direction Finding (ADF).* To operate in the ADF mode, set the V/UHF control panel to TR+H or TR+G+H and the function switch to obtain the required operating frequency. In the rear cockpit the CNI/NAV COMP switch must be set to CNI for ADF information to be displayed on needle 1 of the BDHI. In the front cockpit the navigation function panel BRG/DIST switch must be set to ADF to display the information on the HSI bearing pointer. A low, 155 Hz buzz is audible while the ADF antenna is searching; the buzz reduces as the ADF locks on to a bearing. The ADF system operates only on UHF.

14G. *Antenna Selector Switches.* A 2-position upper or lower antenna selector is fitted in each cockpit. The pilot's antenna switch, marked COMM ANTENNA SEL - UPR/LWR, is positioned on the left console outboard of the throttles. The navigator's antenna switch, marked

UHF ANT SEL - UP/LWR is on the left side of the instrument panel. The cockpit which has COMM CMD, ie, the cockpit in which the COMM CMD green light is lit, has command of the antenna in use for the frequency selected in that cockpit. The standby UHF set automatically uses the aerial not being used by the main set. When a VHF frequency is selected, the upper antenna is used irrespective of the antenna selector switch position.

**WARNING:** Before transmitting on the standby set during taxying, the appropriate antenna selector switch must be set to LWR to ensure the standby set transmits through the upper antenna, thus avoiding interference with the nosewheel steering.

**Normal Operation of the Main Radio and ADF Systems**

◆15. Pre-mod 721, with either generator on line and power to the Left Main 115/200 volt AC busbar, or with the RAT on line, the UHF/VHF communications system is brought into operation by rotating the mode selector to a position other than OFF. To use the UHF/VHF facilities on external power, the CNI GRND POWER switch in the left wheel well must be made. This switch is manually selected and electrically held to the ON position, and continues to hold until manually selected OFF or until external power is interrupted. Post-mod 721, the V/UHF operates either from external power or from the battery, without the CNI GRND POWER switch selected to ON. However, if any other CNI function is required, the CNI GRND POWER switch must be made. ◆

16. With the mode switch at any position other than OFF, the set is listening out on the frequency/channel selected in the cockpit which has COMM CMD. Transmissions are triggered by keying the microphone button in either cockpit. The main and standby sets are normally checked before taxying; however, if it is necessary to check the standby set during taxying, the WARNING in para 14 must be heeded.

17. *Normal Operation of the ADF.* To obtain ADF relative bearing indications on the HSI and BDHI, place the BRG/DIST switch to ADF, the CNI/NAV COMP switch to CNI and the mode selector on the control panel to ADF.

**Emergency Operation of the UHF/VHF Radio**

18. *Transmitter Failure.* If it becomes apparent that the transmitter has failed, first try the transmit button in the other cockpit, having checks that the HF/UHF switches are in the correct position.

19. *Main Radio Failure.* If main radio failure should occur, make the following attempts to regain 2-way communications:

a. Suspect an intercom amplifier failure if the intercom is also unserviceable (para 8).

b. If using UHF, try a VHF frequency (and vice versa).

c. If using a preset frequency, try a manually set one (and vice versa).

d. Try using the alternative UHF antenna when attempting to transmit and receive on UHF frequencies.

If main radio failure is confirmed, select STBY 1 (or STBY 2 if appropriate) in both cockpits and turn down the volume controls on the control panels to a minimum. If the standby set has also failed, the appropriate SOP for total radio failure should be followed. It may be possible to establish air-to-ground communication on the HF set. The IFF mode 3/A code for radio failure is 7600. If an ILS recovery is feasible, ground-to-air voice communication is possible with the ILS volume turned up.

## HF RADIO

**Description of the System**

20. *General.* The HF communication set provides long range voice communications within the frequency range 2.000 MHz to 29.999 MHz. The 28,000 channels available are spaced one kHz apart and have two modes of operation: double sideband and single sideband. In the double sideband (DSB) mode, the set transmits and receives signals using conventional amplitude modulation; in the single sideband (SSB) mode, the set transmits and receives signals using the upper sideband with the lower sideband and carrier suppressed. Advantages of SSB operation are reduced phase distortion, longer range and reduced noise interference. The skin of the aircraft serves as the antenna for the HF radio, with the feed point being at the base of the forward spar in the vertical stabiliser. The HF radio uses the intercom system to amplify signals to both front and rear headsets and to amplify transmissions.

**WARNING 1:** Do not transmit on HF when personnel are working on the aircraft, particularly in the area of the vertical stabiliser, as RF burns could result.

**WARNING 2:** Operation of the HF transmitter when flap is lowered may cause electrical interference in the ARI system.

**WARNING 3:** HF transmissions must not be made whilst in contact during air-to-air refuelling.

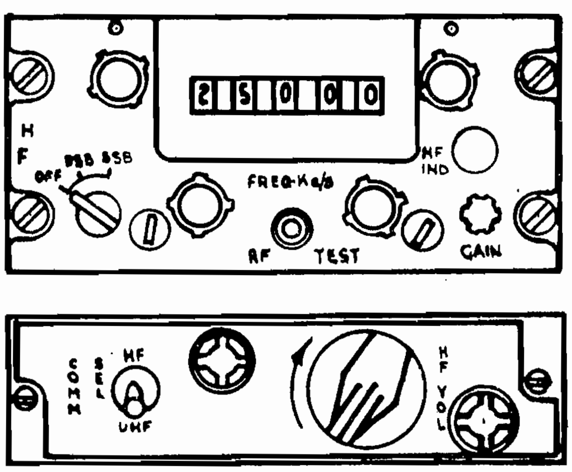
**WARNING 4:** HF transmissions may cause minor deflections of the ILS needles during an ILS approach.

**WARNING 5:** During sustained transmissions on certain HF frequencies, both tape and counter fuel readings can drift. See Part 1, Chapter 7.

21. *HF Control Panel.* The HF control panel is on the left console in the rear cockpit. The control panel and the associated communications selector panel are shown at Fig 3.

22. The HF control panel has the following controls and indicators:

a. *Mode Selector Knob.* The mode selector knob, with position OFF, DSB and SSB, turns the set on and off and selects the operating mode.




**1—13 Fig 3 HF Control Panel and Communications Selector Panel**

b. *Operating Frequency Selector Knobs.* The operating frequency selector knobs set the desired frequency in the operating frequency indicator. There are four selector knobs. The first knob controls the MHz tens and digits, and the remaining three selector knobs control the 100, 10 and 1 kHz digits of the frequency selected.

c. *Operating Frequency Indicator.* The operating frequency indicator furnishes a digital readout of the frequency set in the radio. The instrument is internally lit; light intensity is varied by the instrument panel lights control.

d. *Radio Frequency Test (RF TEST) Pushbutton.* The RF TEST pushbutton, in conjunction with the RF IND light, enables the operator to check the serviceability of the HF transmitter.

e. *Radio Frequency Indicator (RF IND) Light.* If the HF set malfunctions during a normal tuning cycle, the RF IND light begins flashing and continues to flash until a different frequency is selected. After a normal tuning cycle, depressing the RF TEST pushbutton illuminates the RF IND light if the set is operational. If, subsequently, the RF TEST pushbutton is held depressed for more than 16 seconds, the RF IND light will flash until the pushbutton is released.

f. *GAIN Control.* The GAIN control varies receiver sensitivity.

23. *Communications Selector Panel.* There are communications selector panels in each cockpit. Both comprise an HF volume (HF VOL) rotary switch and a COMM SEL switch with HF and UHF positions. In the rear cockpit the panel is aft of the HF control panel on the left console. In the front cockpit the switches are incorporated in the cabin pressure indicator panel outboard of the IFF/SSR control panel on the right console. The HF VOL control adjusts the level of HF volume individually in each cockpit. The COMM SEL switch determines to which communications set the individual cockpit microphone/transmit button is connected. With HF selected, transmissions from that cockpit can only made on HF; similarly, with UHF selected, only V/UHF transmissions can be made.

### Normal Operation of the HF Radio

24. *Tuning the HF Radio.* Set the mode selector to SSB or DSB as required and allow a 5 to 15 minute warm-up period. Set the COMM SEL switch to HF and the HF VOL control to a mid position. Select the required frequency; an 800 Hz tone is heard in the headset while transmitter/receiver tuning takes place. Adjust the GAIN control. Momentarily key the microphone button to the transmit position; the 800 Hz tone is again heard until fine tuning is completed. Press the RF TEST button; if the RF IND light is steady whilst the button is pressed, the set is ready for operation on the frequency selected. If a new frequency is selected, the fine tuning procedure must be followed again and the RF test carried out.

### HF Radio Malfunctions

25. *No Transmissions.* If it is apparent no transmissions are being made, check the COMM SEL switch in the transmitting cockpit is in the HF position.

26. *Flashing RF IND Light.* A flashing RF IND light indicates that the antenna tuning coupler system has failed to tune correctly or, above 10,000 feet, that antenna coupler pressurisation has failed. Do not attempt to transmit with a flashing RF IND light. By selecting another frequency and returning to the required frequency it may be possible to receive but not to transmit. If an alternative frequency can be used, it may be possible to fine tune that frequency without a flashing RF IND light. If antenna coupler pressurisation has failed, an attempt to tune results in a flashing RF IND light on all frequencies whilst above 10,000 feet.

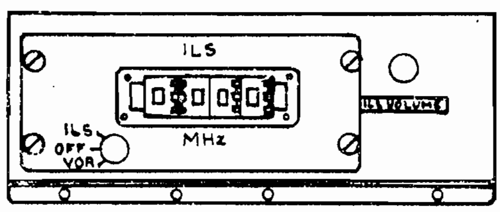
## INSTRUMENT LANDING SYSTEM (ILS)

### Description of the Equipment

27. *General.* The ILS equipment in the aircraft operates in conjunction with fixed ground

transmitters to provide indications of aircraft displacement from localiser and glidepath beams. These indications are displayed on the ILS indicator in the front cockpit. Associated marker beacons are positioned to provide range checks. Electrical power for the system is supplied by the Right Main 28 volt DC busbar via the ILS circuit breaker on No 3 panel in the front cockpit.

28. *Control and Indicators.* The ILS controls and indicators consists of an ILS deviation indicator and marker light on the pilot's instrument panel and an ILS control panel comprises a function switch, frequency control switches and an adjacent ILS VOLUME control. The control panel is shown at Fig 4.




**1—13 Fig 4 ILS Control Panel**

a. *Function Switch.* The function switch is a 3-position switch with the following positions:

(1) OFF: equipment inoperative.

(2) ILS: power applied to the equipment to energise localiser, glidepath and marker receivers.

(3) VOR: the VOR position is not used.

b. *Frequency Control Switches.* The four frequency controls are thumbwheel switches which enable the selection of localiser frequencies between 108.00 and 111.95 MHz which are displayed on the associated frequency indicator. When an ILS localiser frequency is selected a paired frequency is automatically selected for the glidepath receiver.

c. *ILS VOLUME Control.* The ILS VOLUME knob controls the audio level of the beacon identification signal. It has no effect on the volume of marker signals.

29. *ILS Indicator.* The ILS indicator comprises a 2-needle (crossed pointer) presentation and a vertical and horizontal linear scale of dots at 0.5 degree spacing. Aircraft deviation from either the localiser or glidepath is shown by needle movement relative to the linear scale, scale centre representing the aircraft. Indicator lighting is controlled by the instrument panel lights control. Two warning flags are provided. The localiser warning flag is positioned at the bottom of the indicator, and the glidepath flag to the right. When signals are not being received, the warning flags are fully visible. The warning flags gradually move out of sight as the strength of the localiser and glidepath signals increase. The signals being received are not reliable until the appropriate warning flag is not visible.

30. *ILS MARKER Light.* A blue ILS MARKER light, incorporating press-to-test and dimming facilities, is adjacent to the ILS indicator. The light flashes when the aircraft is passing over a marker beacon and, at the same time, an associated radio signal is amplified in the headsets. The visual and audio indication are as follows:

Outer marker: two dashes per second, light and 400 Hz tone.

Middle marker: alternate dot/dash, light and 1300 Hz tone.

### Normal Operation of ILS

31. Set the function switch to ILS and select the appropriate frequency on the thumbwheel control switches. Adjust the ILS VOLUME and identify the selected beacon. When the warning flags have disappeared, the signals received are valid. Should one warning flag remain but all other indications appear normal, the equipment may still be used with the exception of that particular facility.

**WARNING 1:** Minor deflections of the ILS needles are possible during an ILS approach if HF transmissions are made.

**WARNING 2:** Serious errors in ILS function can be caused by transmission on certain VHF and UHF frequencies.

### Emergency Use of ILS

32. After a total radio failure, ie failures of both main and standby sets, it is possible to receive one-way voice communication from ATC on the localiser frequency. To receive instructions, place the function switch to ILS and, having selected the appropriate frequency, turn up the ILS VOLUME control.

## VOICE RECORDER

### Description and Operation of the Voice Recorder

33. *Description.* The voice recorder, located aft of the navigator's left console, is used to record all radio and intercom signals. It has a removable magazine containing sufficient quarter-inch magnetic tape for a maximum of 60 minutes of recording. The recording time remaining is displayed on an indicator, on top of the magazine, in 10-minute increments. The equipment is controlled by a VOICE REC switch on the pilot's pedestal panel which has START and STOP positions. When START is selected, a V/R POWER caption is lit on the navigator's telelight panel. The system requires no warming-up period.

34. *Operation.* The voice recorder runs continuously with the VOICE REC switch in

the START position, recording all signals amplified by the intercom system. The VOICE REC switch should be placed to STOP when the 60-minute recording time has elapsed.

35. *Play Back.* To play back on a standard tape recorder the tape must be removed from the reel, turned through 180° and rewound on a standard tape reel. There is no play back facility in the air.

## IFF/SSR IDENTIFICATION SYSTEM

Note: Airborne interrogator system displays and information can be found in the Aircrew Manual - Weapon System (1977 and 1980 Radar Mod Standards) (CD101B-0901 & 2-15D).

### Description of the System

36. The IFF/SSR system, when operating, automatically transmits identification signals in reply to challenge signals from surface or airborne interrogators. In addition, the equipment can be manually selected to transmit either an I/P (identification of position) or an emergency signal. ◆◆ An airborne interrogator facility is installed to permit the interrogation of other transponders.

37. The transponder system decodes incoming interrogation signals to ascertain the mode. If this mode is selected on the IFF control unit a coded reply is triggered in response. The IFF/SSR modes are listed in Table 2. MODEs 1 and 3/A can be manually selected to settings between 0000 and 7777 at the IFF control unit by the pilot. MODE 2 is preset on the ground. When MODE C is switched on, automatically coded height information is passed to the transponder for transmission when the equipment is interrogated in that mode. ◆◆ MODEs 1 and 3/A can be selected either to MANUAL or AUTOmatic at the automatic code change (ACC) control and display unit. With MANUAL selected the MODEs 1 and 3/A codes manually set at the IFF control unit are triggered; with AUTOmatic selected, MODE 1 and 3/A codes are generated and changed periodically by the ACC equipment in the CNI bay, and those being transmitted can be inspected by pressing the READ button on the ACC control and display unit.

38. Codes for MODEs 1 and 3/A are normally established before flight when the IFF/SSR system is to be set manually, but ground radar stations may request the selection of particular codes or the deselection of one or more modes. ◆◆ Automatically programmed codes can be injected on the ground by a code injection unit. When freshly charged, the ACC unit can hold sufficient codes for MODEs 1 and 3/A to cover a 24-hour period.

39. MODE 3/A codes 7600 and 7700 are selected only in an emergency situation to give ground stations special alarm indications:

a. *Code 7600.* To indicate a radio failure (normally loss of voice contact in controlled airspace).

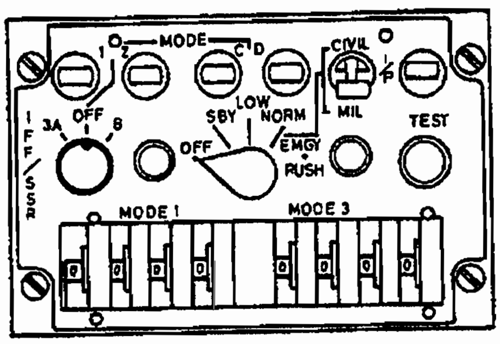
b. *Code 7700.* To indicate that an emergency exists in the aircraft.

Note: ◆◆ These codes are only transmitted when MANUAL is selected on the ACC control and display unit.

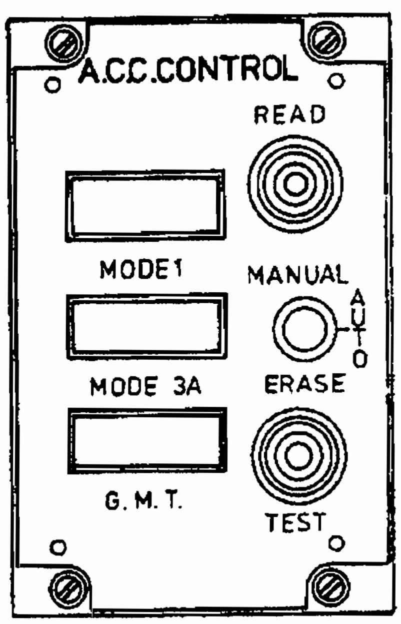
40. When the transponder is replying to an interrogation, the Tacan equipment (which operates in the same frequency band) is momentarily suppressed: IFF/SSR is similarly suppressed when either Tacan or ◆◆ when the airborne interrogation facility is transmitting.

**Table 2 - IFF/SSR Modes**

| *Mode* | *Use* | *Control* |
|---|---|---|
| 1 | General Military control and Command identification. Airways crossing under an ATCRU. | Military radar or ATCRU. |
| 2 | The codes used identify specific aircraft and are pre-set. | Air Defence Radar Stations. |
| 3/A | ATC purposes, airways crossings, identification of in-flight conditions. | Military, Civil and joint ATC Centres. |
| | Airborne Interrogation ◆◆ | Interrogating aircraft. |
| B | An extension of Mode A to give increased cover in confined airspace with a dense flow of traffic | Military, Civil and joint ATC Centres. |
| C | Automatic altitude reporting | As mode B |
| D | Unused | |




**1-13 Fig 5 IFF/SSR Transponder Control Unit**




**1-13 Fig 6 ACC Control and Display Unit**

41. *IFF/SSR Controls and Indicators.* The IFF/SSR controls and indicators in the front cockpit consist of the transponder control unit and an IFF FAIL caption on the telelight panel, ◆◆ an ACC control and display unit on the right console, and an ACC FAIL caption on the telelight panel. In the rear cockpit ◆◆ the equipment comprises the challenge button on the antenna hand control and an indicator lights panel on the lower edge of the main instrument panel. The functions of all controls and indicators are listed in Table 3. An illustration of the transponder control unit is shown at Fig 5 and the ACC control and display unit at Fig 6.

## Normal Operation of IFF/SSR

42. *Manual Operation.* ◆◆ Set the function selector knob to the SBY position until the identification system is to be used and the ACC CONTROL and display unit selector switch to MANUAL. Set the required codes on the MODE 1 and MODE 3/A selectors. Response to interrogation is achieved by setting the function selector knob to LOW or NORM and selecting up the appropriate toggle switches for modes 1, 2 and C, and the 3/A OFF B function knob to 3/A or B, as required. An I/P (identification of position) reply may be transmitted in modes 1, 2, 3/A and/or B by momentarily raising the spring-loaded I/P select switch. The I/P reply is transmitted with the switch in the up position and for 15 to 30 seconds after it is released.

43. *Automatic Operation.* ◆◆ After a 50-second warm-up period with the function selector knob at SBY, select NORM, move the MODEs 1, 2 and C switches to the up position and the 3/A - OFF - B function knob to 3/A. Set the MANUAL/AUTO/ERASE switch on the ACC CONTROL and display unit to AUTO. Replies to interrogation in modes 2 and C are made by the transponder unit, and in modes 1 and 3/A by the ACC unit.

44. *Emergency Mode.* When the function selector is pressed and turned fully clockwise, emergency replies are transmitted in response to ground interrogation in modes 1, 2, 3/A and B, irrespective of other control settings. Emergency replies are also transmitted if the seat in either cockpit is ejected or removed, providing the set has had a 50-second warm-up period. ◆◆ Removal or ejection of either seat or the operation of the crash g-switch in the CNI bay also erases the ACC unit code store memory and brings on the ACC FAIL captions.

45. *Airborne Interrogator System.* ◆◆ After a 50-second warm-up period with the function selector knob at SBY, the airborne interrogation facility is available, providing the primary radar is operating in either the PD or pulse modes and the function selector knob is at any position other than OFF. Interrogation is initiated when the challenge button on the antenna hand control is pressed. If the interrogator is functioning correctly the NO CHAL caption of the IFF indicator lights panel remains off and the BIT light comes on. Pre-mod 806, the interrogator operates only in mode 3A. Post-mod 806, a 2-position MODE 3A/MODE 1 switch in the CNI bay is set to the required interrogator mode before take-off.

## Malfunction of the IFF/SSR System

46. *IFF FAIL Caption.* The IFF FAIL caption comes on if the TEST button has been pressed and the equipment has failed the test, or as a result of signal response being low or non-existent. If the IFF FAIL caption comes on with the function selector in the NORM position, press the TEST button. If the green light comes on it can be assumed that the IFF/SSR system is serviceable.

Note: UHF transmissions in the frequency range 225.5 to 343.3 MHz may interfere with IFF/SSR reliability.

**Table 3 - IFF/SSR Controls and Indicators**

| *Control/Markings* | | *Function* |
|---|---|---|
| **IFF/SSR Control Panel** | | |
| 5-position rotary function switch | OFF | Power supply disconnected, transponder and interrogator inoperative. |
| OFF/SBY/LOW/NORM/EMGY | | Note: The airborne interrogation facility is fully operational in all positions except OFF 90 seconds after switch-on, providing the main radar is operating in PD or pulse modes. |
| | SBY | Power supply on, transponder accepting interrogations, but cannot reply. If interrogated on a selected mode, the IFF FAIL caption flashes. After 50-second warm-up delay the equipment is ready for full operation when selected. |
| | LOW | Equipment functioning but with reduced sensitivity. Used only when requested by ground station, to reduce clutter. |
| | NORM | Equipment functioning fully. Transponder accepts interrogations on the modes selected and transmits replies. |
| | EMGY | When pushed and turned from STBY, LOW or NORM to EMGY, immediate emergency replies are made to Modes 1, 2, 3/A or B (see also CIVIL/MIL switch) interrogations irrespective of mode selected. The emergency reply consists of a normal reply followed by three repeats; the repeats consist of framing pulses with no information pulses. (If selected from OFF, the 50-second warm-up delay is accompanied by a steady IFF FAIL caption.) |
| Four on/off MODE switches (up for on): MODE 1-2-C-D | MODE 1 | Transponder accepts Mode 1 interrogations from an airborne or ground interrogator; transmits selected Mode 1 code. |
| | MODE 2 | Transponder accepts Mode 2 interrogations; transmits pre-set aircraft code. |
| | MODE C | Accepts Mode C interrogations; transmits altitude information in code. ◆◆ |
| | MODE D | Unused. |
| 3-position rotary switch MODE 3/A-OFF-B | OFF | Transponder will not accept or reply to Mode 3/A or Mode B interrogation |
| | MODE 3/A | Transponder accepts Mode 3/A interrogations from an airborne or ground interrogator and replies using selected Mode 3/A/B code. |
| | MODE B | Transponder accepts Mode B interrogation and replies using the selected Mode 3/A/B code. |

*continued*

**Table 3** - *continued*

| *Control/Markings* | | *Function* |
|---|---|---|
| Code number selectors and indicators for Mode 1 and for Mode 3/A/B transponder replies | | Each set of four selectors is used to set appropriate code number. Indicators show 0000 to 7777 allowing 4096 different codes to be set. To set a code, use the left-hand selector for the first digit, eg, code 76 shows as 7600. ◆◆ (This applies to MANUAL selection only; the selectors are inoperative with AUTO selected.) |
| 2-position emergency coding switch: CIVIL/MIL | | Used only in conjunction with EMGY position to establish emergency reply codes for Mode 3/A and Mode B only. |
| | MIL | Normally used. Selected Mode 3/A/B code is transmitted in emergency form in reply to interrogation. |
| | CIVIL | Code 7700 is automatically selected for emergency reply to interrogation irrespective of position of MANUAL/AUTO/ERASE switch. ◆◆ |
| 2-position switch (spring-loaded to off): | I/P | When operated momentarily and released, an identification reply is automatically transmitted for 15 to 30 seconds. The identification pulse takes the following forms: |
| | MODE 1 | Repeat of framing pulses containing selected code. |
| | MODE 2, 3/A/B | Framing pulses containing selected code plus one extra IP pulse. |
| Self-test facility, a push-button incorporating a double filament green light: | TEST | When pressed with equipment switched on, carries out a check of receiver sensitivity, transmitter power output and Mode serviceability. Select NORM, press TEST button (after 50-second warm-up). If test is satisfactory, green TEST light comes on. The IFF FAIL caption should then be/go out. An unsatisfactory test is indicated by a steady IFF FAIL caption and no green TEST light. IFF FAIL caption flashing during test indicates function switch is at SBY. IFF FAIL caption steady during test may indicate that the function switch is set at LOW; to cancel the caption select NORM and press the TEST button again. |
| **Right Vertical Panel** | | |
| IFF FAIL warning light | | Comes on when:<br>a. Rotary function switch is set to OFF.<br>b. Rotary function switch is set to SBY, and transponder is being interrogated but cannot reply (flashing light).<br>c. Transponder is u/s when under interrogation.<br>d. Rotary function switch is set at LOW during self-test.<br>e. Self test is unsatisfactory. |

*continued*

**Table 3** - *continued*

| *Control/Markings* | | *Function* |
|---|---|---|
| ACC FAIL warning light | | See under **IFF Indicator Lights Panel** below. |
| **ACC CONTROL and Display Unit** ◆◆ | | |
| 3-position switch: MANUAL/AUTO/ERASE (ERASE position guarded) | MANUAL | Selects transponder reply code set on IFF control panel for Modes 1 and 3/A. |
| | AUTO | Selects transponder reply code from programmed code in ACC unit for Modes 1 and 3/A. |
| | ERASE | Irreversibly erases code memory in ACC unit. When selected, ACC FAIL captions in both cockpits come on. |
| Read facility: | READ | When pressed with the equipment switched on and AUTO selected, displays show Modes 1 and 3A codes and GMT from ACC unit. |
| Self-test facility | TEST | When pressed with IFF control panel function switch on, each display shows 8888. |
| 4-digit LED displays | | Display Mode 1 and Mode 3/A codes and GMT when READ button is pressed; when TEST button is pressed, displays 8888 to prove system integrity. |
| **Antenna Hand Control** | | |
| Challenge button ◆◆ | | When pressed with NORM selected on IFF control panel and primary radar is operating in PD or pulse modes, IFF interrogation of radar targets is performed; if system is functioning correctly, NO CHAL light remains off and BIT light comes on. |
| **IFF Indicator Lights Panel** (rear cockpit) ◆◆ | | |
| Panel includes low altitude warning light, SEAM LOCK light and four airborne interrogator system indicator lights: | | |
| ACC FAIL | | Comes on to indicate ACC unit failure, code starvation (24 hours after code insertion), battery failure or selection of ERASE on ACC control and display unit. Removal or ejection of either cockpit ejection seat also causes the ACC FAIL lights to come on. |
| Note: The ACC FAIL light is repeated on the right vertical panel in the front cockpit. | | |
| BIT | | Comes on when navigator presses the challenge button on antenna hand control with primary radar in PD or pulse modes, proving integrity of interrogator system. |
| XPDR JAM | | Comes on to indicate that transponder is receiving L-band jamming signals. |
| NO CHAL | | Comes on when challenge button is pressed and primary radar is not operating in PD or pulse modes, indicating that interrogation cannot be performed. |

## NAVIGATIONAL EQUIPMENT

### Introduction

47. The navigational equipment in the aircraft consists of the INAS, the attitude reference set AN/AJB-7, the flight director group and the Tacan. The flight director group consists of the horizontal situation indicator (HSI), the attitude direction indicator (ADI), the bearing distance heading indicator (BDHI) and the remote attitude indicator (RAI). Each of these systems provides its share of information to supply the crew with adequate navigational assistance. The INAS provides the primary attitude reference and the AJB-7 the standby attitude reference.

Note 1: For full information on the INAS, refer to the Aircrew Manual - Weapons System, AP101B-0902-15B.

Note 2: Mod 5055 adds ballast weights to the electrical equipment rack to prevent an adverse shift in the centre of gravity when INAS line replacement units are removed as a temporary measure for certain ferry flights. Temporary labels (marked INOPR, INOPERATIVE or DO NOT SELECT THESE POSITIONS) are placed on those switches affected. In addition, mod 5055 introduces an adaptor loom to maintain essential electrical services.

### Attitude Reference Set AN/AJB-7

48. The AN/AJB-7 system is an all-attitude reference platform which supplies attitude and magnetic heading information. The autopilot and RAI receive AJB-7 attitude information at all times. In addition, attitude, and magnetic or directional gyro heading information, can be supplied to the HSI, ADI and BDHI in certain modes of operation.

49. The major components of the AJB-7 system are the compass adaptor-compensator, the displacement gyroscope and the compass transmitter. The compass adaptor-compensator receives heading information from the compass transmitter and displacement gyroscope. It processes the information and provides a stabilised magnetic heading output. The displacement gyroscope also provides pitch and roll information. The compass transmitter is a direction sensing device which accurately detects its alignment with the earth's magnetic field.

50. There is no on/off switch for the AJB-7 system. Power is applied when the circuit breakers are set, the L GEN and/or R GEN switches are to ON and external power is removed. Erection of the gyroscope unit takes 60 ±15 seconds. If erection is required while on external power, the AN/AJB-7 VERT REF GRD PWR TEST SWitch, positioned above the left console in the rear cockpit, should be moved from NORMAL to TEST.

### Compass System Controller

51. The compass system controller is positioned on the right console in the front cockpit. It controls the attitude reference system used (INAS or AJB-7), the heading reference used (INAS, AJB-7 magnetic or AJB-7 directional gyro) and monitors the accuracy of the AJB-7 magnetic compass function. In the directional gyro mode there are controls for adjusting the heading and for the compensation of apparent wander. The compass system controller is shown at Fig 7. The controller functions are as follows:

a. *PRIM/STBY Switch.* In the PRIM position, the INAS supplies attitude information to the ADI. In STBY, attitude information is taken from the AJB-7 system.

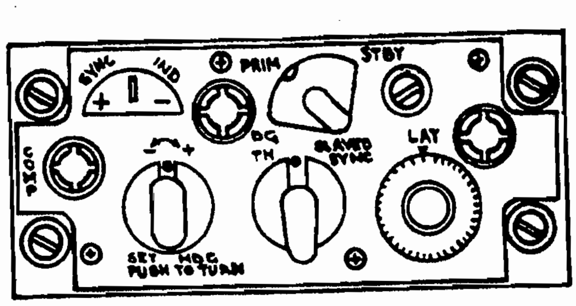
b. *Mode Switch.* The compass mode is controlled by a 4-position rotary switch with TH, DG, SLAVED and SYNC positions. The switch is spring-loaded away from the SYNC position to SLAVED.

(1) *TH.* True Heading. The INAS supplies true heading information to the HSI, BDHI and ADI irrespective of the position of the PRIM/STBY switch, provided the navigation function selector is not selected to TACAN.

(2) *DG.* Directional Gyro. The DG mode is selected when TH and AJB-7 heading information are both suspect. Corrected directional gyro heading information is supplied to the HSI and BDHI.

(3) *SLAVED.* When SLAVED is selected, the AJB-7 supplies gyro-stabilised magnetic heading information to the HSI, BDHI and ADI.

(4) *SYNC.* Synchronise. Momentarily selecting SYNC against the spring loading initiates




**1-13 Fig 7 Compass System Controller**

fast synchronisation of the displacement gyro with the compass transmitter output.

c. *Synchronisation Indicator*. When the SLAVED mode is in use, the synchronisation indicator, marked SYNC IND, provides a check on the accuracy of the magnetic heading shown. If the needle is displaced from the central position, the mode switch is moved momentarily to the SYNC position to achieve correct alignment.

d. *Set Heading Switch*. The set heading switch, marked SET HDG PUSH TO TURN, is used to regulate the initial heading set on the lubber line in the DG mode. To operate, select DG on the mode switch, depress the set heading switch and turn towards the plus or minus sign to decrease or increase the heading indicated on the HSI and BDHI.

e. *Latitude Control*. Compensation for apparent wander in the DG mode is made by selecting the hemisphere switch to N or S and the latitude control, marked LAT, to the correct latitude.

## FLIGHT DIRECTOR GROUP

### Introduction

52. The flight director group consists of the horizontal situation indicator (HSI), the attitude direction indicator (ADI) and the bearing distance heading indicator (BDHI). In the front cockpit certain indications on the HSI and ADI are controlled by the navigation function selector switches. In the rear cockpit, the CNI/NAV COMP switch controls the needle indications on the BDHI.

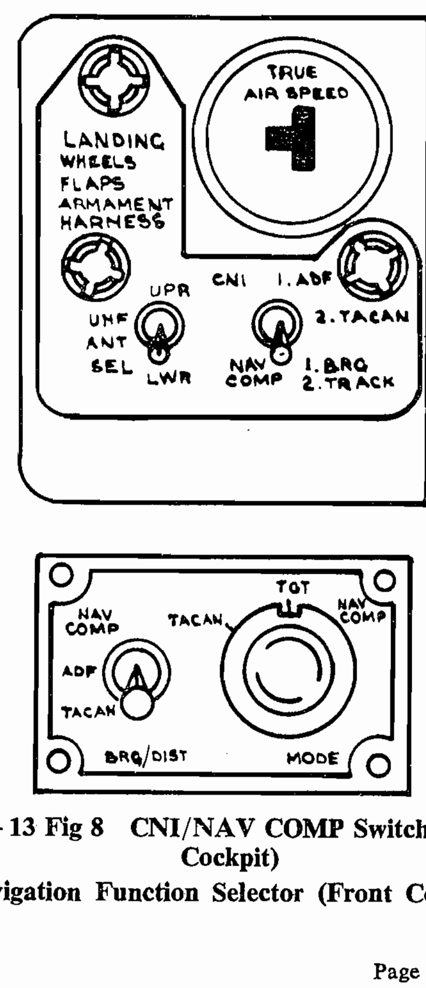
53. The purpose of the flight director group is to provide an integrated display of the navigational situation of the aircraft, deriving information from the INAS, AJB-7, TACAN and the UHF in the ADF mode, via the flight director computer if appropriate. The instruments of the flight director group in the front cockpit are also primary instrument flying references. In the rear cockpit the remote attitude indicator (RAI) and the BDHI are used for instrument flying in 2-stick aircraft.

Note: Full information on the INAS indications on the flight director group instruments is contained in Aircrew Manual — Weapons System, AP 101B-0902-15B, but see Table 4 for a simple list of switch position indications.

54. *Flight Director Computer*. The flight director computer provides navigation information to the HSI and steering information to the ADI. Except for the bearing and distance displays on the HSI, all signals for the HSI and signals for portions of the ADI, pass through or originate in the computer. The flight director computer does not influence the attitude information shown on the ADI. It generates steering signals to provide the pilot with information when flying computed headings or manually-selected Tacan radials. In addition the computer also supplies the necessary warning flag and off scale signals for the ADI.

55. *Navigation Function Selector*. The navigation function selector panel is part of the pilot's main instrument panel and comprises a rotary MODE selector and a BRG/DIST switch. These control separate functions of the HSI and, in the case of the MODE selector, the ADI. They do not necessarily have to be set as a pair. The panel is shown at Fig 8. The instrument indications controlled by the MODE selector and BRG/DIST switch are listed in Table 4.

56. *CNI/NAV COMP Switch*. The CNI/NAV COMP switch is on the navigator's instrument panel. The switch controls the source of signals to the two needles and the distance counter on the BDHI. In the CNI position there are markings of 1. ADF and 2. TACAN; in the NAV COMP position there are markings of 1. BRG and 2. TRACK. The switch is shown at Fig 8. The effect of the switch positions on the two needles and the distance counter is shown in Table 4.

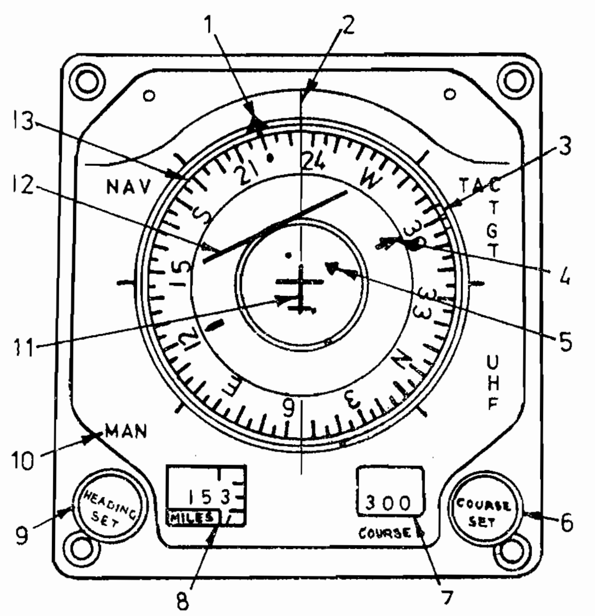



**1 — 13 Fig 8 CNI/NAV COMP Switch (Rear Cockpit)**

**Navigation Function Selector (Front Cockpit)**

### Horizontal Situation Indicator (HSI)

57. *HSI Function.* The HSI provides the horizontal or plan view with respect to the navigation situation, ie the HSI is a planform picture of the aircraft's present situation as seen from above the aircraft. An illustration of the HSI appears at Fig 9 with a key to the indications listed.



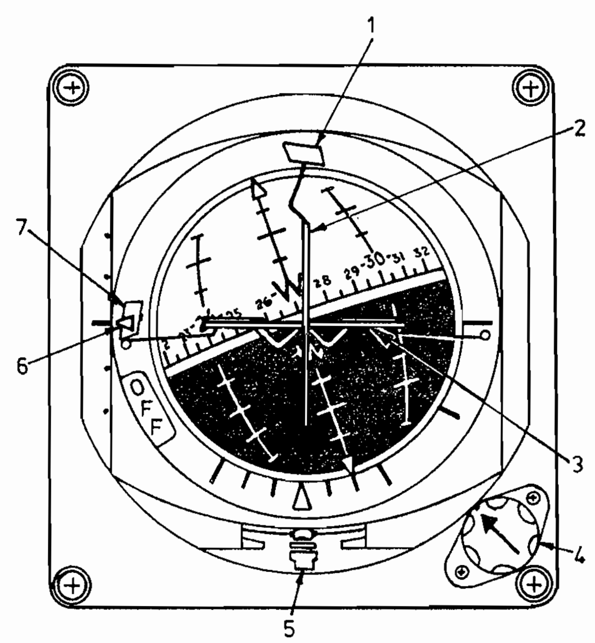

| *Item No* | *Description* |
|---|---|
| 1 | Bearing pointer |
| 2 | Lubber line |
| 3 | Command heading marker |
| 4 | Course arrow |
| 5 | To/from indicator |
| 6 | COURSE SET knob |
| 7 | COURSE window |
| 8 | Range indicator |
| 9 | HEADING SET knob |
| 10 | Mode caption |
| 11 | Aircraft symbol |
| 12 | Course deviation indicator |
| 13 | Compass card |

**1 — 13 Fig 9 Horizontal Situation Indicator (HSI)**

58. *HSI Indications.* The navigation function selector switches control the indications on the HSI as shown in Table 4. The aircraft symbol in the centre of the HSI is the key to assessing the horizontal or planform situation of the aircraft. The compass card rotates so that the aircraft's magnetic or true heading is always under the lubber line. Index marks are provided every 45° round the perimeter for use in holding patterns and procedure turns. Four mode captions are shown on the HSI. These lights are illuminated to indicate the selected mode provided the instrument panel lights are selected ON. Details of the indications in the Tacan mode are contained in the Tacan section of this Chapter.

### Attitude Direction Indicator (ADI)

59. *ADI Function.* The primary function of the ADI is to provide an aircraft attitude reference. An illustration of the ADI is shown at Fig 10.




| *Item* | *Description* |
|---|---|
| 1 | Vertical director warning flag |
| 2 | Bank steering bar |
| 3 | Horizontal director bar |
| 4 | Pitch trim knob |
| 5 | Turn and slip indicator |
| 6 | Vertical displacement pointer |
| 7 | Vertical displacement warning flag |

**1 — 13 Fig 10 Attitude Direction Indicator (ADI)**

60. *ADI Attitude Information.* The ADI takes its attitude reference either from the INAS with PRIM selected on the compass control panel, or from the AJB-7 with STBY selected. When switching from PRIM to STBY or vice versa, attitude information appears almost immediately but may be accompanied by some gyration of the attitude sphere in the instrument. This is a normal phenomenon caused by the AJB-7 gyro, and depends upon which side of the AJB-7 is uppermost during the initial erection. The black and grey sphere is movable and stabilised through all attitudes so that the miniature aircraft wings, against the moving horizon line, give the pilot attitude reference. Pitch angle increments of 10° are marked on the sphere. The pitch trim knob pro-

**Table 4 Instrument Presentations**

**HSI Indications** — *Mode Selector Switch*

| *Indicator* | *Mode Selector Switch Positions* | | |
|---|---|---|---|
| | *TACAN* | *TGT* | *NAV COMP* |
| Mode light | TAC | TGT | NAV |
| Command Heading marker | ◀ Drift-corrected heading to Tacan station | Drift-corrected heading to INAS destination | Drift-corrected heading to INAS destination ▶ |
| Course arrow, course window | Manually set to Tacan radial | Manually set to target radial | True track |
| Course deviation indicator | Deviation from Tacan radial | Deviation from target radial | Centred |
| To/from pointers | Indicates whether selected Tacan radial leads to or from Tacan station | Indicates whether selected target radial leads to or from target | Not in view |
| Compass card | Magnetic heading | ◀ True heading (if TH selected) | True heading (if TH selected) ▶ |

**HSI Indications** — *Bearing/Distance Switch*

| *Indicator* | *Bearing/Distance Switch Positions* | | |
|---|---|---|---|
| | *TACAN* | *ADF* | *NAV COMP* |
| Mode light | TAC | UHF | NAV |
| Bearing pointer | Bearing to Tacan station | Bearing to UHF station | Bearing to target |
| Distance counter | ◀ Slant range to Tacan station ▶ | Covered | ◀ Plan range to target ▶ |

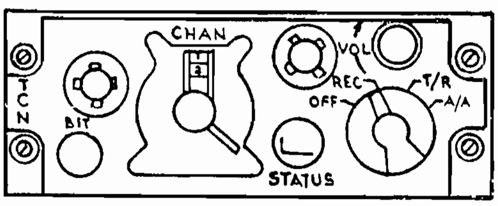
**ADI Indications** — *Mode Selector Switch*

| *Indicator* | *Mode Selector Switch Positions* | | |
|---|---|---|---|
| | *TACAN* | *TGT* | *NAV COMP* |
| Bank steering bar | Asymptotic steering to selected Tacan radial | Asymptotic steering to selected target radial | Steering to destination |
| Vertical director warning flag | Visible when Tacan signal unreliable | Visible when Tacan transmitter/receiver fails | Visible when INAS fails |
| Horizontal director bar | Biased out of view except in some INAS weapon modes | | |
| Vertical displacement pointer | Biased out of view except when in tracking mode with radar | | |

**BDHI Indications** — *CNI/NAV COMP Switch*

| *Indicator* | *CNI/NAV COMP Switch Positions* | |
|---|---|---|
| | *CNI* | *NAV COMP* |
| Single bar pointer | Relative bearing to UHF station | Relative bearing to destination, True or Mag as selected when read against compass card |
| Double bar pointer | Bearing to Tacan station. Pointer slaves to single bar pointer if Tacan unreliable | Aircraft track, True or Mag as selected; drift when read against lubber line |
| Distance counter | Slant range to Tacan station. Covered if Tacan unreliable | Plan range to destination |

line-of-sight distances are displayed on the HSI and BDHI distance counters. Up to five aircraft can determine their distance from a sixth (lead) aircraft. The lead aircraft indications show the distance from one of the other five, but it cannot readily be determined which one.




**1—13 Fig 12 Tacan Control Panel**

67. *Tacan Control Panels.* The Tacan control panel in the front cockpit is on the right console; in the rear cockpit it is on the left console. The NAV CMD pushbuttons and associated lights are on the UHF/VHF control panel in each cockpit (see Fig 2). Pilot and navigator can take or relinquish NAV CMD by operating the button. The cockpit which has NAV CMD has the green light lit, and the Tacan channel selected in that cockpit is the one in use. Tacan information received for the selected channel is displayed in both cockpits simultaneously. An illustration of a Tacan control panel is shown at Fig 12. The panel controls are as follows:

a. *Mode Selector.* The mode selector is a 4-position rotary knob with the following positions:

OFF: Tacan system inoperative.

REC: Tacan system receives and displays only bearing information. No transmissions from the aircraft.

T/R: Tacan system receives bearing information from the selected ground station and, in addition, interrogates the ground station to establish distance.

A/A: Tacan interrogates other aircraft with A/A mode selected and tuned 63 channels apart. Line-of-sight distance displayed. No bearing information.

b. *Channel Selector.* The channel selector, marked CHAN, provides for the tuning and display of 126 Tacan channels.

c. *Volume Control.* The volume control, marked VOL, controls the strength of the Tacan identification signal.

d. *BIT Pushbutton and STATUS Indication.* With NAV CMD established and the set warmed up, depressing and releasing the BIT pushbutton initiates a 20-second self test of the Tacan system. Bearing and range indications on the HSI and BDHI go to 360° and zero respectively. If the Tacan is serviceable a GO indication appears in the STATUS window for the last 10 seconds of the self-test period, after which the window goes blank. If the equipment is unserviceable, the STATUS window remains blank throughout.

Note: The Tacan BIT pushbutton must not be operated until the system has completed a 2-minute warm-up cycle, otherwise damage may occur.

68. Other controls and indications associated with Tacan are:

a. *Antenna Selector Switch.* The antenna selector switch, situated in the front cockpit above the right console, has UPPER, AUTO and LOWER positions. With AUTO selected the system switches automatically from the upper to the lower Tacan antennas in turn until the signal strength at one antenna is sufficient for system operation. Moving the switch to UPPER or LOWER overrides the automatic function.

b. *HSI Controls and Indications.* In the front cockpit, with the navigation function selector panel MODE and BRG/DIST switches both selected to TACAN, the bearing pointer on the HSI shows the magnetic bearing of the selected ground station and the MILES window shows its slant range. In such a 'locked on' situation, the HSI controls and indicators (shown at Fig 9) operate as follows:

(1) *COURSE SET Knob.* The COURSE SET knob rotates the course arrow on the face of the HSI, and the COURSE window provides a digital read-out of the bearing set. When the course arrow is within 90° of the Tacan bearing, the to/from indicator shows on the upper half of the instrument face; when the difference is greater than 90° the to/from indicator appears on the lower half.

(2) *Course Deviation Indicator.* The course deviation indicator works in conjunction with the course arrow. The relationship between the aircraft symbol in the centre of the HSI and the course deviation indicator gives a plan view of the situation. If the course arrow/COURSE window are set to the desired Tacan radial, the course deviation indicator shows the aircraft's relative position to that radial. Angular error from the Tacan radial can be read up to 5°. The two dots on the instrument face, one each side of the centre, each indicate 2·5° of angular error from the selected radial. When the indicator is fully deflected, the error is 5° or more.

c. *ADI Indications.* The vertical bar on the ADI, the bank steering bar (see Fig 10), commands the corrective action required to attain a Tacan radial asymptotically providing the COURSE SET control is turned to that radial. If the bank steering bar is to the left of centre, applying left bank centres the bar. The turn is continued until the bar moves to the right, commanding a reduction in bank or a roll-out. The bank steering bar is only reliable when the aircraft heading is within 60° of the required radial. It commands turns of a maximum of 30° angle of bank. An associated warning flag, the vertical displacement warning flag, appears at the top of the ADI when the Tacan signal is unreliable. A pictorial representation and explanation of the function of the bank steering bar is shown at Fig 13.

d. *BDHI Controls and Indicators.* In the rear cockpit, placing the CNI/NAV COMP switch to CNI puts the double-bar (number 2) pointer and the distance counters into the Tacan mode. The pointer shows the bearing of the Tacan ground station and the counters the distance. See Fig 11.

**Normal Operation of Tacan**

69. *Ground Checks.* To complete a ground check of the Tacan system, establish NAV CMD, check the TACAN ANT SEL is in the AUTO position, and set the MODE selector to REC or T/R. Allow a 2-minute warm-up period. Then complete a BIT programme. Having obtained a GO indication in the STATUS window, the equipment should be working correctly but it can be further checked by selecting a local Tacan beacon (if available) and setting the navigation function switches both to TACAN (front cockpit) or the CNI/NAV COMP switch to CNI (rear cockpit). With T/R selected, range and bearing should lock on to the ground station and the identification signal is heard if the VOL control is adjusted.

70. *Air-to-Ground Operation.* In the air, sophisticated Tacan information is available on the HSI and ADI. With the course arrow on the HSI set to the desired radial, an asymptotic approach to that radial may be made by following the commands of the bank steering bar on the ADI. Once the desired radial is established, compensation can be made for a crosswind by following the command heading marker and the commands of the bank steering bar. Alternatively, if an asymptotic approach is not practicable, the course deviation indicator on the HSI may be used, in conjunction with the bearing indication, to establish and hold a Tacan radial. A full pictorial explanation of these two techniques may be seen in Fig 13.

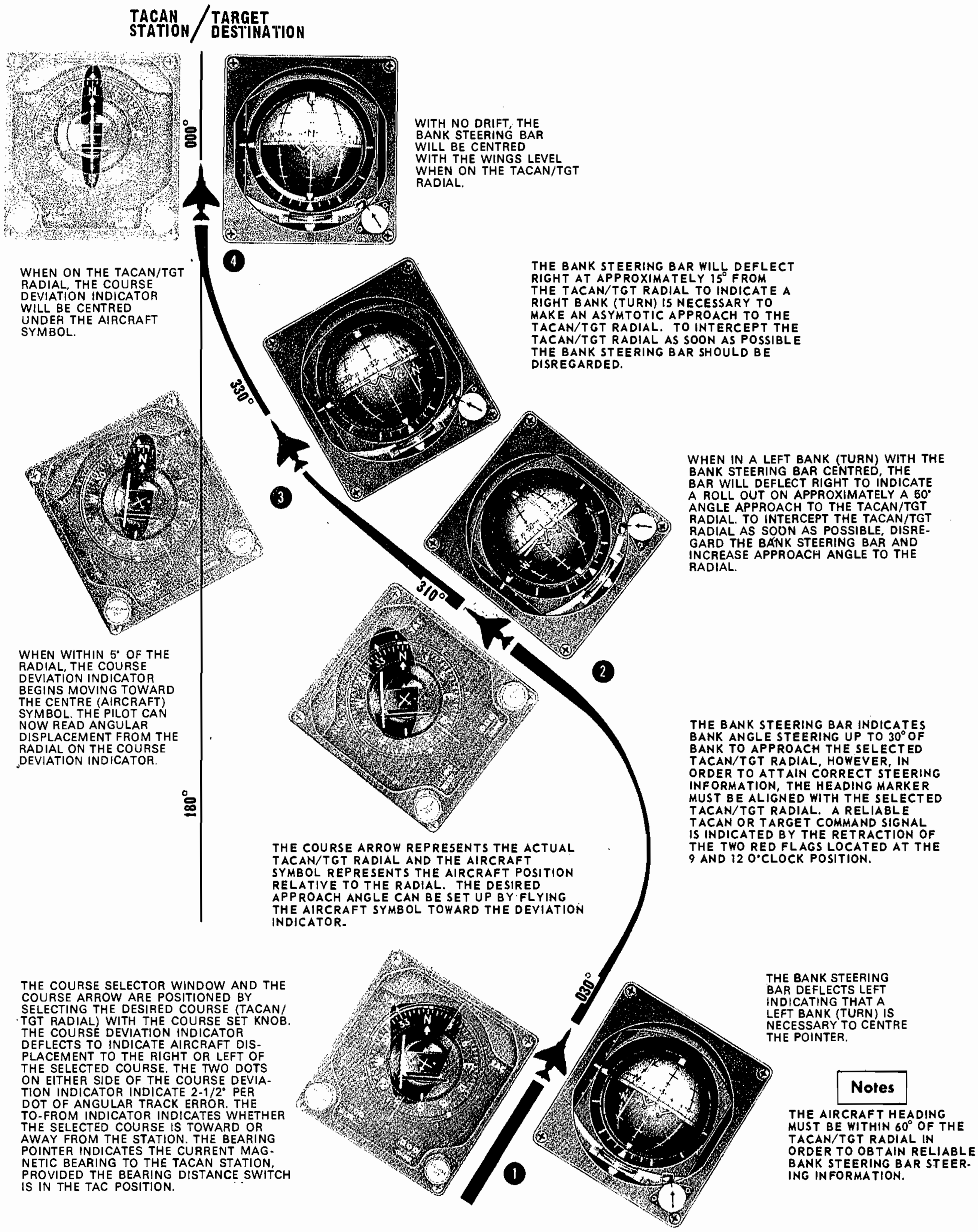
Note: Tacan information may be lost during V/UHF transmissions on various frequencies when the Tacan is locked to a distant station.

71. *Air-to-Air Operation.* To operate in the air-to-air mode, establish NAV CMD and set the MODE selector to A/A in both (or up to 6) aircraft. Place the BRG/DIST switch to TACAN and/or the CNI/NAV COMP switch to CNI. The leading aircraft's channel should be set 63 channels different from the other aircraft. Line-of-sight range information is shown on the distance counters in both (all) aircraft. Bearing information is not available in the A/A mode.

## SONAR LOCATION BEACON

**Description**

72. ◆◆ A sonar locating beacon (SLB) is fitted behind access panel 132L (below the RAT doors). If the aircraft ditches, the SLB is automatically activated as it sinks and transmits acoustic signals which can be received by ship or airborne sonar equipment. The beacon is independent of aircraft power supplies, having an integral battery with a life of approximately five years.




1 – 13 Fig 13 Tacan/Target Displays

*Intentionally Blank*

# PART 1

## CHAPTER 14 - NBC EQUIPMENT (POST-MOD 702)

### Contents



### Introduction

1. Post-mod 702, the aircraft is fitted with a permanent NBC system to supply filtered air to each aircrew respirator NBC No 5 (AR5) in the nuclear, biological and chemical (NBC) role. This equipment replaces the single S6 NBC filter canister introduced as an interim measure pre-mod 702. Reference should be made to AP 3456E, Part 1, Section 2, Chapter 3 for the full NBC and decontamination drills.

2. *Aircraft Equipment.* Each cockpit is fitted with a separate identical NBC system. A fan and motor unit supplies a flow of air via two S6 NBC filter canisters to the air hose of the PEC (suit ventilating air hose, pre-mod 702), which is connected to the air inlet hose of the AR5. A voltage regulator ensures a stable power supply to the blower motor; a hazard warning unit detects failures in this supply and operates the cockpit warning lights. The power supply to both systems is controlled by a single switch in the pilot's cockpit but a switch in each cockpit controls the supply to the individual blower motors. A barometric switch operates to cut the power supply to both NBC systems above a cockpit altitude of 25,000 feet to ensure an adequate supply of oxygen to the crew up to a cockpit altitude of 43,000 feet; emergency demist is used to keep the optical area of the face plate clear. The location of components is shown in Fig 1.

3. *Aircrew Equipment.* Both crew members wear an AR5, illustrated at Fig 2. The edge of the mask seals to the wearer's face and the hood seals round the neck. Air and oxygen supplies are fed to the AR5 through a manifold mounted on the wearer's life preserver. When outside the aircraft, the AR5 is supplied with filtered air from a portable ventilator, the hose of which is connected to the air inlet hose. In the aircraft, the wearer connects the PEC to supply oxygen into the manifold, disconnects the air inlet hose from the ventilator and reconnects the air inlet hose to the air hose of the PEC. It is important to ensure a continuous supply of air or oxygen through the hood otherwise misting of the optical area (visor) of the

**Table 1 - Controls and Indicators**

| *Control/Indicator* | *Marking* | *Position* |
|---|---|---|
| 2-position, locked-toggle NBC role switch | NBC ROLE - ON/OFF | Pilot's left console |
| 2-position NBC fan switch (one in each cockpit) | NBC FAN - ON/OFF | Pilot's/navigator's left console |
| NBC fan warning light | NBC FAN [red (P) amber (N)] | Pilot's/navigator's telelight panel |
| Emergency demist control | EMERGENCY DEMIST | AR5 manifold |

hood occurs within a few seconds.

## DESCRIPTION

### Controls and Indicators

4. The crew-operated controls and indicators are shown in Table 1.

### Power Supplies

5. Power supplies are provided from the Essential 28V DC busbar via two NBC circuit breakers (G3 for the rear cockpit and H3 for the front cockpit) on No 3 circuit breaker panel.

### Operation

6. *Normal Operation.* The fan and motor blowers run continuously, supplying a flow of filtered air to the hood of the AR5. A constant flow of oxygen is delivered to a metering orifice in the manifold and thence along an inner tube which opens into the mask hose just before it reaches the mask inlet valve (see Fig 2). During expiration, the mask inlet valve is closed and the oxygen fills the mask hose which acts as a reservoir. On inspiration, the oxygen from the reservoir is drawn into the lungs followed by filtered air mixed with the continuous flow of oxygen. This arrangement prevents hypoxia during flight up to a cockpit altitude of 25,000 feet.

7. *Operation of the Barometric Switch.* Above a cockpit altitude of 25,000 feet, the volume of the reservoir must be increased in order to prevent hypoxia. To achieve this, the barometric switch operates to energise an altitude relay on the NBC electrical panel. The relay disconnects the power supply to both regulators causing both fan and motor blower units to stop running. The hazard warning units sense the stoppage and supply power to light the NBC FAN captions.

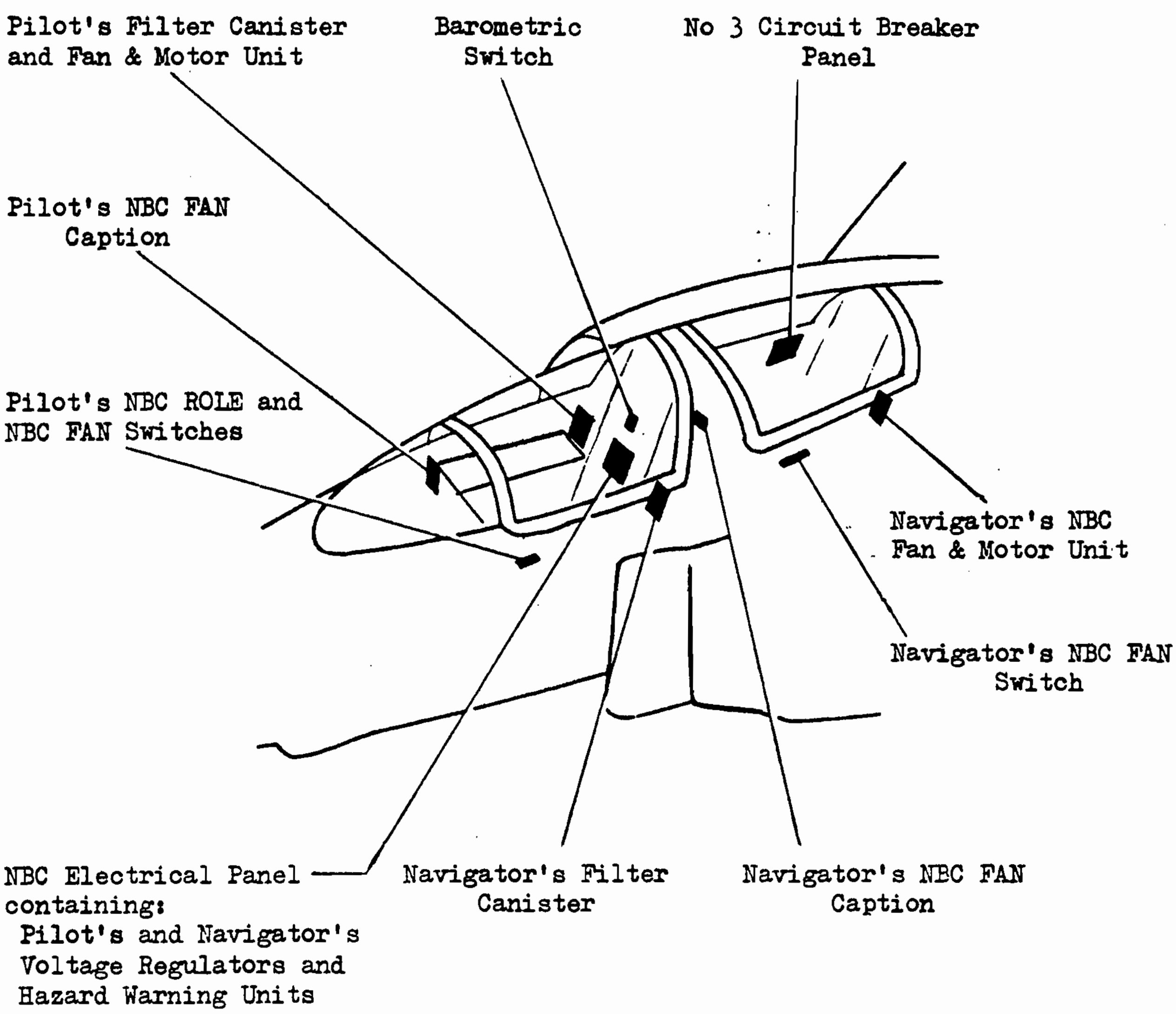
8. *Emergency Operation.* A fan stoppage results in the immediate cessation of the flow of air to the hood thus increasing the volume of the reservoir for the oxygen delivered to the wearer; in this mode, hypoxia is prevented at altitudes up to 43,000 feet. With no air flow to the hood the level of protection against contamination by NBC agents is reduced and misting of the hood visor could occur within 5 seconds. To prevent misting the EMERGENCY DEMIST control on the manifold is to be selected immediately the NBC FAN caption comes on. The reduction in the level of protection against NBC agents is of less immediate importance because, without fan operation, the AR5 provides full protection for a minimum of 30 minutes. In this time a decision can be made to return to an airfield which is known to be free from NBC contamination.

### Consumption of Oxygen

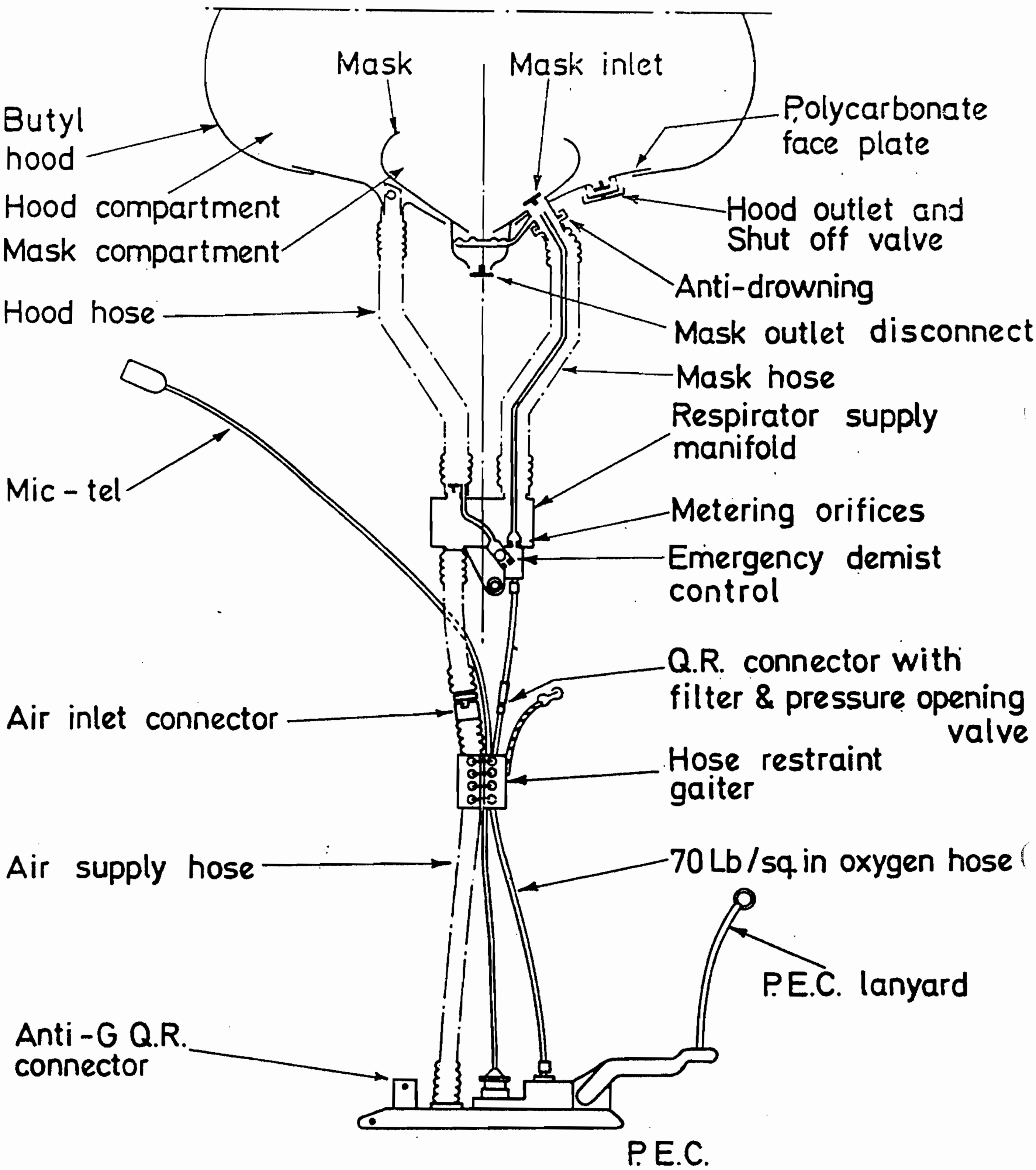
9. The 10-litre liquid oxygen (LOX) converters on Phantom aircraft have a gaseous maximum capacity of 7070 litres and a working capacity of 5300 litres (ie, 0.75 of the maximum capacity). Crews wearing AR5 consume 7 litres per minute each normally, and 20 litres per minute on emergency demist. Maximum flight duration is therefore as follows:

| *Demand* | *Maximum Capacity* | *Working Capacity* |
|---|---|---|
| 2 crew normal | 8hr 20min | 6hr 20min |
| 1 normal + emergency demist | 4hr 20min | 3hr 20min |
| 2 crew emergency demist | 3hr | 2hr 10min |

Note: In normal operation the emergency oxygen bottle lasts for approximately 10 minutes at altitude reducing to 2 minutes at sea level. With EMERGENCY DEMIST selected, these figures reduce to 3½, minutes and less than 1 minute respectively.




**1—14 Fig 1 Location of NBC Components**




**1—14 Fig 2 Aircrew Respirator NBC No 5 and PEC**

**Limitations**

◆10. The NBC system introduced by mod 702 is cleared for use with the communications improvement and modifications 721 and 980 embodied to allow operation in the NBC role at ground-level ambient temperatures up to +20°C and at cockpit altitudes up to 43,000 feet. Only AR5 respirators incorporating mod AR 110 (rip panel release assembly) are to be worn. The MOD(Air) Release to Service should be referred to for the latest release statement and limitations.

**WARNING 1:** The oxygen flow MI, when showing steady white in the NBC role, cannot distinguish between normal flow and leaks between the PEC and the face. Care is to be taken when making the hose connections.

**WARNING 2:** In flight conditions of positive g the AR5 may slip on the head and could obscure the wearer's sight and limit visibility. ◆

## NORMAL PROCEDURES

### Cockpit Entry and Pre-Flight Checks

11. *Cockpit Entry.* Enter the cockpit with the AR5 supplied by the portable ventilator, which is hung from the cockpit sill. The pilot sets the NBC ROLE switch to ON; both NBC FAN captions come on. Turn on the aircraft oxygen supply (OXYGEN PRESS between 60 and 120 PSI). Remove the seat PEC cover and the cover over the man portion of the PEC. Connect the man portion of the PEC (OXY FLOW MI shows white). Set the NBC FAN switch to ON (NBC FAN caption goes out). Remove the blanking plug from the air hose on the man portion of the PEC; whilst temporarily holding the breath, disconnect the air inlet hose from the portable ventilator and reconnect to the air hose of the PEC. Insert the blanking plug into the air hose of the portable ventilator.

12. *Pre-Flight Checks.* Make the following checks of the NBC equipment as part of the pre-flight cockpit checks:

a. NBC captions out.

b. Man portion of PEC locked to seat portion.

c. Oxygen supply hose connected to oxygen inlet hose of AR5 manifold.

d. Air supply hose connected to AR5 manifold.

e. Oxygen supply ON.

f. Oxygen contents at least 7/8 full.

g. Oxygen pressure at least 60 PSI.

h. Oxygen flow MI indicating continuous white.

i. Oxygen flow to mask and air flow to hood checked by noting increase of noise on inspiration (mask flow) and flow of air across face (hood flow).

j. No detectable leaks through seal of mask to face. Re-adjust fit if necessary.

k. Check operation of emergency demist. Set NBC FAN switch to OFF (note NBC FAN caption on), select EMERGENCY DEMIST and note flow of oxygen across face. De-select EMERGENCY DEMIST and set NBC FAN switch to ON, check that NBC FAN caption goes out.

◆ Note: If there is an oxygen leak between the PEC and the oxygen mask, there is no cockpit indication to warn the wearer since the oxygen flow MI is continuously white whether the connections are good or not. Connections between PEC and mask must be meticulously checked. ◆

### In-Flight Checks

13. Carry out the following checks at regular intervals in flight:

a. Oxygen contents adequate.

b. Oxygen pressure greater than 60 PSI.

c. Oxygen flow MI shows continuous white.

d. Oxygen connections at PEC, in hose to AR5 and at mask hose to faceplate intact.

e. Check seal of mask to face.

f. NBC FAN caption out.

### Routine Cockpit Exit

14. The portable ventilator is hung from the cockpit sill by the groundcrew. Release the harness, leg restraints and PSP lowering line in the normal way. Hold the end of the portable ventilator hose beside the air inlet hose. Turn on the portable ventilator and remove the blanking plug. While holding the breath, disconnect the PEC air hose from the air inlet hose and reconnect the air inlet hose to the portable ventilator. Resume breathing and insert the blanking plug into the PEC air hose. Set the NBC FAN switch to OFF (NBC FAN caption comes on). Locate the covers for the man and seat portions of the

PEC; disconnect the man portion of the PEC and fit both covers appropriately. Turn OFF the aircraft oxygen supply (pilot sets the NBC ROLE switch to OFF) and vacate the aircraft.

## EMERGENCIES

### Misting of AR5 Visor

15. In any situation where there is a cessation of ventilation to the hood it is very likely that the internal surface of the AR5 visor will mist over rapidly. The rapidity and intensity of the misting depends on the degree of sweating from the face of the wearer and the local ambient temperature. Cessation of ventilation to the hood is therefore a serious emergency. The causes are:

a. Failure or stoppage of the fan and motor blower units, indicated by the NBC FAN caption coming on (para 8).

b. Lack of oxygen in normal flight when EMERGENCY DEMIST is selected.

c. Disconnection from the system following ejection or after emergency ground egress (para 17 and 18).

16. In flight, if the NBC FAN caption is lit, select EMERGENCY DEMIST to obtain a flow of oxygen to the hood. In this mode, should the aircraft main oxygen supply fail, selection of emergency oxygen provides hood ventilation for approximately 3½ minutes at altitude, reducing to less than 1 minute at sea level.

### Emergency Ground Egress

17. In situations where rapid ground egress is necessary, there is not sufficient time to locate and fit a portable ventilator. In these circumstances, use the standard emergency egress drill. The AR5 visor can be expected to mist over rapidly once ventilation of the hood compartment ceases.

### Post-Ejection Drill

18. Following escape from the aircraft, unfiltered air that may be contaminated by NBC agents, is breathed in through the open end of the air inlet hose at the man portion of the PEC. There is, therefore, no excessive resistance to breathing. Oxygen is added from the emergency oxygen supply up to the time of man/seat separation. On entry to water, the man portion of the PEC (together with the air inlet) becomes submerged. To provide the wearer with access to air and to prevent the hood from rapidly filling with water, the mask hose is disconnected at the anti-drowning disconnect (prior to water entry if possible) and the hood outlet valve is closed.

19. Complete the following post-ejection drill after separation from the seat and before entering the water:

a. Inflate life preserver.

b. Unlock anti-drowning disconnect and pull mask hose away from the faceplate.

c. Close hood outlet valve.

d. Check PSP connections.

e. Lower PSP just before water entry.

Note 1: A firm pull downward is required to separate the mask hose from the AR5 faceplate.

Note 2: After disconnection of the mask hose, the inlet port to the mask may become obstructed by the inflated stole of the life preserver. This can be relieved by turning the head to the right or by depressing the stole in the region of the mask inlet.

20. Should water be drawn into the mask on entering the water, blow it out through the expiratory valve before taking another breath. If it is difficult to avoid breathing water, release the toggle of the AR5 suspension harness and lift the faceplate and mask off the face. This action provides a small additional volume of air for breathing and allows more time to bring the head above water.

21. After entering the liferaft, complete the following drill to remove the AR5:

a. Remove protective helmet.

b. Remove AR5.

c. Disconnect inlet hoses to AR5 manifold.

d. Disconnect AR5 manifold from the socket on the closure plate of the life preserver.

vides manual adjustment of sphere pitch indication; it can be adjusted at least 10° in dive and 5° in climb. The edge of the instrument is marked in 10° bank angle increments up to 30°, and there are also marks at 45° and 90° to match against either the top or bottom bank pointers.

61. *ADI Indications.* Heading information is provided on the horizon line of the sphere. In the SLAVED mode, when heading (not attitude) information is taken from the AJB-7, accurate heading information may not be immediately available on the ADI after completing a turn. To correct, the aircraft should be flown straight and level (rate of turn less than 15° per minute) for approximately 20 seconds before synchronising by momentarily selecting SYNC on the compass control panel. The ADI OFF flag should retract 60±15 seconds after the AJB-7 starts erecting when STBY is selected on the compass control panel, or when INAS attitude information is reliable when PRIM is selected. The operation of the remaining indicators on the ADI is explained either in Table 4 or in the Tacan section of this Chapter.

**WARNING:** The ADI may fail without a visible OFF flag when there is a slight reduction in electrical power or a failure of other components within the system. If there is a suspected or confirmed failure, switch to the alternative attitude reference system and cross check the ADI with the BAI and radar horizon.

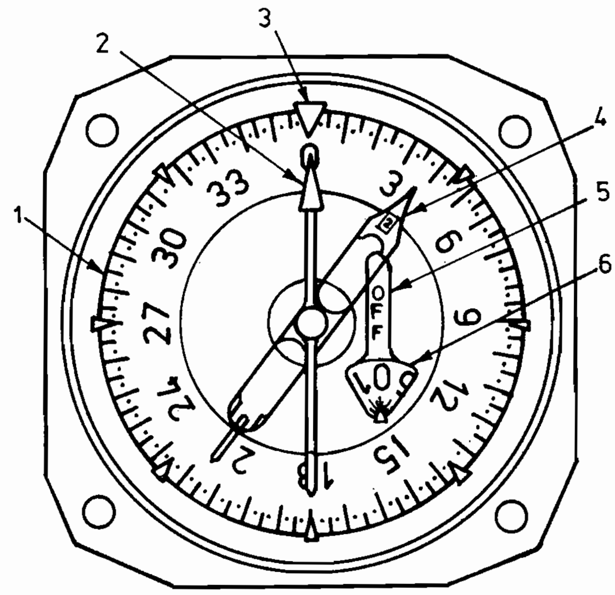
### Bearing Distance Heading Indicator (BDHI)

62. *BDHI Function.* The function of the BDHI is to provide the rear cockpit with information regarding the navigational situation of the aircraft. The BDHI is shown at Fig 11.

63. *BDHI Indicators.* The BDHI compass card is slaved to the HSI compass card, and shows true, magnetic or a directional gyro heading depending upon the position of the mode switch on the compass control panel in the front cockpit. Headings are read off the lubber line. The OFF flag, which partially obscures the distance counter, is removed when the NAV COMP mode is selected and the INAS is operating correctly in aircraft XT 891 to XV 475. On aircraft XV 476 and up, the OFF flag is removed when NAV COMP is selected regardless of INAS serviceability. The indications from the distance counter and the two pointers on the BDHI depend on the position of the CNI/NAV COMP switch. Their indications are listed in Table 4.

### Remote Attitude Indicator (RAI)

64. The RAI, on the rear cockpit instrument panel, visually displays attitude information direct from the




| Item | Description |
|---|---|
| 1 | Compass card |
| 2 | No 1 (single bar) pointer |
| 3 | Lubber index |
| 4 | No 2 (double bar) pointer |
| 5 | OFF flag |
| 6 | Distance counter |

**1 — 13 Fig 11 Bearing Distance Heading Indicator**

AJB-7, regardless of cockpit switch positions. A system failure is indicated by the appearance of the power failure flag.

## TACAN

### Description of the System

65. The Tacan system gives precise bearing and slant distance information at ranges up to 300 miles (depending on aircraft altitude) from a fixed ground station. However, the maximum distance from the ground station at which reliable signals can be obtained depends on the protected range of the beacon. The system provides bearing and distance displays on the HSI and BDHI, and steering information on the HSI and ADI, providing the navigation function selector and the CNI/NAV COMP switches are selected appropriately. The HSI, ADI and BDHI are shown at Figs 9, 10 and 11. The navigation function selector and the CNI/NAV COMP switches are shown at Fig 8.

66. *Air-to-Air Tacan.* The system also has an air-to-air capability when working with another aircraft with a similar capability. When operating in the air-to-air mode the bearing facility is lost but

# PART 2

## LIMITATIONS

List of Chapters



LIMITATIONS

# PART 2

## CHAPTER 1 - ENGINE LIMITATIONS

### Contents



◆ **The limitations given in this Part are taken from the Release to Service Document Issue 5, AL 10. The Release to Service Document must be consulted to ascertain the latest release standard.** ◆

**TGT and HP RPM Limitations - Spey 202**

1. The principal limitations are:

| *Condition* | *HP RPM* % | *TGT* °C | *Time Limit per Hour of Operation* |
|---|---|---|---|
| *Maximum* | | | |
| (With or without reheat) | | | |
| No BLC air bleed | 101 | See Note 1 | 12 mins combined |
| With 7th Stage air bleed | 101 | | |
| With 12th Stage air bleed | 101 | | |
| *Intermediate* | 94.7 | See Note 1 | 30 minutes |
| *Max Continuous* | 93.5 | 640 | Unrestricted |
| *Ground Idling* | 51.5 to 56 (See Note 2) | 650 (See Note 4) | Unrestricted |
| *During Starting* | - | 630 (See Note 3) | Momentary 2 seconds maximum |
| *Relighting* | - | 630 (See Note 3) | Momentary 2 seconds maximum |

Note 1: TGT values vary between engines. Individual engine TGT limitations are to be the highest of the three T6 control settings recorded in the engine log book plus 10°C and rounded off to the nearest 5°C.

Note 2: Ground idling speed depends on the magnitude of the accessory load and the air bleed configuration. With the flaps up the normal TGT at Ground Idle is 400°C to 550°C.

Note 3: During ground starts, 630°C is the maximum TGT when intake temperature (T1) is 15°C. This figure increases directly by 1°C for each 1°C increases in T1 above 15°C, eg, the TGT limit is 640°C for ground starts for a T1 value of 25°C. For relighting in the air, 630°C is the maximum limit in all conditions.

Note 4: During ground idling, 650°C is the maximum TGT when intake temperature (T1) is 15°C. This figure increases directly by 3°C for each 1°C increase in T1 above 15°C, eg, the TGT limit is 680°C for a T1 value of 25°C.

**Transients**

2. During transient conditions the limitations given in para 1 may be exceeded by 15°C TGT and 1% RPM, providing the TGT falls below the limitation within 15 seconds. In addition, when 12th stage bleed is in use, the TGT limit may be exceeded by 100°C following rapid throttle movements. This is acceptable providing the TGT drops below the limitation within 15 seconds.

**BLC Bleed Air**

3. BLC bleed air may be used (ie, flaps) up to 15,000 feet, below 250 knots, at any power setting.

**Ground Starting**

4. Tail wind starts are to be avoided whenever possible since these can lead to hotter than normal starts.

**Relighting**

5. The relight envelopes using Avtur/Avtag and Avcat are provided at Fig 1 and 2. If, after relighting, the TGT rises rapidly towards the limiting value and appears likely to exceed it, the engine is to be shut down immediately.

**Reheat Operation**

6. The reheat lighting and burning limits are given at Fig 3. Attempts to light above the defined limit are permitted but not recommended, and the throttle must not be advanced beyond the MIN reheat position until a satisfactory light-up has been achieved. If the first attempt to light fails, in either case, an immediate reselection is permitted. Following a successful light-up no further restrictions are imposed.

Note: If the initial reheat selection is to any degree of reheat other than maximum, slamming to maximum reheat within 5 seconds of the initial selection may result in light engine surge.

**Throttle Handling**

7. Slam acceleration and decelerations short of idle stop are permitted at all altitudes. The throttle(s) must not be slammed shut against the idle stop since this may either:

a. Momentarily operate the HP cock(s) and cause the engine(s) to flame out or

b. Cause the throttle(s) to move into the HP cock(s) OFF position resulting in engine flame-out.

**Engine Inlet System**

8. The engine intake ramps and bypass valve must be in the low speed position for all take-offs and landings.

9. With the bypass valve fully open (ie, after utility hydraulic or total electrical failure) the following limits apply:

a. At or above the 0.85M, HP RPM must be below 95%.

b. Supersonic flight is prohibited.

c. Plus 1.5g must not be exceeded above 30,000 feet.

Note: There is no cockpit indication of bypass valve position.

10. With inlet ramps in the retracted position there is a risk of compressor surge at speeds above 1.5M.

**Engine Anti-Icing System**

11. The system is cleared for use. See Part 3, Chapter 6 for system operating information.

**Engine Temperature Control Amplifier Warning**

12. Amplifier malfunction is indicated by the L or R IGV malfunction warning light(s) coming on and may result in reduction of engine handling flexibility and possible loss of thrust of up to 30%. In these circumstances throttle movement should be carried out with caution.

**Engine Oil Pressure**

13. The engine must be shut down if the associated L or R ENG OIL PRESS LOW caption comes on:

a. With 1 g or more indicated.

b. With less than 1g indicated when the caption remains on for more than 5 seconds after return to 1g conditions.

## Fuel and Oil Specifications

14. a. Approved Fuels (See Notes 1, 2 and 3)

| *UK Specification* | *Joint Service Designation* | *NATO Code No* | *JP Equiv* |
|---|---|---|---|
| DERD 2452 | AVCAT/FSII (4) | F–44 | JP5 |
| DERD 2453 | AVTUR/FSII(5) | F–34 | JP8 |
| DERD 2454 | AVTAG/FSII(5) | F–40 | JP4 |
| DERD 2486 | AVTAG (4) (6) | — | — |
| DERD 2494 | AVTUR (4) (6) | F–35 | — |
| DERD 2498 | AVCAT (4) (6) | F–43 | — |

Note 1: Jet fuels from RAF sources contain AL38 which is a blend of Fuel System Icing Inhibitor (FSII) (AL31, NATO Code S–748) and lubricity additive (HITEC E515 or approved equivalent to DERD 2461).

Note 2: Phantom aircraft may operate on approved aviation fuels not containing FSII but it is emphasised that the use of such fuels may lead to the formation of ice and fungus in the fuel system, and corrosion of the integral tanks. Unless operational reasons dictate otherwise, the maximum duration of use such fuel should not exceed 14 days and should be followed by an equal period of operation on fuel containing AL38 or FSII.

Note 3: Phantom aircraft may operate for an unlimited period on approved aviation fuel not containing lubricity additive.

Note 4: Does not contain lubricity aid.

Note 5: Contains lubricity additive, except possibly NATO F34 and F–40 from French bases.

Note 6: Does not contain FSII.

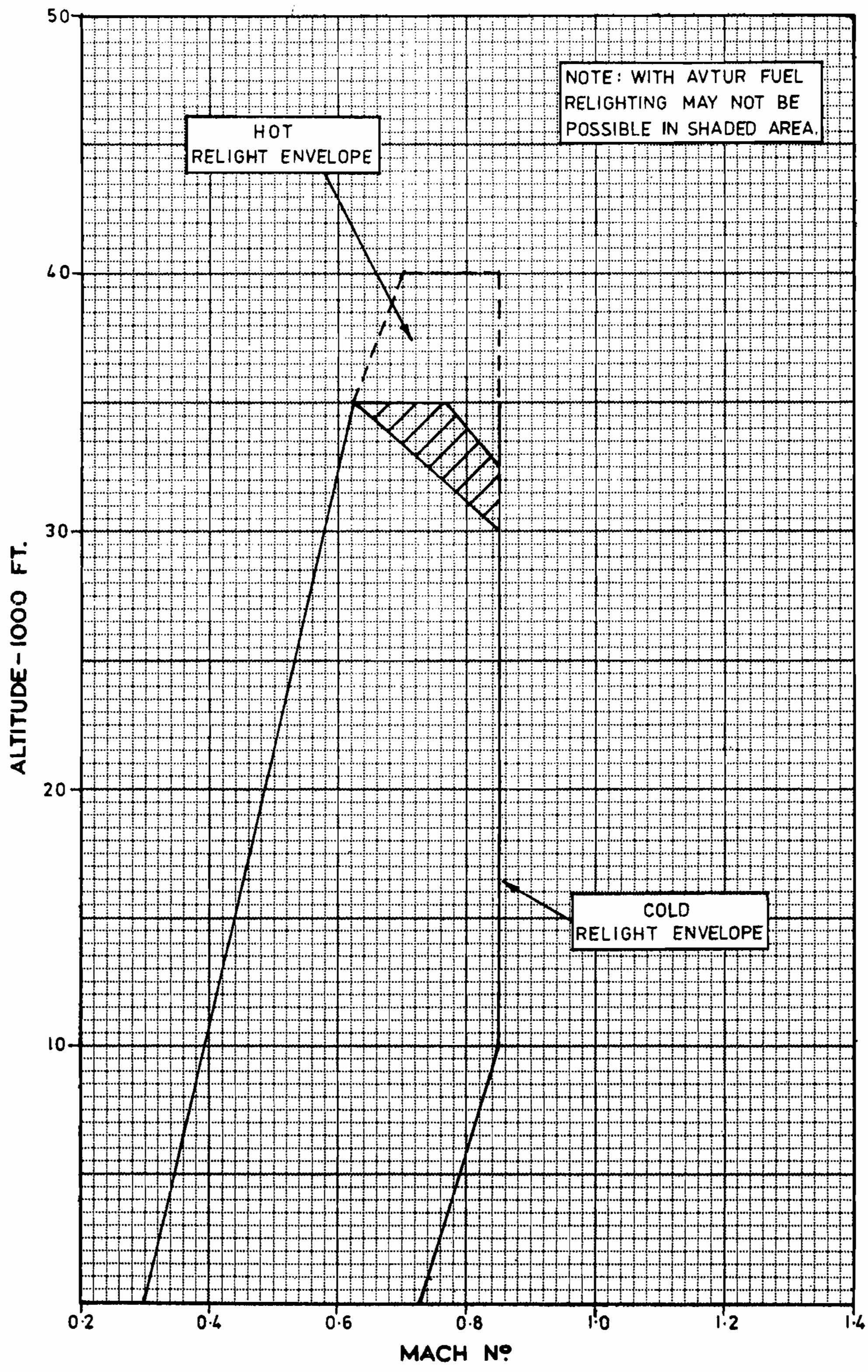
b. *Approved Oils*

| *Specification* | *Interservice Designation* | *NATO Code No* |
|---|---|---|
| D Eng RD 2487 | OX–38 | 0–149 |
| D Eng RD 2493 | OX–38 | — |

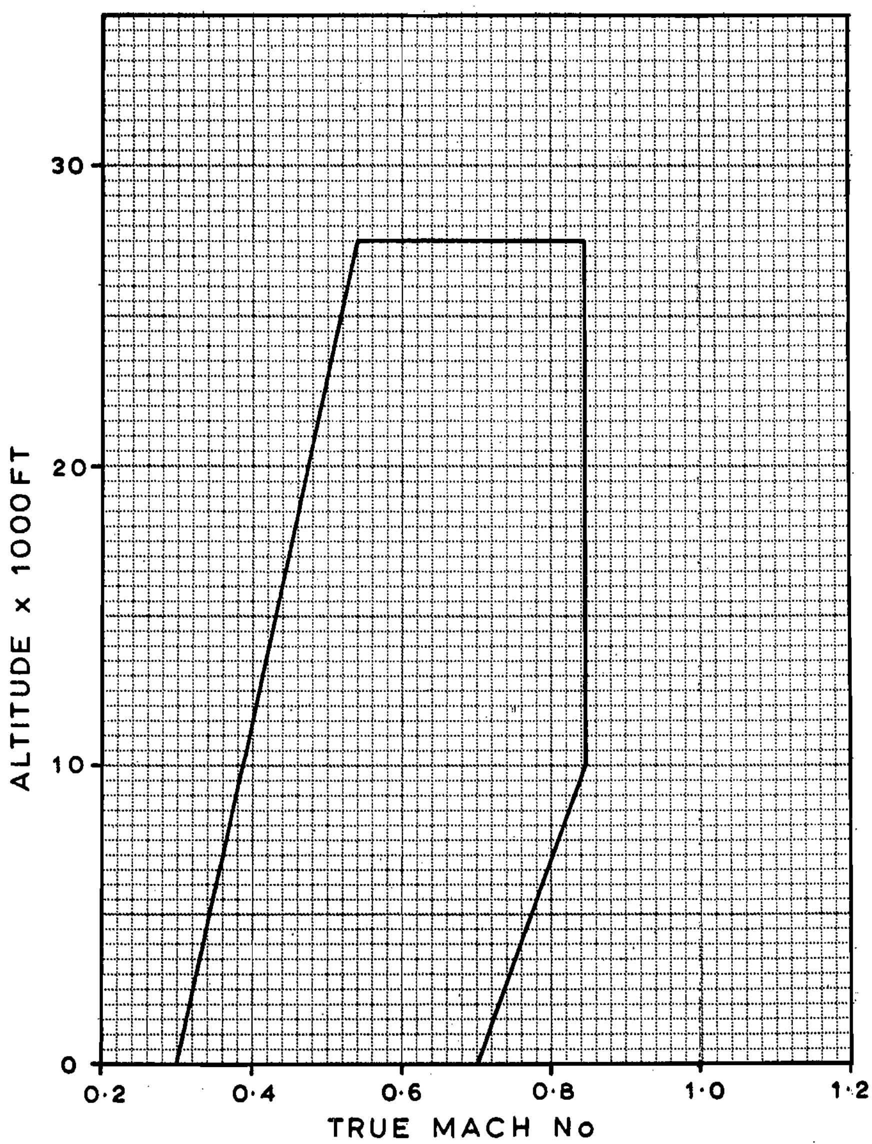
In addition to the engine, the oils are also applicable to the constant speed drive, starter and reheat control system.

## Starter Limitations

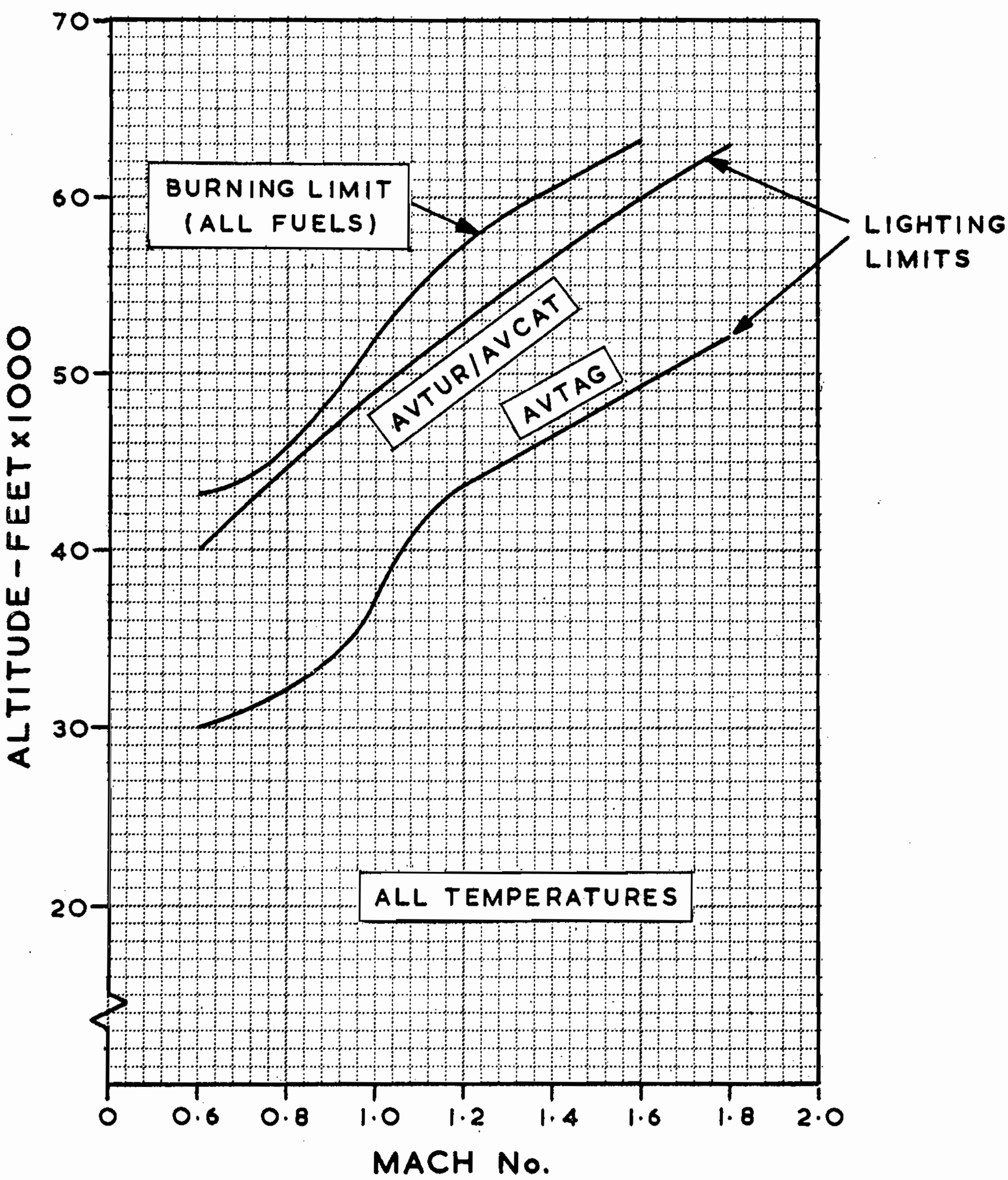
◆ 15. *Gas Turbine Starter.* Three starts may be attempted at a minimum interval of 90 seconds between each attempt. Thereafter a minimum period of 30 minutes must elapse before another series of starts is attempted. This 30 minute cooling period must be observed whenever three starting attempts are made within a period of 20 minutes and before further starts are attempted. ◆




**2—1 Fig 1 Relight Envelope — AVTUR and AVTAG**




2 – 1 Fig 2 Relight Envelope – AVCAT




2 – 1 Fig 3 Reheat Lighting/Burning Limits

# PART 2

## CHAPTER 2 - AIRFRAME LIMITATIONS

### Contents



**WARNING 1:** The maximum speed and g limitations given in this Chapter are 'never exceed' values and have that precise meaning. They represent the limits to which the aircraft has been designed or flight tested and provide no margins against manoeuvring and instrument errors, or atmospheric turbulence.

**WARNING 2:** The cockpit accelerometer indication is less than the aircraft true normal acceleration owing mainly to instrument error. To allow for this error, 0.5g should be added to the indicated figure on the accelerometer to determine the true acceleration when below 4g, and 1g added above 4g. Therefore, a g limit quoted as 5g in this Chapter is achieved when 4g is indicated.

Note: Reference should be made to the Release to Service for the limitations applicable to externally carried stores.

**General**

1. a. The aircraft is released for crew training and air defence duties by day and night from land bases only and in ambient temperatures between minus 26°C and + 50°C at start-up.

   b. The following manoeuvres are prohibited:

      (1) Full deflection aileron rolls in excess of 360°.

      (2) Intentional spins.

      (3) Negative-g for more than 30 seconds.

      (4) Zero g for more than 10 seconds.

      (5) Coarse use of aileron and rudder with nega-

tive-g applied.

(6) Take-offs with more than 22 units of angle of attack indication.

c. Above 30,000 feet, if large amounts of yaw are applied, speed must not be allowed to fall below 200 KCAS or engine flame-out may occur.

**Take-Off and Landing Weights**

2. The maximum allowable all up weights are:

| | | |
|---|---|---|
| ◆ Take-off | 60,000 lb | |
| Normal max landing | 38,000 lb | |
| Normal max landing (flared) | 43,000 lb | |
| Emergency landing (full flap/ 12th stage BLC) | 50,000 lb | See Note |
| Emergency landing (full flap/ 7th stage BLC) | 55,000 lb | See Note |

Note: The following procedures must be used for approach and landing at emergency weights:

a. An AOA of 17 units (on speed +10 knots) should be maintained to the runway threshold, when it should be increased to 19.2 units.

b. Maximum rate of descent during final approach not to exceed 600 feet/minute to maintain a shallow approach angle.

c. A flared landing to be made to reduce vertical velocity at touchdown to a minimum.

d. Braking after touchdown to comply with the limitations at Section 10 of the ODM.

e. In wet runway conditions an arrested landing should be performed. See also para 22.

**Centre of Gravity Limits**

3. The CG limits are as follows:

| | *Forward* | *Aft* |
|---|---|---|
| Clean aircraft | 27% MAC | See Part 3, Chap 2, Fig 2 |
| With external wing stores | 27% MAC | See Part 3, Chap 2, Fig 2 |

4. Take-off with part-filled external fuel tanks is prohibited.

**Flying with Asymmetric Loads**

5. The following limitations are to be applied when flying with asymmetric stores loadings:

a. *Take-Off.* Maximum rolling moment: 160,000 lb in

b. *Approach and Landing.* Maximum rolling moment:

(1) Normal 280,000 lb in

◆ (2) Emergency 350,000 lb in

Note: Any approach with an asymmetric load should be made within the limitations given in Fig 4, using full flap. A speed increment for asymmetry should be added to the normally calculated approach speed using line A or line B of Fig 4. Line A permits a slower approach speed, with reduced lateral control power in the airborne phase, resulting in a shorter landing run but should only be used in conditions of low turbulence; line B should be used when landing distance is not critical and in cases when turbulence is moderate or high.

c. *General Flying*

(1) Up to 70,000 lb in - No restrictions.

(2) 70,000 to 280,000 lb in - Maximum speed 550 KCAS/1.1M whichever is less, subject to overriding external store limitations. Minimum speed to be that which required 2/3 aileron travel to maintain lateral control in 1 g flight. Normal acceleration limited to that which requires use of ½ aileron travel.

(3) 280,000 to 350,000 lb in - emergency approach and landing only, using gentle manoeuvres.

Note 1: Every asymmetric loading will have airspeed/normal acceleration limits beyond which lateral control cannot be maintained and control can only be regained by an increase in speed or a decrease in normal acceleration.

Note 2: For asymmetries in the range of 70,000 lb in to 280,000 lb in there will be combinations of airspeed/altitude which will require the use of more than ½ aileron travel to maintain wings level in 1g flight.

Note 3: For most asymmetries greater than 280,000 lb in (ie, those classed as emergency cases) more than ½ aileron travel will be required to maintain wings level at all airspeeds/altitudes in 1g flight.

Note 4: An asymmetric load of 528 lb on stations 1 or 9 equates to a moment of 70,000 lb in. An asymmetric load of 859 lb on stations 2 or 8 equates to a moment of 70,000 lb in.

**Airspeed Limitations**

Note: See **WARNING 1** at beginning of this Chapter.

6. *Maximum Airspeeds.* The maximum permitted airspeeds are:

a. See Fig 1 for clean aircraft (or with 4 Sparrow/ Skyflash). For external tank limitations see Chapter 3. Armament stores limitations are contained in the Release to Service.

b. Operation of landing gear and flights with gear extended - 250 KCAS.

c. Operation of LE and TE flaps and flight with fully or partly extend flaps - 250 KCAS

d. RAT extension/retraction and flight with RAT extended - 515 KCAS/1.1M

e. With IFR probe extended - 400 KCAS/0.9M

f. Extension/retraction of IFR probe - 300 KCAS/ 0.9M

g. Braking parachute deployment - 200 KCAS

h. Arrester hook lowered - No limit

i. Air brakes extended - No limit

j. With boarding ladder extended - 400KCAS

7. *Minimum Airspeeds.* The minimum permitted speeds at altitude are shown by the stepped line on the graph at Fig 1.

**Normal Acceleration**

Note: See **WARNINGS** at beginning of this Chapter.

8. The maximum permitted normal accelerations are:

a. Above 1.8M: 3g to minus 1g

b. Up to 1.8M: See Fig 2

c. During RAT extension retraction: +3g to zero g

d. With RAT fully extended: +5g to minus 1g

In turbulent conditions manoeuvring load factors applied must be restricted to a value 2g below these limits. Moderate and heavy stall buffet is to be avoided.

9. The acceleration limitations in rolling manoeuvres are shown in Fig 3.

**Braking**

10. Braking is to be in accordance with the Phantom Operating Date Manual [ODM] AP 101B-0901/0902-16:

a. *Normal Braking.* Cross refer to Fig 10.1 and 10.2 of the ODM.

b. *Emergency Braking.* Cross refer to Fig 5.5 and 5.6 of the ODM.

**WARNING:** Emergency pneumatic brakes are not to be used when a hot brake condition exists, as this could lead to a brake explosion.

**Crosswind Limitations**

11. The maximum crosswind components for take-off and landing are given at Fig 4.

**Braking Parachute**

12. The braking parachute may have to be jettisoned when landing in a crosswind component exceeding 20 knots in order to maintain directional control.

**Aircraft Category**

13. The aircraft category for approaches is D.

**Engine Out Allowance (EOA)**

14. The EOA is zero at AUW less than 40,000 lb and 100 feet at AUW greater than 40,000 lb.

**Visual Committal Height (VCH)**

15. The VCH is 200 feet.

**Decision Height (DH)**

16. Decision height for precision approaches is 200 feet plus additional allowances.

### Single-Engined Approach

17. Single-engined approaches may be made with half or full flap, but the use of 12th stage BLC is prohibited. An AOA of 17 units should be maintained until the runway threshold when it should be increased to 19.2 units.

18. Aircraft weight must not exceed 55,000 lb at temperatures up to ISA +8°C (23°C at sea level), reducing linearly to 41,500 lb at ISA +35°C (50°C at sea level). At these weights it is essential that maximum reheat thrust is achieved on the operative engine as quickly as possible in the event of an overshoot, and the technique at Part 3, Chapter 4 must be strictly adhered to.

19. All landings at weight greater than 38,000 lb must be flared.

### Runway Strength Requirements

20. The Aircraft Load Classification for field operations is:

| *Load Condition* | | *Unladen* | *Max Landing* | *Max Take-Off* |
|---|---|---|---|---|
| ◆All Up Weight (lb) | | 32,200 | 38,000 | 60,000 |
| Tyre Pressure (PSI) | | 300 | 300 | 300 |
| Classification | ESWL (lb) | 14,040 | 16,530 | 26,120 |
| | LCG | V | V | IV |
| | LCN | 23 | 27 | 42 |

ESWL - Equivalent Single Wheel Load
LCG - Load Classification Group
LCN - Load Classification Number

Note: For relationship between LCG and LCN see Release to Service Document.

### Airfield Barrier Engagement

21. The aircraft is cleared for entry into the RAF Mk 6, Mk 12A, Type A and Type B barriers. The Mk 12A and Type B barriers are to be used at the 'heavy' setting whenever possible.

**WARNING 1:** The maximum entry groundspeed for all the above types of barrier, irrespective of aircraft mass, is 120 knots. Exceeding 120 knots could result in the aircraft breaking through the barrier without experiencing substantial retardation.

**WARNING 2:** Exceeding the mass/speed (ie, energy absorption) limits of the barrier could result in the barrier reaching its run-out limits before the aircraft has been brought to a halt. Graphs for mass/speed limits are given in AP119J-1400-1, and limits for selected AUW are given below:

| *Barrier* \ *AUW (lb)* | *35,000* | *37,000* | *40,000* | *45,000* |
|---|---|---|---|---|
| Mk 6, Type A | 86 kt | 84 kt | 81 kt | 75 kt |
| Mk 12A Type B (heavy setting) | 113 kt | 110 kt | 106 kt | 99 kt |
| Mk 12A, Type B (light setting) | 84 kt | 82 kt | 78 kt | 73 kt |

**WARNING 3:** If external fuel tanks are carried they are to be empty. If the tanks contain fuel there is a danger of the tanks being ruptured by the bottom wire of the barrier net, thereby creating a fire hazard. If an aircraft carrying external fuel *does* engage the barrier, the aircraft must be evacuated without delay after the arrest. The canopies must not be opened until completion of the arrest.

**WARNING 4:** Entry into the barrier with the refuelling probe extended is not recommended.

Note: If the hook has been lowered before the barrier engagement, it may be left down.

### Airfield Cable Arresting Gear

22. The aircraft is cleared for engagement of RHAG Mk 1, PUAG Mk 21, PAAG, BAK 9, BAK 12 and 13 cable arresting systems up to individual gear limitations and subject to the following aircraft limitations:

a. For *normal* predetermined arrested landings the following limitations apply:

*Aircraft Weight:* Less than 38,000 lb or less than 43,000 lb for PAAG with max entry speed of 165 knots.

*Without use of brakes:* Total fuel in tanks 1 to 6 not more than 5100lb.

*With use of brakes:* Total fuel in tanks 1 to 6 not more than 4000 lb.

Note: Internal and external wing tanks should be empty.

b. For *emergency* use, arresting systems may be engaged up to the limits for either aborted take-offs or landings. Arresting gear entry speed limits at maximum take-off and landing weights are given in the FRC.

**WARNING:** There is a possibility of damage to internal wing tanks if arresting gears are engaged at high speed and heavy fuel load.

**Traversing Cable Arresting Gear**

23. The aircraft is cleared to traverse RHAG Mk 1, PUAG Mk 21, PAAG, BAK 9, BAK 12 and BAK 13 in the raised position without speed restriction unless the BLU-27 baggage container is carried on the lower position of CBTE No 2 at station 2 or 8, when the maximum traversing speed limitation is 10 knots. However, pairs take-offs are prohibited across a cable arresting gear in the raised position where the second aircraft has less than 395 mm ground clearance between the nosewheel and the main wheels (eg, PEWT pod).

**WARNING:** When stores are carried which involve a traversing speed limitation and an approach-end engagement is carried out, there is a possibility of damage to the store.

**Air-to-Air Refuelling (AAR)**

24. The aircraft is cleared to refuel in flight from the following tanker aircraft subject to the associated limitations:

a. *General Limitations*

(1) AAR is not permitted if the initial CG position is at the limit of line A in Fig 1 of Part 3, Chapter 4, and external fuel tanks are carried. (In this condition it is possible to exceed the permissible CG limit.)

(2) Where either tanker or receiver is equipped with HF radio, HF transmissions are not permitted while in contact, or within 50 metres of Tristar tankers.

b. *Hercules C Mk 1K Tanker.* AAR from Hercules is cleared by day and night subject to the following limitations:

*Min Speed:* 220 knots or that which gives 15 units AOA, whichever is the greater

*Max Speed:* 255 knots or the maximum available by the tanker

*Optimum Speed:* 240 to 250 knots

*Max Altitude:* Up to the tanker's maximum altitude (approx 20,000 feet)

*Max AOA:* 15 units AOA is not to be exceeded.

**WARNING 1:** Practice AAR with pitch stab aug inoperative is prohibited; in an emergency with pitch stab aug inoperative, care should be taken not to over control.

**WARNING 2:** Practice single-engine AAR is prohibited; in an emergency, single-engine AAR should be carried out in cold power if possible.

Note 1: The use of airbrakes when in contact causes a slight nose-up trim change.

Note 2: At slow speeds the hose trails low and care should be taken to fly down the natural trail angle during disengagement or the drogue may descend out of sight after withdrawal.

Note 3: At high refuelled weights and slow speed, the AOA limit of 15 units may preclude turning while in contact.

c. *VC 10 Mk2 and Mk3.* AAR from VC 10 is cleared by day or night subject to the following limitations:

*Min Speed:* 240 knots (centreline station); the greater of 235 knots and cruise boundary speed of the VC 10 at initial AUW (wing stations)

*Max Speed:* The lesser of 320 knots or 0.8M

*Optimum Speed:* 270 to 280 knots

*Max Altitude:* Up to tanker's max altitude (approx 30,000 feet)

*Equipment:* Mk 32 pod on wing stations; Mk 17 HDU on centreline station

**WARNING 1:** Practice single-engine AAR is prohibited; in an emergency, single-engine AAR should be carried out in cold power if possible.

**WARNING 2:** Practice AAR with pitch stab aug inoperative is prohibited; in an emergency, with pitch stab aug inoperative, care should be taken not to overcontrol.

**WARNING 3:** Refuelling from the centreline station must cease when the receiver aircraft is full.

Note 1: Refuelling should be carried out in cold power whenever possible, but above 25,000 feet reheat on one engine may be necessary.

Note 2: On wing stations, trim settings are approximately 1/3 aileron and slight rudder trim away from tanker.

Note 3: Errors in ASI and altimeter readings up to 40 knots and 500 feet may be encountered in close proximity to the basket and during AAR at slow speeds. The airspeed change may cause rudder gearing changeover and/or aux air doors to cycle. These occurrences do not affect the difficulty of AAR.

Note 4: At tanker AUW above 131.5 tonnes and at altitudes below 24,000 feet the tanker's ailerons are set up by 8°. This slightly increases the difficulty of making contact on the wing stations.

Note 5: In mild turbulence the VC 10 tail unit and wing tips flex quite markedly. This flexing, initially quite alarming, has no effect on AAR.

Note 6: Owing to the response characteristics of the hose, contact at low overtaking speeds is advised.

◆ d. *Tristar K Mk 1 and KC Mk 1.* AAR from Tristar K Mk 1 and KC Mk 1 is cleared from the fuselage station by day and night subject to the following limitations:

*Min Speed:* 230 knots unless a higher speed is dictated by tanker buffet boundary limitations.

*Max Speed:* 320kt/0.84M (optimum 280 to 300 knots)

*Max Altitude:* 35,000 feet

*Equipment:* Twin Mk 17 HDU on centreline station

**WARNING 1:** Practice AAR with pitch stab aug inoperative is prohibited.

**WARNING 2:** Practice single-engine AAR is prohibited. ◆

**WARNING 3:** Tests have shown that a longitudinal hose oscillation can occur immediately after making contact. This results in a loud banging which can be heard and felt in the cockpit (similar to engine surge), and the drogue may unlatch itself from the probe. If such an oscillation occurs, an immediate break of contact is to be made. Another approach to the drogue may be made but, if the oscillation recurs, further attempts should only be made in different flight conditions and/or using the other HDU.

**WARNING 4:** When in the nominal refuelling position (half the hose amber band outside the HDU tunnel), the receiver is slightly closer to the Tristar than is the case with other tanker types. The nose of the Phantom overlaps the No 2 engine tail pipe fin fairing by about 2 feet. However, adequate safety margins remain to allow for receiver movements from the nominal refuelling position. If the receiver is flown in a close refuelling position (ie, the amber band pushed fully inside the HDU tunnel) significant overlap occurs (up to 10 feet). This, together with the low-set tailplane of the Tristar, increases the risk incurred from poor station-keeping or stab aug malfunction. Particular care must be taken to maintain a position at or aft of the nominal refuelling position.

**WARNING 5:** Only gentle manoeuvres are permitted during AAR.

Note 1: The large size of the Tristar, the low-set tailplane and the proximity of the hose to the No 2 engine, exaggerate the reduced hose length tending to give the receiver the impression of flying significantly closer to the Tristar than with other tankers.

Note 2: Refuelling should be carried out in dry power whenever possible, but reheat may be required above 20,000 feet.

Note 3: Errors in the ASI reading of about 10 knots may be encountered when in close proximity of the drogue, in the vicinity of the tanker and during AAR at slow speed. This may cause rudder gearing changeover, but this does not affect aircraft handling significantly.

e. *Victor Tanker.* AAR from the Victor Tanker is cleared by day and night subject to the following limitations:

*Min Speed:* 250 knots

*Max Speed:* With Mk 20B pods and stainless steel Mk 2 hose - 300 kt/0.88M. With Mk 17 HDU fitted with high speed drogue Mk 2, the maximum speed with hoses trailed is 320 kt/0.88M, whichever occurs first

*Optimum Speed:* In cold power, 270 knots; in reheat, 290 kt/0.85M, whichever is the less

*Closing Speed:* 5 knots is recommended

*Max Altitude:* 43,000 feet

Note: Above 25,000 feet to 30,000 feet, depending on AUW and configuration, it may be necessary to use partial reheat on one engine.

f. *Buccaneer Tanker.* The Buccaneer tanker is cleared for AAR by day or night subject to the following limitations:

*Min Speed:* 230 knots.

*Max Speed:* 290 knots up to 25,000 feet, reducing linearly to 240 knots at 40,000 feet

*Optimum Speed:* 260 knots

*Closing Speed:* 5 knots is recommended

*Max Altitude:* 43,000 feet

Note: Above 25,000 feet to 30,000 feet, depending on AUW and configuration, it may be necessary to use partial reheat on one engine.

g. *USN KA-3/EKA-3B.* The aircraft is cleared for AAR with suitably equipped USN KA-3/EKA-3B tanker aircraft subject to the following limitations:

◆ *Speed:* 220 to 300 KCAS (250 to 270 KCAS recommended) ◆

*Height:* Sea level to 35,000 feet

Note 1: Unless cleared by the tanker pilot, the drogue should not be engaged with the amber fairing light inoperative; reel response may be inoperative, fuel transfer may be impossible, and an engagement could damage either aircraft.

Note 2: The rate of transfer of fuel from the tanker to the tanker's refuelling store is slightly slower than the rate at which the store can feed the receiver (420 gall/min). This may necessitate intermittent refuelling stoppage.

h. *USN A-4 (D-704 store).* The aircraft is cleared for AAR with suitably equipped USN A-4 tanker aircraft subject to the following limitations:

*Max Speed:* 300 KCAS/0.8M (whichever is lower)

*Height:* Sea level to 35,000 feet

Note: The rate of transfer of fuel from the tanker to the tankers refuelling store is slightly slower than the rate at which the store can feed the receiver (180 gall/min). This may necessitate intermittent refuelling stoppage.

i. *USN KA-6D.* The aircraft is cleared for AAR with suitably equipped USN KA-6D tanker aircraft subject to the following limitations:

*Speed:* 220 to 320 KCAS (250 to 270 KCAS recommended)

*Height:* Sea level to 35,000 feet

Note 1: Unless cleared by the tanker pilot, the drogue should not be engaged with the amber advisory lights inoperative as damage to both aircraft is possible.

Note 2: If the red advisory lights come on, or if fuel or hydraulic fluid is seen leaking from the tanker's aft refuelling bay, inform the tanker immediately.

Note 3: The rate of flow is 350 gall/min.

j. *A6 (D-704 store).* The aircraft is cleared for AAR with suitably equipped A-6 aircraft subject to the following limitations:

*Max Speed:* 300 KCAS/0.8M, whichever is the lower

*Height:* Sea level to 35,00 feet

Note: The flow is 180 gall/min.

k. *A-7 (704 store):* The aircraft is cleared for AAR with suitably equipped A-7 aircraft subject to the following limitations:

*Max Speed:* 300 KCAS/0.8M, whichever is the lower

*Height:* Sea level to 35,000 feet

Note: The rate of transfer of fuel from the tanker to the refuelling store is substantially slower than the rate at which the store can feed the receiver (180 gall/min). This may necessitate intermittent refuelling stoppage. The store is carried on the left outboard pylon only.

l. *KC-130F.* The aircraft is cleared for AAR with suitably equipped KC-130F aircraft subject to the following limitations:

*Speed:* 230 KCAS below 21,000 feet

Note 1: If the tanker's lower rotating beacon is operating, do not engage the drogue.

Note 2: Refuelling at or below 21,000 feet can normally be made at a constant altitude and airspeed. As the receiver aircraft approaches maximum AUW, a minimum of 215 KCAS is required for satisfactory receiver performance.

Note 3: The flow rate can vary between 150 gall/min and 600 gall/min depending on tanker configuration. The tanker normally uses the lowest transfer fuel pressure consistent with the allotted refuelling time.

m. *USN F-4.* The aircraft is cleared for AAR with suitably equipped USN F-4 aircraft subject to the following limitations:

*Speed:* 300 KCAS/0.8M max, whichever is the lower (nominal 190 to 300 KCAS)

*Height:* Sea level to 35,000 feet

n. *USAF KC-135.* The aircraft is cleared for AAR with suitably equipped USAF KC-135 tanker aircraft subject to the following limitations:

*Recommended Speed:* 295 KCAS/0.77M at 29,000 feet

| *Tanker Drogue* | *Phantom Nozzle* | *Limitation* |
|---|---|---|
| MA-2 | MA-2 or FRL 8 | Nil |
| MA-3 | FRL 8 | AAR prohibited |
| MA-3 | MA-2 | Nil |

Note 1: There is no hose take-up response with this system. Receiver aircraft should exercise extreme caution during the engagement phase and avoid an excessive closure rate and the possibility of a broken hose/probe.

Note 2: No attempt should be made to chase the drogue in pitch. Disregard small oscillations of the drogue while closing for contact. Closure rates higher than 2 knots are likely to cause the hose to whip, possibly damaging the probe, drogue or receiver.

Note 3: Very slow closure rates may not seat the probe firmly. Closing slowly on the drogue may induce drogue chasing and making contact difficult.

Note 4. Because of the KC-135's boom operator's limited field of view, it is possible for contact or disconnection to take place without the boom operator's knowledge.

◆ o. *French Air Force C135F and C135FR Tankers.* The aircraft is cleared for AAR with the FAF C135F and C135FR tankers by day only within the limitations which follow.

(1) Minimum speed: 275 kt

(2) Maximum speed: 295 kt

(3) Optimum speed: 285 kt

(4) Maximum altitude: 30,000 ft using dry power or one engine in reheat.

(5) Stab aug: The stab aug pitch and yaw channels must be fully operative during AAR. ◆

◆ (6) Boom position: The C135F/FR boom position should be set to 30° down and 6° right.

WARNING: Owing to the short, more rigid fuel hose and the close proximity to the tanker boom tip, AAR from the C135F/FR requires a higher level of skill than that required for the UK systems. Conversion to the C135F/FR should only be considered for operational pilots who are fully trained and current in AAR (see Note 8).

Note 1: *Meteorological Conditions.* AAR should be conducted clear of any cloud formations. Tanking in moderate to severe turbulence is likely to be very difficult and is not advisable.

Note 2: *Pre-Contact Position.* The boom tip should be used as the main reference point for initial line-up with the basket, with frequent reference to the tanker forward fuselage and wings for a wider spatial view. Owing to the short hose length and heavy basket, the basket is very stable making it possible (and desirable) to position the probe as close as 3 to 4 feet behind the basket and still make small line-up corrections without disturbing the stability of the basket.

Note 3: *Approach to Contact.* Once stable behind the basket, the throttles should be advanced to give a slow overtake speed, not exceeding an estimated 1 knot. The throttles should then be left in this position as the resistance of the basket once contact has been made offsets the excess thrust. (Unlike operations with the UK AAR systems, there is no risk of a soft contact and a low overtake speed increases the probability of a successful engagement and fuel transfer.)

Note 4: *In Contact.* Once contact has been made, the aircraft should be moved left and forward so that the probe is level with and 3 to 4 ft abeam the boom tip. The tolerance in this position is approximately a 3ft radius sphere based on the ideal position, making the task of maintaining contact significantly more demanding than with UK tankers. If required, the boom operator can give advice on positioning.

Note 5: *Use of Reheat.* When refuelling at higher altitudes, the selection of reheat on one engine may be required to conduct successful AAR. If reheat is required on one engine, it should be selected in a hold-off position, well astern of the basket, but after the dry power engine has be set to 92 ±2%. (Reheat settings at 30,000 ft are approximately 1/4 to 3/8 nozzle at high AUW with near full fuel.) Adjustments may be necessary in the pre-contact position to maintain a speed which corresponds to that of the tanker. A setting of 92 ±2% on the dry power engine provides the optimum thrust response, and modulation of this engine should be used to maintain position in contact. If additional thrust is necessary, it is possible ◆

◆ to adjust the reheated engine setting very gently. However, actual selection or deselection of reheat while in contact (except for an emergency disconnect) must not be attempted. If reheat is required after contact has first been made with the engines in dry power, the receiver should first break contact and then engage reheat on one engine before making contact again.

Note 6: *Disconnect.* From the refuelling position, power should be reduced slightly to achieve a slow, stable deceleration which can be judged relative to the boom tip and shape of the hose. As soon as the basket is aft of the boom tip, apply very slight right aileron and rudder inputs to align the probe with the boom tip. Disconnect must occur with the basket as close to its natural trail position as possible prior to breaking contact, thus ensuring a clean separation.

Note 7: *Emergency Disconnect.* Reduce power smoothly to idle while applying very slight right aileron and rudder to minimise the lateral offset at disconnect, as for a normal disconnect. However, owing to the small lateral offset, any aggressive lateral inputs significantly increase the risk of striking the boom and/or the risk of the disconnect not occurring with the hose in its freestream trail position, thus increasing the chances of the basket striking the nose or windscreen of the aircraft following the disconnect (particularly during a disconnect to the right of the boom). Emergency disconnects should not, therefore, be practised.

Note 8: *AAR Training.* Conversion to the C135F/FR should only be considered for operational pilots who are fully trained and current in AAR (preferably within the previous month). A dedicated conversion/training sortie is recommended, ideally with a navigator who has experienced AAR with the C135F/FR before. Prior to the first sortie, aircrew should be briefed by a receiver pilot experienced in C135F/FR AAR on the techniques to be used.

Note 9: *General.* If damage is thought to have occurred to the probe assembly, consideration should be given to leaving it out so that it can be observed for possible subsequent fuel leaks and prevent any potential damage during stowage, eg, trapping or severing of hydraulic lines. Extra attention should be given to the probe and surrounding structure during the post-flight inspection. ◆

## Flight Without Main Landing Gear Doors

25. If maintenance or operational considerations require flight without main landing gear doors, the following limitations are to be applied.

Below 20,000 ft - 250 KCAS max

20,000 to 35,000 feet - 0.85M max

Above 35,000 ft - 250 KCAS/0.85M, whichever is the greater

Descent: 250 KCAS (or the onset of any buffet)

## Electro-Magnetic Compatibility

26. Table 1 shows the HIRTA low flying grading bands.

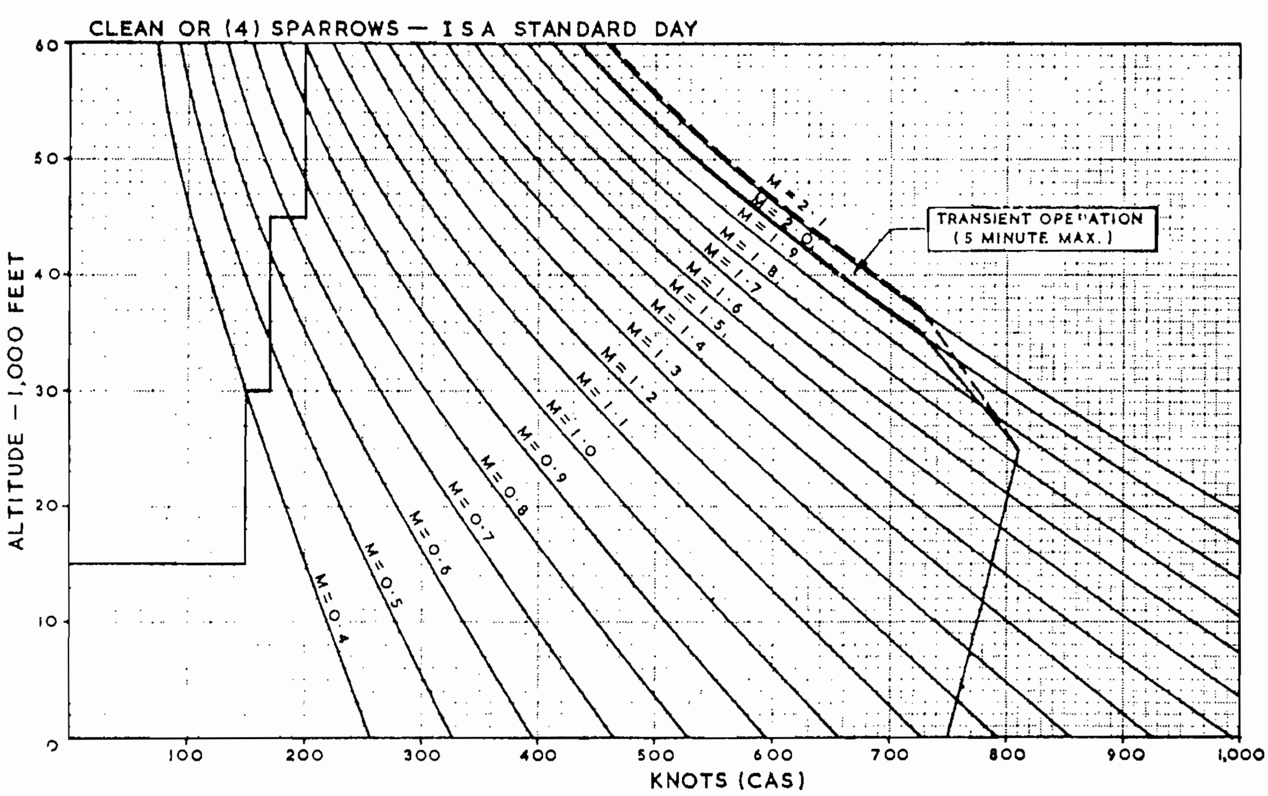
27. *HIRTA Low Flying Grades.* The HIRTA low flying grades for the aircraft and its weapons/stores are:

| | *Low Flying Grades* | | | |
|---|---|---|---|---|
| | *A* | *B* | *C* | *D* |
| *Clean Aircraft:* | | | | |
| Flight Systems | 2 | 3 | 2 | 2 |
| *With Weapons/Stores:* | | | | |
| 20mm gun | 1* | 1 | 1 | 1 |
| Sidewinder 9G (all configs) | 2 | 3 | 2 | 2 |
| Sidewinder 9L (all configs) | 2 | 3 | 2 | 2 |
| Launcher Aero 7A | 2 | 3 | 2 | 2 |
| Launcher Aero 27A | 2 | 3 | 2 | 2 |
| Centreline pylon | 2 | 3 | 2 | 2 |
| Outboard pylon | 2 | 3 | 2 | 2 |
| Sky Flash (all EED) | 2 | 3 | 2 | 2 |
| Sparrow (all EED) | 2 | 3 | 2 | 2 |
| AN/ALE 40 (enable switch OFF) | 1 | 1 | 1 | 1 |
| Clean Aircraft | 2 | 3 | 2 | 2 |
| Worst case weapons/stores CW | 2 | 3 | 2 | 2 |
| Worst case weapons/stores pulsed | 1* | 1 | 1 | 1 |

Note: * indicates that the store is sensitive to pulsed RF transmissions.

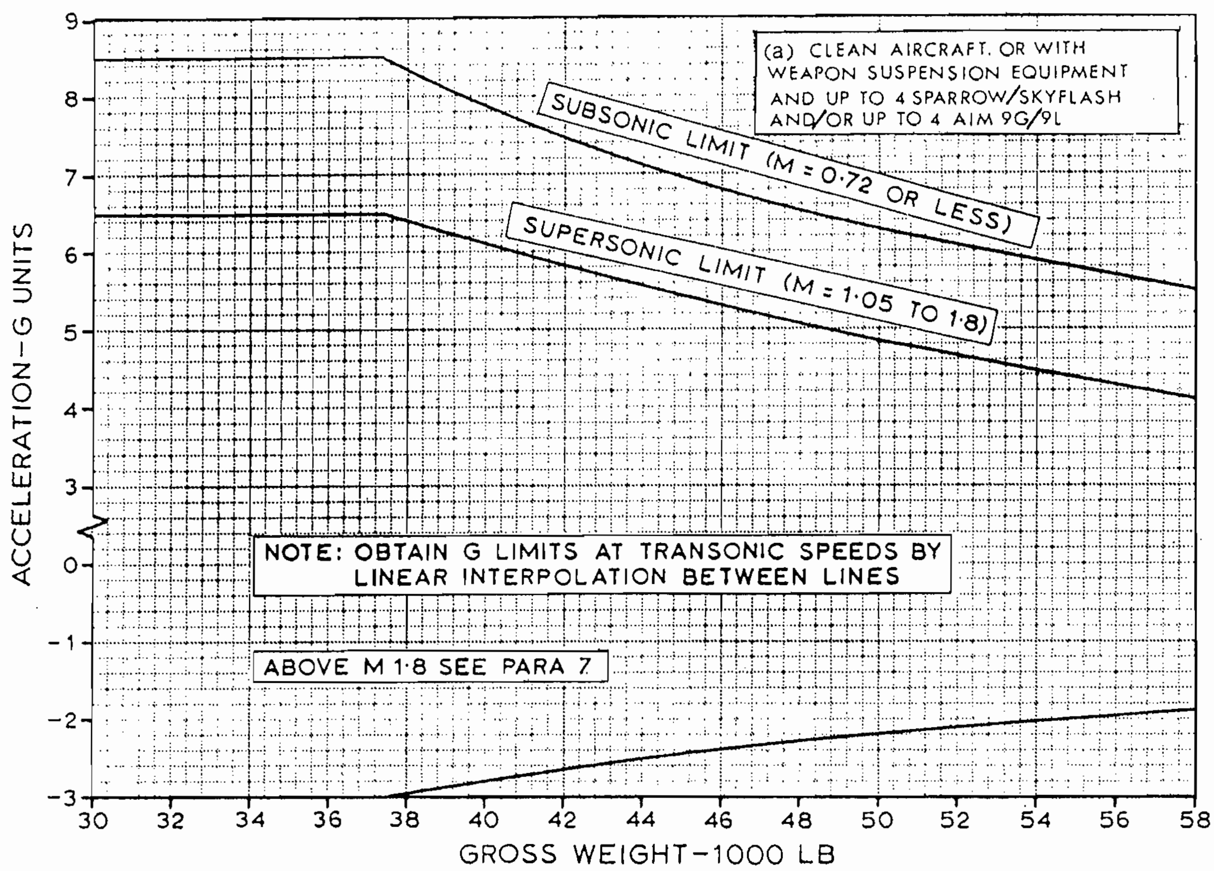
**Table 1 - HIRTA Grading Bands**

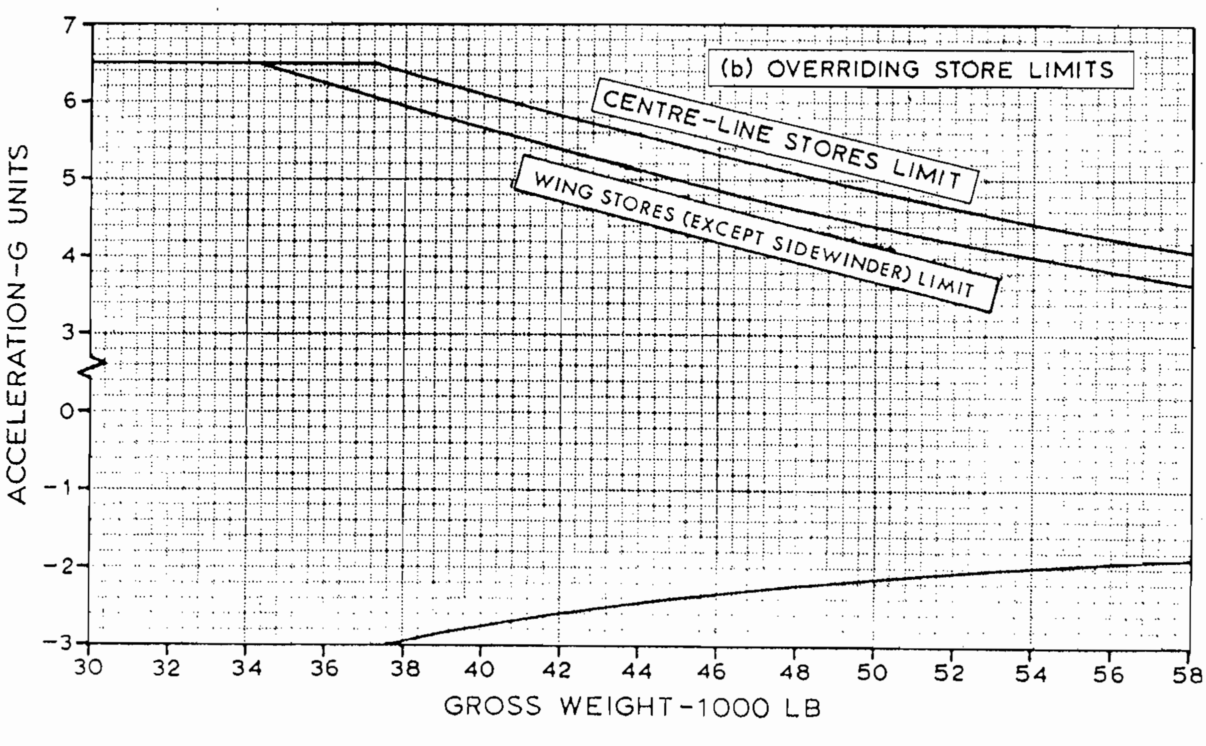
| *Frequency Band* | *Band Code* | *Power Density Grade* | *Power Density* | |
|---|---|---|---|---|
| | | | *W/M²* | *V/M* |
| 0.525 - 2 MHz | A | 1 | >239 | >300 |
| | | 2 | 238.9 - 26 | <300 - 100 |
| | | 3 | 25.9 - 6 | <100 - 50 |
| | | 4 | 5.9 - 2 | <50 - 25 |
| 2.0 - 32 MHz | B | 1 | >106 | >200 |
| | | 2 | 105.9 - 26 | <200 - 100 |
| | | 3 | 25.9 - 6 | <100 - 50 |
| | | 4 | 2.9 - 2 | <50 - 25 |
| | | 5 | 1.9 - 0.25 | <25 - 10 |
| | | 6 | 0.24 - 0.02 | <10 - 3 |
| 32.0 - 790 MHz | C | 1 | >100 | - |
| | | 2 | <100 - 10 | |
| | | 3 | <10 - 1 | |
| | | 4 | <1 - 0.25 | |
| 0.79 - 40 GHz | D | 1 | >1000 | - |
| | | 2 | <1000 - 100 | |
| | | 3 | <100 - 10 | |



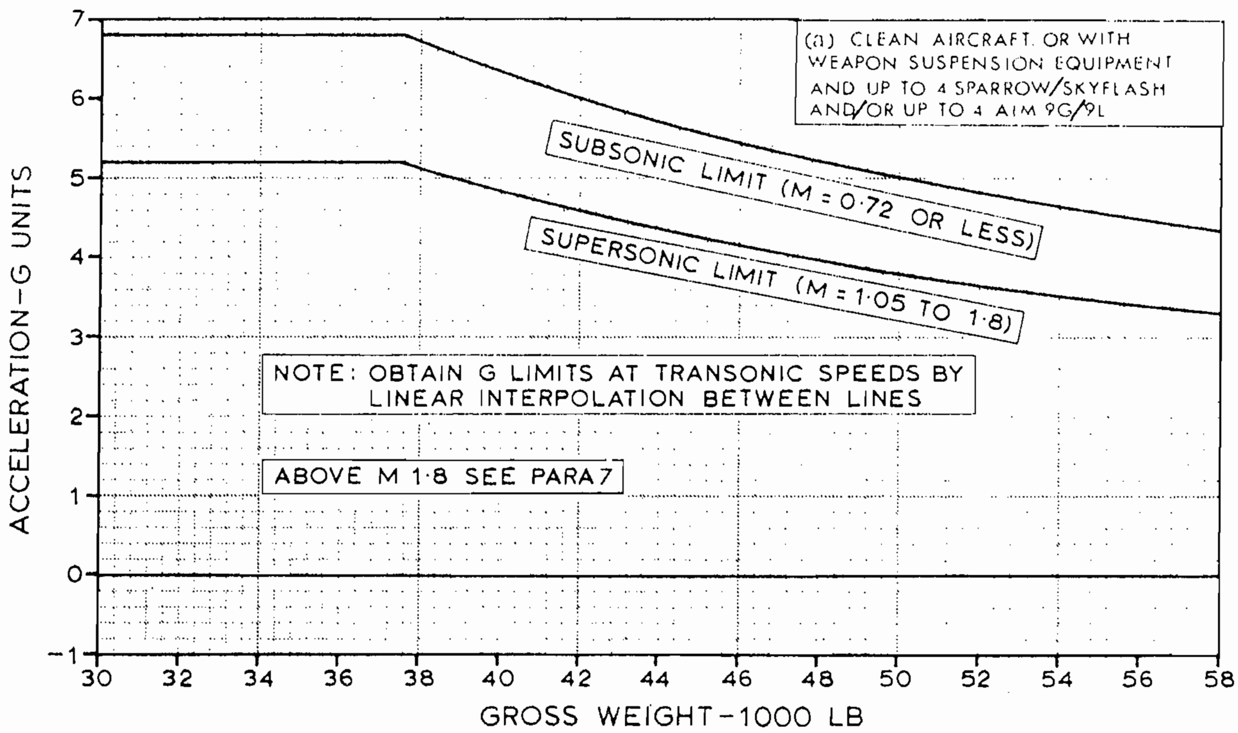

Note: Minimum speeds from 15,000 feet upwards are indicated by the stepped line on the left of the graph.

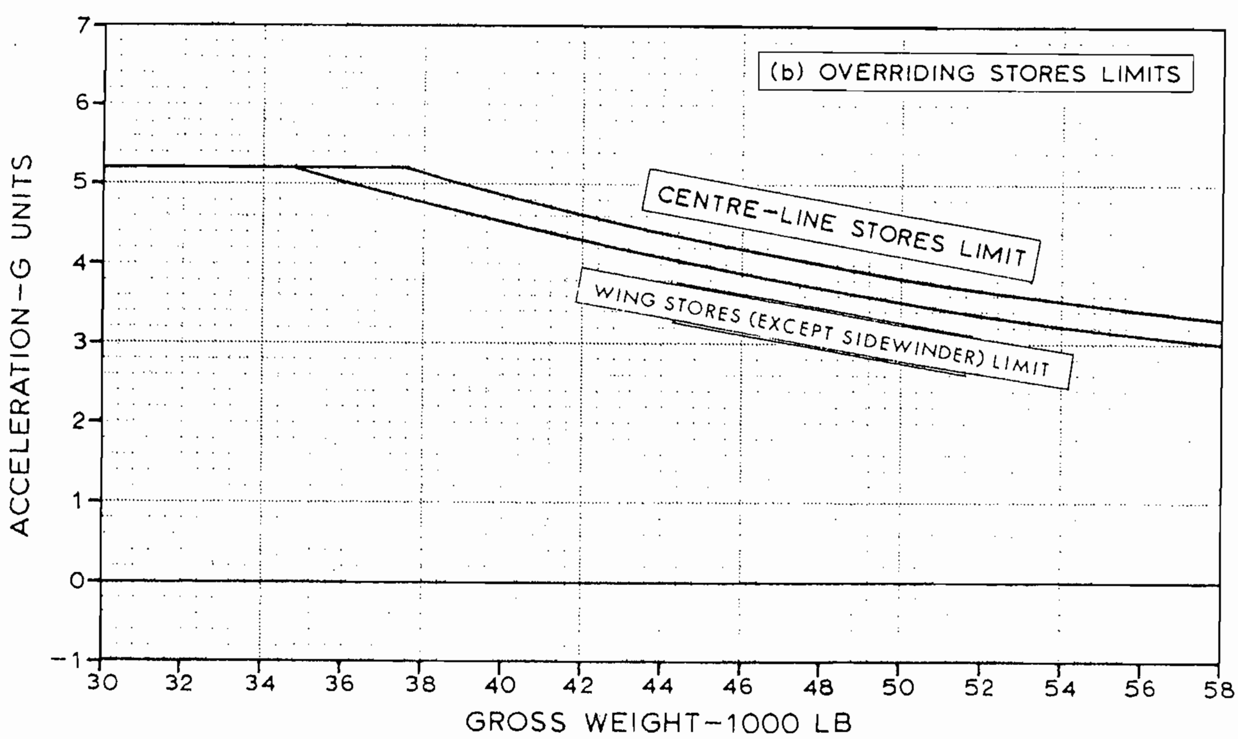
**2-2 Fig 1 Airspeed Limitations**



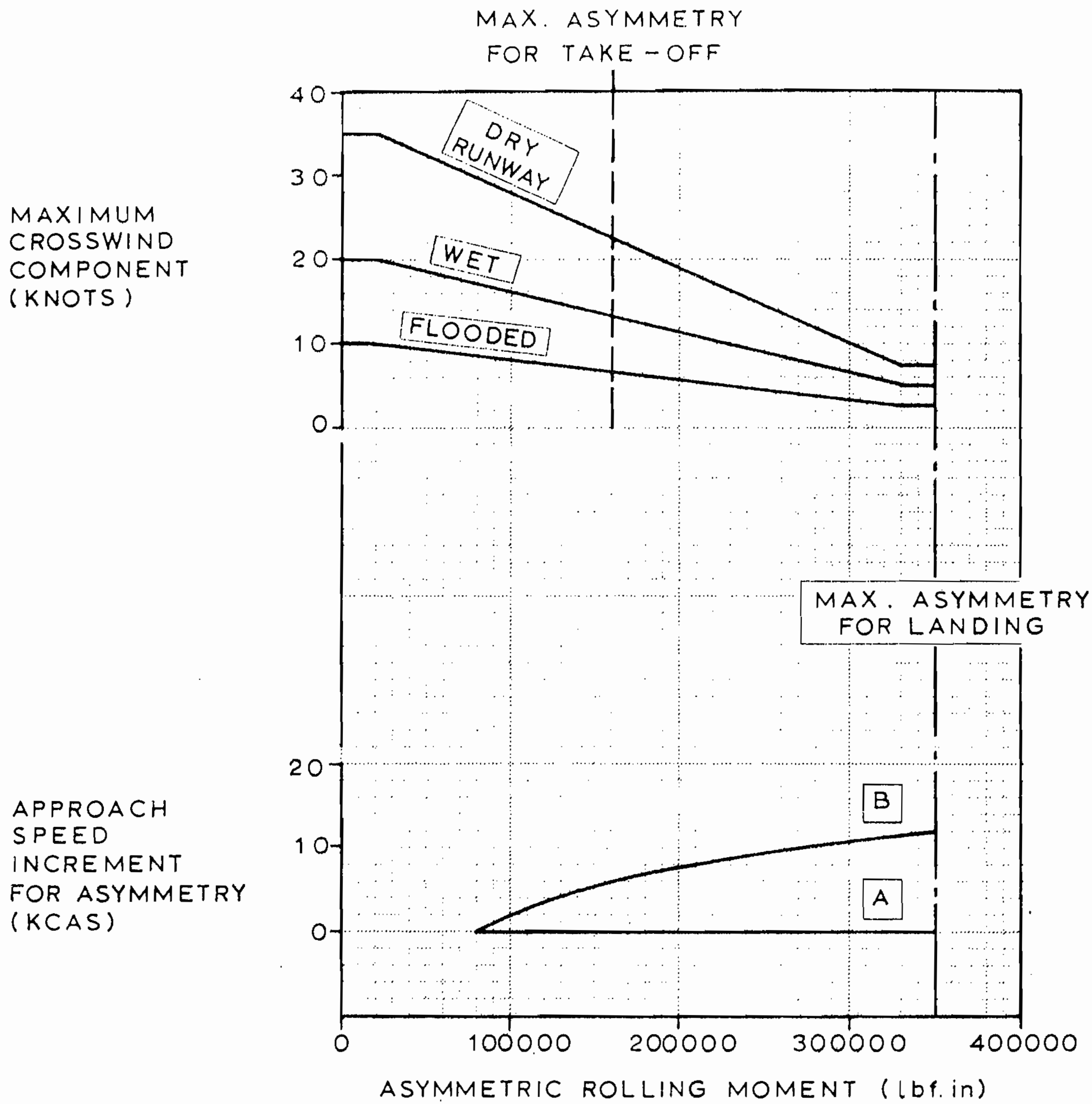

**2-2 Fig 2 Normal Acceleration Limitations - Normal Manoeuvres**




**2-2 Fig 3 Normal Acceleration Limitations - Rolling Manoeuvres**

NOTE :- INBOARD PYLON ARM = 81·5in
OUTBOARD PYLON ARM = 132·5in




LINE [A] MAY BE USED WHEN LANDING DISTANCE IS CRITICAL, IF TURBULENCE LEVEL IS LOW.

LINE [B] MAY BE USED WHEN LANDING DISTANCE IS NOT CRITICAL, OR WHEN TURBULENCE LEVEL IS MODERATE OR HIGH.

**2-2 Fig 4 Crosswind and Asymmetric Stores Landing Limitations**

# PART 2

# CHAPTER 3 - SYSTEMS AND EQUIPMENT LIMITATIONS

## Contents



### Angle of Attack System (AOA)

1. The calibrated AOA system must be fitted and used on all flights. Not more than 22 units must be used at any stage of take-off.

**WARNING:** The AOA indication with landing gear lowered is 3 to 4 units greater than when the gear is fully up, at the same airspeed.

### Automatic Flight Control System (AFCS)

2. The system, including stability augmentation, is cleared for use subject to:

a. Autopilot must not be used below 1000 feet.

b. Intentional manoeuvres exceeding auto-disengagement limits are prohibited, except as required for flight testing.

c. If INAS is not fitted, the compass controller mode switch must be in the STBY position before autopilot heading hold mode is selected.

### Air Conditioning and Pressurisation System

3. For engine ground runs above 92% HP RPM with flaps up, the EMERG VENT knob must be out to dump cabin pressure. There are no limitations for ground runs with half or full flaps, for take-off or in flight.

### Canopies

4. a. The canopies are cleared to remain fully open at speeds up to 60 knots (separation design speed is 100 knots).

b. Canopy closure must not be attempted with engines running above stabilised ground idle, otherwise the canopy may not lock fully owing to back pressure from the aircraft pressurisation system.

### Nosewheel Steering

5. The system is cleared for use. The lower UHF antenna must not be selected for taxying, take-off or landing when it is intended to use nosewheel steering. If, after engaging nosewheel steering with the upper UHF antenna selected, no response is noted or unscheduled steering commands are detected, the nosewheel steering is to be disengaged immediately and is not to be re-engaged. To prevent the landing gear struts from being subjected to abnormal side loads, do not use nosewheel steering and brakes simultaneously during a turn.

### Windscreen Rain Removal

6. The system must not be operated in flight with a dry windscreen nor at speeds above 1.0M. For static ground checking, flaps must be fully down and HP RPM below 84%.

**Radio, Navigational and Missile Control Equipment**

7. The following are fully cleared for use:

UHF/VHF PTR 374 and AD120/PTR 1751X (ARI 23199 and 23300/25) (see para 5)

Standby UHF (ARI 23200)

AN/AJB7

ADF AN/ARA-50 (ARI 23120)

Voice Recorder AN/ASQ 19

Flight Director Group

◆◆

Radio Altimeter STR 70 (ARI 23178)

Passive Warning Receiver (PWR) (ARI 18228)

Telebrief

8. The following are cleared for use subject to certain limitations:

a. *CNI Equipment.* Except for the intercom system and the main V/UHF set, all CNI equipment is subject to a limit of 10 minutes of accumulated operation within any 1 hour during ground operation without cooling air. This limitation is additional to the limitations for specific items of CNI equipment.

b. *TACAN AN/ARN 91 ARI 23205.* For ground operation, if HP RPM are below 85% and ½ flap is selected, the set must be OFF, or set to REC, for not more than 10 minutes.

c. *AN/AWG 12 Radar (ARI 5967).* The radar is cleared for use in the air-to-air and ground mapping modes only. The terrain mode is not to he used. Operating time limits are given in the Release to Service Document.

d. *LCOSS.* Cleared for use in air-to-air and DIRECT modes.

e. *HF Radio (ARI 23146/2).* The HF radio is cleared for use up to 50,000 feet. HF transmissions can interfere with the ARI system and transmissions are not to be made with the flaps ½ or full down at airspeeds below 230 KCAS. During sustained transmission on certain frequencies the fuel tape and counter readings can drift, returning to the correct reading within approximately 30 seconds after transmission stops.

◆ **WARNING:** The HF is not to be used in the HAS/ARB environment. ◆

f. *ILS (ARI 18227).* The ILS is cleared for use but UHF/VHF transmissions on certain frequencies can cause serious errors in ILS indications. If the HF transmitter is used during an ILS approach, minor deflections of the ILS needles may be caused.

g. *IFF/SSR and Airborne Interrogator.* The IFF/SSR and airborne interrogator systems are cleared for use; refer to the Aircrew Manual CD101B-0901/2-15D for operating limitations. UHF transmissions on 257.5 and 343.3 MHz may cause IFF blanking. IFF transmissions may interfere with the UHF standby receiver.

h. *INAS.* See AP101B-0902-15B.

◆ i. *Intercom System.* The intercom system is cleared for use. The post-mod 980 intercom system is also cleared for use providing the aircrew equipment is fitted with phase 3 noise-reducing microphones. ◆

**External Tanks Limitations**

Note 1: See Part 2, Chapter 2, Fig 2 and 2A for overriding stores g limits in normal and rolling manoeuvres.

Note 2: Take-off with partially filled wing or centre-line tanks is prohibited.

Note 3: Jettison of external tanks is to be carried out in 1g level flight with airbrakes in and gear and flaps up.

**WARNING:** Tanks should normally be jettisoned either full or empty. The jettison of partially-filled or damaged tanks is prohibited, except in an emergency, because major airframe damage and control problems may result. In an emergency, where the risk of possible aircraft damage and/or control problems are acceptable, partially-filled or damaged tanks should be jettisoned at the lowest attainable airspeed in the clean configuration.

9. *External Wing Tank Limitations*

a. *Maximum Speed:*

Part-filled... ... 550 KCAS/1.6M

Empty... ... ... 750 KCAS/1.6M

b. *Manoeuvre.* The maximum permissible lateral control column deflection is one half of the total travel except in the take-off or landing configuration. The manoeuvre limits are:

More than 3/4 full ... minus 1 to +4g normal, zero to +2g rolling

Less than 3/4 full ... minus 2 to +5g normal, zero to +4g rolling

Empty ... ... ... ... minus 2 to +6g normal, zero to +4.8g rolling

c. *Jettison* (See Note 3 and WARNING above)

Minimum speed ... 175 KCAS

Maximum speed ... 410 KCAS above 30,000 feet, 375 KCAS below 30,000 feet

Note: External wing tanks may be jettisoned at up to 450 KCAS in normal manoeuvres with +2 to +3g applied. Minor damage may result below 5000 feet.

10. *External Centreline Tank Limitations*

a. *Maximum Speed:* ... 600 KCAS/1.8M

b. *Manoeuvre.* Only gradual, co-ordinated turns are permitted. The maximum permissible lateral control column deflection is one half the total travel except in the take-off or landing configuration. The manoeuvre limits are:

Full tank ... ... ... zero to +3g normal, +1g only rolling

Less than 3/4 full ... zero to +5g normal, +1 to +3g rolling

c. *Jettison* (See Note 3 and WARNING above)

Minimum speed ... 175 KCAS

Maximum speed ... 425 KCAS/1.8M (jettison between 375 and 425 KCAS below 15,000 feet may result in minor airframe damage)

*Intentionally Blank*

Part 3

Handling

List of Chapters



# SECTION 4

# TAKE OFF NAT FLIGHT PATH

# PART 3

## CHAPTER 1 - STARTING, TAXYING AND TAKE-OFF

### Contents



**Preparation for Flight**

1. a. Obtain the aircraft's centre of gravity position and Total Stability Index to determine if special fuel management is required.

◆ b. From the Operating Data Manual calculate the Minimum Go Speed and $V_{STOP}$, unstick speed, and note the take-off run. ◆

c. Complete the **Aircraft Safe for Parking Checks, External Checks** and **Internal and Pre-Start Checks** in the FRC.

**Starting the Engines**

2. *External AC Start*

a. Start the engines in accordance with the drills listed in the FRC.

◆ b. Pre-mod 848, select the CNI ground power switch to ON to allow the aircraft radios to be used during the start. ◆

3. *External DC Start*

a. Start the engines in accordance with the drills listed in the FRC.

b. The appropriate generator cannot come on line until the external power plug is disconnected from the aircraft. Intercom between aircrew and ground crew is lost during the disconnection. The second engine is started on internal AC power.

c. If AC power is not available, the fire warning system is inoperative. See the FRC for further considerations.

Note: For alignment of the INAS and the effects of interruption to power to the INAS see Aircrew Manual Weapons System (AP 101B-0902-15B).

4. *Battery Start*

a. Start the engines in accordance with the drills listed in the FRC.

b. During the starting of the first engine, the ENG OIL PRESS LOW, FIRE and OVHT warnings, hydraulic gauges and fuel flow meter are inoperative until one or both generators are switched ON. Indications available are TGT, RPM and nozzle position. Once both generators are switched ON, normal indications are then available and the instruments and gauges of the first engine started should be carefully checked.

5. *General*

a. To reduce the peak TGT during starting, select the NORMAL 12TH STAGE/ISOLATE switch to ISOLATE.

b. Avoid starting in tailwinds if possible.

c. With external power connected and either ENGINE MASTER switch ON, the throttles must not be moved from the OFF position except during a normal start. If the throttles have been moved from OFF, start must not be attempted until the access doors are opened.

d. To ensure correct LP shaft rotation, the following procedure must be used:

(1) With a headwind or LP compressor static, move the throttle lever to IDLE at 5% HP RPM.

(2) With a beam wind move the throttle to IDLE at 10% HP RPM.

(3) With a tailwind move the throttle to IDLE at 15% HP RPM.

e. In order to ensure that the HP cock is open move the throttle 2 inches forward of the idle stop then return it to IDLE. Light-up should normally occur within 5 seconds after moving the throttle to IDLE and ground idling RPM (51.5% to 56%) should normally be achieved within 1 minute. If, during the start, the HP RPM stabilises at a sub-idle speed between 47% and 51.5%, the throttle may be eased open gently, closely monitoring TGT, to achieve normal ground idling within 1 minute. After both engines are running satisfactorily, both throttles should be closed to IDLE. If ground idling speed is not attained within 1 minute the throttle should be set to OFF.

Note: When closing the throttles to IDLE ensure that the throttle stops function correctly. It is possible to shut down an engine in flight inadvertently if the throttle stops are worn.

f. If automatic starter disengagement does not occur at 38 ±2% RPM, select the ENGINE START switch to OFF.

◆ Note: Post-STI/677, the engine 60-second start timer relays are disabled. If the left or right engine is not self-sustaining within 40 seconds, select the ENGINE START switch to OFF. ◆

g. (1) If the starting TGT limit is rapidly approached and appears likely to be exceeded move the throttle to OFF. RPM stagnation below 47% must not be allowed to persist.

(2) A hot start may result if the engines are started with the flaps fully down.

(3) In the event of a shut-down due to a hot start, the subsequent attempt after 2 minutes may be assisted if half flap is selected.

6. *Failure to Start.* If the engine fails to light up within 10 seconds from moving the throttle to IDLE, or to attain idling RPM within 1 minute, move the throttle to OFF, select the ENGINE START switch to OFF and allow the engine to drain for 2 minutes.

**Starter Limitations**

7. To prevent the gas turbine starter motor over-heating, allow a minimum of 90 seconds to elapse between each starting cycle and an interval of at least 30 minutes after three consecutive cycles.

**Functional Checks**

8. Carry out the **Functional Checks** listed in the FRC. To prevent abnormal TGT during the flap checks, increase engine RPM to 60% to 65%, or select the NORMAL 12TH STAGE/ISOLATE switch to ISOLATE. Ground crew should be warned to expect reduced BLC blow on 7th stage air.

**WARNING:** Operation of the flight controls, speed brakes, AFCS, or the cycling of the generators presents a hazard to the ground crew.

Note: For stabilator trim settings after the AFCS check, see para 15, Note 3.

9. If, during the **Functional Checks**, the flaps indicate transit (barber's pole), leave the FLAPS switch at its selected position and have the fault investigated.

**Taxying**

10. There is no parking brake. After removal of the chocks, taxy forward and check the brakes and then the nosewheel steering over the full range. Taxy slowly using nosewheel steering for directional control and smooth steady braking as required. Slow the aircraft down before making sharp turns to avoid excessive side loads on the landing gear.

11. Nosewheel steering is engaged by pressing and holding the nosewheel steering button on the control column. Always ensure that the rudder bar is aligned to the direction of travel of the aircraft, as the nosewheel deflects to an angle appropriate to rudder bar deflection when nosewheel steering is engaged. The maximum nosewheel deflection is 70° though it may caster beyond this angle, and steering is then not available until the nosewheel is positioned within the 70° travel.

12. Steering by differential application of wheelbrake is possible but not recommended for normal use. Wheelbrakes should not be used in opposition to nosewheel steering.

13. Pneumatic wheelbrakes may be used at any time as they do not introduce air into the normal braking system. They do not act differentially and if used should be applied carefully, allowing for a delay of up to 2 seconds in operation.

**WARNING 1:** The use of wheelbrakes during normal taxying to maintain a reasonable ground speed can cause high wheel temperatures; the brakes should be used as little as possible, particularly at high AUW and/or where taxying distances are excessive.

**WARNING 2:** To avoid risk of fire, do not use the pneumatic wheel brakes if the wheel drums are hot.

14. *Taxying in Icing Conditions.* Engine anti-icing should normally be switched on immediately after starting and left on for taxy and take-off if the following conditions are present:

Dry bulb temperature is below +10°C.

Visible moisture is present or the runway is wet.

When holding on the ground in conditions below +1°C with fog or rain and with anti-icing selected ON, it is recommended that the engines are accelerated to 90% RPM for 4 seconds at intervals of not more than 10 minutes. Ensure the air intakes are clear of ice prior to take-off

**Before Take-Off**

15. Carry out the **Take-Off Checks** and **Runway Checks** as listed in the FRC.

Note 1: The use of pitot heat on the ground should be limited to a period of 1 minute.

Note 2: The ANTI-SKID switch is selected ON either with no braking applied or stationary at IDLE/IDLE because, when selected ON, the anti-skid system carries out an automatic self test which momentarily releases any pressure at the brakes. Ensure adequate clearance from other aircraft before selecting the anti-skid system ON.

Note 3: To reduce excessive out-of-trim forces after take-off, the stabilator trim setting used for take-off is varied depending on aircraft configuration, as follows:

| *Config ±Missiles* | *Trim Setting* |
|---|---|
| No external tanks - | 3° nose down |
| No external wing tanks, gun pod fitted - | 2½° nose down |
| External wing tanks or centreline fuel tank - | 2½° nose down |
| External wing tanks and centreline fuel tank - | 2° nose down |
| External wing tanks and gun pod fitted - | 2° nose down |

**Engine Run-Up**

16. Engine run-ups before take-off are not mandatory. However, if run-ups are carried out, the following considerations and actions apply:

a. Extensive ground erosion may occur if the engines are run-up on unsuitable surfaces.

b. If the engines are run-up with the flaps up, the emergency vent knob must be pulled to prevent the cockpit refrigeration unit overheating.

c. Do not run-up the engines at MIL power for longer than 1 minute with the flaps down to prevent BLC duct overheating.

d. Do not run-up the engines in reheat power.

e. *HP/LP RPM Checks.* Make a check of transient HP RPM/LP RPM during the pre-take-off run-up. Open each engine singly to MIL power, with ½ flap selected (7th stage BLC). If the achieved HP RPM is below the relevant minimum value (see sub-para f) the aircraft must not be flown. If it is within +0.3% of the minimum, the aircraft must be placed unserviceable on completion of the sortie. Operate the HP/LP switch to LP and check the appropriate LP RPM.

Note: Low HP RPM may be experienced on a cold day during the first run of the day. In this case the check may be repeated before deciding serviceability.

f. *Minimum Transient HP RPM Values*

| *OAT °C* | *HP RPM% (See Note 1)* | *Δ RPM $^{+0}/_{-4}$ (See Note 2)* |
|---|---|---|
| -25 | 94.9 | 6.4 |
| -20 | 94.9 | 7.0 |
| -15 | 94.9 | 7.4 |
| -10 | 94.8 | 8.0 |
| -5 | 94.7 | 8.4 |
| 0 | 94.6 | 8.8 |
| +5 | 94.4 | 9.4 |
| +10 | 94.3 | 10.0 |
| +15 | 94.1 | 10.4 |
| +20 | 93.9 | 10.8 |
| +25 | 93.65 | 11.4 |
| +30 | 93.4 | 12.0 |
| +35 | 93.2 | 12.5 |
| +40 | 92.8 | 13.0 |
| +45 | 92.65 | 13.5 |

Note 1: *Transient* HP RPM is the engine speed obtained within 15 to 20 seconds of opening the throttle to MIL, ie, 5 to 10 seconds after achieving controlling TGT. It is normal for HP RPM to creep upwards with continued running at MIL.

Note 2: Δ RPM is the difference between HP RPM and LP RPM and is the amount by which the tachometer reading should *decrease* when the HP/LP switch is set to LP.

Example:

| | | |
|---|---|---|
| OAT | 20°C | |
| Δ RPM | $10.8^{+0}_{-4}$% | From above table |
| Min permissible transient HPRPM | 93.9% | |
| Actual achieved HP RPM | 94.3% | |
| Expected LP RPM | 94.3-$10.8^{+0}_{-4}$% | |
| = | 83.5% min | |
| or | 87.5% max | |

**Take-Off**

17. The normal configuration for take-off is ½ flap.

Note: Use of ENGINE ANTI-ICING reduces maximum thrust by approximately 1.2%

18. Nosewheel steering should be engaged prior to entering the runway. Thereafter do not disengage the nosewheel steering until the rudder becomes effective during take-off roll (approximately 80 KCAS). However, see **WARNING 2.**

19. Align the aircraft on the runway and increase the power to approximately 82% RPM to check the brakes and ensure that the nozzles close. Release the brakes and advance the throttles to MIL power. Select maximum reheat without delay. The nozzles go immediately to pre-open (1/8 to ¼ position). The reheat thrust increase occurs within 4 to 5 seconds of selection and the nozzle area increases to ½ to ¾ open. If either reheat fails to light on the first selection, abandon the take-off. On operational sorties this limitation may be waived and a re-selection attempted. If the re-selection is unsuccessful, select the failed reheat throttle to MIL power and continue the take-off.

**WARNING 1:** During the take-off roll, do not re-engage the nosewheel steering once it has been disengaged ◆ unless aborting for a burst tyre (para 31). ◆

**WARNING 2:** After a nosewheel steering malfunction on engagement or subsequently, it is vital to release the NWS button immediately.

Note: In conditions of high ambient temperatures and humidity, the engine may suffer a thrust loss owing to condensation effects in the intake. At a temperature of 30°C with 90% humidity the thrust loss could be in the order of 5%. At lower humidity values and ambient temperatures the thrust loss figure quickly diminishes to an insignificant value.

20. The control column is held fully aft from brakes release during normal take-offs. Nosewheel unstick speed varies with AUW and CG but is normally 140 to 165 KCAS. Less than full aft control column delays unstick and lengthens the take-off ground run.

**WARNING:** Rapid movement of the control column to the fully aft position should be avoided from 30 knots below take-off speed until the aircraft is fully airborne, otherwise over-rotation of the aircraft may occur with a consequent risk of stalling, or of lift-off before safe flying speed, or of the stabilator striking the runway.

21. As the nosewheel unsticks, move the control column forward to prevent over-rotation and maintain approximately 10° nose-up attitude. The aircraft lifts off cleanly.

22. When safely airborne, raise the landing gear. Raise the flaps when the airspeed is over 180 KCAS. During a reheat take-off, when the flaps are selected up, a thrust pulse may be felt accompanied by a nozzle movement. This is normal.

23. The WHEELS light flashes if the flaps are still retracting when the landing gear is up. The MASTER CAUTION and L and R AUX AIR DOOR captions may also come on momentarily as the Aux Air doors close.

24. It is important to check that the BLC MALFUNCTION caption does not come on after the flaps are up. The WHEELS light should also be out with the flaps and landing gear indicating up.

**WARNING:** Operation at a normal power setting in excess of 30 seconds with the flaps up and the BLC MALFUNCTION caption on may damage the warning circuit wiring, which then puts out the warning light. Continued flight with the flaps up could damage the wing by overheating.

25. *Take-Off with Aft CG or Flaps Up.* When taking-off ◆ with an aft CG (ie, in Area 2 in 3-2 Fig 2) or with flaps up, ◆ the aircraft ends to over-rotate after nosewheel unstick. For this reason such take-offs are made using a less than fully aft control column position and with prompt and progressive forward control column movement as the nosewheel unsticks.

26. *Take-Off with CG Forward.* The nosewheel unstick speeds increase by approximately 4 to 5 knots for every 1% of forward CG movement. During take-off the control column should be held fully back otherwise the nosewheel may not unstick.

**Single Engine Failure During Take-Off**

27. If an engine fails during take-off the relevant $V_{GO}$ and $V_{STOP}$ speeds in the ODM indicate whether the take-off should be abandoned or continued.

28. *Take-Off Abandoned.* Close the throttles, stream the brake parachute, apply the wheelbrakes and hold the control column fully back. If stopping distance is marginal, the hook should be lowered sufficiently early to allow it to be recycled in the event of failure to lower (it takes up to 5 seconds to lower). The wire should be engaged going straight and, if possible, in the centre. If a barrier is to be engaged, keep the canopies closed until stopped. If heavy braking has been used to stop the aircraft, do not apply the emergency pneumatic brake.

29. *Take-Off Continued.* There is a definite yaw towards the failed engine which can be corrected with rudder or nose gear steering if necessary. After unstick, the external stores may have to be jettisoned if the climb away is inadequate or control problems exist owing to asymmetric loading coupled with side slip. Raise the landing gear as soon as safely airborne. Raise the flaps between 180 to 200 KCAS depending upon the AUW.

Note 1: At high AUW, especially with an aft CG, longitudinal stability is improved if the FUEL TRANS selector is left at STOP until the fuel tape reading is approximately 6000 lb (see Part 3, Chapter 2, **Improvement in Longitudinal Stability**). This moves the CG forward to a mid range and allows wing fuel to be dumped, if necessary, without an adverse effect on handling.

◆ Note 2: At high AUW with many of the possible combinations of runway length, stopping aids and engine state, an engine failure on take-off can occur within a band of airspeeds in which the aircraft may neither be brought to rest within the remaining runway length nor a single-engine take-off achieved. This makes the precise calculation of $V_{STOP}$ and $V_{GO}$ values of the utmost importance.

Note 3: In the event of a single-engine failure soon after take-off at a high AUW, it may not be possible to sustain flight without jettisoning stores. ◆

**Burst Tyre During Take-Off**

30. If a tyre bursts during take-off the decision to abandon or continue depends on certain factors. The following should be taken into consideration:

a. Following a mainwheel tyre burst, it is probable that utilities failure will also occur owing to damaged brake lines caused by the 'flailing' tyre.

b. A burst mainwheel tyre may cause damage to the flaps and aileron.

c. A burst nosewheel tyre may cause damage to one or both engines.

d. The weather conditions at base and at possible diversions should be considered, as an approach-end engagement should be made.

31. *Take-Off Abandoned.* Keep straight using NWS, throttle back to IDLE, and deploy the brake parachute. Before braking, turn the ANTI SKID switch OFF, because the system senses a mainwheel tyre burst as a skid and releases all brake pressure to both main wheels. Since directional control is the main problem following a mainwheel tyre burst, the control column should be positioned forward of neutral to load the nose-wheel and to ensure that the nosewheel microswitch is closed. If required, the hook should be lowered sufficiently early to allow it to be recycled in the event of failure to lower - do not lower the hook immediately however, as the hook shoe might be worn away on a long runway. *Leave the flaps at ½.*

32. *Take-Off Continued.* Keep straight using NWS as necessary. Once airborne, leave the landing gear down and flaps at ½. Be prepared for a total utilities failure. Consult the FRC for **Landing with a Burst Tyre.** If a tyre bursts on a roller landing, leave the landing gear down and the flaps at the selected position.

**Take-Off Abandoned for Other Reasons**

33. Carry out the FRC drill for **Single Engine Failure during Take-Off (Take-Off Abandoned),** unless the take-off is abandoned at a very low speed.

**Engine Failure Immediately After Take-Off**

34. Carry out the drill listed in the FRC.

*Intentionally Blank*

# PART 3

## CHAPTER 2 - HANDLING IN FLIGHT

### Contents



**Climb**

1. a. Complete the **Checks After Take-Off** and carry out the following sequence of handling checks at 350 knots at a safe height:

(1) Pull 2g and release the control column; the pitch oscillations should damp out in one cycle. Displace the slip ball one ball's width and release the rudder; the yaw oscillation should damp out in one cycle. Roll rapidly through 30° of bank and release the control column; the roll should stop immediately.

(2) If the sortie is to include high AOA manoeuvring disengage the roll axis of the stability augmentation. (At high AOA the roll stab aug continues to detect uncommanded roll rates and opposes them with spoiler and aileron inputs. These lateral control inputs cause adverse yaw and therefore, sideslip; the aircraft tends to roll in the same direction as the original uncommanded roll. Therefore, the roll stab aug magnifies any lateral disturbances and makes smooth, accurate lateral control of the aircraft difficult.)

(3) The rear seat occupant should check the ailerons visually in straight and level flight at about 350 KCAS. If an aileron is deflected by more than 1 inch at the trailing edge, degraded handling can be expected.

Note: The above handling checks are always to be completed before any high AOA manoeuvring. The rigging check at sub-sub-para (3) above is also to be completed after AAR, if wing tanks are fitted.

b. Accelerate to climbing speed:

| *Config* | *Speed (kt/M)* |
|---|---|
| Clean | 400/0.85 |
| B, C, D fit | 350/0.82 |
| Reheat climb | 400/0.9 |

Note: It is normal for the pressurisation to surge at approximately 25,000 feet.

c. The fuel feed should be checked during the climb as follows:

(1) Select INT WING and check that the tape increases slowly.

(2) Select CENTER and check that the CTR EXT FUEL caption comes on and then goes out. Also check that the tape and counters increase.

(3) Select OUTBD and check that the L EXT FUEL and R EXT FUEL captions come on and then go out. Also check that the tape and counters increase.

**Engine Handling in Flight**

2. *General.* The life of turbine components is adversely affected by time spent at high temperature and by rapid temperature changes. Engine life is conserved by using the lowest practicable power setting and avoiding rapid throttle movements in either direction. Unless operational necessity dictates otherwise, throttle movements should he made smoothly and progressively.

a. Operate the throttles smoothly at all times.

b. When accelerating the engine, the nozzle should move from pre-open to closed by 82% RPM. When decelerating, the nozzle goes from closed to pre-open between 85% and 65% RPM. Faster deceleration results in lower changeover RPM.

c. If the throttles are moved rapidly above 25,000 feet, pop surges may occur. These surges are acceptable provided there is no abnormal rise in TGT or the RPM does not stagnate.

d. If the surge persists, or if surge/intake banging occurs below 25,000 feet, decrease the angle of attack and increase the airspeed without moving the throttles. If surging still persists, throttle to idle, check the positions of the ramps - if incorrect, carry out the **Ramp Failures** drill in the FRC. If the positions of the ramps are correct and the condition clears the engine(s) may be accelerated slowly, carefully monitoring RPM and TGT. If the symptoms do not reappear, the engine(s) may be used as normal. If the condition does not clear, or if the TGT continues to rise, move the throttles to OFF.

**WARNING:** During any subsequent relight, engine response must be closely monitored.

e. Slight adjustment of the throttles may be needed above 40,000 feet to keep the RPM within limits. At high altitudes and low airspeed there may be a reduction in RPM and TGT.

f. Large amounts of yaw should be avoided when flying above 20,000 feet with airspeed below 200 KCAS. If the throttles are moved or power is at less than 80% RPM in these flight conditions, an engine surge and over-temperature is likely to occur. The engine in the direction of yaw is likely to flame out if reheat is selected.

g. To avoid damage to the 7th stage bleed air non-return valves, selection from half flap to full flap should not be made above approach power settings.

**WARNING:** Snap closure of the throttle(s) to IDLE may momentarily operate the HP cock(s) and cause the engine(s) to flame out. ◆◆

3. *Reheat Operation*

a. The reliable reheat lighting limits and the reheat burning range are given in Part 2, Chapter 1, Fig 3. Within the lighting limit, reheat is best lit by first setting military power and allowing the TGT and RPM to stabilise, and then moving the throttles straight to maximum reheat.

b. Attempts to engage reheat above the lighting limit are permitted but not recommended. Minimum reheat must be selected from military power after allowing the TGT and RPM to stabilise. If a successful light-up is obtained, wait 5 seconds and then slowly advance the throttles to the reheat position required. If the nozzles do not open as the throttles are advanced, cancel reheat.

*If the throttles are moved to maximum reheat in less than 5 seconds, engine surge and/or flame out may occur.*

**WARNING:** When attempting to engage reheat close to (or above) the lighting limit, and particularly when manoeuvring or at high AOA, there is a possibility that the engine may surge or flame-out. In these circumstances, therefore, it is recommended that reheat is selected on one engine at a time.

c. Reheat is unlikely to light if slam selection into reheat from IDLE is made when above 15,000 feet subsonic and 25,000 feet supersonic.

d. As the reheat burning limit is approached, the nozzles may oscillate with associated small thrust changes. If reheat blow-out occurs, the nozzles should go to the closed position. In this case move the throttle(s) into the military power range.

4. *Relighting.* The engine relighting envelopes are given in Part 2, Chapter 1. Optimum relights are obtained if the airspeed and altitude within these envelopes give a windmilling HP RPM of 15% to 18%. Below 15% HP RPM at altitudes of 25,000 feet and above, a relight becomes progressively less likely. Below 10% HP RPM a successful relight is unlikely and the turbine may be damaged. The minimum relighting speeds are given in the FRC.

a. The full relighting drill for both single and double engine flame-out is given in the FRC.

Note: In the event of a double engine flame-out, the RAT or battery provide adequate electrical power for a simultaneous double engine relight. However, unless lack of height dictates otherwise, the FRC drill is to be carried out.

b. The speed range recommended for relighting after a double engine flame-out is 250 to 300 KCAS. With a double engine flame-out, windmilling RPM tend to be lower than with a single-engine flame-out.

c. If a double-engine flame-out occurs at very low KCAS, the initial gliding speed may have to be increased to 300 to 400 KCAS to get the wind-milling RPM up to 10 to 15%.

◆ d. Should an engine fail to relight, select the throttle OFF and wait 2 minutes to allow the engine to drain ◆ before making another attempt.

## Flying Controls

5. *Ailerons/Spoilers.* The lateral controls are positive ◆and effective throughout the flight envelope except at high AOA (see para 26 et seq). Spring feel provides a ◆ stick force which varies with lateral displacement. Slight feed back from the stability augmentation system may be experienced during rolling manoeuvres but smooth lateral control should still be possible. Lateral control must be used carefully when above 15 units AOA as large aileron/spoiler deflections at high angles of attack induce adverse yaw.

6. **Stabilator**

a. In the approach configuration, longitudinal response to stabilator movement is slow but positive and the control column is near its aft stop. Stick forces are light.

b. As the airspeed increases, the aircraft becomes progressively more responsive to the stabilator and pitch control is more sensitive.

c. In the transonic region, the pitch control becomes less sensitive and, at supersonic speeds, large control movements are required to manoeuvre.

7. *Rudder.* Rudder becomes effective at about 80 KCAS on take-off and light pedal pressure produces good aircraft response up to 215 to 250 KCAS. The rudder then reverts to high feel and response to relatively large pedal pressures is small.

8. *Trimmers*

a. Trim rates are slow.

b. The wing trim and rudder position indicators show control surface position and movement. The stabilator trim gauge shows the trim actuator position but does not show stabilator movement.

c. Changes of power, operation of landing gear and speed brakes produce only slight trim changes. There is a nose-down trim change when flaps are lowered and a nose-up trim change when flaps are raised.

## Stability and Control

9. Large variations in stability and control occur throughout the flight envelope. Pitch stability varies with Mach number and also with centre of gravity (CG) location. Control effectiveness is affected by Mach number and is also affected as much, if not more, by q (dynamic pressure).

## Stability Augmentation

10. Stability augmentation is provided in the pitch, roll ◆and yaw axes. Pitch and yaw stab augs should be engaged for all normal flying; roll stab aug can be engaged if desired for all flying except when flying at high angles of attack unless in the landing configuration. ◆

11. High subsonic speeds must be avoided if the pitch channel is not functioning correctly, as pilot-induced oscillations (PIO) may occur.

12. Temporary transients in pitch, roll and yaw may occur during the loss of electrical power to the stability augmentation system. These transients may be violent at high speed, particularly at low altitude.

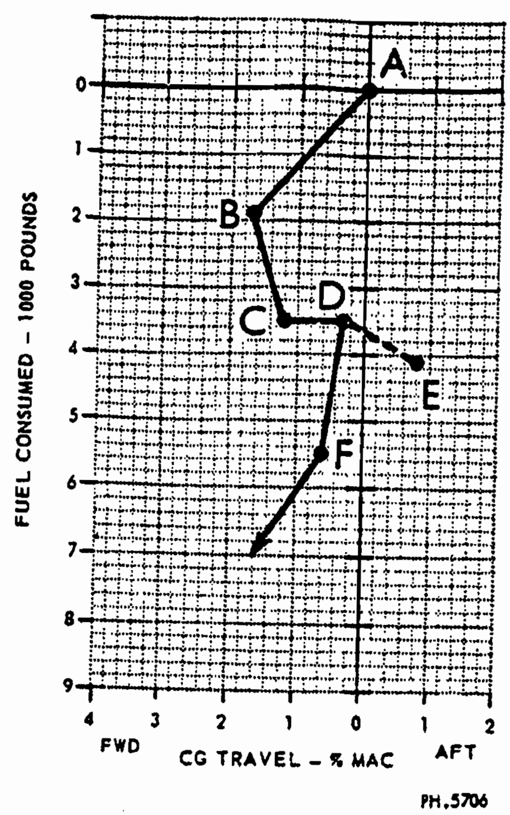
13. Before disengaging stability augmentation in the air, ensure the aircraft is in trim.

## Longitudinal Stability

14. The forward centre of gravity limit is based on aircraft strength and longitudinal control effectiveness. The aft centre of gravity limit is based on stability. For the clean aircraft the aft limit is 36% Mean Aerodynamic Chord (MAC) which provides an acceptable static margin. (Refer to the centre of gravity limitations in Fig 2). The static margin is a physical measurement of longitudinal stability and is the distance in % MAC between the centre of gravity and the aerodynamic centre (AC) (see A of Fig 3). As the centre of gravity moves aft towards the aerodynamic centre stability is reduced (see B of Fig 3). The centre of gravity position alone does not define stability but rather the relative positions of the centre of gravity and the aerodynamic centre. The movement of the aerodynamic centre is a major contributor to stability. A shift in the aerodynamic centre can be felt when decelerating through the transonic region whilst applying g. In this instance the aerodynamic centre moves from its aft supersonic position to a forward subsonic position, noticeably reducing the stability (see C of Fig 3). Attempting to apply a constant g loading through this deceleration produces a pitch up of approximately 1g when the aerodynamic centre shifts. At high angles of attack the aerodynamic centre moves forward when the wing tip stalls and again a reduction in stick forces occurs.

15. When a store or a tank is loaded under the wing a change in the aerodynamic centre position results. The amount of movement of the aerodynamic centre is a function of the geometric characteristics of the store and/or tank (see D of Fig 3); centreline stores have essentially no aerodynamic effect on stability. The aerodynamic effect of any wing mounted store and/or tank is *always* destabilising.

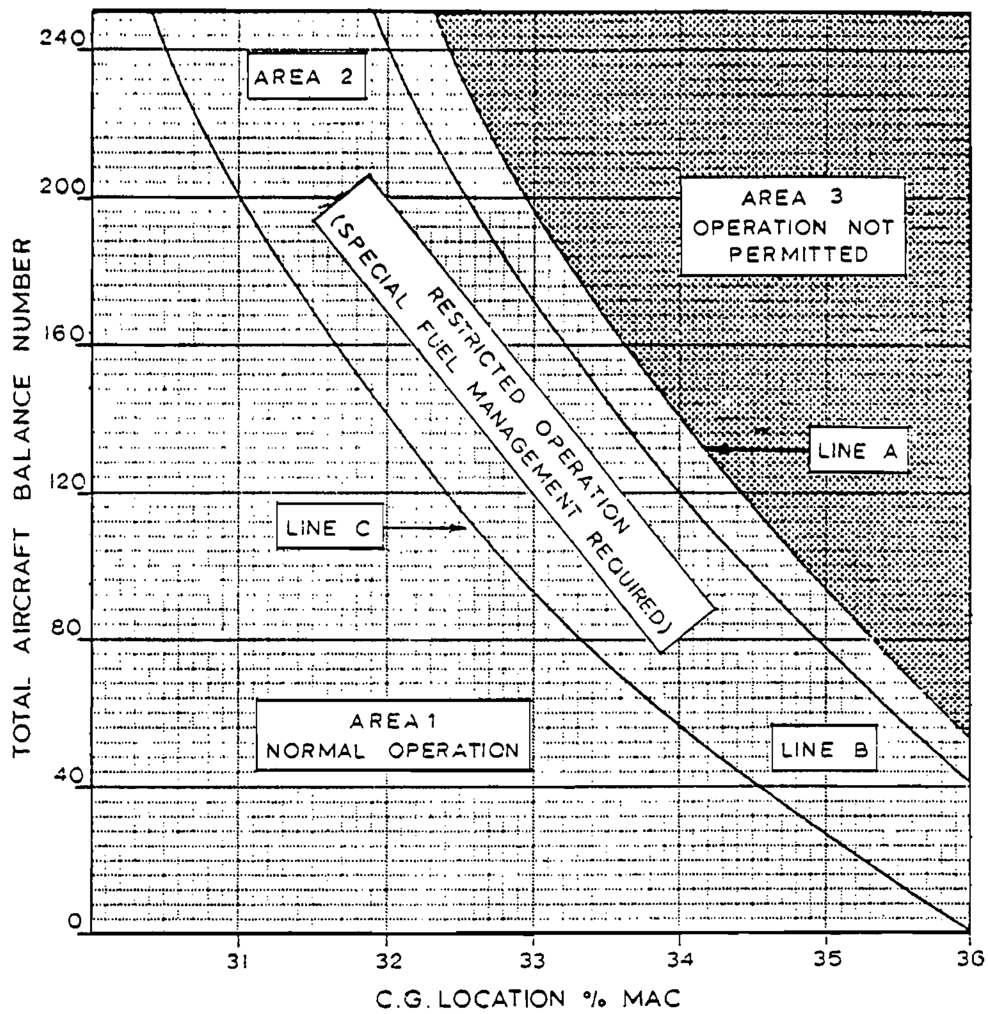
16. The static margin for a given configuration changes throughout the flight. Fig 1 illustrates the trend of centre of gravity travel during the normal fuel transfer sequence with two external wing tanks fitted. During ground operation the centre of gravity moves forward as fuselage fuel is transferred forward and consumed (line A to B in Fig 1). When external fuel transfer is selected the centre of gravity starts moving aft and continues to move aft slowly throughout the climb (line B to C in Fig 1). On reaching height and throttling back to cruise, the centre of gravity moves aft rapidly as the fuselage cells are refilled from the external tanks (line C to D in Fig 1). The effect of dumping internal wing fuel is to move the centre of gravity aft and degrade stability (line D to E in Fig 1). During the cruise, the centre of gravity remains near the aft starting point as external fuel continues to refill the fuselage cells (line D to F in Fig 1). When the external tanks are empty and turned off (point F) the centre of




**3-2 Fig 1 CG Travel During Normal Fuel Transfer - Two External Wing Tanks Fitted**

gravity again moves forward as internal (wing and fuselage) fuel is consumed. The travel of the centre of gravity because of fuel consumption is shown graphically at Fig 4.

17. A stability index (or balance number) system is used to ensure that the aircraft is not outside the permitted longitudinal stability limits. Every configuration has a CG location expressed in terms of mean aerodynamic chord (MAC), normally as a percentage (% MAC), and the aerodynamic effect. of wing-mounted stores determines the total aircraft balance number (or stability index). The relationship between these two figures decides the degree of longitudinal stability for the configuration. The ODM lists the most common operational and training configurations, giving %MAC and balance number/stability index information for each; configurations not listed can be calculated by reference to AP 101B-0900-1A (Aircraft Servicing Manual) and the ODM. Having obtained the %MAC and balance number figures, the longitudinal stability of the configuration is assessed by reference to Fig 2, which defines the following three areas of operation:




**3-2 Fig 2 Aft CG Limits**

Fig 2 (above) defines the aft CG limits with variation in total stability index:

a. Line A defines the maximum permissible aft CG limit on the ground prior to start-up and must not be exceeded.

b. Line B defines the maximum permissible aft CG limit in flight.

c. Line C defines the normal in-flight aft CG limit.

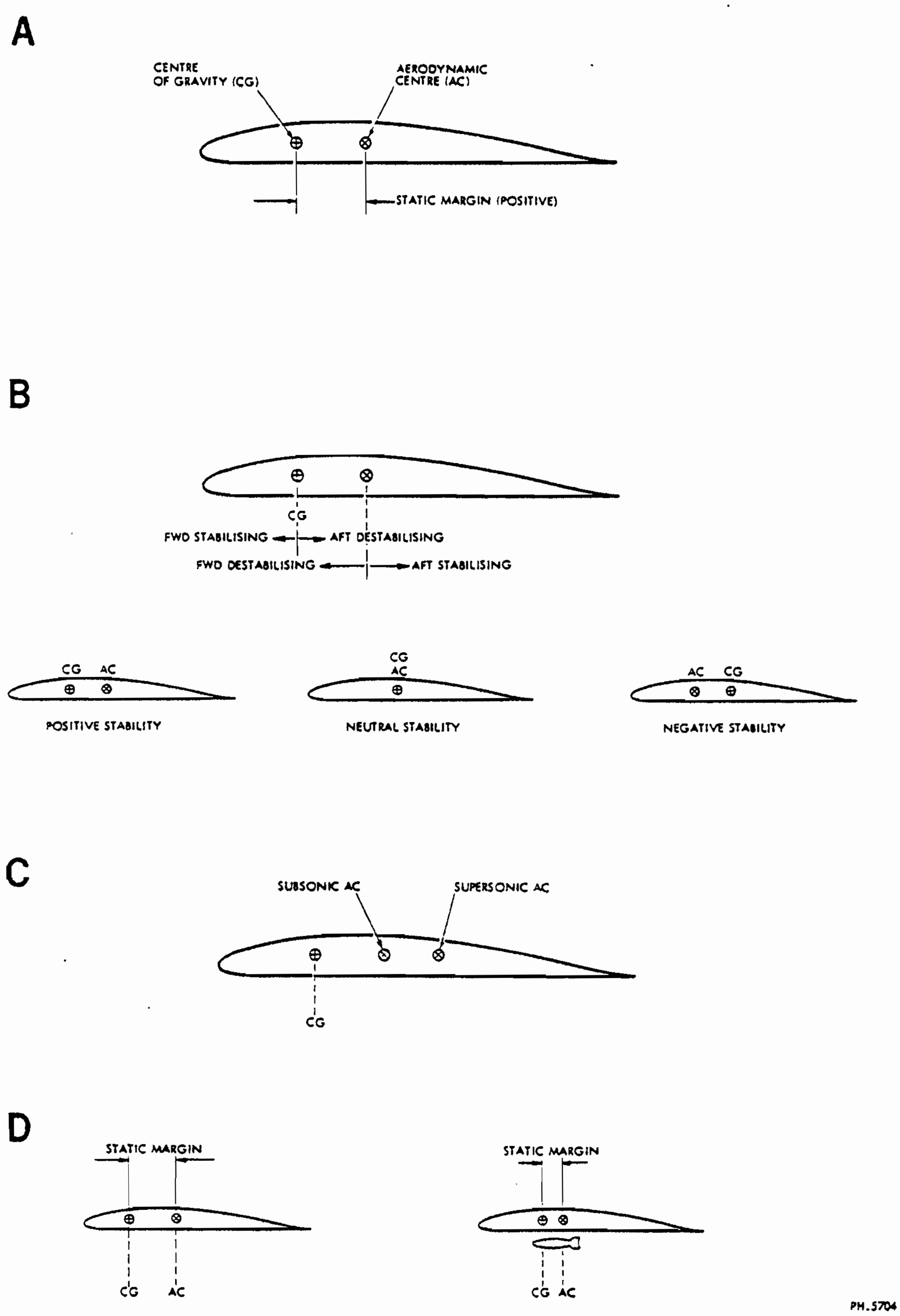
**WARNING:** The CG range between lines B and C (Area 2) is a restricted handling area where longitudinal stability is low and manoeuvring flight is only permitted, with care, up to buffet onset or store-limiting g whichever occurs first. Flight without pitch stab aug is not recommended with a CG position in Area 2; if pitch stab aug fails, speed should be reduced to the lesser of 350 KCAS/ 0.7M, altitude to below 10,000 feet, and only gentle manoeuvres and slow accelerations/decelerations are permitted.

Note 1: When fuel is carried in external tanks and the CG position falls anywhere in Area 2, special fuel management (para 19b) must be used unless technical or operational reasons dictate otherwise.

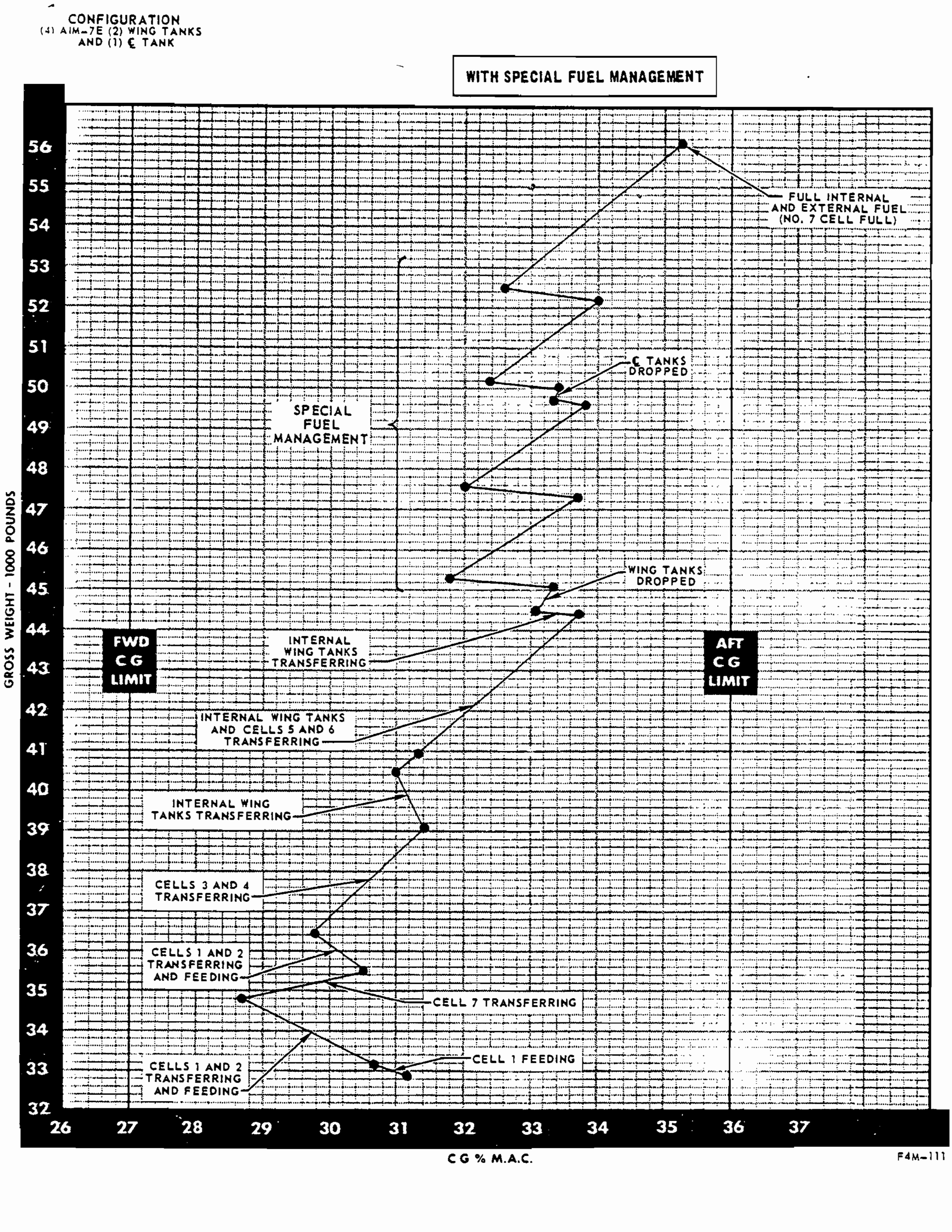
◆ Note 2: In full operational fit (eg, two external tanks, four radar missiles and two or four Sidewinder missiles plus gun or centreline tank) and without special fuel management, the CG remains in the restricted handling zone until the total fuel weight is reduced to approximately 12,000 lbs. In such circumstances it is also possible for the aft CG to exceed the permissible in-flight limit if, for example, wing fuel were dumped shortly after AAR to full. ◆

Note 3: For a full explanation of the method of calculating %MAC and balance number, refer to AP101B-0902-16 (ODM) and AP101B-0900-1A (Aircraft Servicing Manual).

◆◆




3-2 Fig 3 Stability Effects




3-2 Fig 4 Approximate CG Travel Due to Fuel Consumption ◆◆

*Intentionally Blank*

a. *Area 1.* In Area 1 there are no immediate longitudinal stability problems; there are good manoeuvring and tracking characteristics. The fuel may be managed as desired. However, when the CG position is within 1 to 2% of line C, caution should be exercised when manoeuvring.

b. *Area 2.* Area 2 is the area between lines B and C on Fig 1. Flight is permitted in Area 2 but the safe margin of longitudinal stability is reduced. Special fuel management (see para 19b) must be used to keep the CG within bounds unless technical or operational reasons dictate otherwise. Only gentle manoeuvres are permitted and control inputs must be smooth.

c. *Area 3.* Flight is prohibited in Area 3. The configuration must be rearranged or the fuel load modified to give an Area 1 or 2 solution before flight is permitted.

Note 1: Line B on Fig 2 is parallel to Line A, there being a 0.4% MAC difference. Aircraft may be loaded to line A prior to start-up but the CG position must be brought to Line B before take-off by using fuselage fuel.

Note 2: The minimum acceptable level of longitudinal stability defined by Line B of Fig 2 does not take into account abrupt and large control inputs. When the configuration and fuel state bring the aircraft close to the CG limit, the stick force required for a given attitude change is light and there is a tendency to overshoot the desired pitch change. Over-controlling must be anticipated and avoided.

◆◆

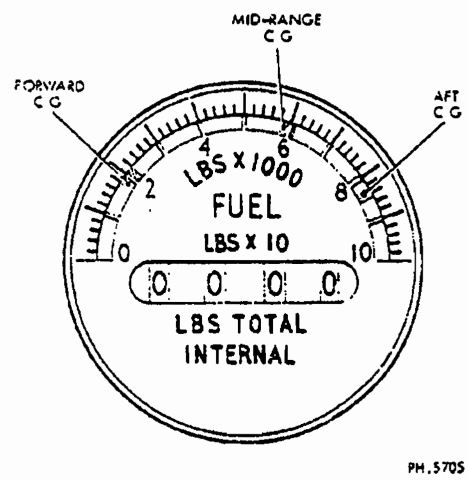
18. During heavy all up weight operation, maximum performance manoeuvring and low speed flight, longitudinal and lateral control inputs must be made smoothly to avoid critical angles of attack which may lead to the stall. At the first indication of departure from controlled flight the controls should be centred laterally and 'unloaded' longitudinally to recover the situation. See the WARNING associated with Fig 2.

### Improvement of Longitudinal Stability

19. There are two methods of improving longitudinal stability:

a. *External Stores Configuration.* When planning external loadings stability effects must be considered. Stores carried on the inboard stations provide a forward centre of gravity movement and normally this forward movement offsets the corresponding aerodynamic effect and a net increase in static margin is obtained. However, empty containers or light stores with large stability/balance numbers can result in a net decrease. Stores carried on the outboard wing stations normally result in a small rearward movement of the centre of gravity; this movement combined with the normal aerodynamic destabilising effect can result in a large decrease in static margin. It should be noted that higher stability/balance numbers are given to external wing tanks when they are being carried in conjunction with stores mounted on the inboard wing stations. Even though stores carried on the centre station (station 5) have no significant aerodynamic destabilising effect, the static margin could be affected owing to the resultant movement of the centre of gravity. Stores carried on the centreline station normally move the centre of gravity rearwards. The approximate centre of gravity effects caused by loading fuselage-mounted AIM-7E missiles are:

| *Configuration* | *CG Shift* |
|---|---|
| 2 missiles forward (stations 4 and 6 only) | Forward 1.48% MAC |
| 2 missiles aft (stations 3 and 7 only) | Aft 0.82% MAC |
| 4 missiles (stations 3, 4, 6 and 7) | Forward 0.66% MAC |




**3-2 Fig 5 Relationship Between Fuel Remaining and Centre of Gravity**

b. *Special Fuel Management.* Fuselage fuel distribution is the primary centre of gravity position control. Burning fuselage fuel provides better stability since the aft tanks empty first, and as shown in Fig 1 (line A to B), delaying the transfer of external and internal wing fuel causes a favourable rate of movement of the centre of gravity forwards. As fuselage fuel is used the centre of gravity moves forward by approximately 1% for every 1000 lb of fuel used. To effect special fuel management:

(1) Set the fuel transfer selector to STOP and allow the tape to decrease to 5000 lb.

(2) Set the fuel transfer selector to OUTBOARD or CENTER and allow the tape to increase to 7000 lb.

(3) Set the fuel transfer selector to STOP and continue this same drill until all external fuel has been used and then transfer the internal wing fuel.

When using special fuel management, care must be exercised to prevent fuel starvation to the engines. Fuel is trapped in the wing tanks and external tanks when the FUEL TRANS switch is to STOP but the counter on the fuel gauge (Fig 5) shows the total of fuselage and wing tank fuel. For this reason all fuel readings must be expressed as tape over counter figures and not as counter only. An approximate indication of the CG position is found by referring to the fuel gauge. A tape (internal fuselage fuel quantity) indication of 8000 lb indicates an aft centre of gravity condition as all tanks are full. At approximately 5500 lb on the tape, a mid-range of gravity condition exists (fuel cells 5 and 6 nearly empty and fuel distributed predominantly in cells 1 to 4 inclusive). At approximately 2500 to 2000 lb, the centre of gravity is forward (fuel in cells 1 and 2).

20. *Handling with Aft CG Condition.* Care must be taken in handling the aircraft when the CG is aft, especially at high AUW. Small stick forces can induce high g loadings and the airframe can be easily overstressed particularly when applying aft stick during dive recovery manoeuvres and aerial combat.

**General Flying**

21. *Subsonic Region.* Longitudinal and lateral response is good. However, moderate angles of bank at high altitude place the aircraft in mild buffet.

22. *Transonic Region*

a. In the transonic region at high altitude, stabilator effectiveness is reduced and higher stick forces are required to manoeuvre.

b. Reducing speed through the transonic region while applying g results in a pitch-up of approximately one additional g. This factor must be considered when operating near maximum permitted g to prevent possible overstressing. Selecting airbrakes out increases the pitch-up tendency.

c. Although the aircraft is positively stable at transonic speeds, a PIO may occur at low level. To minimise this possibility, keep the aircraft in longitudinal trim and, where possible, avoid rapid power changes. If a PIO occurs, recover by:

Applying positive g or

Releasing the control column if practicable

Reducing airspeed

If fore-and-aft stick movements are used in an attempt to damp out PIO, they are likely to be in phase with the oscillation and may aggravate the situation.

23. *Supersonic Region*

a. In the supersonic region, longitudinal stability increases with Mach number. Stabilator effectiveness decreases, and manoeuvring stick forces become higher. Manoeuvring capability is limited by stabilator effectiveness at high Mach numbers at high altitude. For example, full aft stick at 2.0M at 50,000 feet produces about 3.5g. However, at supersonic speed and/or low altitude the structural limits can be easily exceeded with abrupt control movements.

b. No abnormal lateral or directional control problems exist during supersonic flight. Directional stability remains good and the rate of roll adequate up to the limiting Mach numbers. The rolling limitations must be adhered to otherwise inertia cross-coupling may result.

24. *Use of Angle of Attack Indicator*

a. *Low Angle of Attack Recovery.* When recovering from low airspeed and high pitch attitude, fly to 5 to 10 units AOA. This places the aircraft in near-zero g flight. Recovery is accomplished safely at any speed sufficient to provide stabilator effectiveness. If a wing drops during recovery, do not attempt to level the wings with large lateral control movements or rudder movements as this may cause a departure. If the aircraft is maintained at 5 to 10 units AOA, it recovers in a nose-down accelerating condition irrespective of roll attitude.

◆ b. *Optimum Acceleration.* Setting 3 to 5 units AOA ◆ minimises induced drag and gives the best acceleration.

25. *Medium Angle of Attack Manoeuvring.* When manoeuvring at less than 15 units AOA the aircraft response to controls is conventional.

26. *High Angle of Attack Manoeuvring*

Note 1: The speed for a given AOA increases with weight.

Note 2: The aircraft's longitudinal static stability is reduced as the CG is moved aft. Therefore, when manoeuvring with an aft CG, extra care must be taken to ensure aircraft control is maintained. (See para 19 for **Improvement of Longitudinal Stability.**)

a. Before carrying out high angle of attack manoeuvring (eg, ACM), the sequence of handling checks given at para 1a are to be carried out to ensure handling capability is not degraded and to make certain no noticeable fuel imbalance exists, particularly in the wing drop tanks.

b. Above 15 units AOA the aircraft response and flight characteristics begin to change. The primary characteristics exhibited at high AOA are dihedral effect and adverse yaw.

c. *Dihedral Effect.* If the aircraft is yawed (sideslipped) with rudder, it rolls in the same direction as the yaw (opposite to the sideslip) due to the changes in the coefficient of lift ($C_L$) of the two wings. The $C_L$ of the wing into the relative airflows increases, while that of the downstream wing decreases. This roll with yaw is known as dihedral effect (a simplified description is given here; refer to AP3456A, Part 1, Sect 1 'Stability', for a more detailed explanation). The roll with yaw becomes more pronounced as the AOA and/or airspeed are increased because the net difference between the $C_L$ of the wings is increased.

d. *Adverse Yaw.* Adverse yaw is the tendency, when aileron is applied, to yaw in the opposite direction to the roll. This is caused by induced drag from the downgoing aileron. In the Phantom at low to moderate AOA the induced drag on the aileron of the upgoing wing tends to be balanced by profile drag from the opposite spoiler. However, at high AOA the spoiler becomes increasingly blanked from the airflow and the induced drag on the aileron becomes dominant, causing a powerful yawing moment, the secondary result of which (due to dihedral effect) is a rolling tendency opposite to that demanded by the lateral control surfaces. The roll with yaw due to dihedral effect can be strong enough to overcome the roll force from the aileron/spoiler combination and, depending on the balance of forces, the result can be a reduced rate of roll, no roll or opposite roll. Sideslip is always present.

e. *Handling Implications of Dihedral Effect and Adverse Yaw.* Attempts to roll the aircraft with the lateral controls at high AOA results in yaw (accompanied in extreme cases by roll) opposite to the intended direction. The higher the AOA the more pronounced these effects become. In all cases the condition is characterised by sideslip and, if allowed to persist, a total breakdown in directional stability, nose slice and spin entry is likely to result. If, when manoeuvring at high AOA, sideslip, reduced roll rate, roll hesitations or roll reversal are encountered, the lateral controls and rudder should immediately be centralised and the AOA reduced until co-ordinated fully controlled flight is regained. The only effective and safe way to manoeuvre the Phantom at high AOA is to keep the ailerons neutral and to control the aircraft laterally with the rudder, using the powerful roll forces induced through dihedral effect.

27. *Maximum Performance Manoeuvring.* Three factors determine maximum manoeuvrability; they are: structural limitations (g), stabilator effectiveness, and aerodynamic limitations (stall). Structural limitations are covered in Part 2 and the Release to Service, and stabilator effectiveness is covered in para 6. The aerodynamic limitations are mainly a function of AOA. In this area maximum rate turns are made using 19 to 20 units AOA and reheat whilst keeping within the structural limits of the aircraft. The adverse yaw caused by the use of lateral controls at high AOA has been covered above and, therefore, as the AOA increases from 15 to 17 a progressive change from using lateral controls to using rudder for rolling manoeuvres should be made. Above 17 units, rudder should be used exclusively for rolling (this does

not apply with flaps down since ARI reduces adverse yaw). During rudder rolling at high AOA, inertia coupling can cause the AOA to increase by as much as 2 to 3 units. Thus, as rudder deflection and hence roll rate is increased, the back stick pressure should be relaxed slightly to keep the AOA within the desired handling regime of 19 to 20 units. If the roll rate induced by rudder at high AOA is insufficient, higher roll rates can be achieved by unloading to below 15 units AOA and using lateral controls; then centralising the lateral controls and re-establishing the required AOA. At the first indication of departure from controlled flight, centralise the lateral controls and rudder and unload the aircraft.

**Stalling**

28. *Stalls in the Clean Configuration*

a. Normal 1 g stalls are preceded by a wide band of buffet. The stall sequence is as follows:

Buffet starts at about 40 knots above the stall (15 units AOA) and increases from moderate to heavy buffet immediately before the stall. Stall warning is provided by a pedal shaker (which may be missed in the general buffet level) ar 23 unit AOA. Wing rocking normally starts about 10 knots before the stall (24 to 25 units AOA) and can be as much as ±30° at the stall. The AOA at the stall is between 27 and 28 units. The stall is characterised by a slight pitch up and/or a yawing motion in either direction.

b. Recovery from a stall in the clean configuration is effected by moving the control column forward to achieve 5 to 10 units AOA while maintaining neutral rudder and lateral controls and increasing power as required. Wing rocking may continue during the recovery up to 10 to 15 knots above the stall.

29. *Stalls in the Approach Configuration*

a. With the landing gear and flaps down, the aircraft stalls at approximately 27 units AOA. The stall is preceded by a slight nose rise and stick force lightening at 24 units AOA usually followed by wing rocking at 25 units AOA, which increases in intensity with further speed reduction, although normally not exceeding ±30°. There is moderate buffet just prior to the stall and, as speed is further reduced, there is a second nose rise followed immediately by a nose down pitch. Stall warning is provided by a pedal shaker (which may be missed in the general buffet level) at 22.3 units AOA which is approximately 13 knots above the stall and 8 knots before wing rock with the gear down.

**WARNING:** With flaps down and landing gear up the indicated AOA at the stall is about 3 units lower because of the different airflow characteristics around the AOA probe with the nose gear up.

b. Recovery from a stall in the approach configuration is achieved by unloading the aircraft, maintaining rudder and lateral controls neutral, and increasing power to MIL or reheat. Ideally the aircraft should be unloaded to 5 to 10 units AOA, but this usually results in a recovery attitude of 30° nose down. Therefore, if proximity to the ground is a factor, the aircraft should only be unloaded sufficiently to unstall the wings (ideally, ◆◆ aim for 15 units AOA), and full reheat must be used. Do not raise flaps below 180 KCAS.

c. Stalls with ½ flap are similar to full flap stalls.

d. Use of BLC above 10,000 feet may cause systems using bleed air to become inoperative.

30. *G-Stalling.* Only general stall characteristics are covered; specific characteristics vary with aircraft rigging, loading configurations, and control techniques. (Note: Because of general airframe buffet it is unlikely that the pedal shaker will be felt.) G-stalls are preceded by moderate buffet which increases progressively to heavy buffet immediately prior to the stall. Rapid application of full aft stick results in immediate heavy buffet as the aircraft stalls. Lateral instability (wing rocking) is usually, but not always, present. It can occur at any time between buffet onset and the stall, and normally progresses to a fairly high frequency, large amplitude roll oscillation. The AOA at the stall is between 27 and 28 units AOA, but rapidly applied g can induce a stall at a lower indicated AOA. Increasing the rate of aft stick movement increases the magnitude and rate of roll and yaw at the stall. Applying and holding the control column fully aft can result in an incipient spin. Immediately prior to departure from controlled flight, the centre of pressure moves forward on the wing. This results in the need for less nose-up stabilator to maintain the desired flight path and the pilot is conscious that rearward stick forces lighten. This may progress to a positive nose rise which can be accompanied by departure in yaw - demonstrated by nose slice. If recovery is delayed until after 'stick lightening' or nose rise has been encountered, then the control column must be moved further forward to effect a recovery and the impression is given of an increased push-force requirement. Prompt centralising of the controls effects recovery from a g-stall; ◆◆ control column position is of paramount importance in recovering from the stall. Oscillations in roll and yaw which may occur during recovery should be allowed to damp themselves out, and should not be countered with lateral controls or rudder.

**WARNING:** The use of lateral controls or excessive rudder when approaching a stall could cause a departure.

31. *Inverted Stalls.* An inverted stall (negative AOA) can only be achieved by abrupt application of full forward stick. Light to moderate buffet occurs at the stall and there are no distinct yaw tendencies. Recovery is made by relaxing the forward pressure on the control column and maintaining 5 to 10 units AOA until recovered from the unusual attitude.

**Spinning**

**WARNING 1:** If the aircraft is not under control by 10,000 feet AGL (under control means that all yaw and roll has stopped and airspeed is increasing) - *Eject.*

**WARNING 2:** Intentional spinning is prohibited. The following information is to acquaint pilots with spin characteristics and recovery procedures.

**WARNING 3:** External stores should be retained in a spin. Stores jettison is not required for spin recovery and increases the risk of aircraft damage from probable aircraft and stores collision.

32. *Incipient Spin*

a. The incipient spin is the initial phase, following a stall, during which irregular oscillations occur about all three axes. The oscillations depend on the speed and the type of entry and they are not predictable; if the AOA is not reduced, a fully developed spin could result. Stalls and incipient spins are best prevented by proper control of AOA and by the judicious use of controls at low airspeed. When faced by an unusual attitude and decreasing airspeed, attempt to maintain the AOA at 5 to 10 units with the control column while keeping the rudder and lateral controls central. The use of rudder or lateral controls at slow airspeeds and high AOA produces yaw which could result in a spin. The control of AOA at low air-speeds requires larger than normal control column movements. In some instances the aircraft may enter a series of rolls which could be mistaken for a spin. It is often possible to recognise an imminent departure from controlled flight by nose slice. If, at any stage of flight, the aircraft does not respond normally to control inputs (ie, it is reluctant to roll in the required direction or it rolls in the opposite direction to that required), laterally centralise the control column and reduce AOA to 5 to 10 units.

Note: If the AOA is maintained below the stall value (irrespective of airspeed) the aircraft is not spinning.

Once the nose has dropped below the horizon and the airspeed has built up, normal recovery action can be taken to regain controlled flight. Do not exceed 16 units AOA during recovery. The large oscillations in roll and yaw which may be present during recovery must not be mistaken for a spin. If the AOA is under control either through use of full forward stick, or of the brake parachute, the aircraft will not spin. Use of full spin recovery (for either an upright or inverted spin as detailed in paras 33 and 34) during the incipient stage could, however, cause a spin. The brake parachute should produce recovery within one turn. It is not necessary to jettison the brake parachute since it separates as the airspeed builds up.

b. *Recovery from an Incipient Spin*

(1) Move the control column smoothly forward (fully forward if necessary) to reduce AOA.

(2) Centralise the ailerons and rudder.

(3) Monitor height.

(4) Pull the throttles back to just below MIL power, ideally to 80 to 85% RPM (see para 36a).

(5) Momentarily press the paddle switch (to disengage the autopilot).

*If control not immediately regained, then without delay:*

(6) Deploy the brake chute, maintaining control column fully forward, with ailerons and rudder central. If the airspeed is above, or increasing through 200 KCAS, the aircraft is probably not spinning and the brake chute is likely to detach through failure of the risers, particularly at the higher RPM settings.

(7) Extend the RAT.

*If still out of control:*

(8) Take the appropriate full spin recovery action.

33. *Upright Spin*

a. An upright spin is very oscillatory in pitch, roll and yaw. Pitch may vary from 90° nose-down to 30° nose-up, roll up to as much as 60° of bank angle and the yaw rate between 10° and 80° per second. Altitude loss is approximately 20,000 feet to 24,000 feet per minute. The spin is typified by positive g and an

AOA of approximately 30 units. Before taking full recovery action the direction of spin is best verified by reference to the turn needle which indicates the direction of yaw. Ball indications may be erratic and should be ignored.

b. *Recovery from an Upright Spin*

(1) Monitor height.

(2) Control column fully forward with rudder central.

(3) Apply full aileron with the spin (with the turn needle).

(4) As aircraft recovers [see para 36d(1)] centralise the ailerons.

(5) Recover from the unusual attitude, using no more than 19 units AOA during the pull-out.

34. *Inverted Spin*

a. The aircraft is highly resistant to inverted spin entry and tests indicate that pro-spin controls are necessary to sustain it. The inverted spin is less oscillatory than the upright spin and is typified by negative-g and an AOA of zero units. The direction of spin is best determined by the turn needle because outside references can be confusing when assessing the direction of yaw from an inverted position.

b. *Recovery from an Inverted Spin*

(1) Monitor height.

(2) Apply full rudder against the yaw (opposite the turn needle).

(3) Centralise the ailerons.

(4) Move the control column to the central position.

(5) When the yaw rate stops, centralise the rudder.

(6) Recovery from the unusual attitude using no more than 19 units AOA during pull-out.

35. *Flat Spin*

a. A flat spin may develop within one or two turns of an incipient spin or after several turns of an upright spin. Unlike the upright and the inverted spin, the flat spin has no apparent oscillations in pitch or roll. Yaw rates may vary between 90° and 120° per second and altitude loss between 20,000 and 30,000 feet per minute.

b. There is no known recovery from a flat spin - *Eject*

36. *General Spinning Information*

a. *Engine Effects.* One or both engines may flame-out during an incipient or fully developed spin. Provided that the throttles are retarded and not advanced, setting them to just below MIL power reduces the possibility of engine surge and/or flame-out; the ideal RPM setting is 80 to 85%. No attempt should be made to advance the throttles from a lower power setting as this would increase the probability of surge/flame-out during engine acceleration. A good indication of flame-out is the MASTER CAUTION light on and one or both GEN captions on. Attempts to relight an engine during a spin are unlikely to succeed and it is recommended that relighting is delayed until the aircraft is under control.

b. *Electrical Power.* If both engines flame out, the RAT does not provide electrical power until the spin is broken. The battery powers the AOA indicator, together with all other services fed by the Essential 28V DC bus.

c. *Power Controls.* If both engines flame out, windmilling RPM should provide adequate PC-1 and PC-2 pressure for at least five turns.

d. *Recovery*

(1) The most positive sign that the spin recovery action is taking effect in an incipient or upright spin is when g falls to zero or becomes negative. Large oscillations in roll and yaw may occur during recovery and these should not be mistaken for reversal of the spin direction. If the aircraft's nose remains in approximately the same position relative to an outside reference, the aircraft is rolling not spinning. If the aircraft recovers as a result of deploying the brake chute, recovery may be marked by a rapid roll through approximately 270°.

(2) No attempt should be made to fly AOA whilst large roll or yaw oscillations exist as they cause errors in AOA indications (see para 30). ◆

(3) Total altitude loss from entry to recovery to level flight from a fully developed spin may be as little as 10,000 feet but is normally closer to 15,000 feet.

(4) Altitude loss in pulling out of a 90° dive at 10,000 feet and 200 KCAS, using a maximum of 19 units AOA, is approximately 5000 feet.

**Aerobatics**

37. Aerobatic manoeuvres must conform to the limitations in Part 2. Within these limitations, aerobatics are easy and pleasant to perform.

38. *Rolling Manoeuvres*

◆ a. The lateral controls are effective at low values of AOA and available roll rates are high. Rapid rolls in ◆ excess of 360° are prohibited to avoid inertia cross-coupling.

b. The recommended speed for rolling manoeuvres below 15,000 feet is 300 to 350 KCAS.

39. *Looping Manoeuvres*

a. About 8000 feet is covered in looping manoeuvres.

b. If practicable reduce AUW to below 40,000 lb.

c. The recommended entry speeds at 10,000 feet are 350 KCAS (reheat) and 475 KCAS (MIL power). An initial pull of 4g should be applied and held until mild buffet is reached. During pull out, avoid exceeding 0.9M if practicable, as transonic trim changes make smooth pitch control difficult.

**Zoom Climb**

40. a. The recommended entry to a zoom climb is to accelerate at the optimum flight level and then initiate a high energy climb using up to 60° in pitch. Exceeding 60° makes subsequent recovery more difficult.

b. Recovery from a zoom climb is best effected either by using the near zero g technique (para 24a) or by gently rolling inverted and recovering with 10 units AOA. The inverted recovery is not recommended if the initial recovery speed is very low.

c. During all zoom climbs the TGT and RPM must be closely monitored.

d. During recovery from a zoom climb, the OIL PRESS low warning is allowed to come on for 2 minutes. If it remains on after this time, shut down the engine.

**Flight in Severe Turbulence**

41. If it becomes necessary to fly in severe turbulence, the recommended speed for penetration is 300 KCAS.

**Flight in Rain**

42. a. The rain removal system must not be used above 1.0M or when the windshield is dry.

b. Switch off the rain removal system immediately after clearing the runway if the system has been used on landing.

c. The drill for the WINDSHIELD TEMP HIGH caption on is detailed in the FRC.

**Descent**

43. Complete the **Descent Checks** listed in the FRC.

44. The recommended descent configurations are:

a. *Instrument Descent*

0.9M/350 KCAS
Speed brakes OUT
80% RPM
Defog as required

b. *Range Descent*

300 KCAS
Speed brakes IN
75% RPM
Defog as required

*Intentionally Blank*

# PART 3

# CHAPTER 3 - CIRCUIT PROCEDURE AND LANDING

## Contents



**Fuel Allowance**

1. An overshoot, circuit and landing require up to 500 lb of fuel. An overshoot followed by a normal GCA to land requires 800 lb to 1000 lb of fuel.

**Joining**

2. Complete the **Recovery Checks** and the **Rejoining Checks** listed in the FRC and calculate the airspeed corresponding to 19.2 units AOA as follows:

◆ Allow 145 KCAS for the normal training configuration (34,500 lb dry weight) and add 2 knots for each 1000 lb of fuel remaining. If half flap is used for landing, add a further 10 KCAS. ◆

Note: Because of tolerances in the CADC system, the actual speed experienced at 19.2 units AOA may differ from the calculated speed by up to 4 KCAS.

**Downwind**

3. Complete the **Checks Before Landing** in the FRC. It is recommended that flaps are lowered in non-manoeuvring flight at 210 KCAS which will avoid delay in lowering due to the airspeed switch, ◆◆ which is set to preclude flap lowering above 225 KCAS. The flaps must be lowered in accordance with the following instructions:

a. Full flap is to be selected in two stages, pausing at the selected position to ensure that no marked rolling tendency is experienced before selecting fully DN.

b. If a marked rolling tendency is apparent while the flaps are travelling, or at half or full down, or if unusual flap indications are observed, refer to Flap Malfunctions in Part 4, Chapter 2.

c. When practicable, formation spacing is to be increased to a minimum of one full wing span while lowering flap.

d. When the flaps are, fully down, the pilot is to check that both ENGINE BLEED captions are on. If either caption fails to come on, revert to 12th stage bleed by selecting NORMAL 12TH STAGE.

**Approach and Landing**

4. a. Turn onto the final approach at 17 units AOA. Decrease the speed to 19.2 units AOA during the roll out for the final approach.

◆ b. Check the AOA against airspeed; with 12th stage engine bleed and while maintaining 19.2 units AOA on the approach, the ASI may indicate up to 3 knots below the pre-calculated 'on speed'. ◆

c. Do not reduce power significantly before touchdown as the reduction in the BLC air and thrust results in a rapid increase in the rate of descent. 12th stage engine bleed may be re-selected any stage on the approach, when a small nose-down trim change and a 2% reduction in HP RPM occurs. HP RPM should be restored to the original value by adjusting the throttles.

d. Maintain a steady rate of descent until touchdown. If the AUW is above 36,000 lb, it may be necessary to make a small increase in power just prior to touch-down to reduce the rate of descent.

Note: In the full flap configuration the throttles should be handled symmetrically to avoid the condition where, with one engine at high power and providing all the BLC air bleed, accelerating the slower running engine produces excessive overfuelling and the possibility of an overtemperature on that engine.

e. After the mainwheels touch the runway, throttle back to IDLE. The nosewheel should be lowered and held on the runway with neutral to forward stick. Deploy the brake parachute and apply the wheel brakes as required. Just prior to applying the brakes, move the stick aft to load the mainwheels.

f. *Braking*. The limiting speeds for application of maximum continuous braking (pedals held fully down - anti-skid system operating) are:

(1) During normal operation at landing weights up to 38,000 lb when brake and tyre life is a prime consideration:

(a) With brake parachute deployed: 125 knots

(b) Without brake parachute: 105 knots

(2) When short field performance is the prime consideration see the ODM, Section 10. This figure also provides the braking limitations when landing at weights above 38,000 lb.

Note 1: These speeds assume a cool brake on initial application.

Note 2: As an example: at a landing AUW of 44,000 lb, using maximum continuous braking from 120 KCAS, and brake parachute deployed, the maximum brake temperature reaches about 380°C. It can take up to 2 hours, on the ground, for the brakes to cool from this temperature to 60°C.

The locked wheel memory circuitry in the anti-skid system, which is described in Part 1, Chapter 8, can cause problems in aquaplaning or viscous skidding conditions during a landing run. On a totally aquaplaning wheel, the net hydrodynamic force acts forward of the wheel centre-line, imposing a torque on the tyre which opposes rotation whilst the 'wedge' of water ahead of the tyre lifts it from contact with the ground; for these reasons a totally aquaplaning tyre ceases to rotate, even if unbraked. When either main wheel ceases to rotate, the anti-skid system first removes all brake pressure from both wheels to allow the wheels to spin again. Then, if the wheel remains stationary because it is aquaplaning, full pilot-applied brake pressure, proportional to the effort at the brake pedals, is transmitted to both wheels at the expiry of locked wheel memory time. Thus, if a wheel is aquaplaning and a constant pressure is applied to the brake pedals, the wheels are locked stationary by the brakes, causing a skid and probable tyre burst when the aircraft encounters a non-aquaplaning speed or condition. A similar result can occur if the wheel is slow to spin up to the true groundspeed rate in conditions close to full aquaplaning. In practical terms, because the coefficient of friction is so low at high landing speeds the pilot cannot easily detect whether an aircraft is aquaplaning or not. Therefore, in conditions where skidding or aquaplaning might occur, the pilot, having applied the brakes with caution, may assess the lack of retardation as brake or anti-skid failure. Do *not*, however, switch off the anti-skid unless the ANTI-SKID OFF caption is lit or some other emergency so dictates. First release the brakes and then carefully and progressively reapply pressure. This ensures that the wheels are not being held stationary by direct brake pressure and allows them a positive chance to spin and become subject to anti-skid control. Thus the pilot assesses brake effectiveness in severe landing conditions and achieves the best performance from the braking system without the danger of tyre burst. It may be necessary to test the situation by releasing and applying the brakes more than once before effective, safe braking is available. In skidding or aquaplaning conditions the landing distance obviously increases; remember that at 15 knots groundspeed anti-skid protection is automatically removed and only direct braking is available.

g. *Directional Control.* Directional control should be maintained by the use of rudder and ailerons until NWS is required. The rudder is effective down to approximately 80 knots. *Before engaging NWS ensure the rudder bar is neutral.* NWS should be engaged without 'blip' testing. In order to gain maximum benefit from the NWS, the stick should be placed forward of neutral to load the nosewheel and to ensure that the nosewheel microswitch is closed. If differential braking is used to aid directional control, the landing run is increased.

**WARNING:** The pilot is to disengage the NWS immediately if any unscheduled steering commands are detected.

h. *After Landing.* After landing, jettison the brake parachute as required.

i. *Crosswind Landing.* For maximum crosswind limitations see Part 2, Chapter 2, Fig 4. Carry out a wings level approach with the nose offset into wind; do not kick off the drift but fly the aircraft to an unflared landing in the crabbed position. After touchdown allow the nose to point down the runway, then deploy the brake parachute. Aileron and rudder should be used to steer down the runway. In extreme conditions the NWS can be engaged with the rudder pedals central. Above 120 KCAS keep the stick forward to central to maintain effective nosewheel steering; below 120 KCAS bring the stick fully back for maximum wheelbraking effectiveness.

j. *Landing on a Wet or Flooded Runway.* Reduce AUW to the minimum practical. Use normal landing technique with a firm landing. Only gentle braking should be applied initially as anti-skid protection is not available until the mainwheels have 'spun-up'. If stopping distance becomes critical, the starboard engine may be shut down; if arresting cables are available, the arrester hook should be lowered sufficiently early to allow it to be recycled in the event of failure to lower. In extreme conditions, or with a known unserviceable NWS, an approach-end engagement should be considered.

k. *Roller Landings.* Keep the throttles advanced to give a minimum of 80% RPM to ensure a good response from the engines. Advance the throttles to MIL power and apply back stick until 10° pitch attitude is attained. Maintain this attitude until safely airborne; raise the landing gear and then the flaps at a minimum if 180 KCAS. If full flap is used, nose gear lift-off speed is higher than for a normal take-off since full flap degrades stabilator effectiveness while the aircraft is on the ground. The nose wheel lifts off rather abruptly at very close to normal take-off speed; caution must be exercised, therefore, to prevent over-rotation to a higher than normal take-off attitude.

**Failure of the Brake Parachute**

5. a. A possible failure of the brake parachute should be anticipated on all landings. The decision to stay down or go round again depends upon the runway length, condition of runway, wind, landing speed, AUW and fuel remaining.

b. If a decision is made to stay down, hold the control column fully back and employ braking as required. If the stopping distance is marginal, shut down the right engine and lower the arrester hook sufficiently early to allow it to be recycled in the event of failure to lower. If a barrier is available but not an arresting cable, do not lower the hook.

c. If a decision is made to overshoot, open the throttles to MIL power and jettison the brake parachute. After the overshoot, carry out either a landing as in sub-para b above or make an approach-end arrested landing.

**Use of 7th Stage Bleed/Full Flap Configuration**

6. a. *Advantages:*

(1) The use of 7th instead of 12th stage bleed air during the full flap approach is of benefit in conserving life of 'hot-end' components and, in the case of an overshoot, a much improved thrust response.

◆ (2) With 7th stage bleed selected, the lesser bleed offtake results in lower turbine temperatures and increases turbine lives. ◆

(3) In the event of an overshoot with 12th stage bleed selected, the very short acceleration time, due to the overfuelling, results in high blade temperatures at low cooling air flows.

(4) During an approach or overshoot with 7th stage bleed selected, the required thrust is obtained at a lower RPM and a lower temperature than with 12th stage bleed; this is beneficial to the turbines.

(5) During an overshoot, the thrust response in 7th stage bleed is always better than 12th stage bleed in that more thrust is available earlier and without the disadvantage of high turbine temperatures. Under the same conditions at full Military power, 7th stage bleed gives approximately 36% more thrust than 12th stage bleed.

(6) Significantly improved safety after single-engine failure.

b. *Disadvantages:*

(1) Some degradation of lateral control effectiveness may occur.

(2) Increased landing speed (up to 5 KCAS).

(3) Increased landing distance.

(4) Reduction of rain dispersal windscreen blow.

(5) Increased cabin temperature.

◆ **WARNING:** The use of the 7th stage configuration ◆ when landing in heavy rain, strong crosswind conditions or on a short runway may sometimes be operationally unacceptable. In these circumstances land in the 12th stage engine bleed/full flap configuration.

Note: Whenever a selection away from FULL FLAP is made the pilot must select NORMAL after the flap selection has been made. However, during multiple approaches, the switch should be left at ISOLATE.

**Approach in Turbulent Conditions**

7. In turbulent conditions, fly the approach at 10 KCAS above the normal 'on-speed'. Wing rock is likely to occur and the airspeed and angle of attack indications may fluctuate.

**Flapless Approach and Landing**

8. Fly a wider circuit and carry out a longer than normal straight-in approach. Hold 17 units AOA until roll out on the final approach and then fly 19.2 units AOA until touchdown. The indicated airspeed for 19.2 units AOA with flaps up is 25 knots faster than for flaps fully down. This speed increment is only correct in the weight range 36,000 to 40,000 lb. Above this weight, more than 25 knots will need to be added to achieve 19.2 units AOA and, below it, less than 25 knots. This is because the weight increment of 2 knots per 1000 lb is incorrect at the higher and lower AUW in the flapless configuration. When flying flapless at high AOA, use the rudder to keep the ball in the middle since the ARI is inoperative. Because of the degradation in lateral control at high incidence, only gentle turns should be made.

Note: The landing distance is considerably longer than for a normal landing.

9. From handling considerations, fuel and/or store asymmetries should be minimised. Crosswinds greater than 10 knots or asymmetric loadings greater than 70,000 lb in should be avoided.

**Landing with a Burst Tyre**

10. The drill for landing with a burst tyre is given in the FRC. It should be noted that there is a possibility of a complete utilities failure owing to the 'flailing' tyre damaging the brake lines.

**Single Engine Failure on Final Approach**

11. If an engine failure occurs during the final approach carry out one of the following procedures:

a. *Above VCH.* If above VCH and the fuel state ◆ permits, overshoot. Select power on both engines to MAX reheat and control yaw with rudder. Without delay raise the landing gear and the flaps to ½ maintaining 17 units AOA until a positive rate of climb is established. Thereafter maintain 15 units AOA. At normal AUW, raise the flaps in the climb when above 180 KCAS. Deal with the failed engine in accordance with FRC and carry out a single-engine landing as ◆ described in Chapter 4.

b. *Below VCH.* If below VCH, or if committed to land for fuel or other reasons, continue the approach. Leave the flaps as selected but, if full flap is down, ensure ISOLATE is selected. Increase power as necessary on the good engine (including reheat) to maintain 17 units AOA to the threshold, keeping the slip ball centred throughout by use of rudder. At the threshold increase AOA to achieve a touchdown at 19.2 units.

12. The combination of one engine at full reheat and one engine failed at the low speeds and high angles of attack that may develop in this situation, could lead to lateral control difficulties if yaw is allowed to develop. Therefore, yaw must be carefully controlled with rudder.

**Instrument Approaches**

13. a. *Speeds and Power Settings.* The recommended speeds and power settings are given in Table 1. At very high AUW, it may not be possible to lower the flaps at 'on-speed' +30 knots. It is necessary, therefore, to reduce speed below the maximum flap lowering speed of 225 to 230 KCAS and, once the flaps have lowered, to remain below the flap 'blow up' speed of 235 to 242 KCAS.

**WARNING:** The low speed, zero flap, high weight condition is potentially dangerous and can be made worse by turbulence, application of bank, or mishandling.

b. *Overshoot Procedure.* Increase power as required, raise the landing gear and at 180 to 200 KCAS (depending on AUW) raise the flaps and retrim as necessary.

**Table 1 - Instrument Approach Speeds and Power Settings**

| *Flight Condition* | *Landing Gear* | *Flaps* | *Approximate %RPM* | *AOA Units* | *Speed* |
|---|---|---|---|---|---|
| Level | Up | Up | 82 | - | 250 knots |
| Level | Down | Full Down | 85 | - | 'On-speed' +30 knots |
| Glide Path | Down | Full Down | 83 | 17.0 to 19.2 | 'On-speed' +10 knots to decision height, then 'on-speed' |

## Checks After Flight

14. a. Complete the **Checks After Landing** listed in the FRC.

b. Taxying with full flap and 12th stage bleed is not recommended. If it is unavoidable, the TGT must be closely monitored particularly when moving the throttles.

c. Complete the **Shut Down Checks** listed in the FRC.

d. Following prolonged ground running at low engine RPM there is a risk of stiction within the HP cock owing to the high temperature conditions created. If the engine does not shut down when the HP cock is selected closed, the engine should be run at 70% HP RPM for at least 3 minutes and a further attempt made to shut down the engine. If this is not successful, then the groundcrew should be instructed to disconnect the throttle linkage and manually shut of the fuel supply to the engine. If no groundcrew are available, the engine may be shut down by selecting the ENGINE MASTER switch to OFF. ◆

*Intentionally Blank*

# PART 3

## CHAPTER 4 - SINGLE-ENGINE FLYING

### Contents



**Single-Engine Flying**

1. When flying on one engine, low to moderate rudder force is required to prevent yaw towards the failed engine providing 17 units Angle of Attack (AOA) is not exceeded. Care should be taken to trim the aircraft directionally otherwise lateral control will be degraded. Yaw must be controlled with rudder since it is possible, inadvertently, to balance the situation with aileron and spoiler, which might result in loss of control. The rudder forces can either be held by physical effort or may be trimmed out. Banking 5° towards the good engine reduces the rudder displacement required to keep the turn-and-slip ball in the middle.

2. The aircraft design is such that no one system is entirely dependent upon a specific engine. Thus loss of one engine does not result in the loss of a complete system. However, since the handling qualities are severely degraded with a Utility hydraulic failure, the Utility gauge must be carefully monitored.

3. The service ceiling for single-engine operation (MIL power or reheat) is a function of aircraft configuration and gross weight, and is approximately the altitude at which level flight can he maintained at 250 KCAS with MIL power or reheat on the good engine. If required to climb, use reheat on the good engine maintaining 250 KCAS.

4. During single-engine operation with various landing gear and flap configurations, exercise care to avoid rapid airspeed reductions and/or excessive sink rates.

◆ 5. For simulated single-engine approaches, the DH and VCH should not be allowed to fall below 300 feet since a failure of the 'live' engine at the start of the overshoot may result in the loss of up to 250 feet (depending on AUW and ambient temperature) before the 'dead' engine achieves maximum reheat power.

Note: The EOA, DH and VCH values quoted in the Release Document and Part 2, Chapter 2 are valid for airfields below 1000 feet AMSL at ambient temperatures below ISA +15°C. ◆

**Single-Engine Approach and Landing**

6. Single-engine approaches and landings are permitted using half flap, or full flap with 7th stage BLC. The use of full flap with 12th stage bleed is prohibited on one engine. When making a single-engine approach, aircraft weight must not exceed 55,000 lb AUW at temperatures ◆up to ISA +8°C (23°C at sea level), reducing linearly to 41,500 lb AUW at ISA +35°C (50°C at sea level). All ◆ landings above 38,000 lb AUW must be flared. When making a single-engine approach, the following points should be considered.

a. *Power Settings.* At AUW between 48,000 and 53,000 lb, depending on ambient temperature and flap configuration, the power setting required on the final approach is in the max MIL/min reheat range and power changes in and out of reheat may be required to maintain a speed of datum +10 knots. The use of full flap in ISOLATE gives a lower datum speed but a higher power setting is required; conversely, the use of ½ flap requires a lower power setting but the datum speed is higher. In both cases at these AUW, MIL power/reheat changes may be necessary, the critical power required in full flap and ISOLATE equating to the same power in ½ flap when the AUW is increased by approximately 2000 lb. Above 53,000 lb AUW, reheat power is usually required throughout the final approach. The approximate maximum power settings required at the highest permissible single-engine landing weight are shown in Table 1.

b. *Datum Speeds.* A maximum AOA of 17 units (datum +10 knots to datum 15 knots at high AUW) should be maintained until the runway threshold, when it should be increased to 19.2 units. The datum speed at 19.2 units AOA with full flap and 7th stage bleed is 3 to 5 knots faster than for full flap with 12th ◆ stage bleed. Add 10 knots to the full flap/7th stage ◆ speed to obtain the datum speed for ½ flap approaches.

c. *Checks Before Landing.* Before joining to land, ◆◆ extend the RAT, select the ENG INLET CONTROL switch to OVERRIDE, and select the NOR-

**Table 1 - Single-Engine Instrument Approach Power Settings**

| *Flight Condition* | *Landing Gear* | *Flap* | *Approx Max Power Req'd* | *AOA (Units)* | *Speed (KCAS)* |
|---|---|---|---|---|---|
| Level | Up | Up | Military | - | 250 to 300 depending on AUW |
| Level | Down | ½ | Half Reheat | 17.0 | - |
| Glidepath | Down | ½ or Full (7th Stage) | Half Reheat | 17.0 | Datum +10 to threshold, then decrease to 'on speed' |

Note: These power settings are for a practice single-engine PAR at the maximum single-engine landing weight. The power required for an actual single-engine PAR depends on AUW and whether the unserviceable engine is windmilling or not.

MAL 12th STAGE/ISOLATE switch to ISOLATE. Ensure that the FRC **Checks Before Landing** are completed by the start of the final descent.

d. *Approach Pattern.* If possible, make an instrument approach being lined up with the runway 15 miles from touchdown, using 300 KCAS as the manoeuvring speed. When settled on the extended centreline, allow the speed to reduce to 250 KCAS by 10 miles from touchdown. Lower the landing gear 3 miles from the start of descent and ½ flap 2 miles later, having reduced the speed to 220 KCAS. If full flap is to be used it is lowered at the interception of the glidepath. Maintain a maximum of 17 units AOA.

Note: At a very high AUW, more than 17 units AOA may be required, transiently, before the speed switch, which operates between 230 and 225 KCAS, permits the flap to lower.

e. *Visual Approach.* If any circumstances dictate that a visual circuit has to be flown, fly as wide a circuit as practicable, paying particular attention to airspeed, AOA and bank angle. When close to the maximum permitted AUW the aircraft may be performance limited, restricting the bank angle possible without descending.

f. *Final Approach.* Using rudder, keep the slip ball centred throughout the approach and use reheat, if required, to maintain a maximum of 17 units AOA to the threshold. (Reheat is only necessary at very high AUW, or in high ambient temperatures depending on AUW.) At the threshold the AOA should be increased to achieve a touchdown at 19.2 units.

Note: If the failed engine is windmilling, the associated PC system normally remains operative. However, at some stage during the approach and landing it is likely that this PC pressure will drop below 1500 PSI, thus bringing on the CHECK HYD GAUGES and MASTER CAUTION captions.

**Single-Engine Overshoot**

7. When overshooting on one engine it is essential that maximum reheat thrust is achieved on the operating engine as quickly as possible. The following points should be considered:

a. *DH and VCH.* It is essential that DH and VCH are calculated as described in Part 2.

b. *Overshoot Technique.* At or above decision height, increase power to MAX reheat on the good engine and control yaw with rudder. Without delay raise the landing gear and maintain 17 units AOA until a positive rate of climb is established. Thereafter maintain 15 units AOA. At normal AUW, raise the flaps in the climb when above 180 KCAS. When close to the maximum permitted AUW, raise the flaps at a minimum of 200 KCAS. Achieve 250 KCAS and 1000 feet before turning downwind.

WARNING: Do not exceed 17 units AOA in the climb or else climb capability is decreased because of the rise in drag.

**Single-Engine Flying with Utility Hydraulic System Failure**

8. Lateral control is much more critical if a Utility hydraulic failure is combined with a single-engine failure because of:

a. The loss of aileron and spoiler on one wing, and

b. The fact that the rudder is now manually operated and the amount of deflection obtainable is dependent upon air loads on the rudder surface. The foot loads in manual on the rudder are high.

Reduce speed to below 300 KCAS, but not below 230 KCAS until the landing gear is down. It is recommended that 230 KCAS is maintained as a minimum manoeuvring speed. Yaw and roll caused by asymmetric thrust at heavy weights significantly degrades the handling characteristics when operating below 230 KCAS. Avoid rapid roll rates or large thrust changes. If turns are required, use a small bank angles (15° maximum) and, as far as possible, make all turns into the operating engine and wing.

9. The following considerations apply:

a. Maintain a minimum manoeuvring speed of 230 KCAS.

b. Jettison any asymmetric load.

c. Reduce all up weight to the practical minimum so that the final approach airspeed is below the maximum engagement speed for the type of arresting gear to be used. The CG position and stability index should be considered in deciding whether to jettison internal or external fuel. (Jettisoning external wing tanks improves stability while dumping internal wing fuel decreases stability.)

◆ d. Plan a straight-in approach. If an approach-end cable is available, make a flapless approach for a cable engagement. ◆

e. Carry out the checks in the FRC.

f. Fly no slower than 17 units. Aircraft handling is improved with increased airspeed; therefore, planning the approach to touchdown at the maximum cable engagement speed improves aircraft handling.

**WARNING:** If reheat is required during the approach or for an overshoot, it must be used cautiously since there may not be sufficient control authority to compensate for full reheat on one engine.

*Intentionally Blank*

# PART 3

## CHAPTER 5 - AIR-TO-AIR REFUELLING

### Contents



### Considerations

1. *Height/AUW/Drag Index.* Above an altitude of 25,000 feet to 30,000 feet (depending on AUW, drag index and temperature) it may be necessary to use partial reheat on one engine to achieve acceptable AAR contacts. However, partial reheat is not a suitable technique for normal service use because the limit of 12 minutes per hour at maximum RPM is likely to be exceeded. Partial reheat ◆should therefore only be considered if the refuelling conditions make it necessary. With Tristar, refuelling ◆ should be carried out in cold power whenever possible, but above 25,000 feet reheat may be required on one engine. If reheat has to be used, descend and/or increase speed to within the reheat lighting limits before recovering to the tanker and synchronising speeds.

2. *Aft CG.* At an aft CG the aircraft is easily overcontrolled in pitch which can result in increased difficulty of making and remaining in contact. Care should be taken to ensure the CG remains within limits when fuel is accepted from the tanker (see para 4b) - especially when refuelling with three external tanks fitted.

3. *Limitations.* This chapter should be studied in conjunction with Part 2, Chapter 2, which lists the limitations for each cleared tanker. In particular, Part 2, Chapter 2, contains WARNINGS and notes to each tanker type.

4. *Probe Switch Position*

a. *EXTEND Position.* With the PROBE switch at EXTEND, fuel transfer in the aircraft is normal. If wet contacts are carried out in the EXTEND position, fuel is accepted from the tanker into fuselage cells 1, 3 and 5 unless the FUEL TRANS selector is set to INT WING, when only cells 1 and 3 are filled. When these cells are full, fuel is accepted at the rate of the receiver's fuel consumption. The EXTEND position should be used for all dry contacts and for wet contacts if the initial fuselage (tape) fuel contents are low.

b. *REFUEL Position.* With the PROBE switch at REFUEL, all fuel transfer from centreline tank, external and internal wing tanks ceases. Provided the REFUEL SELECT switch is set to ALL TANKS, fuel is accepted from the tanker and fills all empty external and internal fuel tanks. If the REFUEL SELECT switch is set to INT ONLY, fuel flows into the internal wing tanks and fuselage fuel cells 1 to 6.

**WARNING:** When the probe switch is in the REFUEL position, it is important to monitor the fuselage tape fuel for two reasons:

(1) To detect reverse fuel flow from fuselage cells into external or internal wing tanks. Reverse flow occurs because of failure of one or two valves in the fuel system and results in a rapid depletion of fuselage (tape) fuel which, if uncorrected, could lead to a double engine flame-out. If reverse transfer occurs, carry out the emergency drill listed in the FRC.

◆ (2) If difficulty is experienced in making probe/drogue contact, the fuel available to the engines is fuselage (tape) fuel only as the transfer of external and/or internal wing tank fuel is stopped. ◆

### Actions Before and After Refuelling

5. Complete the FRC **Air-to-Air Refuelling Checks.**

### Making Contact

6. Extend the probe and trim out the aircraft before moving into a position 5 to 10 feet astern of the drogue. Synchronise speed and retrim if necessary. Increase

power to accelerate and as soon as contact is made adjust ◆power to maintain an appropriate overtake speed. If reheat is being used, set approximately ¼ nozzle on the reheated engine and use the cold powered engine to accelerate and formate. At night the probe light illuminates the drogue from a range of 15 to 20 feet.

**In Contact**

7. Continue to overtake the tanker until the amber section of the hose reaches the hose drum unit (HDU). Reduce the power slightly so that speeds are synchronised when the amber section is partly wound onto the HDU. Maintain position during refuelling by keeping the hose at its natural trail angle and the amber section steady on the HDU. Monitor fuel gauge readings and check for full tanks on the telelight panel.

Note 1: During contact with Tristar, the low set tailplane and the proximity of the hose to the No 2 engine tend to give the impression of flying significantly closer to the Tristar than with other tankers. When in the normal refuelling position there is a longitudinal overlap between the nose of the Phantom and the Tristar No 2 engine tailpipe fairing of about 3 feet. This, together with the low set tailplane of the tanker, increases the risk of a collision owing to poor station-keeping, an autostab malfunction or a longitudinal PIO when at aft CG.

Note 2: With Tristar, errors in the ASI reading of approximately 10 knots may be encountered in close proximity to the drogue, in the vicinity of the tanker and during AAR at low speed. These may cause rudder gearing change-over with associated yawing and rolling moments, but this does not significantly affect handling.

**Breaking Contact**

8. Reduce power slightly and withdraw the hose at a low rate (less than 5 feet per second) keeping the hose at its natural trail angle. If the hose is withdrawn at more than 7 feet per second, the HDU safety break operates and causes immediate disconnection of the probe and drogue. ◆When wing tanks are fitted, carry out a rigging check after leaving the tanker [Part 3, Chapter 2, para 1a(3)].

**WARNING:** In certain configurations (eg, full operational fit) following AAR to full, special fuel management is necessary to keep the CG in the normal operating zone while total fuel weight remains above approximately 12,000 lbs. ◆

**Emergency Break**

9. Move the throttles to IDLE. When the hose withdrawal rate exceeds 7 feet per second, disconnection occurs.

**Hose/Drogue Malfunction**

10. Structural failure of the hose or drogue may result in ◆ excessive fuel spillage which may enter the intake(s) and cause engine flame-out(s). If this occurs, wait for at least one minute before attempting to relight.

**Single-Engined Refuelling**

11. Practice single-engine refuelling is prohibited. In emergency situations, it has been estimated that single engine refuelling is possible up to a maximum of 25,000 feet using half to three-quarters nozzle reheat or 15,000 feet using cold power. The refuelling speed should be around 270 KCAS, and the refuelling, whenever possible, done in cold power and not partial reheat.

**Refuelling When Carrying Three External Tanks**

12. In the three external tanks configuration, refuelling should be carried out below 30,000 feet whenever possible. Although it is possible to plug in using cold power at low fuel states at 30,000 feet, as the tanks are topped up ◆it becomes necessary to use reheat. In this situation, if partial reheat has not already been engaged, break contact and engage reheat within the reheat lighting limits before continuing AAR. ◆

**Fuel Consumption During Refuelling**

13. a. Both engines cold power (FL 300): 110 to 150 lb/min.

b. One engine ¼ nozzle reheat, other engine cold power (FL 300-350): 250 to 300 lb/min.

**Fuel Transfer Rates**

◆14. a. The initial fuel transfer rates are as follows (lb/min):

| | *Centreline* | *Wing* |
|---|---|---|
| Tristar | 4000 | - |
| VC10 | 4000 | 2500 |
| Victor | 4000 | 1250 |
| Buccaneer | 1250 | - |

b. In each case, the rate of fuel transfer drops as the fuel tanks are topped-up. ◆

**Crew Co-ordination**

15. Experience has shown that the navigator can aid the pilot by:

a. Checking stabilised position and line-up.

b. Telling the pilot when contact is made.

c. Telling the pilot where he missed the drogue, if applicable.

This co-ordination lessens the tendency for the pilot to 'basket watch' during contact.

# PART 3

## CHAPTER 6 — COLD WEATHER OPERATION

### Contents



**Pre-Flight**

1. Ensure that the aircraft is free from snow and ice. If pressure sensitive tape has been applied to the flaps to prevent water ingress, ensure that it is all removed. Particularly ensure that the following are free from snow or ice:

a. Exposed mechanisms and switches.

b. Intakes and openings.

c. Spoilers, flaps, and airbrakes.

d. Nosewheel steering and nosewheel drag brace.

e. Wheels and brakes.

Note: After extended cold soaking at temperatures below minus 40°C, both pneumatic and hydraulic leaks can be expected.

**Engine Starting**

2. At temperatures below minus 15°C, engine RPM may hang at approximately 25% and the engine fail to accelerate; the lowering of ½ flap and/or setting the throttle to a maximum of one inch open (measured at the top of the throttle) will in most cases facilitate a start within the engine limitations. However, it is recommended that the start be performed with the flaps fully down, and with 7th stage bleed selected. See also para 21.

Note 1: Do not lower the flaps if icing is suspected in the BLC system.

Note 2: Carefully monitor TGT, particularly if the throttle has been advanced. The throttle should be reduced to idle as the engine accelerates through 40% RPM.

**After Start**

4. If icing is suspected in the BLC system the engines should be run at 85% for 12 to 15 minutes before the flaps are operated. If the flaps have been left fully down this precaution is unnecessary.

5. The rain removal system can be used to remove ice from the windscreen and the foot heat/defog lever should be placed to defog to clear any misting on the inside of the windscreen.

Note: Use of the rain removal system on the ground is limited to a maximum of 84% and the flaps must be fully down.

6. If the BLC light comes on with the flaps *down*, the flap limit switches are probably sticking. This can be cleared by cycling the flaps three or four times. If the BLC light comes on with the flaps *up*, treat the indication as genuine and shut down.

7. Keep the aircraft clear of powdered snow if possible, since it could be sucked up into the aux air doors, melt and subsequently refreeze. Packed snow and ice in the aux air doors can cause stiff throttles.

**Instruments**

8. If the ambient temperature is below minus 20°C, all instruments, communications, navigation and

radar equipment require a warm-up period of at least 10 minutes before giving reliable indications.

### Engine Icing

9. Engine anti-icing should be used for ground running and take-off when the following meteorological conditions prevail:

a. In icing conditions.

b. When all the following conditions are fulfilled:

(1) Dry bulb temperature below +8°C.

(2) Wet bulb temperature below +4°C.

(3) Visible moisture is present ie rain, sleet, snow, fog, hail or a wet runway.

c. If the wet bulb temperature is not known the following conditions require the use of de-icing:

(1) When the dry bulb temperature is below +10°C

and

(2) Visible moisture is present, or the runway is wet.

Note: These conditions often occur when it is not necessarily considered 'cold weather'.

### Taxying

10. Taxy with caution, particularly over rutted snow, since frozen brakes may result. Do not use nosewheel steering while the aircraft is stationary. Loose ice blown up by jet wash can cause considerable damage. When taxying in formation, taxy sufficiently far behind the aircraft in front to avoid slush and ice being thrown up onto the aircraft.

Note: With locked brakes the aircraft will slide on ice at 75% RPM.

### Take-Off

11. Engine run-up will probably not be possible since the low temperature will increase engine thrust and the brakes will probably not hold. Because of this increase in thrust the take-off distance will be shorter, although snow or slush, if present, will increase the take-off distance. Delay retraction of the landing gear to allow snow and slush to be blown clear. If the take-off is aborted at high speed on a runway covered with snow, slush, or water, flame-out may occur.

Note: If throttle stiffness occurs this may be caused by snow/ice in the aux air doors and the stiffness should clear once the ice melts. Use of engine anti-ice results in a thrust loss of approximately 1·2%.

### In Flight

12. Since there is no anti-ice protection to the nose cowl and air intake system, it is recommended that flight in icing conditions should be avoided.

13. If it becomes necessary to fly through icing conditions, select anti-icing on before entering cloud and switch it off when clear of icing conditions.

14. If icing conditions are inadvertently encountered during straight and level flight, switch on the anti-icing and climb or descend out of the icing as quickly as possible at the highest practicable RPM.

15. Continued flight in icing conditions may cause an abnormal rise in TGT requiring the engine to be throttled back to keep the TGT within limits. If flame-out occurs, relight immediately. After icing has ceased, switch off the anti-icing system.

16. If icing has been encountered during the latter stages of a flight it is recommended that the response of each engine be checked prior to the initial approach to land.

17. If freezing of the longitudinal control system is experienced, excessive stick forces may be required although full control should still be available. If icing of the bellows occurs, the control column will receive a nose down force — similar in feel to that which is experienced on the ground. Trim should not be applied to relieve this force as violent pitch transients may occur when the bellows unfreeze.

### Landing

18. If the runway is covered with water, slush or ice, land with the airbrakes out to prevent damage to the flaps. If snow or slush has stuck to the top surfaces of the airbrakes leave them out so that they can be cleaned. As soon as practicable after the landing run, retract the flaps. This cuts off BLC air which can cause loose snow to be drawn into the engine compartments through the aux air doors. If this happens the snow will melt, and ice will form after engine shutdown.

19. Land the aircraft firmly and be prepared to use nosewheel steering immediately any difficulties are encountered in directional control.

### After Landing

20. Avoid parking the aircraft on ice or water since the tyres may freeze to the concrete.

21. Before shutdown, it is recommended that ISOLATE is selected ~~(or the ENGINE BLEED circuit breakers pulled)~~ and the flap fully lowered to facilitate the subsequent start. AL15

22. If the weather permits, leave the canopy partially open to allow air circulation. This will prevent the canopy from cracking due to unequal cooling and decreases the possibility of misting.

# PART 3

## CHAPTER 7 — FLYING WITH ASYMMETRIC LOADS

*(Issued at AL12)*

### Contents



**Introduction**

1. The information given in this chapter applies to asymmetric loadings in the region of 160,000 lb in (maximum permitted take-off asymmetry) for take-off, and 350,000 lb in (maximum permitted emergency approach and landing asymmetry) thereafter. It should be noted that every asymmetric loading will have angle of attack limitations beyond which lateral control cannot be maintained, and control can only be regained by an increase in speed, or a decrease in normal acceleration. For smaller asymmetric loadings than those quoted above the following information still applies but with reducing effect. If, whilst asymmetrically loaded, handling problems occur following engine failure, consideration must be given to stores jettison. See Part 2 for limitations.

**Take-Off**

2. As reheat is selected there is a tendency for the aircraft to turn into the heavy wing. Nosewheel steering is required as full rudder deflection is not sufficient to keep the aircraft straight at low speed.

3. On lift-off there is a tendency for the heavy wing to drop: this can easily be countered by the lateral controls, and, if necessary, rudder; therefore, a moderate lateral control input should be applied away from the heavy wing as the aircraft is rotated into the take-off attitude. If there is a crosswind from the side opposite the heavy wing the effect of the asymmetric load is reduced, whereas a crosswind from the same side as the heavy wing aggravates the situation. Abrupt lift-offs should be avoided.

**Straight and Level Flight**

4. In normal flight rudder and lateral trim are required to maintain balanced flight and, at very high indicated airspeeds, it is possible to run out of rudder trim. It must be remembered that a rapid application of g could cause loss of control.

**Manoeuvring**

5. The main factor to be considered when manoeuvring with an asymmetric load is that lateral control decreases as angle of attack increases (ie as the indicated airspeed decreases, and or g is applied).

6. *Manoeuvring at High AOA in the Speed Range 250 to 400 KCAS.* When manoeuvring above 400 KCAS, high AOAs are restricted by the aircraft g limits; therefore, only speeds below 400 KCAS need be discussed. In the speed range 250 to 400 KCAS it is easier to lose control of an asymmetrically loaded aircraft than one which is symmetrically loaded. This applies regardless of whether the aircraft is turning into or away from the heavy wing (eg, one full *internal* wing tank with the other empty is sufficient to cause loss of control if the aircraft is manoeuvred around 20 units AOA). Unless absolutely necessary, therefore, only gentle manoeuvres should be performed in an asymmetrically loaded aircraft.

7. *Manoeuvring Below 250 KCAS.* The primary problem when manoeuvring below 250 KCAS is the

degradation of lateral control; this could be insufficient to recover the heavy wing if it drops, eg, following a wind gust. The wing may not necessarily be near the stall, and there may be little buffet to provide warning of this situation. Speed should, therefore, be kept as high as is reasonably possible since, if lateral control becomes marginal, it is possible to depart and spin whilst trying to recover a wing drop. If the wing drops, the aircraft should be unloaded, if possible, and accelerated. Rudder should be used to raise the down-going wing as lateral control could introduce adverse yaw.

**Stalling**

8. Asymmetric loads do not significantly alter the stalling speeds; however, as the stall is approached, more aileron and rudder are required to keep the wings level.

**WARNING 1:** Roll rates into the heavy wing can be high and difficult to stop precisely.

**WARNING 2:** It is recommended that the aircraft is not stalled unless it is symmetrically loaded.

**Approach and Landing**

9. The following paragraphs refer to an aircraft with an asymmetric loading of 327,000 lb in (ie a full fuel tank on stations 1 or 9).

10. If fuel permits, fly the aircraft at a safe height down to the approach speed in the full flap configuration prior to entering the circuit in order to become familiar with the lateral control characteristics, and to establsh trim settings for the approach. It is important to keep the control column central while trimming the ball into the middle using rudder trim alone since, with spoilers, it is possible to centre the ball by deflecting the lateral trim. If difficulty is experienced in lifting the heavy wing, lateral control can be assisted by the use of rudder which is effective in controlling bank angle at approach speeds. If there are any doubts about the lateral control of the aircraft consideration should be given to jettisoning the asymmetric load.

Note: Lowering the landing gear and flaps normally produces some wing rock; therefore, the landing gear and flaps should be lowered in straight and level flight, and as close to their limiting speeds as possible to ensure adequate lateral control to counter the wing rock.

11. Avoid large or abrupt pitch changes since it may be difficult to recover the downgoing wing. At 19·2 units AOA, with undercarriage and full flap, roll control is adequate away from the heavy wing; however, roll rates towards the heavy wing are rapid, and if full aileron is used bank overshoots of up to 80° are possible.

**WARNING:** Do not use half flap on a conventional 2-engined approach. Minimum trim speed is increased and lateral control degraded.

12. Make a full-flap straight in approach and landing, or fly an extended circuit. The turn on to finals should be made with a maximum of 17 units AOA keeping the speed as high as practicable, and with not more than 20° of bank. Where possible turns should be made away from the heavy wing. Turns towards the heavy wing are more easily initiated, but the more easily induced rates of roll towards the heavier wing may be difficult to control. The correct speed for the final approach and landing should be calculated from the FRC. This should be regarded as the minimum speed: a higher speed is advantageous if practical. AOA is the key to asymmetric handling, and an AOA of 16 to 17 units is recommended.

13. Fly the selected approach speed to touchdown. Avoid abrupt roundout since this causes a roll into the heavy wing.

14. There may be a tendency for the nosewheel to lift when the brake parachute is deployed.

15. Where possible try to select an airfield which has no crosswind. If a crosswind is unavoidable it is better for the crosswind to come from the heavy wing side.

16. During the landing roll the aircraft tends to turn away from the heavy wing; this also happens when the brakes are applied — the harder the braking, the stronger the tendency to turn. However, a crosswind from the heavy wing side reduces this tendency and the aircraft may even turn into wind. Maintain directional control using rudder, lateral control and nosewheel steering as required. Differential braking may also be used, but this increases the landing roll and may lead to the wheel brakes energy absorbtion capability being exceeded.

17. If an overshoot is carried out, use MIL power: if it is necessary to use reheat, any roll towards the heavy wing will be accentuated. Do not pull back on the stick abruptly to initiate the overshoot, otherwise the heavy wing will drop. It is recommended that flaps are not raised until a minimum of 200 KCAS.

PART 4

EMERGENCIES

List of Chapters



# SECTION 4

# TAKE OFF NAT FLIGHT PATH

AL 11

# PART 4

## CHAPTER 1 - EMERGENCIES INDEX

*(Completely Revised at AL 24)*

### Contents



1. Table 1 lists the location of all emergency procedures in the Flight Reference Cards and in the text of this Manual.

**Table 1 - Malfunctions and Emergencies**

| *Malfunction or Emergency* | *Text* | *FRC Tab Marking* |
|---|---|---|
| ASI/CADC/SPC/AOA | | |
| ASI failure | - | Instruments |
| SPC altimeter check | - | |
| CADC malfunctions | 1-2 para 10 and 11 | CADC/AOA |
| AOA malfunction | 1-2 para 6 | |
| STATIC CORR OFF caption | 1-2 para 9 and 1-3 para 35 | |
| AFCS/TRIMS | | |
| A/P PITCH TRIM caption | 1-3 para 24 to 27 | |
| Stab aug failures | 1-3 para 45 | Stab Aug/AFCS/ Trims/Radio |
| Autopilot malfunctions | 1-3 para 37 to 44 | |
| ARI malfunctions | 1-9 para 18 and 19, and 1-3 para 43 | |
| Feel bellows failure | 1-9 para 37 to 39 | |
| Runaway stabilator trim | 1-9 para 40 and 41 | |
| Rudder or aileron runaway trim | - | |
| BLEED AIR SYSTEMS | | |
| BLC MALFUNCTION caption | 1-1 para 41 and 42, and 4-2 para 4 | Bleed Air |
| R or L ENG BLEED captions | 1-1 para 28A | |
| ENG BLEED OVERPRESS caption | - | |
| Bleed air duct failures | 4-2 para 9 | |
| WINDSHIELD TEMP HIGH caption | 1-1 para 21 | Windshield/Cabin/Equip/ Turb/CNI/Flaps |
| CABIN TURB OVERSPEED caption | 1-1 para 36 and 37 | |
| Equipment cooling turbine malfunction | 1-1 para 38 | |
| RADAR CNI COOL OFF caption | 1-1 para 39 and 40 | |
| BURST TYRE | | |
| Burst tyre on take-off | 3-1 para 30 to 32 | - |
| Landing with a burst tyre | 3-3 para 10 | Low Spd Handling/ Burst tyre/Anti-Skid/ S-E land |
| Burst tyre during landing | - | |

*continued*

**Table 1** - *continued*

| *Malfunction or Emergency* | *Text* | *FRC Tab Marking* |
|---|---|---|
| CANOPIES | | |
| Fail to lock closed | - | |
| Fails to open on the ground | - | Abandoning/Canopies |
| Canopy jettison | 1-8 para 65 to 68 and 4-2 para 34 | |
| EJECTION | | |
| Ejection | 1-4 para 40 and 4-2 para 34 | Abandoning/Canopies |
| Manual bale out | 1-4 para 44 | |
| Emergency exit on ground | 1-4 para 41 | |
| ELECTRICAL | | |
| Single generator failure | 1-5 para 27 | |
| Double generator failure | 1-5 para 35 | Electrics |
| LH GEN OUT, BUS TIE OPEN captions | 1-5 para 28 | |
| RH GEN OUT, BUS TIE OPEN captions | 1-5 para 31 | |
| Electrical power transients | 4-2 para 18 | Transients/RAT |
| Operative equipment after electrics failures | 1-5 Fig 3 | |
| Charts of circuit breakers (rear cockpit) | - | Circuit Breakers |
| ENGINES | | |
| Single engine failure during take-off | 3-1 para 27 to 29 | Telelight Captions/ Engine Failures |
| Mechanical failure | - | |
| Engine seizure | 4-2 para 33 | |
| Single engine flame out | - | |
| Double engine flame out | - | Flame-out/Relighting |
| Relighting | 3-2 para 4 | |
| Engine oil pressure low | 2-1 para 13 | |
| IGV malfunction | 1-6 para 19 | |
| Aux air door malfunctions | 1-6 para 16 | |
| Ramp failures | 1-6 para 11 | IGV/Aux Air/Ramps/ |
| Landing with both ramps fully extended | - | Surge/Inlet Temp High |
| Compressor stall/surge | - | |
| ENGINE INLET TEMP HIGH caption | 1-6 para 12 | |
| Nozzle failures | - | Nozzles |
| Landing with both engines inoperative | 4-2 para 35 | - |
| EXTERNAL STORES JETTISON | 4-2 Fig 1 | Barrier/Jettison |
| FIRES | | |
| Rear fuselage fire (fuselage fuel leaks) | 4-2 para 29 | Fuel |
| FIRE/OVHT/ENG caption on the ground | - | |
| FIRE/OVHT/ENG caption in flight | 4-2 para 21 | Fires |
| Electrical fire | - | |
| Elimination of smoke and fumes | - | Smoke/Oxygen |
| FUEL | | |
| Boost pump failures | 1-7 para 49 | |
| Fuel transfer failures | 1-7 para 51 to 54 | |
| Reverse fuel transfer | 1-7 para 55 to 57 | Fuel |
| CHK FUEL FILTERS caption | 1-6 para 31 | |
| Fuselage fuel leaks | 4-2 para 29 | |

*continued*

**Table 1** - *continued*

| *Malfunction or Emergency* | *Text* | *FRC Tab Marking* |
|---|---|---|
| HYDRAULICS | | |
| Single and complete Utility failure | 4-2, para 2 and 1-8, para 4 to 8 | Hydraulics |
| Single PC failure with complete Utility failure | 1-9 para 32 to 36, | |
| Double PC failure | 1-3 para 40 and | PC1/PC2/Hook/S-Brake Pneumatics |
| PC-1 failure | 3-4 para 7 | |
| PC-2 failure | 3-4 para 7 | |
| Arrester hook emergency lowering | 1-8 para 85 | |
| Speed brake emergency retraction | 1-8 para 29 | |
| IFF/RT | | |
| IFF FAIL caption | 1-13 para 46 | - |
| Main RT failure | 1-13 para 19 | Stab Aug/AFCS/Trims/ Radio |
| ACC caption | 1-13 Table 3 | - |
| INAS | | |
| INERTIAL NAV SYS OUT caption | - | INAS Faults |
| LANDING EMERGENCIES | | |
| Single engine failure on final approach | 3-3 para 11 | Telelight Captions/ Engine Failures |
| Premeditated single engine landing | 3-4 para 6 | |
| Landing with a burst tyre | 3-3 para 10 | Low Spd Handling/ Burst Tyre/Anti-Skid/ S-E Land |
| Burst tyre during landing | - | |
| Anti-skid failure on landing | - | |
| Landing on unprepared surfaces | - | |
| Approach-end arrested landing (hook) | 4-2 para 3 | Landing Emergs/ Arresting |
| Overrun-end arrested landing (hook) | 4-2 para 3 | |
| Arrester gear landing limitations | 2-2 para 22 | |
| Flapless landing | 3-3 para 8 | - |
| Brake chute failure | 3-3 para 5 | - |
| LANDING GEAR AND FLAPS | | |
| Failure to lower three wheels | - | Gear |
| Flap malfunctions | 4-2 para 36 | Windshield/Cabin/Equip Turb/CNI/Flaps |
| OXYGEN | | |
| Elimination of vapour, smoke or fumes | - | Smoke/Oxygen |
| Hypoxia | - | |
| Oxygen contamination | - | |
| Difficulty in breathing | - | |
| NBC oxygen emergencies | - | Oxygen/NBC |
| PNEUMATICS | | |
| Landing gear emergency lowering | 1-8 para 81 to 83 | PC1/PC2/Hook/S-Brake/ Pneumatics |
| Flaps emergency lowering | 1-8 para 80 and 4-2 para 39 | |
| Pneumatic wheelbrake operation | 1-8 para 84 | |
| Emergency extension refuelling probe | 1-7 para 42 | |
| Landing gear retraction after emergency lowering | - | Landing Emergs/ Arresting |

*Intentionally Blank*

# PART 4

## CHAPTER 2 - EMERGENCY PROCEDURES

### Contents



**General**

1. Although system malfunctions are covered in the text of this Manual and in the FRC, considerations to be borne in mind and background information on certain emergencies are given in this Chapter.

**Landing With Utility Hydraulic Failure**

2. If there is no approach-end arresting gear available, the following considerations apply to directional control during the landing run:

a. Nosewheel steering is not available.

b. Only small rudder deflections are available owing to high pedal forces (the rudder control reverts to manual).

c. Ailerons/spoilers aid directional control.

d. The brake parachute should be used with caution in crosswinds, and should be jettisoned immediately if directional control becomes marginal or large differential braking is required to counter its effect.

e. The anti-skid system is switched OFF for landings without utility pressure. The brake accumulator holds sufficient pressure for 7 brake applications, which is sufficient to stop the aircraft and provide differential braking if no cable is available. To conserve accumulator pressure, do not pump the brake pedals but make one steady application, remembering that anti-skid protection is not available.

f. Once the accumulator becomes depleted, manual brakes provide differential braking and the emergency pneumatic brake lever should be operated to stop the aircraft. The pneumatic brakes provide no differential braking.

WARNING: If a decision to roll is taken after missing the arresting gear and a swing develops owing to a crosswind, directional control is difficult; a force of 300 lb may be needed on the rudder pedal to achieve effective rudder movement.

**Cable Engagement**

3. If it is decided to use the cable either for an aborted take-off, or for an emergency landing, the following procedures should be used:

a. *Aborted Take-Off:*

(1) Retard the throttles to IDLE.

(2) Stream the brake parachute.

(3) Apply the brakes when below the maximum braking speed.

(4) Lower the hook sufficiently early to allow for a recycle should it fail to lower on first selection. Do not, however, lower it too early since the hook shoe may be worn away. (About 2000 feet before the cable should be adequate.)

Note: If, on the down selection, the handle feels 'spongy', it is unlikely that the hook will lower. Raise the handle and, as the hook contacts the underside of the fuselage, reselect down. This problem is normally caused by failure of the hook unlock latch to release owing to wear. By raising the hook, hydraulic pressure lifts the hook up, off the latch, allowing it to release on the subsequent down selection. Alternatively, the hook may lowered after circuit breaker T2 (blue) on the No 2 panel is tripped.

(5) Aim for the centre of the cable. However, it is better to engage the cable off centre going straight than to engage it in the centre at an angle.

Note: When runway centreline lights are installed, a slightly off-centre 90° engagement is recommended because of the risk of hook bounce which could cause the hook to miss the cable.

(6) Release the brakes 100 feet before the cable.

(7) Cable engagement can usually be confirmed by looking into the rear view mirrors and watching the tapes. RHAG retardation is so gentle that it is difficult initially to confirm engagement.

(8) When the aircraft stops moving forward, be prepared for some rearward movement as the cable detensions. If necessary, control the rearward movement with power. Do not apply the brakes if they have been used extensively, as there is a considerable risk of hot brakes welding on.

b. *Emergency Landing*. There are several situations, covered in the FRC, which require an approach-end cable engagement. The decision whether or not to deploy the brake parachute depends on the ability to go round again should the hook miss the cable. When approaching to land with a complete utility failure, care should be exercised when applying aileron. Without yaw stabilisation the aircraft is susceptible to dutch roll, and foot loads are high, making corrections difficult. Exercise care when applying rudder to ensure that brake is not inadvertently applied. An approach-end arrestment is recommended, as difficulty may be experienced in maintaining directional control on the runway if a crosswind is encountered.

(1) Reduce AUW to a practical minimum.

(2) Refer to the FRC for speed/weight limitations.

(3) Confirm that the hook has extended if practicable.

(4) Fly a normal approach aiming to touch down at the threshold.

Note 1: Do not land short or the hook may pick up a barrier (if fitted) or the edge of the runway.

Note 2: Ensure that all three wheels are on the ground before engaging the cable. If the aircraft 'balloons' on engagement, the cable could force the nose down with possible drastic consequences.

(5) Once the hook touches the ground (it can be felt as a slight 'grating' through the airframe) it is impossible to stop all three wheels contacting the runway shortly thereafter.

(6) Retard the throttles to IDLE.

(7) If required, deploy the brake parachute.

(8) Aim for the centre of the cable. However, it is better to engage the cable off centre going straight than to engage it in the centre at an angle.

Note: When runway centreline lights are installed, a slightly off-centre 90° engagement is recommended because of the risk of hook bounce which could cause the hook to miss the cable.

(9) Release the brakes 100 feet before the cable.

(10) Cable engagement can usually be confirmed by looking into the rear view mirrors and watching the tapes.

◆ (11) When the aircraft stops moving forward, be prepared for some rearward movement as the cable detensions. If necessary, control the rearward movement with power. Apply the brakes only when the aircraft is finally at rest. ◆

**BLC Malfunction**

4. Operation at normal power settings in excess of 30 seconds with the flaps up and BLC MALFUNCTION caption on may damage the warning circuit wiring which then extinguishes the warning light. Continued flight

with the flaps up could damage the wing by overheating.

**External Stores Jettison**

5. The drills for external stores jettison are to be found in Fig 1. When the RAT has been extended and a centreline store is to be jettisoned by use of the CENTER STORES JETTISON switch on the fuel panel, the cover of the switch fouls the RAT handle. To jettison the centreline store without retracting the RAT, move the RAT handle up just sufficiently far to allow full movement of the CENTER STORES JETTISON switch cover, and then operate the switch. Moving the RAT handle up this small amount does not retract the RAT.

**Emergency Attitude Reference Using Radar**

6. Radar ground returns provide a means of obtaining some attitude reference in the event of a failure of the aircraft attitude instrumentation. Immediately attitude failure is diagnosed the navigator should take the following actions:

a. Gyros out.

b. Set 30° to 40° depression on the elevation strobe.

c. Set VI mode Range 2.

d. Adjust gain to obtain best ground returns.

7. Crews should note:

a. Roll information is immediately available and gives the wings level indication to within about 5° of bank angle.

b. The etched graticule is used as the real horizon and the ground line as the aircraft's wings.

c. If inverted, no ground returns are apparent. Leave the scanner set and roll the aircraft until ground returns appear and the aircraft can then be levelled.

d. Reliable pitch and roll information can be obtained with a little practice.

8. Although this procedure should be considered primarily as a means of piloting the aircraft safely back to VMC conditions, it is likely that useful attitude reference to heights as low as 1500 feet above surface level will be obtainable.

**Bleed Air Duct Failures**

9. Engine bleed air is used for:

a. BLC.

b. Cockpit conditioning and pressurisation.

c. Windscreen demisting and rain removal.

d. Equipment conditioning.

e. Fuel tank pressurisation and transfer.

f. Anti-g system.

g. Emergency pneumatic system.

10. To supply these services, air is taken from either the 7th or 12th stage of the HP compressor of each engine. A pressure switch normally dictates which stage is selected and this stage selection occurs automatically (see Part 1, Chapter 1) except when certain other control selections have been made, in which case the engine is locked in either 7th or 12th stage.

11. The engine is locked in 12th stage if the flaps are fully down and NORMAL 12TH STAGE is selected.

12. The engine is locked in 7th stage if:

a. ½ flap is selected.

b. ISOLATE is selected or the engine bleed control circuit breakers have been tripped.

13. Air taken from each engine is distributed around the airframe through large diameter steel ducts or pipes. Either engine can supply all the services which use bleed air and, except for the area downstream of the shut off valve for the BLC and the rain removal systems, it is not possible to shut off the airflow in the event of a duct or valve failure. To prevent damage to the engines by overbleeding, the engine mounted off-take ducts contain venturis which limit the amount of air bleed in the event of duct or engine failure. The bleed ducting runs between the engines, below the fuselage fuel tanks, along the leading and trailing edges of the wings and forward to the cockpit and equipment cooling systems in the front fuselage. If any of these ducts fails, very hot, high pressure air is discharged into the fuselage or wings. This hot air causes damage in two ways:

a. It causes heat damage to the airframe structure and systems, and burns electrical wiring.

b. It causes overpressurisation of the airframe and thus can rupture internal compartments and blow off panels and doors.

14. Normally, if a duct fails, the pressure in the system

falls below 75 PSI if the engine is on 7th stage, and the system will therefore change over to 12th stage bleed. (At sea level and at 92% HP RPM the 12th stage temperature is about 410°C, whereas the 7th stage temperature is about 290°C. There is a corresponding difference in the pressures.) With the flaps down and the BLC system operating, the bleed flow taken from the engines is greatly increased and this flow results in a large increase in the pressure and temperature loss across the engine flow limiting venturis. The bleed pressures and temperatures experienced in the airframe are consequently reduced. (At sea level and at 92% HP RPM the 7th stage temperature would be reduced to about 260°C.)

15. The FRC actions require reversion to 7th stage bleed and the lowering of full flap as quickly as possible. It is recommended that gear is lowered as soon as the speed is below 250 KCAS, followed by full flap when below the airspeed switch limit. If range is critical, the landing gear should be raised; if it is also necessary to raise the flaps, minimum power should be used. Although damage can still be caused by 7th stage air, the risks are greatly reduced.

Note: When lowering flaps, asymmetric blowing may occur if a duct has broken, and the pilot should be ready to apply the necessary trim correction.

16. The FRC contain a list of possible symptoms which have been noted in previous bleed air duct failures. The list is not exhaustive and any odd warnings occurring in a random sequence could signify a bleed air duct failure. The reason that these warnings appear is usually that the wiring has burnt through. It is possible to get just one of the warnings in isolation but more normally, two or more warnings occur. It should be noted that these warnings are not necessarily related in any way, except the systems which rely on bleed air; eg, STATIC CORR OFF caption on, followed by pressurisation failure, followed by fuel failing to transfer.

Note: It is impossible to cover all combinations of malfunctions and it is for the crew to decide which emergency has occurred from the symptoms experienced. The information in para 9 to I6 is provided to assist the crew in their diagnosis.

**Electrical Malfunctions**

17. In general, electrical emergencies and their associated drills are straightforward. There have been a few instances in which a series of unrelated captions and warnings have appeared; subsequent ground tests have shown that these circuit malfunctions have occurred as a result of the generator control circuit failing to isolate automatically, following the development of phase or circuit component failures. This can result in a combination of any of the following captions or warnings:

a. MASTER CAUTION caption on.

b. One or both IGV MALFUNCTION captions on, or flickering.

c. ADI, BAI frozen with OFF flags showing.

d. FIRE and OVHT captions on dimly.

e. WINDSCREEN TEMP HIGH caption on.

f. STATIC CORR OFF caption on, and the system will not reset.

g. High-pitched tone in the intercom.

h. Control transients. These are caused by jumps in the stab aug system which in turn are caused by electrical power transients.

i. Radar blooming.

Note: These warnings are not normally accompanied by either of the GEN OUT captions coming on.

18. *Electrical Power Transients.* Control transients are often caused by short circuits in the radar system affecting the electrical system (both stab augs and the radar are supplied from the Left Main 200/115V AC busbar). Control transients may also be associated with a malfunction of the left generator's voltage regulator supervisory panel (VRSP) when it fails to isolate a generator properly. The FRC **Electrical Power Transients** drill is designed to stop the control transients (paddle switch pressed, stab augs off) and then to isolate the cause (radar OFF, L GEN OFF). If these actions clear the fault, a single generator recovery may be made with the stab augs reconnected. If unsuccessful, the right generator is isolated in turn (L GEN ON, R GEN OFF) in an attempt to clear the electrical transients. Finally, if the condition persists, the malfunction can be cleared by switching off both generators, which entails a recovery on RAT power with all the implications of a double generator failure.

Note: RAT power can take up to 4 seconds to come on line after selection.

**FIRE and OVHT Warnings**

19. The information given here is supplementary to that given in Part 1, Chapter 6, and is provided to assist in the diagnosis of warnings.

20. The FRC contain drills for FIRE and OVHT warnings on the same engine, a single FIRE or OVHT warning and

for a FIRE or OVHT warning on the ground. Advice on double warnings, ie, simultaneous or sequential FIRE warnings and double OVHT warnings, is given in para 26 to 28, and for fuselage fires resulting from fuselage fuel leaks in para 29 to 31.

21. The FIRE and OVHT detection circuits and elements are completely independent of each other. Consequently, if both captions come on together, there is almost certainly a real fire. Therefore, if both FIRE and OVHT captions come on together, or if one warning comes on with other signs of fire, the engine must be shut down immediately (providing the aircraft can maintain safe flight on one engine). If a warning occurs in a situation where it would be hazardous to shut down the affected engine, that engine should be left operating until a safe flight regime is attained. Once the engine has been shut down, select the ENGINE MASTER switch OFF. This is to cater for:

a. Failure of the microswitch in the rear of the throttle box, allowing the main fuel shut-off valve to remain open.

b. Inadvertent movement of the throttle after engine shutdown, causing re-opening of the main fuel shut-off valve.

The throttle microswitch and ENGINE MASTER switch are in series; operation of either closes the main fuel shut-off valve.

**WARNING:** Care must be taken in identifying the correct ENGINE MASTER switch as incorrect selection results in double engine shutdown.

22. If only one warning comes on, with no other signs of fire, the throttle must be brought back to idle. A period of 5 seconds is allowed at idle for the detection element to cool down following a hot gas leak (normally from the BLC ducting or an anti-icing valve). If the throttle is retarded immediately the caption comes on, thereby removing or reducing the heat source, the detection element will probably not have been heated very far above its 'threshold' temperature; combined with the high ventilation flow rate in the engine bay, experience has shown that a warning caused by a hot gas leak nearly always goes out within 5 seconds. If, after 5 seconds, the warning has not gone out, then the engine must be shut down.

23. A spurious warning is normally caused by a chafe or break in the detection element, or an electrical short circuit - sometimes associated with vibration. It is unlikely that a spurious warning will go out on throttling back to idle unless it is caused by vibration. The FRC drill, therefore, leads to engine shutdown. It is still necessary to confirm that there are no other signs of fire. Ultimately, a warning that remains on for over 5 minutes, with no other symptoms of malfunction, is almost certainly spurious.

24. A warning resulting from real fire, rather than a hot gas leak, may take up to 60 seconds to go out since the bay has to cool following engine shutdown. The time taken depends on the severity of the fire and the degree of engine bay overheating.

25. *Other Signs of Fire.* Other signs of fire may include, but are not limited to:

a. Abnormal engine RPM/temperature/fuel flow indications.

b. Smoke trail observed either from the cockpit or from an external source - care must be taken to ensure that dumped fuel or jettisoned hydraulic fluids, following actuation of the emergency pneumatic services, are not taken to be a smoke trail.

c. Smoke and fumes in the cockpit.

d. Unusual engine/airframe thumps.

e. Engine/airframe vibration.

f. Hydraulic system failure.

g. Generator failure.

h. Circuit breakers popping.

i. Throttle stiffness.

**Double Fire and Double Overheat Warnings**

26. *Simultaneous FIRE Warnings.* When a centreline tank is fitted and two simultaneous or near simultaneous FIRE captions come on, especially immediately after take-off, the cause is most probably a leaking connection between the centreline tank and the fuselage fuel system. As the landing gear handle is placed in the up position the centreline tank is pressurised, irrespective of the positions of the TRANS PRESS and FUEL TRANS switches, and fuel is forced into the engine bays if the centreline tank connection is leaking. The remedy is to stop the fuel from the centreline tank leaking into the engine bays and this is best done by jettisoning the tank without delay. If immediate jettison is precluded for an operational or safety reason, depressurisation of the fuel system is achieved by selecting the PROBE switch on the FUEL SYSTEM panel to REFUEL (the probe extends).

Note: If the simultaneous double FIRE warnings are preceded by a catastrophic failure of one engine, the cause is obviously not a leaking centreline tank but the failure of one engine affecting the other.

27. *Sequential FIRE Warnings.* When a fire occurs in one engine bay, the fire warning in the other engine bay may later be triggered either by the conduction of heat from one bay to the other, or by the pressure differential between the two bays causing burning fuel or hydraulic fluid to flow into the second engine bay through an aperture in the centreline keel (eg, an insecure centreline bomb rack access door). In both cases, if the fire in the first engine to show a FIRE caption can be extinguished by engine shut-down, the fire source is removed and both FIRE captions go out.

28. *Double OVHT Warnings.* Double OVHT captions are most likely to be caused by an upper fuselage fuel leak from a broken fuel transfer pipe or a ruptured fuselage tank (see para 29). Fuel streaming aft from a source outside the engine cavities does not light until an ignition source is encountered. An operating reheat is a good source, so that double OVHT warnings occurring shortly after reheat engagement almost certainly indicate a fuselage tank leak, and para 30 deals specifically with this situation. If one FIRE caption precedes or follows double OVHT warnings, the cause can be diagnosed as a fuel or hydraulic leak in an engine bay and closing down the engine with the FIRE caption may control the fire.

**WARNING:** When a double OVHT warning is confirmed as a fire there is danger of loss of stabilator control. Be prepared to eject if the warnings do not go out within a reasonable time or if a fire is confirmed and not under control.

**Fuselage Fuel Leaks - Rear Fuselage Fire**

29. Fuel fumes in the cockpit, a rapid decrease in fuel contents, or fuel streaming from the rear fuselage/nozzles area should all be treated as a potential rear fuselage fire. Either a fuselage fuel cell or a fuel transfer pipe is ruptured and danger of a catastrophic fire exists if the fuel is ignited.

30. If a fire does not occur immediately, it will probably not ignite unless conditions are changed. All actions must be deliberate and unhurried. Keep throttle movements to a minimum and do not use reheat. Make any descents or climbs gradual to avoid excessive attitude changes; other manoeuvring should be gentle. Maintain a speed of 250 to 300 KCAS to allow optimum ventilation of the fuel tank and engine bay areas. Select the FUEL TRANS switch to STOP, the PROBE switch to REFUEL and reduce fuselage fuel to less than 5000 lb. If possible, reduce the fuel to less than 2800 lb since the danger of leaking is lessened if all fuselage fuel is in cells 1 and 2; further fuel transfer should not be made unless essential for recovery. Land as soon as possible from a straight-in approach, bearing in mind the above considerations.

31. If fire occurs, the most probable result is a double OVHT warning (see para 28). The other possible indications that a rear fuselage fire exists are:

a. Smoke and/or fuel streaming from the rear fuselage.

b. Thumps or bangs.

c. Hydraulic system failure (Utility system failure has frequently been the first indication).

d. Loss of rudder control, rudder position indication or popping of rudder-associated circuit breakers.

e. Control system transients.

Note: Previous fuselage fire incidents have usually been associated with aerobatic manoeuvring and the use of reheat. When fire affects the stabilator controls, PC-1 and PC-2 failures may occur resulting in a violent pitch up.

**ENG Warning**

32. The drills dealing with a lit ENG caption are included in the FRC in the same place as those for a FIRE or OVHT caption for ease of reference, although the warnings have entirely different implications. As described in Part 1, Chapter 6, the ENG caption indicates an internal malfunction of the engine. This does not necessarily lead to a fire, and if the engine is shut down immediately, no further damage should occur. The warning may, however, remain on for some time, ie, until the engine has cooled sufficiently. The time it takes to cancel depends on the temperature of the engine and aircraft speed, and could be up to 2 minutes.

Note: The internal engine conditions which produce an ENG warning may also produce engine vibration or oil vapours from the jet pipe, or both. These may persist after engine shut-down, particularly if the engine windmills.

**Engine Seizure**

33. With one engine seized, control of the aircraft is provided by one PC and one utility pump. It is possible that while operating gear and flap, output from the utility pump will be insufficient to prevent a transient drop in utility pressure to zero. Control of the aircraft is then

temporarily limited to aileron and spoilers on one wing and manual rudder. The crew should, therefore, consider the height at which to carry out landing checks as experience has shown that up to 500 feet can be lost following a wing drop when the rudder reverted to manual and the pilot was not prepared for the extra loads.

**Ejection**

34. *Canopy Jettison.* The auxiliary thrusters in the front canopy jettison system ensure that the canopy leaves the ◆aircraft during an ejection sequence at any subsonic ◆ speed, attitude or altitude. No trials have been carried out supersonically, but theoretical assessments indicate that the excess power available in the jettison system is sufficient for satisfactory operation up to the limits of the aircraft.

Note: If the pilot ejects first during supersonic flight, it is likely that the navigator will experience severe buffeting when the front canopy has left the aircraft.

**Landing with Both Engines Inoperative**

35. Do not attempt to land with both engines inoperative.

**Flap Malfunctions**

36. Although engineering action has been taken to eradicate some flap defects, all flap malfunctions must be treated with caution. The procedures below have been determined after considering the effects of the following defects:

a. Cracking of the centre leading-edge flap actuator cylinders.

b Failure of flap actuator rod ends.

c. Failure of trailing edge flap drive ribs.

d. BLC leaks.

e. Air in the utility hydraulic system.

f. Mis-rigging of the flap limit switches.

g. Faulty cockpit flap indicators.

37. *Considerations*

a. Cracking of the centre leading edge flap actuator cylinder could cause loss of utility hydraulic pressure and, because of air loads, asymmetric flap retraction. Subsequent use of emergency flap lowering would result in the loss of pneumatic pressure. The probable indications of this failure are the appearance of a 'barber's pole' for the leading edge flaps whilst operating with half or full flap, followed by asymmetric flap and loss of utility hydraulic pressure. Although the flaps might retract asymmetrically, the aircraft should be controllable. The consequences of this defect can be minimised by selecting flaps UP immediately the symptoms appear and landing flapless.

b. Fatigue failures of flap drive ribs or actuator rod ends may be indicated by a 'barber's pole' and are most likely to occur on selection of half or full flap. Asymmetric flap might result causing a marked rolling tendency during or after flap operation. Subsequent re-cycling of the flaps causes airframe damage.

c. BLC leaks might cause a 'barber's pole' indication, usually while operating with the flaps UP. If no action is taken, serious airframe damage might occur.

Note: The WHEELS light flashes if the flaps are not indicating UP when the landing gear is UP.

d. Air in the utility hydraulic system might cause asymmetric flap movement when half or full flap is selected. Air in the down line results in unequal flap movement and a marked rolling tendency as the flaps lower.

e. Mis-rigging of the flap limit switches causes cockpit indications of flap in transit with the flaps in the selected position. A leading edge 'barber's pole' is commonly encountered if the flaps are lowered in a turn, or the aircraft is manoeuvred with half or full flap. The indications should return to normal when non-manoeuvring flight is resumed; however, the limit switch rigging must be investigated.

f. Faulty cockpit indicators might indicate flap in transit with the flaps in the selected position. When indicators are fitted in both cockpits this defect is readily identified.

38. *Procedures.* (See also Part 3, Chapter 3, para 3.)

a. *Barber's Pole While Operating with Flaps Up Following Normal UP Indications.* Suspect a BLC leak and complete the **BLC Malfunction** drill immediately.

b. *Barber's Pole After Selecting Flaps UP.* If after the normal interval during which the flaps should have retracted fully, a barber's pole indication remains, suspect flap drive failure. Leave flaps selected

UP and make a flapless landing as soon as practicable.

c. *Barber's Pole After ½ or DOWN Selection*

(1) *Manoeuvring Flight:* Allow 5 seconds after return to non-manoeuvring flight. If symptoms persist, suspect a flap drive or fatigue failure, leave flaps as set and land as soon as practicable.

(2) *Non-Manoeuvring Flight:* Suspect flap drive or fatigue failure. Leave flaps as set and land as soon as practicable.

Note 1: Check the indicators in both cockpits if applicable.

Note 2: After landing with a barber's pole indication, do not move the flaps from the set or up position. If full flap is down, monitor TGT whilst taxying or have ISOLATE selected to stop 12th stage bleed.

d. *Asymmetric Flap.* If a marked rolling tendency is experienced with the flaps at ½ or full down, or during flap lowering, immediately select flaps UP. Leave the flaps UP, reduce AUW, jettison asymmetric loads in excess of 70,000 lb in, complete a low speed handling check at a safe altitude with the landing gear DOWN, and land flapless.

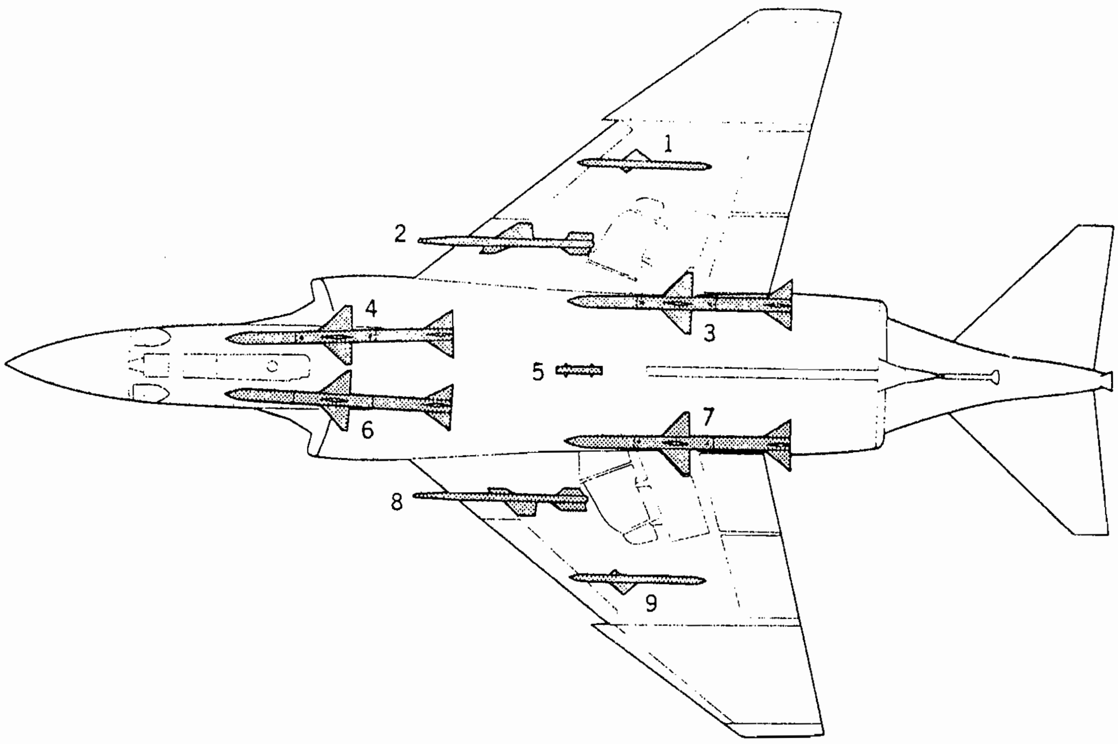
39. *Flap Emergency Lowering.* The flaps should be lowered on the emergency system at a safe height according to the drill in the FRC. Some asymmetry on lowering should be expected. If flap asymmetry results from the emergency lowering, it should be possible to control the aircraft with both PC systems operating. If this is not possible, attempt to retract the flaps by resetting the circuit breaker and selecting UP. If, following a complete utilities failure, it is not possible to lower the flaps at a safe altitude, consideration should be given to carrying out a flapless landing, bearing in mind the cable limitations.

**Runway Departure**

40. If, after landing or during take-off, departure from the runway at high speed is imminent, a rapid decision must be made to minimise risk to the crew and aircraft damage. Considerations include departure speed, angle, skid, terrain, obstructions, and ejection capability.

41. A go-around or a continued take-off may not be possible. The ability to get airborne safely depends on surface conditions, obstructions, distance required to accelerate to flying speed, and aircraft condition. Once airborne, consideration must be given to possible engine foreign object damage and airframe damage. A controllability check should be carried out prior to landing.

42. If a go-around or continued take-off is not attempted, consider engine shut-down to eliminate fire sources such as hot engines, pressurised hydraulics, and full power electrics. The decision to eject versus remaining with the aircraft must be tempered by the situation. Considerations include obstructions, terrain, speed, skid, and landing gear integrity.




| EXTERNAL STATION | GEAR HANDLE POSITION | METHOD OF RELEASE (1) |
|---|---|---|
| 1 to 9 | UP or DOWN (2) | Press EXTernal STORES EMERgency RELease button. |
| 1 and 9 | UP or DOWN | OUTBD STORES JETTISON switch to release position. |
| 2 or 8 | UP or DOWN | Select L WING or R WING on missile jettison selector and press PUSH TO JETT button (MISSILE STATUS panel). |
| 3, 4 (3), 6 (3) or 7 | UP or DOWN | Select L FWD, R FWD, L AFT or R AFT on missile jettison selector and press PUSH TO JETT button (MISSILE STATUS panel). |
| 5 | UP or DOWN (2) | CENTER STORES JETTISON switch to release position. |

**NOTES**

(1) The jettison safety switch must be set to READY before any stores, except centreline (5), can be jettisoned.

(2) Weight must be off landing gear.

(3) Missiles mounted on fuselage stations 4 and 6 cannot be jettisoned if a fuel tank is installed on centreline station 5.

**4-2 Fig 1 External Stores Jettison Chart - Conventional Stores**

*Intentionally Blank*

PART 5

COCKPIT ILLUSTRATIONS

# SECTION 4
# TAKE OFF NAT FLIGHT PATH

AL 10

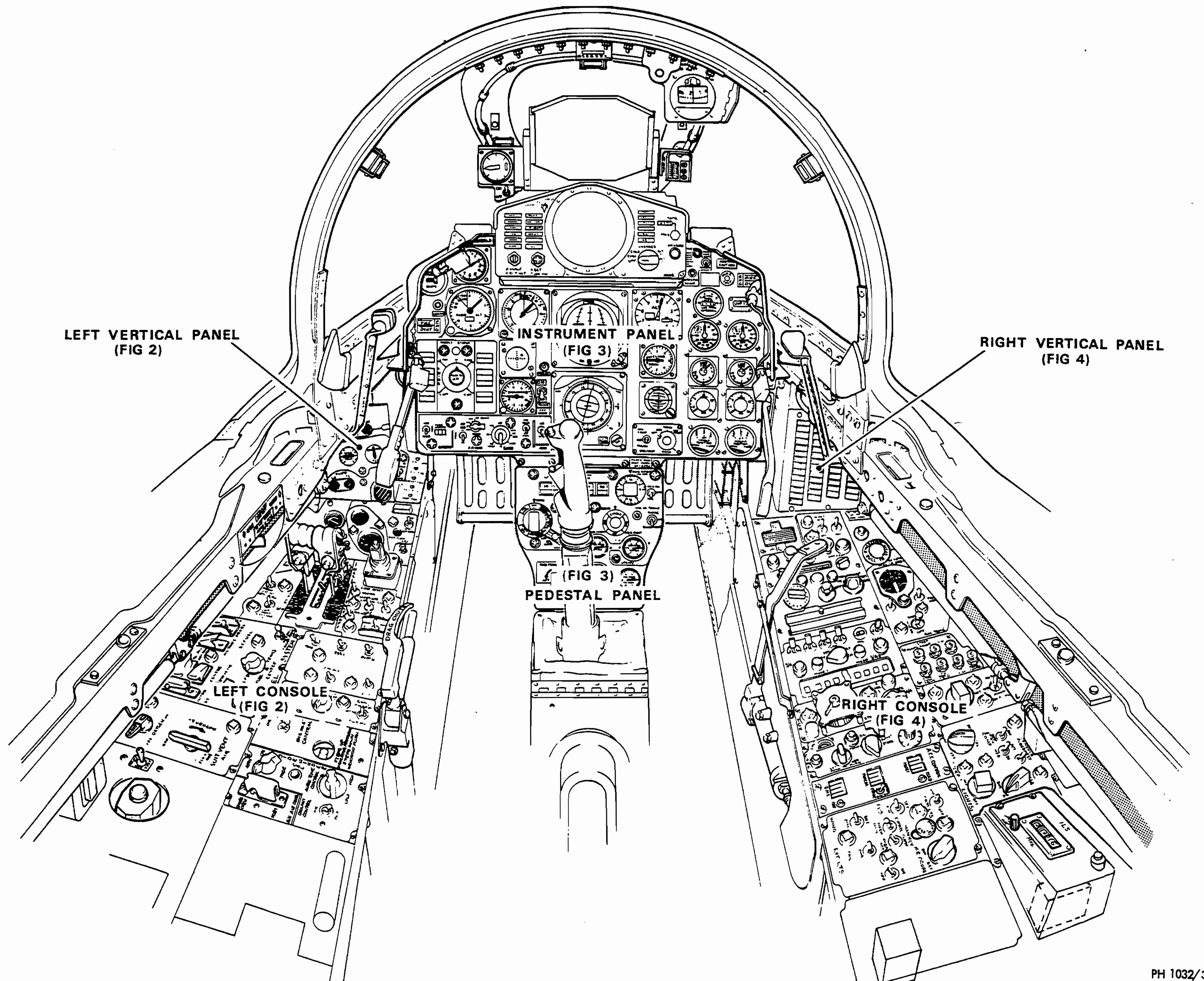
# PART 5

## CHAPTER 1 — COCKPIT ILLUSTRATIONS

◀ *(Completely revised at AL15)* ▶

### Contents

*Intentionally Blank*




**5-1 Fig 1 Front Cockpit - General Arrangement**

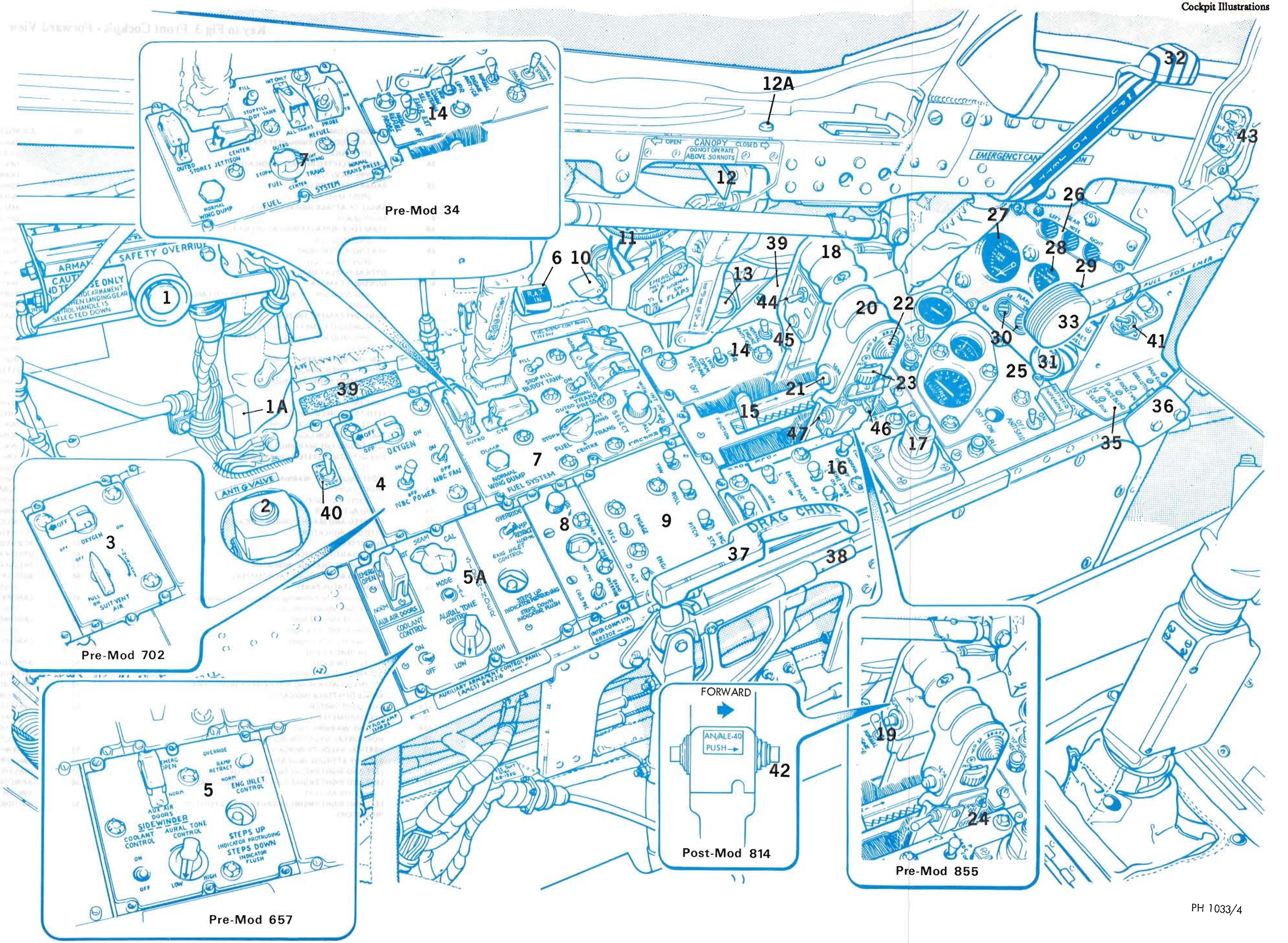
# Key to Fig 2 Front Cockpit - Left Side

1 **ARMAMENT SAFETY OVERRIDE SWITCH**
1A **TELEBRIEF INDICATOR**
2 **ANTI-G VALVE**
3 **PRESSURE SUIT/OXYGEN CONTROL PANEL**
*(PRE-MOD 702)*
*Contains the following controls*
*OXYGEN control valve - OFF/ON*
*SUIT VENT AIR control - OFF/INCREASE/FULL/ON*
4 **PRESSURE SUIT/OXYGEN CONTROL PANEL**
*(POST-MOD 702)*
*Contains the following controls*
*OXYGEN control valve - OFF/ON*
*NBC ROLE switch - OFF/ON*
*NBC FAN switch - OFF/ON*
5 **AUXILIARY ARMAMENT CONTROL PANEL**
*Contains the following controls and indicators*
*AUX AIR DOORS switch - EMERG OPEN/NORM*
*ENG INLET CONTROL switch - OVERRIDE/RAMP RETRACT/NORM*
*SIDEWINDER COOLANT CONTROL switch - ON/OFF*
*SIDEWINDER MODE switch - BST/SEAM/CAL*
*SIDEWINDER CAL light*
*SIDEWINDER AURAL TONE CONTROL switch - LOW/HIGH*
*Integral steps mechanical indicator:*
*STEPS UP - INDICATOR PROTRUDING*
*STEPS DOWN - INDICATOR FLUSH*

6 **RAM AIR TURBINE CONTROL HANDLE**

7 **FUEL SYSTEM CONTROL PANEL**
*(PRE-MOD 34)*
*Contains the following controls:*
*STORES JETTISON switch - OUTBD*
*STORES JETTISON switch - CTR*
*BUDDY TANK switch - FILL/STOP FILL*
*REFUEL switch - INT ONLY/ALL TANKS*
*PROBE switch - REFUEL/EXTEND/RETR*
*WING DUMP switch - DUMP/NORMAL*
*FUEL TRANS switch - STOP/OUTBD/INT WING/CENTRE*
*TRANS PRESS switch - NORMAL/ON*
7 **FUEL SYSTEM CONTROL PANEL**
*(POST-MOD 34)*
*Contains the following controls:*
*STORES JETTISON switch - OUTBD*
*STORES JETTISON switch - CTR*
*BUDDY TANK switch - FILL/STOP FILL*
*PROBE emergency switch - NORM/EMER EXT*
*PROBE normal switch - REFUEL/EXTEND/RETRACT*
*TRANS PRESS switch - NORMAL/ON*
*WING DUMP switch - DUMP/NORMAL*
*FUEL TRANS switch - STOP/OUTBD/INT WING/CENTER*
*REFUEL SELECT switch:*
*ALL/INT WITH 7/INT W/O 7/ALL*

8 **INTERCOMMUNICATION CONTROLS**
9 **AUTOMATIC PILOT ENGAGING CONTROLLER**
*Contains the following controls:*
*STAB AUG PITCH switch - ENGAGE*
*STAB AUG ROLL switch - ENGAGE*
*STAB AUG YAW switch - ENGAGE*
*AFCS switch - ENGAGE*
*ALT switch - ENGAGE*
10 **FLAPS NORMAL CONTROL SWITCH**
*NORMAL SW FLAPS - UP/½/DN*
11 **FLAPS EMERGENCY CONTROL HANDLE**
*EMERG PULL HANDLE AFT*
12 **CANOPY NORMAL CONTROL LEVER**
*CANOPY - OPEN/CLOSED*
12A **PORT AUXILIARY CANOPY THRUSTER** (POST-MOD 427)
13 **COMMAND EJECT LIGHT/SWITCH**
14 **OUTBOARD ENGINE CONTROL PANEL**
*Contains the following controls:*
*ENGINE ANTI-ICING switch - DE-ICE/NORMAL*
*COMM ANTENNA SEL switch - UPR/LWR*
*REFUEL PROBE emergency switch - EMER EXT/NORM*
*(this switch is repositioned on fuel system control panel post-Mod 34)*
*NORMAL 12th STAGE/ISOLATE bleed air switch*
15 **THROTTLES FRICTION LEVER**
16 **INBOARD ENGINE CONTROL PANEL**
*Contains the following controls:*
*CADC switch - CORR RESET/NORMAL/CORR OFF*
*L ENGINE START switch - ON/OFF*
*R ENGINE START switch - ON/OFF*
*R ENGINE MASTER switch - ON/OFF*
*L ENGINE MASTER switch - ON/OFF*
*RUDDER TRIM switch - L/R*
17 **BOMBING HAND CONTROL**
18 **LEFT ENGINE THROTTLE LEVER**
19 **LEFT ENGINE RELIGHT IGNITION BUTTON**
20 **RIGHT ENGINE THROTTLE LEVER**
21 **RIGHT ENGINE RELIGHT IGNITION BUTTON** (PRE-MOD 855)
22 **SPEED BRAKES CONTROL SWITCH**
*SP BRAKE - IN/OUT*
23 **MIC SWITCH**
*ICS/UHF*
24 **STRIKE CAMERA CONTROL SWITCH**
*CAMERA - ON/OFF*
25 **LEFT CONSOLE UTILITY PANEL**
*Contains the following controls and indicators:*
*BOOST PUMP PRESSURE GAUGE*
*BOOST PUMP CHECK switch - L/R*
*OXY TEST switch*
*OXYGEN PRESSURE GAUGE*
*OXYGEN QUANTITY GAUGE*
*OXYGEN FLOW INDICATOR*
*ANTI-SKID OFF warning light*
*ANTI-SKID selector switch - OFF/ON*
*ARI circuit breaker*
*TOWED TARGET DROP ALTERNATIVE switch (post-mod 823)*
26 **LANDING GEAR POSITION INDICATORS**
*GEAR - LEFT/NOSE/RIGHT*
27 **STABILATOR TRIM POSITION INDICATOR**
28 **AILERON TRIM POSITION INDICATOR**
29 **RUDDER POSITION INDICATOR**
30 **FLAPS POSITION INDICATOR**
*FLAPS - LE/TE*
31 **EXTERNAL STORES EMERGENCY RELEASE SWITCH**
*PUSH TO RELEASE*
32 **CANOPY EMERGENCY JETTISON HANDLE**
*PULL TO JETT*
33 **LANDING GEAR CONTROL HANDLE**
*PULL FOR EMER*
34 DELETED
35 **EJECTION SEAT SAFETY PINS STOWAGE RACK**
36 **CANOPY INITIATOR SAFETY PINS STOWAGE BLOCK**
37 **BRAKING PARACHUTE OPERATING HANDLE**
38 **BRAKING PARACHUTE RELEASE BUTTON**
39 **VELCRO CONSOLE COVER ATTACHING STRIPS**
40 **TELMY - ON/OFF/TEST** (POST-MOD 5076)
41 **TOWED TARGET DOORS OPEN INDICATOR** (POST-MOD 823)
42 **TOWED TARGET NORMAL DROP SWITCH** (POST-MOD 832)
◆43 **AN/ALE-40 READY LIGHTS** (POST-MOD 855)
44 **STRIKE CAMERA CONTROL SWITCH**
*CAMERA - ON/OFF*
45 **LEFT ENGINE RELIGHT IGNITION BUTTON**
46 **AN/ALE-40 PILOT'S SELECT SWITCH** (POST-MOD 855)
47 **RIGHT ENGINE RELIGHT IGNITION BUTTON** ◆

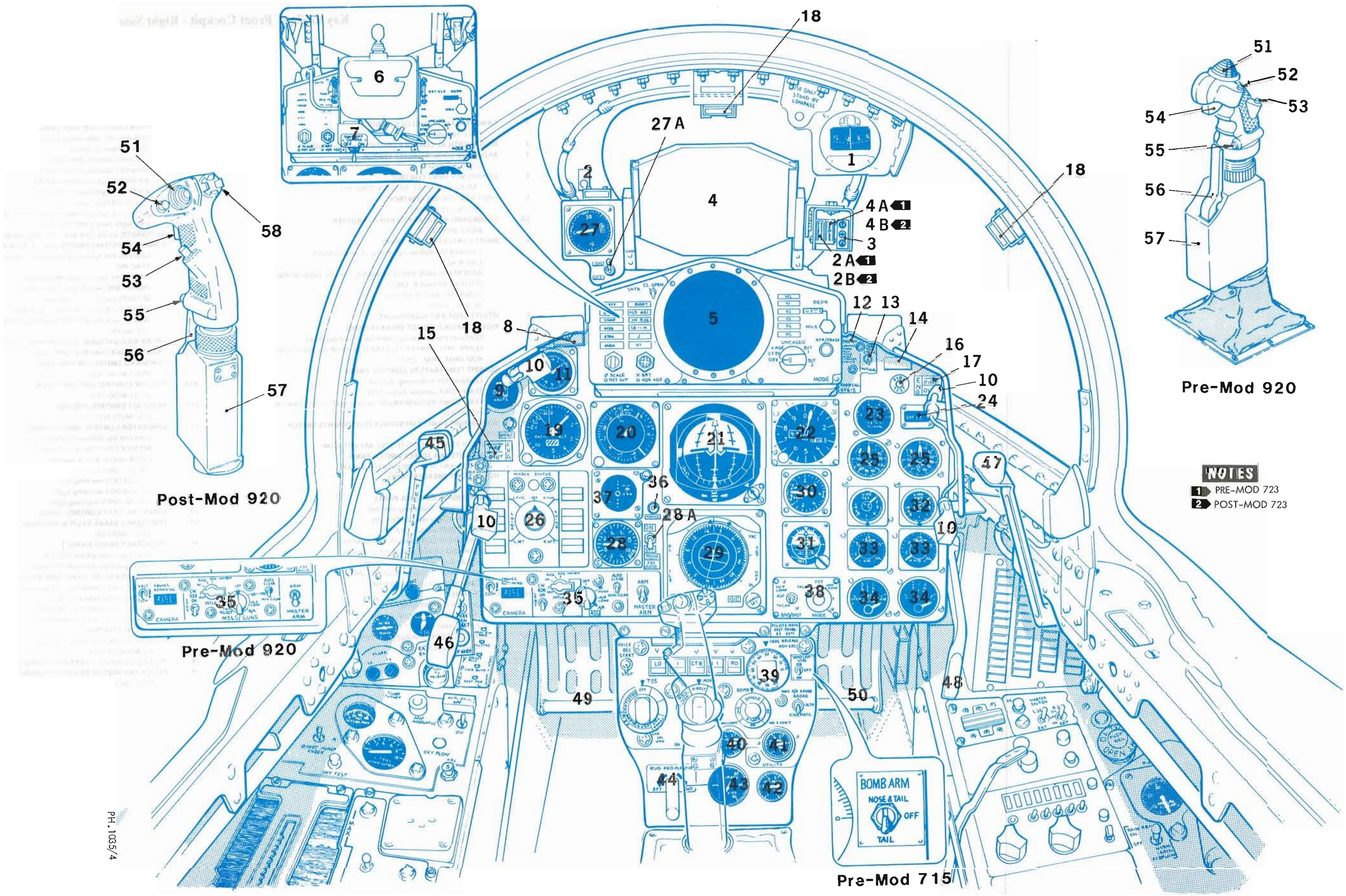



5-1 Fig 2 Front Cockpit - Left Side

## Key to Fig 3 Front Cockpit - Forward View

1 STANDBY COMPASS
2 LOW ALTITUDE WARNING REPEATER LIGHT
*(POST-MOD 255)*
2A MISSILE SELECTED REPEATER INDICATOR LIGHT
*(PRE-MOD 723)*
2B RADAR INDICATOR LIGHT
*(POST-MOD 723)*
3 ANGLE OF ATTACK INDEXER LIGHTS
4 SIGHT GLASS
4A SEAM LOCK REPEATER INDICATOR LIGHT
*(PRE-MOD 723)*
4B HEAT INDICATOR LIGHT
*(POST-MOD 723)*
5 OPTICAL DISPLAY UNIT
6 GUNSIGHT CAMERA
*(PRE-MOD 504; OR ROLE EQUIPMENT POST-MOD 5061)*
7 GUNSIGHT CAMERA SWITCH
*GUNSIGHT CAMERA OFF-ON*
*(PRE-MOD 504; OR ROLE EQUIPMENT POST-MOD 5061)*
8 LANDING GEAR WARNING LIGHT
9 GROUND SPEED INDICATOR
10 INSTRUMENT PANEL EMERGENCY FLOODLIGHTS
11 CLOCK
12 TAKE-OFF CHECKLIST
13 FEED TANK CHECK SWITCH
*FEED TANK, CHECK - NORMAL*
14 MASTER CAUTION LIGHT
15 LEFT ENGINE FIRE WARNING LIGHT
16 FIRE DETECTION SYSTEM CHECK SWITCH
*FIRE TEST*
17 RIGHT ENGINE FIRE WARNING LIGHT
18 SHOOT LIGHT
*(POST-MOD 804)*
19 RADIO ALTIMETER
20 AIRSPEED AND MACH NUMBER INDICATOR
21 ATTITUDE INDICATOR
22 ALTIMETER
23 FUEL QUANTITY INDICATOR
24 UHF REMOTE CHANNEL INDICATOR
25 LEFT AND RIGHT ENGINE TACHOMETERS
26 MISSILE STATUS PANEL
*Contains the following indicators and controls:*
*TK tank aboard indicator*
*One SEAM OUT light*
*One SEAM LOCK light*
*Four SELECTED lights*
*Six READY lights*
*Four SW lights*
*PRESS TO JETT switch,*
*OFF-R FWD-R WING-R AFT-L AFT-L WING-L FWD*
27 ANGLE OF ATTACK INDICATOR
27A AOA LIGHT SWITCH
28 ACCELEROMETER
28A PASSIVE WARNING P.R.F. AUDIO SWITCH
29 HORIZONTAL SITUATION INDICATOR
30 VERTICAL VELOCITY INDICATOR
31 BACK-UP ATTITUDE INDICATOR
32 LEFT AND RIGHT ENGINE TGT INDICATORS
33 LEFT AND RIGHT ENGINE FUEL FLOW INDICATORS
*(XV399 AND UP)*
34 LEFT AND RIGHT ENGINE EXHAUST NOZZLE POSITION INDICATORS
35 A/A MSLS AND MASTER ARM PANEL
*Contains the following indicator and controls:*
*Strike camera switch,*
*FAST-OFF-SLOW*
*FRAMES REMAINING indicator*
*RDR CW switch, ON-STBY-OFF*
*INTLK switch, DOG INHIBIT-DOG-IN-OUT*
*MSLS/GUNS mode switch, SW REJECT-SW-SP 111-OFF-A/G*
*FIXED-A/G COMP-(PRE-MOD 804)-A/A COMP (POST-MOD 804) - A/A*
*(Note: POST-MOD 5055, A/G COMP position is marked INOPR)*
*Gun clear switch, AUTO-CLEAR-NON CLEAR*
*MASTER ARM switch, ARM -SAFE*
36 ILS MARKER LIGHT
37 ILS INDICATOR
38 NAVIGATION FUNCTION SELECTOR PANEL
*Contains the following controls:*
*BRG/DIST switch, NAV COMP-ADF-TACAN*
*(Note: POST-MOD 5055, NAV COMP position is marked INOPR)*
39 PEDESTAL PANEL
*Contains the folowing controls:*
*STA SEL switch, LO-LI-CTR-RI-RO*
*WPN selector switch*
*MODE switch*
*INAS advance control, INAS RELEASE ADV SEC*
*BOMB switch*
*INAS A/G RANGE switch; RADAR -ALTM-KINEMATIC*
*(Note: POST-MOD 5055, these positions are marked INOPERATIVE)*
*BOMB ARM switch, NOSE & TAIL-SAFE-TAIL (PRE-MOD 715)*
*MMP CAMERA HTRS switch ON-OFF-ON (POST-MOD 715)*
40 PC I HYDRAULIC SYSTEM PRESSURE GAUGE
41 PC II HYDRAULIC SYSTEM PRESSURE GAUGE
42 UTILITY HYDRAULIC SYSTEM PRESSURE GAUGE
43 PNEUMATICS SYSTEM PRESSURE GAUGE
44 RUDDER PEDALS ADJUSTMENT CONTROL
*RUDDER PEDAL ADJUST-AFT-FWD*
45 CANOPY EMERGENCY JETTISON HANDLE
*PULL TO JETT*
46 LANDING GEAR SELECTOR HANDLE
*PULL FOR EMER*
47 CANOPY MANUAL UNLOCK HANDLE
*PULL TO UNLOCK*
48 ARRESTING GEAR CONTROL HANDLE
49 LEFT RUDDER AND BRAKE PEDAL
50 RIGHT RUDDER AND BRAKE PEDAL
51 AILERON/ELEVATOR TRIM SWITCH
52 SEAM LOCK ENABLE/REJECT SWITCH
*(PRE-MOD 823)*
SEAM LOCK ENABLE/TARGET STREAM SWITCH
*(POST-MOD 823)*
53 NOSEWHEEL STEERING SWITCH
54 TRIGGER SWITCH
55 INAS FIX-TAKE SWITCH
56 AP/NOSEWHEEL STEERING EMERGENCY DISENGAGE SWITCH
57 MOTIONAL PICKUP TRANSDUCER

PH13357
(XEROX)

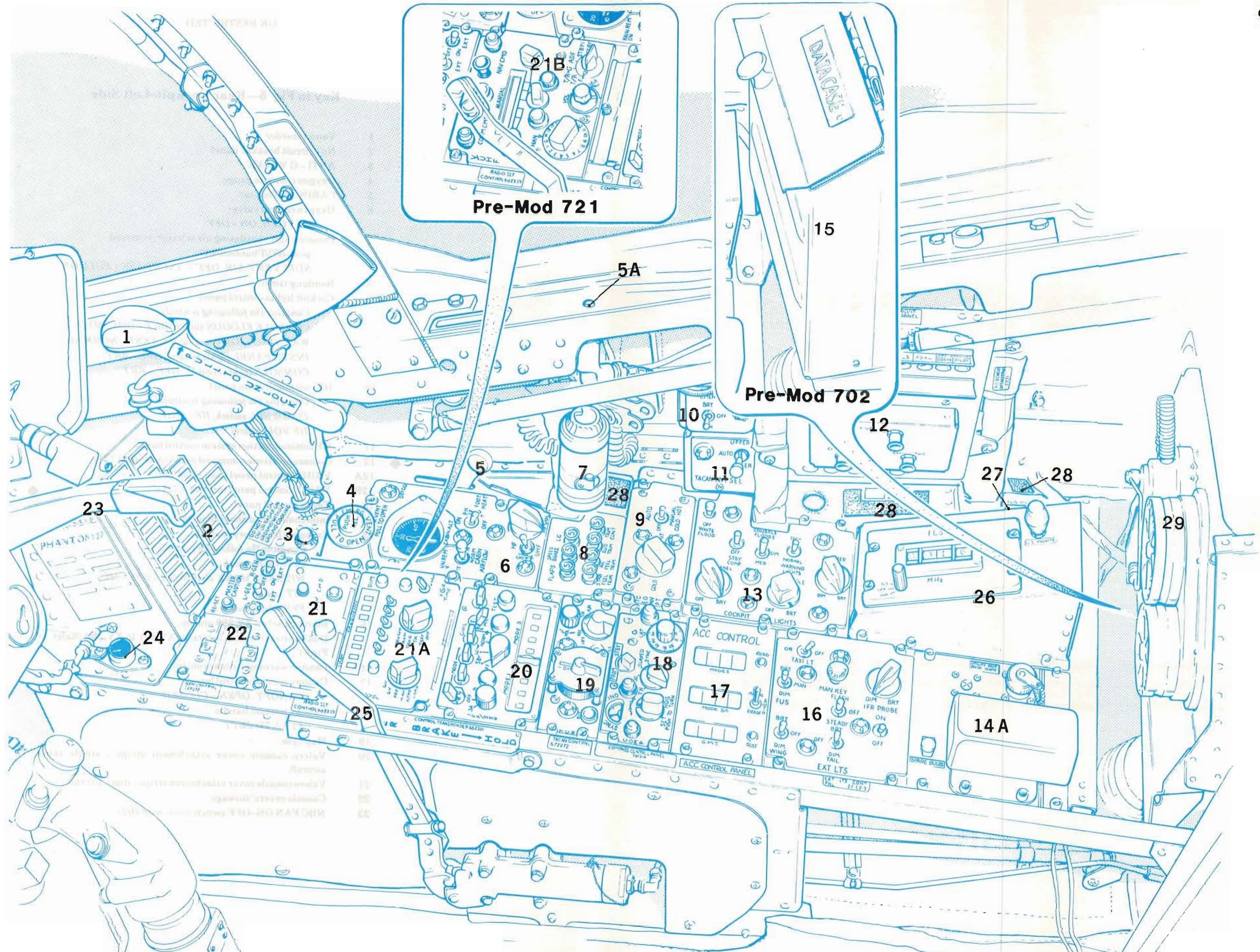



5-1 Fig 3 Front Cockpit - Forward View

## Key to Fig 4 Front Cockpit - Right Side

1 CANOPY MANUAL UNLOCK HANDLE
*PULL TO UNLOCK*
2 RIGHT VERTICAL CONSOLE CAUTION LIGHTS PANEL
3 RADAR CNI COOLING RESET SWITCH
*COOLING RESET*
4 EMERGENCY VENT CONTROL
*EMERG VENT PULL TO OPEN-PUSH REL*
5 FOOT HEAT/DEFOG CONTROL
*DEFOG-FOOT HEAT*
5A STARBOARD AUXILIARY CANOPY THRUSTER
*(POST-MOD 427)*
6 RIGHT CONSOLE UTILITY PANEL
*Contains the following indicator and controls:*
*CABIN ALT*
*RAIN REM/CABIN AIRFLOW switch, ON-OFF-LOW-NORM*
*PITOT HEAT switch, ON-OFF*
*COMM SEL switch, HF-UHF*
*HF VOL control*
7 UTILITY SPOT AND FLOODLIGHT
8 RIGHT CONSOLE CIRCUIT BREAKER PANEL
*Contains the following essential circuit breakers:*
*FLAPS- SPEED BRAKE-LG-STAB FEEL TRIM-AIL FEEL TRIM-RUD TRIM-TRIM CONT*
9 COCKPIT TEMPERATURE CONTROL PANEL
*Contains the following controls:*
*TEMP CONT control, COLD-HOT*
*TEMP CONT AUTO/MANUAL switch, AUTO-OFF-MANUAL-HOT-COLD*
10 INSTRUMENT PANEL EMERGENCY FLOODLIGHTS SWITCH PANEL
*INSTR PANEL EMERG FLOOD, BRT-OFF -DIM*
11 TACAN ANTENNA SELECT SWITCH PANEL
*TACAN ANT SEL, UPPER-AUTO-LOWER*
12 NO.3 CIRCUIT BREAKER PANEL
13 COCKPIT LIGHTS CONTROL PANEL
*Contains the following controls:*
*WHITE FLOOD switch, OFF-ON*
*STBY COMP switch, OFF-ON*
*CONSOLE FLOODS switch, BRT-DIM-MED*
*WARNING LIGHTS switch, TEST-NORM*
*INDEXER LIGHTS control, OFF-BRT*
*INSTR PANEL lights control, OFF-BRT*
*CONSOLE light control OFF-BRT*
14 UTILITY PANEL
*Contains the following:*
*UTILITY RECEPT 28V DC 10 AMP*
*SPARE LAMPS holder*
14A AUTOMATIC CODE CHANGE BATTERY
15 MAP AND DATA CASE
16 EXTERIOR LIGHTS CONTROL PANEL
*Contains the following controls:*
*TAXI LT switch, ON-OFF*
*FUS lights switch, BRT-MAN-DIM*
*MAN KEY button, PUSH TO KEY*
*IFR PROBE light control, DIM-BRT*
*IFR PROBE light switch, ON-OFF*
*FLASH-STEADY switch*
*WING join-up lights switch, BRT-OFF-DIM*
*TAIL light switch BRT-OFF-DIM*
17 AUTOMATIC CODE CHANGE CONTROL PANEL
18 COMPASS SYSTEM CONTROLLER C-4781/AJB-7
*Contains the following indicator and controls:*
*SYNC IND*
*PRIM-STBY switch, (pre-Mod 5055)*
*INOPR/PRIM switch (post-Mod 5055)*
*SET HDG-PUSH TO TURN switch*
*TH-DG-SLAVED-SYNC switch (pre-Mod 5055)*
*INOPR-DG-SLAVED-SYNC switch (post-Mod 5055)*
*LAT switch*
19 TACAN NAVIGATIONAL SET CONTROL C-7402/ARN-91
20 TRANSPONDER CONTROL UNIT 16929
21 COMMAND SWITCH UNIT PV1755B
*(POST-MOD 721)*
21A VHF/UHF CONTROL UNIT PV1754AB
*(POST-MOD 721)*
21B RADIO SET CONTROL PTR374A
*(PRE-MOD 721)*
22 GENERATOR CONTROL SWITCH PANEL
*Contains the following indicators and controls:*
*MASTER CAUTION RE-SET switch*
*L-GEN switch, R-GEN switch, ON-OFF-ON EXT*
*LH GEN OUT warning light*
*RH GEN OUT warning light*
*BUS-TIE OPEN warning light*
23 ARRESTING GEAR CONTROL HANDLE
24 EMERGENCY BRAKE SYSTEM PRESSURE GAUGE
*(POST-MOD 54)*
25 EMERGENCY BRAKE HANDLE
*HOLD position added POST-MOD 3*
*HOLD position deleted POST-MOD 797*
26 ILS LOCALIZER/GLIDE SLOPE CONTROLLER/RECEIVER PANEL
*Contains the following indicator and controls:*
*ILS frequency indicator MHz*
*ILS control switch, ILS-OFF-VOR*
*ILS frequency control switches*
27 ILS VOLUME CONTROL
*Controls the following indicator:*
*ILS MARKER light*
28 'VELCRO' CONSOLE COVER ATTACHING STRIPS
29 PILOT'S FAN MOTOR AND FILTER CANNISTERS
*(POST-MOD 702)*

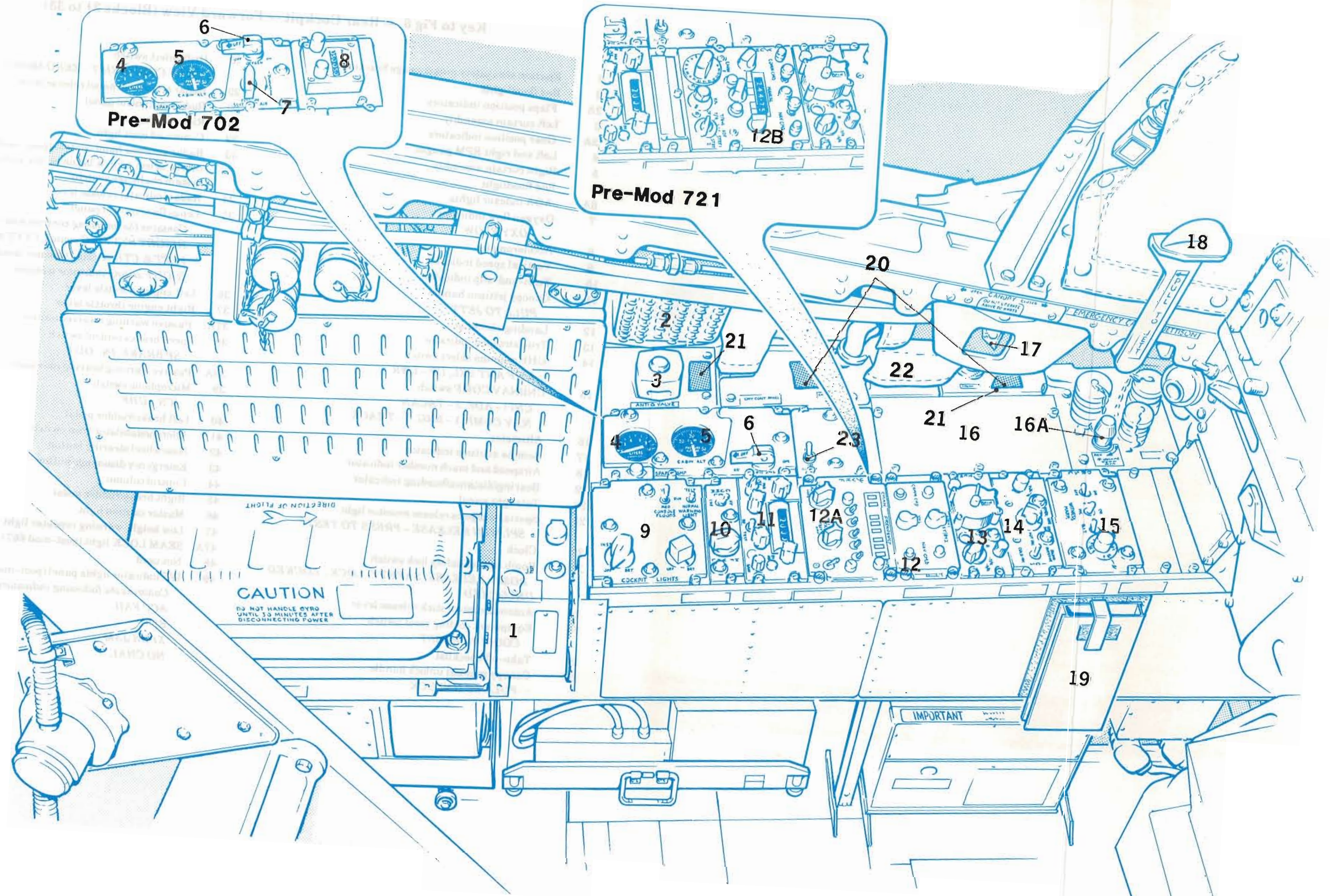
PH13358
(XEROX)




5—1 Fig 4 Front Cockpit—Right Side
◆ *(Updated to latest mod standard)* ◆

## Key to Fig 5—Rear Cockpit-Left Side

1 Voice recorder
2 No 1 circuit breaker panel
3 ANTI-G VALVE
4 Oxygen contents gauge
5 CABIN ALTimeter
6 Oxygen control valve
*OXYGEN, ON-OFF*
7 Pressure suit ventilating air selector (removed post-STI/Phantom/437)
*SUIT VENT AIR, OFF — INCREASE - FULL ON*
8 Bombing timer
9 Cockpit lights control panel
*Contains the following controls:*
*CONSOLE FLOODS switch, BRT - DIM - MED*
*WARNING LIGHT test switch, TEST - NORMAL*
*INSTR PANEL lights control, OFF - BRT*
*CONSOLE lights control. OFF - BRT*
10 HF communication panel
*Contains the following controls:*
*COMM SEL switch, HF - UHF*
*HF VOL control*
11 HF communication system control panel
◆ 12 Communications command panel (post-mod 721)
12A V/UHF control panel (post-mod 721)
12B V/UHF control panel (pre-mod 721) ◆
13 Tacan control panel
14 Intercommunication control panel
15 Exposure frequency control
*Contains the following controls:*
*ON - OFF switch*
*WITNESS MARK switch, ON - OFF - MC*
*BIT switch*
*FPS selector switch*
16 Blank panel on XV 399 and up
Dual control throttle levers on XT 891 to XV 398 (Refer to Fig 6)
16A Passive warning volume control
17 Canopy normal control lever
*CANOPY, OPEN - CLOSED*
18 Canopy jettison handle
*PULL TO JETT*
19 Map case
20 Velcro console cover attachment strips - single stick aircraft
21 Velcro console cover attachment strips - dual aircraft
22 Console covers' stowage
23 NBC FAN ON-OFF switch (post-mod 702)

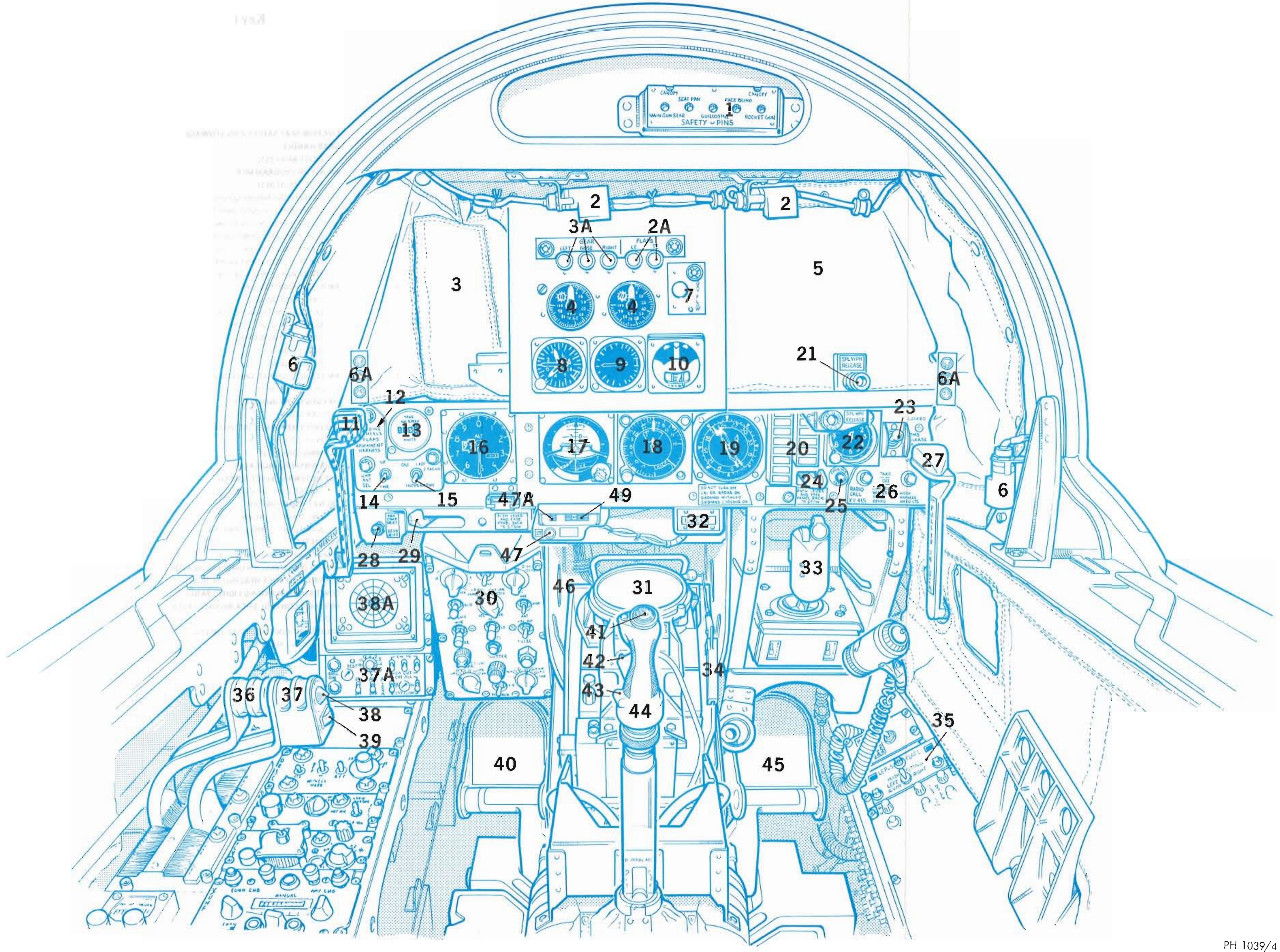



5—1 Fig 5 Rear Cockpit—Left Side
◆ *(Illustration updated)* ◆

PH1038/1

## Key to Fig 6 — Rear Cockpit — Forward View (Blocks 31 to 33)

1 Ejection seat safety pins stowage bracket
2 Red floodlights
2A Flaps position indicators
3 Left curtain assembly
3A Gear position indicators
4 Left and right RPM gauges
5 Right curtain assembly
6 Red floodlight
6A AOA indexer lights
7 Oxygen flow indicator
*OXY FLOW*
8 Accelerometer
9 Vertical speed indicator
10 Turn-and-slip indicator
11 Canopy jettison handle
*PULL TO JETT*
12 Landing checklist
13 True airspeed indicator
14 UHF antenna select switch
*UHF ANT SEL, UP - LWR*
15 CNI/NAV COMP switch
*CNI 1 - ADF, 2 - TACAN*
*NAV COMP, 1 - BRG, 2 - TRACK*
16 Altimeter
17 Remote attitude indicator
18 Airspeed and mach number indicator
19 Bearing/distance/heading indicator
20 Telelight panel
21 Special weapons release monitor light
*SPL WPN RELEASE - PRESS TO TEST*
22 Clock
23 Bomb release safety lock switch
*BOMB RELEASE SAFETY LOCK, LOCKED - UNLOCKED*
24 Antenna control stick release lever
25 Equipment cooling reset switch
*COOLING RESET*
26 Take-off checklist
27 Canopy manual unlock handle
*PULL TO UNLOCK*
28 Drift select switch
*NAV COMP DRIFT - ZERO DRIFT*
29 Radar set control panel release lever
30 Radar set control panel
31 Radar indicator
32 Command eject light
33 Radar antenna hand control (post-mod 650 the collision course select switch becomes the airborne interrogator system challenge switch)
34 Radar indicator release lever
35 Lepus flare control panel
*Contains the following controls and indicators:*
*HEIGHT SETTING switch, LEFT & CTR - RIGHT*
*LEFT & CTR setting indicator window*
*RIGHT setting indicator window*
36 Left engine throttle lever
37 Right engine throttle lever
37A Passive warning receiver control
38 Speed brakes control switch
*SP BRAKE, IN - OUT*
38A Passive warning bearing indicator
39 Microphone switch
*ICS - UHF*
40 Left brake/rudder pedal
41 Aileron/stabilator trim switch
42 Nosewheel steering button
43 Emergency disengage button
44 Control column
45 Right brake/rudder pedal
46 Master caution light
47 Low height warning repeater light
47A SEAM LOCK light (post-mod 667)
48 Not used
49 IFF indicator lights panel (post-mod 607)
*Contains the following indicators:*
*ACC FAIL*
*BIT*
*XPDR JAM*
*NO CHAL*

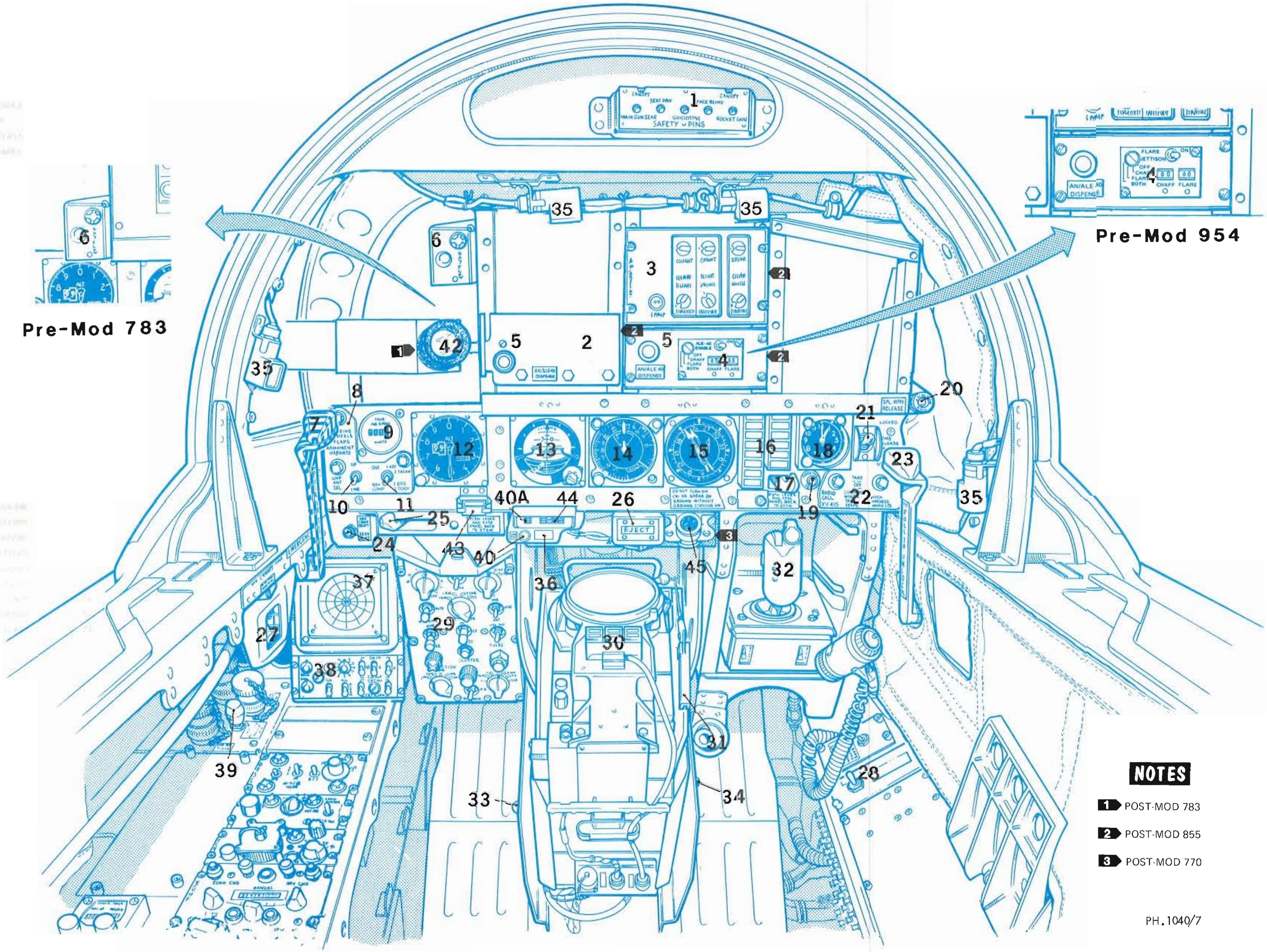



**5-1 Fig 6 Rear Cockpit - Forward View (Blocks 31 to 33)**

# Key to Fig 7 Rear Cockpit - Forward View (Blocks 34 to 38)

1' EJECTION SEAT SAFETY PINS STOWAGE BRACKET
2 GRAB HANDLE
*(POST-MOD 855)*
3 AN/ALE-40 PROGRAMMER
*(POST-MOD 855)*
*Contains the following controls.*
*CHAFF BURST COUNT switch*
*CHAFF BURST INTERVAL switch*
*CHAFF SALVO COUNT switch*
*CHAFF SALVO INTERVAL switch*
*FLARE BURST COUNT switch*
*FLARE BURST INTERVAL switch*
4 AN/ALE-40 CONTROL UNIT
*(POST-MOD 855)*
*Contains the following controls:*
*Mode switch, OFF-CHAFF-FLARE-BOTH*
*FLARE JETTISON switch*
*CHAFF counter*
*FLARE counter*
5 AN/ALE-40 DISPENSE SWITCHES
*(POST-MOD 855)*
6 OXYGEN FLOW INDICATOR
*OXY FLOW*
7 CANOPY EMERGENCY JETTISON HANDLE
*PULL TO JETT*
8 LANDING CHECKLIST
9 TRUE AIRSPEED INDICATOR
10 UHF ANTENNA SELECT SWITCH
*UHF ANT SEL, UP-LWR*
11 CNI NAV COMP SWITCH
*CNI, 1-ADF, 2-TACAN*
*NAV COMP, 1-BRG, 2-TRACK*
12 ALTIMETER
13 REMOTE ATTITUDE INDICATOR
14 AIRPSEED AND MACH NUMBER INDICATOR
15 BEARING DISTANCE HEADING INDICATOR
16 CENTRALISED WARNING LIGHTS PANEL
17 ANTENNA CONTROL STICK RELEASE LEVER
18 CLOCK
19 EQUIPMENT COOLING RESET SWITCH
*COOLING RESET*
20 SPECIAL WEAPON RELEASE MONITOR LIGHT
*SPL WPN RELEASE-PRESS TO TEST*
21 BOMB RELEASE SAFETY LOCK SWITCH
*BOMB RELEASE SAFETY LOCK, LOCKED-UNLOCKED*
22 TAKE-OFF CHECKLIST
23 CANOPY MANUAL UNLOCK HANDLE
*PULL TO UNLOCK*
24 DRIFT SELECT SWITCH
*NAV COMP DRIFT-ZERO DRIFT*
25 RADAR SET CONTROL PANEL RELEASE LEVER
26 COMMAND EJECT LIGHT
27 CANOPY NORMAL CONTROL LEVER
28 MISSILE MONITORING POD CONTROL PANEL
*Contains the following control:*
*LH-OFF-RH*
29 RADAR SET CONTROL PANEL
30 RADAR INDICATOR
31 RADAR INDICATOR RELEASE LEVER
32 RADAR ANTENNA HAND CONTROL STICK
33 ICS FOOT SWITCH
34 UHF FOOT SWITCH
35 RED FLOODLIGHTS
36 MASTER CAUTION LIGHT
37 INDICATOR BEARING
38 CONTROL RECEIVER
39 PASSIVE WARNING VOLUME CONTROL
40 LOW ALTITUDE WARNING REPEATER LIGHT
40A SEAM LOCK INDICATOR LIGHT
41 DELETED
42 TELESCOPIC SIGHTING SYSTEM
*(POST-MOD 783)*
43 SHOOT LIGHT
44 IFF INDICATOR LIGHTS PANEL
*Contains the following indicators.*
*ACC FAIL*
*BIT*
*XPDR JAM*
*NO CHAL*
45 CW POWER MONITOR INDICATOR
*(POST-MOD 770)*

PH13361
(XEROX)

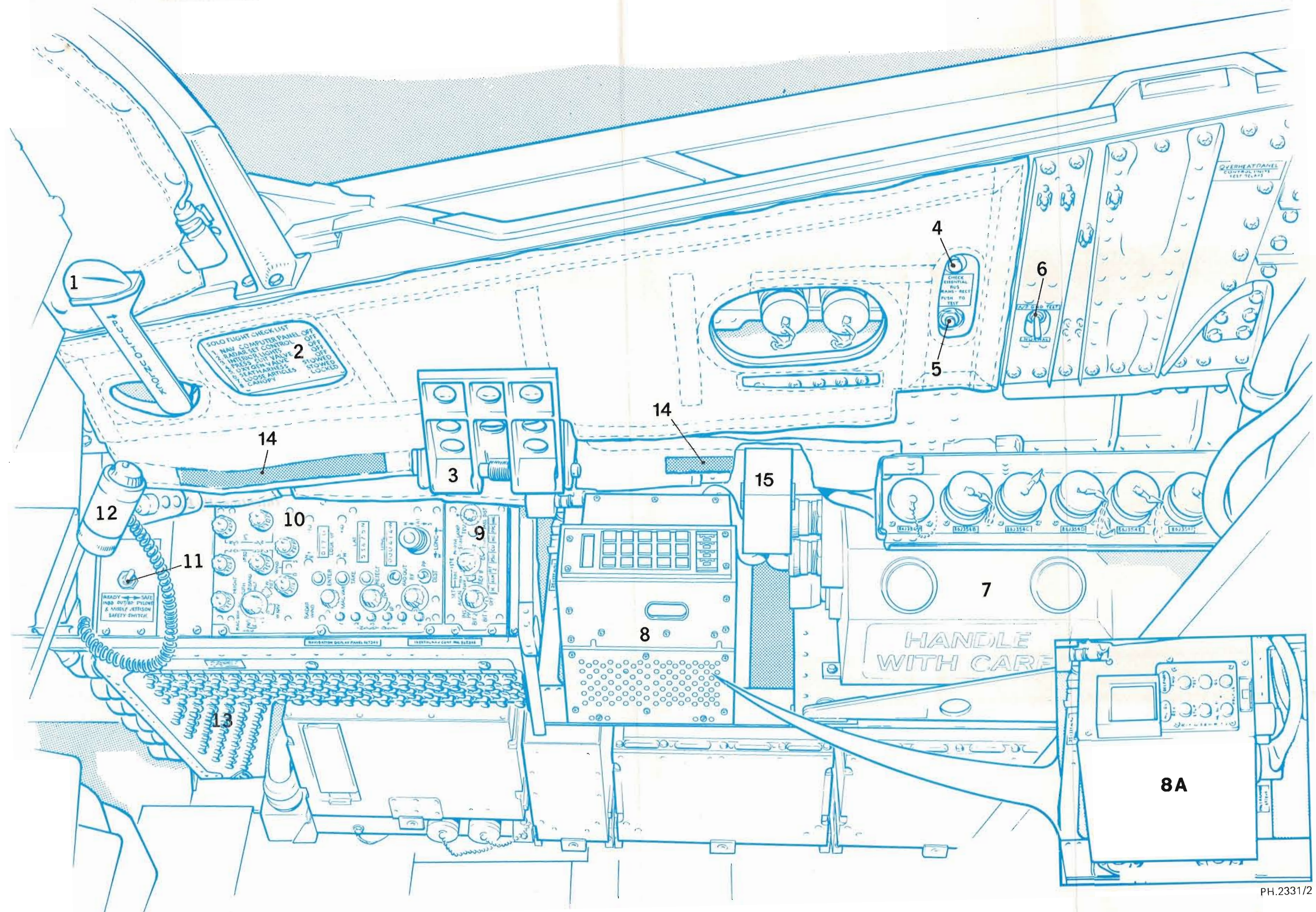



5-1 Fig 7 Rear Cockpit - Forward View (Blocks 34 to 38)

## Key to Fig 8 Rear Cockpit - Right Side

| | |
|---|---|
| 1 | CANOPY MANUAL UNLOCK HANDLE |
| | *PULL TO UNLOCK* |
| 2 | SOLO FLIGHT CHECKLIST |
| 3 | ARMREST ASSEMBLY |
| 4 | ESSENTIAL DC BUS TEST LIGHT |
| 5 | ESSENTIAL DC BUS TEST SWITCH |
| 6 | AUTOPILOT GROUND TEST SWITCH |
| | *A/P GND TEST - NORMAL* |
| 7 | INERTIAL PLATFORM |
| 8 | MCS TEST CONTROL INDICATOR |
| | *(POST-MOD 804)* |
| 8A | MCS SELECTOR TEST PROGRAMMER |
| | *(PRE-MOD 804)* |
| 9 | INERTIAL NAVIGATION CONTROL PANEL |
| 10 | NAVIGATION DISPLAY CONTROL PANEL |
| 11 | INBD - OUTBD PYLONS & MISSILE JETTISON SAFETY SWITCH |
| | *READY-SAFE* |
| 12 | UTILITY SPOT AND FLOODLIGHT |
| 13 | NO.2 CIRCUIT BREAKER PANEL |
| 14 | 'VELCRO' CONSOLE COVER ATTACHING STRIPS |
| 15 | TACTICAL INFORMATION RETRIEVAL UNIT |
| | *(POST-MOD 5102)* |
| 16 | AC POWER SUPPLY TEST RECEPTACLE |
| 17 | FIRE DETECTION/OVERHEAT TEST RECEPTACLE |
| 18 | NAVIGATOR COMPUTER |
| 19 | POWER SUPPLY UNIT |
| 20 | WEAPON AIMING COMPUTER |
| 21 | PRESENT POSITION COMPUTER |
| 22 | MISSILE MONITORING POD CONTROL PANEL |
| | *(POST-MOD 5062)* |
| | *Contains the following control.* |
| | *LH-OFF-RH* |
| 23 | INAS TEST RECEPTACLES |
| 24 | OVERHEAT CONTROL PANEL ASSEMBLY |
| 25 | PLATFORM AND COOLING UNIT RACK |

PH13362
(XEROX)




5—1 Fig 8 Rear Cockpit — Right Side
◆ *(Illustration Updated)* ◆

*Intentionally Blank*