A HUMAN FACTORS EVALUATION OF AN ELECTRONIC DISPLAY SYSTEM FOR AN AIRCRAFT FLIGHT DECK

by

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A Master's Thesis

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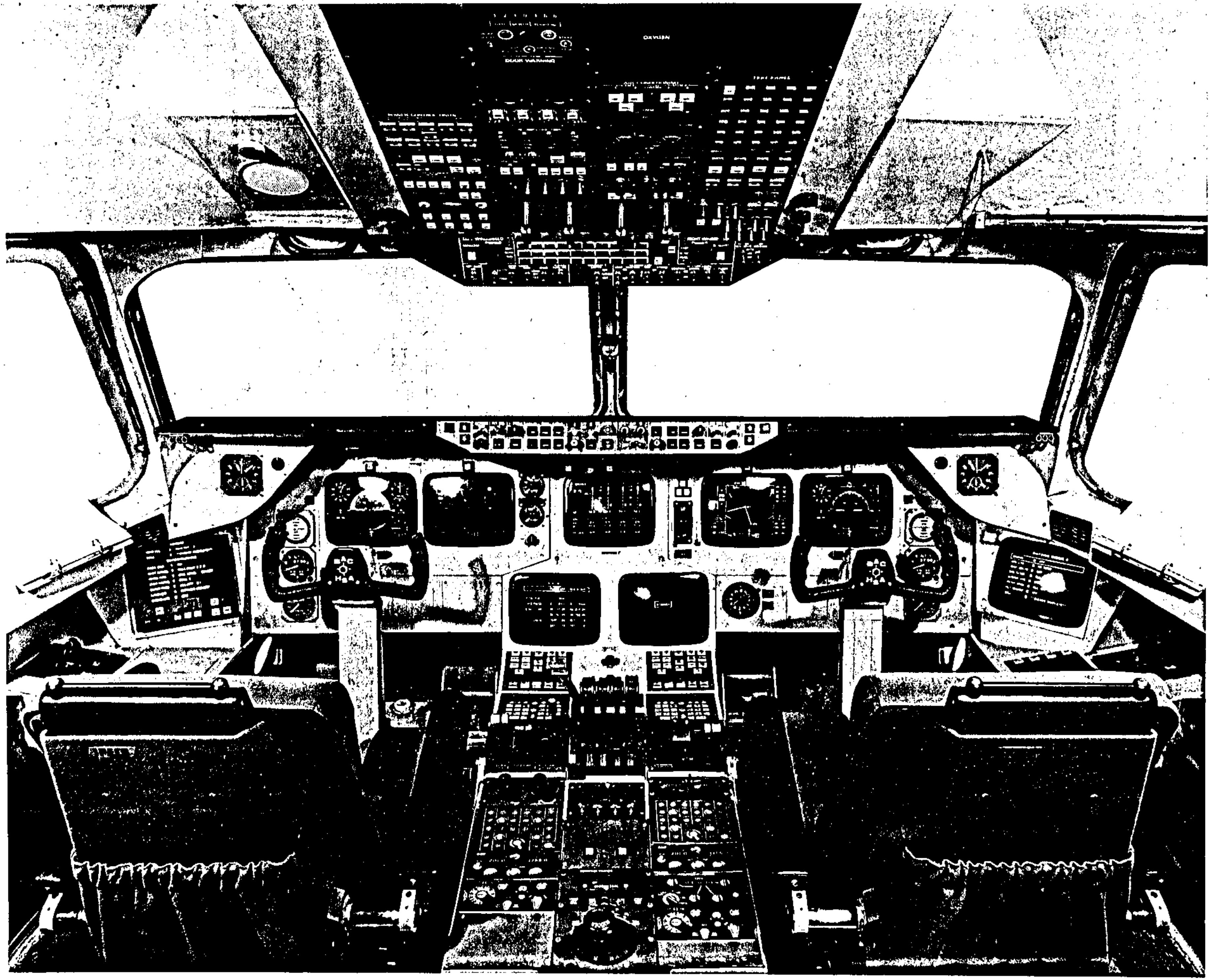

SUMMARY

This thesis describes a two and a half year study of the human factors associated with the introduction of electronic displays, i.e. cathode ray tubes, and their associated controls onto a civil transport aircraft flight deck.

A simulator was constructed for the evaluation which was managed jointly by the British Aircraft Corporation Ltd. and Hawker Siddeley Aviation Ltd. (now British Aerospace) under a Ministry of Defence contract.

The programme was divided into three parts:-

(A) An initial pilot assessment on the general aspects of the flight deck, but mainly aimed at familiarizing the pilots with the aircraft's new systems.

(B) An evaluation of the systems displays and controls for normal operation and for a selection of systems failures.

(C) An evaluation of electronic flight displays and the electronic presentation of aircraft documentation.

Because the human factors work was an integral part of the whole evaluation project, the project itself is described in this thesis, but with the emphasis placed upon the human factors programme. Specific chapters introduce the human factors research, describe the methods adopted in each of the three parts, and summarise and discuss the results and conclusions.

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ACKNOWLEDGEMENTS

For permission to present this thesis I must acknowledge with grateful thanks the Ministry of Defence and British Aerospace.

Many people have been engaged on the project from which I am able to present this research study, but I would like to thank particularly four persons at the Weybridge-Bristol Division of British Aerospace for their help:- Mr. P.M.White, who, as Observer on the Flight Deck, collected much of the data to my specifications; Mr. B.J.Bleach for help in analysing and presenting the data; and Messrs. A. Teeder and J. Stockdale who provided the computer print-outs to my requests.

I also wish to thank Prof. B. Shackel of Loughborough University of Technology for his help and guidance.

GLOSSARY OF TERMS AND ABBREVIATIONS

ADC	- Air Data Computer
ADI	- Attitude Director Indicator
Aerad	- Make of Navigation Charts
AFCS	- Automatic Flight Control System
AIR COND	- air conditioning
ARINC	- Aeronautical Radio Incorporated
ATC	- Air Traffic Control
ATIS	- pre-recorded weather details
BAC	- British Aircraft Corporation Ltd.
BAC 1-11	- narrow-bodied twin-jet short-haul aircraft
BAC 3-11	- wide-bodied twin-jet short-haul aircraft project, cancelled in 1970.
Basic Tee	- the layout of primary flight instruments on a conventional aircraft
BITE	- Built-in Test Equipment
CAA	- Civil Aviation Authority
CAS	- computed airspeed
CDG	- Paris (Charles de Gaulle) Airport
CNCL	- Cancel
CRT	- cathode ray tube
CSD	- constant speed drive
CTRLS	- flying controls
DME	- distance to a VOR radio beacon
EADI	- electronic attitude director indicator
EFI	- electronic flight instrument
EGT	- exhaust gas temperature
EHSI	- electronic horizontal situation indicator
ELEC	- electrics
ENG	- engine
EPR	- engine pressure ratio

ETA	- estimated time of arrival
F1,F2,F3,F4	- electronic flight displays (see Figure 1)
FL	- Flight Level (aircraft height to altimeter pressure setting of 1013.2 mb)
HDG	- heading
HSA	- Hawker Siddeley Aviation Ltd.
HSI	- horizontal situation indicator
HYD	- hydraulics
IAM	- Institute of Aviation Medicine, Farnborough
ILS	- instrument landing system
INJ	- fault injection
INS	- inertial navigation system
LED	- light emitting diode
LP	- low pressure
L1011	- Lockheed wide-bodied tri-jet airliner
MOD	- Ministry of Defence
MWS	- master warning system
N2	- speed of high pressure turbine
P1	- left-hand seated pilot
P2	- right-hand seated pilot
PRESSN	- Pressurization
QFE	- height of aircraft with altimeter set to a pressure giving 0 ft. on ground.
QNH	- height of aircraft with altimeter set to a pressure giving 0 ft. at mean sea level
RAE	- Royal Aircraft Establishment
REM	- fault removal
RMI	- radio magnetic indicator
R/T	- radio telephone
S1,S2,S3	- electronic systems displays (see Figure 1)
S4	- electronic documentation display (CRT)
SING ENG	- single engine format

VC-10	- BAC constructed long-range four-jet aircraft
VDU	- computer term for CRT
VHF	- very high frequency radio
VOR	- VHF omnidirectional radio beacon
WAPNT	- as WPT, but printed-out by computer
WPT	- waypoint on flight plan

CHAPTER 1

INTRODUCTION

1.1. This thesis describes a programme of research into the human factors associated with the introduction of electronic displays and controls into civil transport aircraft. The programme was managed and performed jointly by Hawker Siddeley Aviation Ltd. and British Aircraft Corporation Ltd. (now British Aerospace) under a Ministry of Defence contract. Although very many people were involved in a programme of this magnitude, it is the planning, conduct and analysis of the human factors programme for which the author was responsible and with which this thesis is concerned.

1.2. The use of electronic displays to replace conventional electro-mechanical instruments in civil transport aircraft has been under discussion for many years and has formed the subject of other research studies, mainly in the United States of America. Recent advances in electronic techniques have demonstrated their feasibility in the next generation of aircraft. The study described herein is unique in that it was concerned with the development of a total aircraft system and demonstrated the operational and human factors aspects in addition to the gain of experience in the design and manufacture of suitable systems.

1.3. The escalating costs of aircraft operation must be minimised if future air transport is to be competitive in today's inflationary situation. One method is to achieve two-crew operation and this can only be obtained by ensuring that the crew workload is acceptable and flight safety is not degraded. Although two-crew operation has been demonstrated airline influence has led to the possibility that three-crew operation may still continue. As a result the Flight Deck has been designed to enable a third member to operate as an integral part of the flight crew if that manning level is to continue.

1.4. Although not directly related to human factors the programme has embraced cost of ownership studies to reduce, or at least maintain, these costs at a relatively constant level in spite of increasing system complexity. The use of electronic displays appears to offer some significant advantages.

1.5. The programme of work was designed to explore the various aspects of flight deck design and management using the technology appropriate to subsonic transport aircraft likely to enter airline service during the 1980's.

1.6. The programme was divided into three parts and this thesis has been structured to reflect this. Part A was aimed at making the pilots familiar with the Flight Deck, the displays and control systems and the techniques to be employed in the assessments. Part B concentrated on the evaluation of the Systems Displays and Controls, and the Flight Displays evaluation formed the major part of Part C.

1.7. In this thesis each of the three parts is considered by first describing the Flight Deck, the displays and controls and the simulation used for that part (see chapters 4,5,6,7,14,21 and 22). The human factors aspects are next desribed with chapters on the Monitoring and Recording facilities and the Programme and Exercises (see chapters 8,9,15,16,23 and 24). Other essential aspects of the programme, e.g. the Check Lists used and the Navigation, follow (see chapters 10,11,17 and 18). A description of each Questionnaire is also included (see chapters 12,19 and 25). Each part concludes with a chapter on the results, a discussion and the conclusions (see chapters 13,20 and 26). Summaries of the major findings and the lessons learned from the programme are included at the end of the thesis (see chapters 28,29 and 30).

1.8. Where illustrations are referred to in the text these are included at the end of the chapter concerned unless referred to in a previous chapter.

1.9. Throughout the programme the human factors aspects were integrated into the whole study. It was decided that to deal with the human factors separately would have been artificial. A specific introduction to the human factors is given in Chapter 2 in which particular aspects are referred to by relevant chapters, but the results are not separated out into equipment and human factors aspects in each part. However, the specific human factors results are separated in Chapter 29 following the general summary and conclusions in Chapter 28. The thesis ends with a discussion of the human factors programme and some suggestions for future work (Chapter 30).

CHAPTER 2

HUMAN FACTORS PROGRAMME

2.1. The Human Factors Programme was carried out in two phases. Phase 1 investigated the feasibility of using electronic displays for the aircraft systems displays and Phase 2 explored the use of electronic flight displays. Phase 1 started in mid-1975 and lasted for eighteen months and Phase 2 was carried out between May 1977 and October 1977 although most of the planning started before these dates.

2.2. The project used a static two-crew flight deck and comprised a research programme which investigated the human factors associated with the electronic displays and their related control techniques. The programme utilised facilities and equipment made available to the British Aircraft Corporation Ltd. at Weybridge, Surrey.

2.3. The static flight deck employed was the then existing BAC 3-11 mock-up suitably modified for the task. Control column and rudder pedals with rudimentary feel, and flap, trim and throttle controls were incorporated.

2.4. Digital computing techniques were employed to allow the full simulation objectives of the programme to be achieved.

2.5. The aircraft systems simulated were based on a four-engine civil transport (Super VC-10) with suitable modifications and adaptions to take account of advances in the state of the art and to omit complexities not directly relevant to future short haul two-crew aircraft.

2.7. The symbology for the electronic flight displays used in Phase 1 was limited to that developed for a study at BAC Bristol in 1974 (see ref: B.J.Bleach, CAD/AP-BJB/100, Jan 1975). Phase 2 was an evaluation of symbology developed specifically for this programme.

2.8. The assessment programme objectives were to study:

a) Practical arrangements of CRT displays in relation to pilot seat and eye reference points and within likely design constrants.

b) The reaction of pilots to seven CRT displays in a representative flight deck environment in conditions of simulated flight.

c) The ability of pilots to cross-monitor CRT displays.

d) The effect of off-set presentations and reversionary data (e.g. simulated gross failures).

e) The ability of pilots to control systems with control panels remotely situated in relation to their associated displays.

f) Crew workload assessment under nomal and failure conditions.

g) Comparison of varying levels of "Basic Tee" conventional instrumentation with EADI and EHSI.

h) Pilots' reactions to presentation of relevant systems displays when initiated automatically by the master warning system.

i) Recommend locations for systems control panels.

j) Assessment of crew workload associated with manual selection of display formats and the extent to which the required display formats can be presented as a function of normal mode selection (e.g. an An AFCS (automatic flight control system) mode selection will cause the appropriate Flight Information format to be displayed).

k) Recommend engine and systems displays formats.

2.9. The pilot assessments for both Phases 1 and 2 were carried out by suitably qualified engineering test pilots provided by BAC, HSA, the Ministry of Defence, the Civil Aviation Authority Airworthiness Division, and several senior airline pilots. Ideally airline pilots should have been used throughout, but the practicalities of arranging these were not possible. In addition, pilots who were able to appreciate and comment on some of the engineering aspects were preferred.

2.10. For the human factors research both subjective assessments (see chapters 12,19 and 25) and objective measurement techniques (see chapters 8,9,15,16,23 and 24) were employed in each of the three parts of the programme.

2.11. Each pilot was required to undertake a set programme of exercises (see chapters 9,16 and 24) in which he was required to fly given flight profiles (see chapters 11 and 18). During the flights he was asked to read certain parameters from each of the formats and his response times were measured. The readings had two aims, firstly to measure his response time to give an indication of the clarity of the data on the format, and secondly to ensure that he had seen the data on the formats in order that he could comment later in the programme. The exercises of the Familiarization Programme (see chapter 9) provided a background for each pilot to enable him to become used to the techniques employed and the

Note: A complete list of abbreviations is given on pages 9 to 11.

Flight Deck in advance of the Systems Evaluation.

2.12. Some of the readings involved format selections, particularly later in the programme, and these enabled the pilots to become familiar with the format controls and the formats on which the respective information was displayed.

2.13. Simple exercises were given first and these were used, in turn, as bases for the succeeding exercises, i.e. the programme was designed on a "building-block" principle. The later exercises used the knowledge the pilots had gained to enable them to deal with simple failures and malfunctions of the displays and aircraft systems. Their reactions to the MWS (master warning system) were observed and their times taken to remedy or cope with the failures and malfunctions injected. The Flight Plans used for the exercises also became progressively more complicated, in a similar manner to the exercises. For more explanation see para. 9.2.2.

2.14. Similar methods were used for the evaluation of the EFIs (electronic flight instruments) although, because of the shorter time available, the programme was more concentrated.

2.15. Questionnaires (see chapters 12,19 and 25) were given to each pilot at the end of each day. Simple questionnaires were used in the Familiarization Programme which included rating scales. From the lessons learned in using these questionnaires improvements were made for both the Systems and EFI evaluations to enable considerably more detail to be covered in the time available.

2.16. Each pilot completed his programme with a tape recorded debriefing. These debriefings were conducted using the Observer's notes and the Questionnaires as a basis for the discussions to ensure all aspects were covered. These debriefings concluded with discussions on general topics. For the EFI evaluation a further debriefing interview was given as a result of the lessons learned earlier in the programme.

2.17. For detail about the human factors aspects of the programme see the following:-

Techniques of Measurement	- Chaps. 8, 15 and 23
Programme and Exercises	- Chaps. 9, 16 and 24
Questionnaires	- Chaps.12, 19 and 25

2.18. Insufficient data were collected for comprehensive statistical analyses, but they are presented pictorially in Chapter 13, Appendix 1 and Appendix 2.

CHAPTER 3

LITERATURE SURVEY AND DISCUSSIONS ON RELATED STUDIES

3.1. Prior to the commencement of the programme many reports and papers were consulted and a list of these is shown in para. 3.2. Discussions took place with about a dozen persons working in associated fields were electronic displays were used. A brief summary of the discussions is given in para. 3.3.

3.2. Literature Survey - (References)

The following reports were studied:-

AGARD - "Electronic Displays" CP167, 1975 (contains many relevant papers.

Baty, D.L. - "Rationale and Description of a co-ordinated Cockpit Display for Aircraft Flight Management", NASA TM X-3457, 1976.

Beyer, R., Schenk, H.D. & Ziellow, E. - "Investigations on the Readability and Interpretability of Electronic Displays", RAE Library Translation 1641, Sept. 1973.

Beyer, R. - " Assessment of Cockpit Displays", Translation of DLR-FB 7303, 1973.

Beyer, R. - "Comparison of Conventional and Advanced Aircraft Displays", AGARD Conference.

Bird, J.M. - " On the display of Three-dimensional Air Traffic Control Situations", A.P. Note 47, Applied Psychology Dept., University of Aston, 1975.

Bleach, B.J. - "A simulator Evaluation of Electronic Displays", BAC Filton, CAD/AP-BJB/100, Jan. 1975.

Bregström, B. - "Interpretability studies of electronic flight instruments", SAAB TN61, 1967.

Brigham, M.R. - "Some quantitative considerations in questionnaire design and analysis", Applied Ergonomics 1975, 6.2., 90-96.

Brown, M. - "Trends in flight deck instrumentation from Smiths Industries", Interavia 7.1977 p 736-7.

Christensen, J.M. & Mills, R.G. - "What does the operator do in a Complex System?" Human Factors, 1967, 9(4), 329-340.

Cooper, G.E. & Harper, R.P. - "The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities", NASA TN D-5153, 1969.

Duncanson, J.P. - "The measurement of user opinion of telephone transmission quality", Fourth International Symposium on Human Factors in Telecommunications, Bud Wessee, West Germany, Sept. 1968.

Dersch, W.E. and Johnson, R.T. - "Computer-Managed Display System for Advanced Commercial Transports", Boeing Co.

Elson, B.M. - "Aircraft Systems Monitor Under Study", Aviation Week & Space Technology, Aug.4, 1975 p46-9.

Gray, M. - "Questionnaire typography and production", Applied Ergonomics, 1975. 6.2. p81-9.

Grindon-Ekins, P.M. & Humphries, D.E. - "Digital Computing and Aircraft Displays", Journal of Navigation 1974, Vol 27 Pt.3, p331-341.

Hall, G.S. - "The Dependence of Reaction Times on the Location of the Stimulus".

Heglin, H.J. - "Navships Display Illumination Design Guide. Section III - Human Factors", AD-770 478, 1973.

Kelly, G.R. & Wargo, M.J. - "Cross-Adaptive Loading Tasks", Human Factors, 1967, 9(5), 395-404.

Knowles, W.B. - "Operator Loading Tasks", Human Factors, April 1963, pp155-161.

Krzanowski, W.J. & Nicholson, A.N. - "Analysis of Pilot Assessment of Workload", Aerospace Medicine, Sept.1972, p993-997.

Oborne, D.J. - "Examples of the use of Rating Scales in Ergonomics Research", Applied Ergonomics 1976, 7.4. p201-4.

Oborne, D.J. & Clarke, M.J. - "Questionnaire surveys of passenger comfort", Applied Ergonomics, 1975, 6.2., 97-103.

Premsalaar, S.J. et al - "Integrated Information Presentation and Control Systems Study", AFFDL-TR-70-79, 1971.

Ritchie and Baker - "Psychological Aspects of Cockpit Design - A Symposium Report", WADC Tech. Rept. 57-117.

Rohmert, W. & Laurig, W. - "Work Measurement: Psychological and physiological techniques for assessing operator and workload", Int. J. Prod. Res., 1971, Vol.9, No.1, 157-168.

Rolfe, J.M. et al - "Evaluating Measures of Workload using a Flight Simulator", AGARD CP-146, Apr. 1974.

Rolfe, J.M. & Chappelow, J.W. - "The Application of Aircrew Opinions on Cockpit Tasks and Equipment to Flight Safety Research", AGARD CP-132, 1973.

Roscoe, S.N. & Kraus, E.T. - "Pilotage Error and Residual Attention: The Evaluation of a Perfomance Control System in Airborne Area Navigation", Navigation, Vol.20, No.3, 1973.

Schenk, H.D. & Kohnen, E. - "Comparison of Conventional and Electronic Indicator Instruments in a Flight Simulator and in a Test Aircraft", ESRO TT-13, 1974.

Semple, C.A. et al - "Analysis of Human Factors Data for Electronic Flight Display Systems", AFFDL-TR-70-174, 1971.

Sinclair, M.A. - "Questionnaire Design", Applied Ergonomics 1975, 6.2., 73-80.

Waller, M.E. & Wise, M.A. - "The Oculometer in Flight Management Research", AIAA Paper 75-107, 1975.

Vartabedian, A.G. - "The Effects of Letter Size, Case, and Generation Method on CRT Display Search Time", Human Factors 1971, 13(4), 363-8

Wharf, J. - "Flight Instrument Displays of the Future", Air Clues, Feb. 1977, p52-56.

3.3. Discussions on related studies

3.3.1. R.A.E. (Mr. S. Cox)

The Royal Aircraft Establishment has been responsible for the design and operation of eye movement recorders and has used them to analyse the eye movements of helicopter pilots in low level flight. The eye recorder could have a useful application for the assessment of electronic displays and the advanced flight deck. At the time of this study it was thought that the eye recorder would not be cost effective to use because of the length of time required for analysis which was done manually (about one man-week for five minutes recording time). However, a method of analysis by computer is now available.

3.3.2. Institute of Aviation Medicine (Dr.J.M.Rolfe and Mr. J. Chappelow)

The discussions at the I.A.M. were mainly about workload measurement. Methods of both measuring workload objectively and using subjective assessment techniques were considered. A combination of measures seemed to be the most appropriate for assessing flight deck layout, task complexity and operator workload. It was generally felt that direct performance measures were preferable to secondary task techniques.

3.3.3. Loughborough University of Technology (Dr. E.Edwards)

Studies at Loughborough had been concerned with flight deck activity on the British Airways Trident fleet. Similar conclusions were reached as with I.A.M.

3.3.4. University of Aston (Mr. D. Whitfield)

Aston University were working on a contract with R.R.E.

Malvern on techniques for predicting aircraft flight paths on ATC displays. Various methods of representing the three spatial dimensions on a two dimensional display were being considered. The discussion was mainly concerned with electronic displays and associated operator problems.

3.3.5. H.S.A. Brough (Mr. J.W. Lyons and Mr. J. Brown)

H.S.A. Brough were concerned with similar problems to those associated with the Advanced Flight Deck Study. At the time of the discussion they were defining workload measurement and analysis techniques for the use of electronic displays in military fighter aircraft. They were also concerned with the control of remotely piloted vehicles by a navigator of a fighter aircraft while at the same time performing his normal navigation functions. Electronic displays were being used for this function.

The discussions were mainly about questionnaires and direct performance measures.

3.3.6. H.S.A. Kingston (Messrs. J.Allen, K.Dunkelly, I.Best, M.Ruscoe-Pond and N.Ibbert)

H.S.A. Kingston were concerned with the design of a fighter aircraft whose instrumentation could only be contained in a small panel area. The use of electronic displays was thought to be appropriate. The team was also conducting workload studies, but in the laboratory situation. Their problems of method, measurement and analysis were similar to those for the Advanced Flight Deck Study. Many of their measurements were similar to those then proposed for the A.F.D. programme, i.e. measurement of reaction times, displays reading and subjective ratings.

PART A

FAMILIARIZATION PROGRAMME

CHAPTER 4

DESCRIPTION OF FLIGHT DECK

4.1. Flight Deck Structure and Main Panels

The flight deck was a wooden mock-up originally constructed for the now defunct BAC 3-11 project. The windows and sill lines of this aircraft were maintained, together with the glareshield, which gave a 19° downward forward view to the pilots. Modifications were made to the glareshield for the EFI assessment and these are described in Chapter 21.

The original instrument and roof panels were removed and replaced with metal structures to which were attached the sub-panels forming the complete main displays and roof layouts.

4.2. Displays

Seven standard commercial CRT displays of the Litton Precision Product type SNA9/N were installed.

The criteria observed were:-

a) The EADI centres to be installed on the pilots' centre-lines.

b) The glareshield visual cut-off to be as defined for the BAC 3-11 aircraft.

c) The control column visual cut-off to be as defined for the BAC 3-11 aircraft.

d) Recognition to be given to the dimensions of the ARINC instruments and the structural limitations of the BAC 3-11 aircraft.

To the left upper panel and the right upper panel for P1 and P2, respectively, were mounted LED displays of waypoint numbers (1 to 9) (see Chapter 11) and 'Outer', 'Middle' and 'Airways' marker lights which were functional.

Laid out around the CRT displays were standby instruments. These were:

a) Artificial Horizon for each pilot (representation only)

b) Altimeter for each pilot (representation only)

c) Airspeed Indicator for each pilot (representation only)

d) Engine Instruments. One each for EPR and EGT and both functional. (The EPR was changed to N2 after the Familiarization Programme). A switch was provided to allow these instruments to be switched to each of the four engines. An OFF position was also provided in order that the pilots' normal scanning patterns of the CRT's would not be interrupted by moving needles.

e) Miscellaneous, e.g. a functional clock for each pilot, RMI (representation only) and two brake pressure gauges (representations only).

Placard speeds were provided on the main instrument panel together with clip-on cards for specific flight data relevant to each flight configuration.

The layout of the panel is shown in Figure 1.

4.3. Pedestal

The Pedestal was a VC-10 unit which was modified by shortening the pitch trim levers, both main and standby, in order to improve access to the new forward end of the pedestal (the displays controllers) and the visibility of the central CRT displays (S1 and S3) from the seat aft of the pedestal.

Forward of the throttles was a three-digit LED display giving 'distance to go to the next waypoint' (see Chapter 11). Forward of this display was the EPR setting knob.

To improve visibility of the centre pedestal the throttle idle position was moved forward.

The main area of the pedestal aft of the throttle levers housed a set of cardboard dummy radio and navigation panels, but the main VHF radio channel select panel was a functional dummy. The controls, e.g. trims, throttles, slats, flaps, etc., were functional, the thrust reverser levers were also functional. These lever movements provided analogue voltages relative to position by means of linear or rotary potentiometers coupled to driven linkages.

The layout of the Pedestal is shown in Figure 2.

4.4. Roof Panel

The majority of functional items were installed in the forward roof panel, the Master Warning panel was a separate roof panel above the windscreen line. The systems sub-panels were of three types:

i) Fully Functional. Any demand manually injected or otherwise initiated resulted in an appropriate response from the displays, controls, M.W.S., etc. from a complete computer model of that system.

ii) Functional Dummy. Warning lights illuminated and could be acted on appropriately, but the related system performance was not simulated.

iii) Non-functional Dummy. This was an inert panel or part of a panel. It was made up of actual buttons or switches, but its purpose was only to assess its suitability for two-crew operation.

The layout of the Roof Panel is shown in Figure 3.

4.5. Flying Controls

The control columns were BAC 1-11 flight standard units mounted below the floor on a metal structure and cross-connected electrically. Feel in pitch and roll was provided by an electro-hydraulic feel unit of proven design. Associated with this was a feel computer to enable virtually any feel characteristics to be simulated.

A stick-shaker was provided to shake at 5 c/sec. for stall warning.

Rudder force was not critical for the tasks so it was designed as bungee loaded to a fixed arbitrary force. The pedal position was variable and rudder trim was simulated. Tailplane and aileron trims were functional. Nosewheel steering was not provided.

4.6. AFCS Controller

The AFCS was based on a configuration likely to be required, but was not compatible with the existing facilities of the VC-10.

In order to correlate the course select functions of the flight system and the autopilot with the radio frequency selected the navigation frequency was transferred from the combined NAV/COMM unit and resited on the Glareshield.

The autopilot and the flight director mode controls were located on the Glareshield on a panel 16.25 in. long.

The autothrottle system, course and heading inputs were also controlled from this panel. As the EFIs were paralleled only one input from course and heading was available, the other unit was a dummy.

It was assumed that in a modern aircraft the flight director and the autopilot modes would be fed from a central computer and only one selector would be required. It was possible to turn the flight director on and off, and with a similar situation on the autopilot either one or both systems could be activated as required. Autopilot manometric locks were selected on the AFCS panel, but these were restricted to the VC-10 standard.

The AFCS controller is shown in Figure 4. The controller was redesigned for the EFI evaluation and this new controller is described in Chapter 22.

4.7. Seats

The two pilots' seats were initially BAC 1-11 crew seats, but these were later changed to the variable-posture crew seat marketed by IPECO Europe Ltd. The seats were rail mounted and fully adjustable. A pilot's eye datum was provided to enable either pilot to establish his correct position. Lap-strap seat belts were provided to apply some constraint to crew movement, but full harness was not available.

Two, and later three, further seats were positioned behind the pilots for spectators and the Observer. The Observer's seat is described in Chapter 8.

4.8. Intercom

Five intercom jack-sockets were provided on the flight deck. A loudspeaker was provided in the Conference Annex and additional intercom facilities were available to the Flight Controller, Exercise Controller and the computer personnel.

The Pilots', Observer's and Controllers'/Computer personnel cross-talk could be selected or isolated as required.

Audible warnings (see Chapter 7) associated with the M.W.S. were mounted within the flight deck. Their tones could be injected into the headsets if required.

4.9. Recording Facilities

A tape-recorder was used by the Observer to record intercom conversation during selected periods and his comments on the exercises without the pilots' knowledge. (For the Systems Evaluation four additional recorders were installed for ATC simulation - see Chapter 11).

4.10. Flight Deck Lighting

There were three main sources of illumination:

a) A general low level background light from a 50" fluorescent batten facing forward and mounted above the entrance door.

b) Main instrument panel illumination was by 3 battens of small filament lights mounted under the glareshield.

c) A pair of concealed floodlights installed in the aft pedestal gave overall illumination of the roof panels.

All lighting was controllable from the appropriate lighting panel switches and dimmers.

4.11. Air Conditioning

The flight deck was fitted with two axial flow fans incorporating heater elements driven from a control panel capable of providing, cold, warm or hot air. The flow rate provided an air change every five minutes.

4.12. Miscellaneous

Engine noise was simulated in conjunction with throttle setting.

Wheel noise was simulated in conjunction with touchdown.

Push-button captions were applied in "Letraset" with a protective coat of varnish.

The CRT displays were fitted with neutral density filters to increase contrast ratio. Each also had an ON/OFF button above it at the top of the panel.

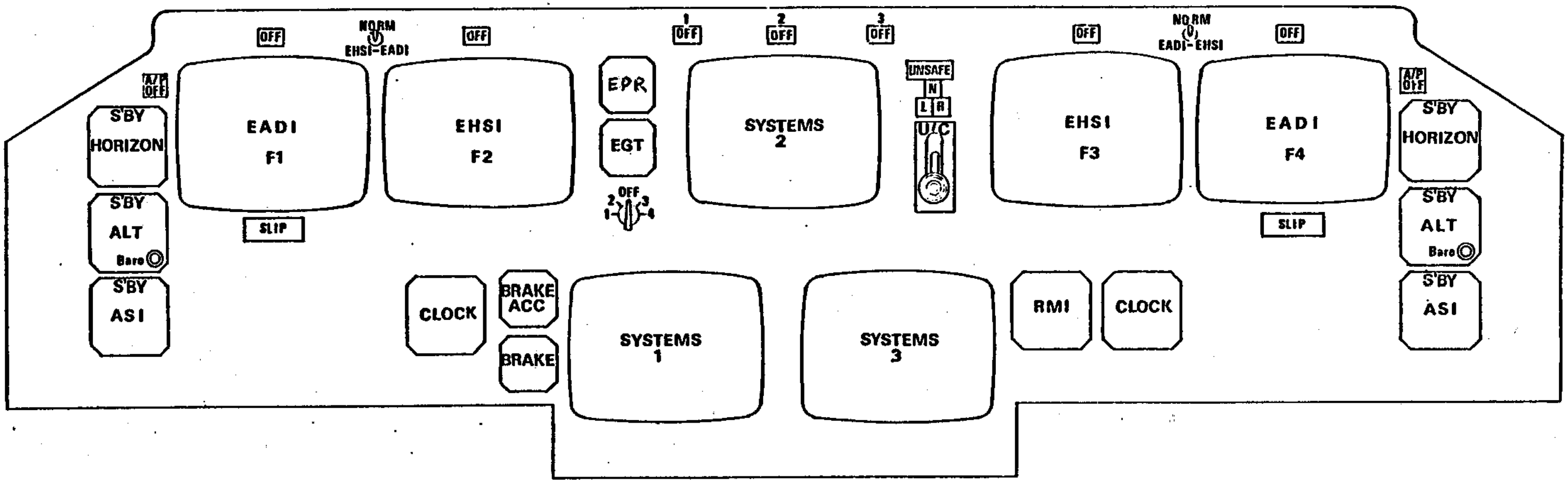


Figure 1

Main Instrument Panels

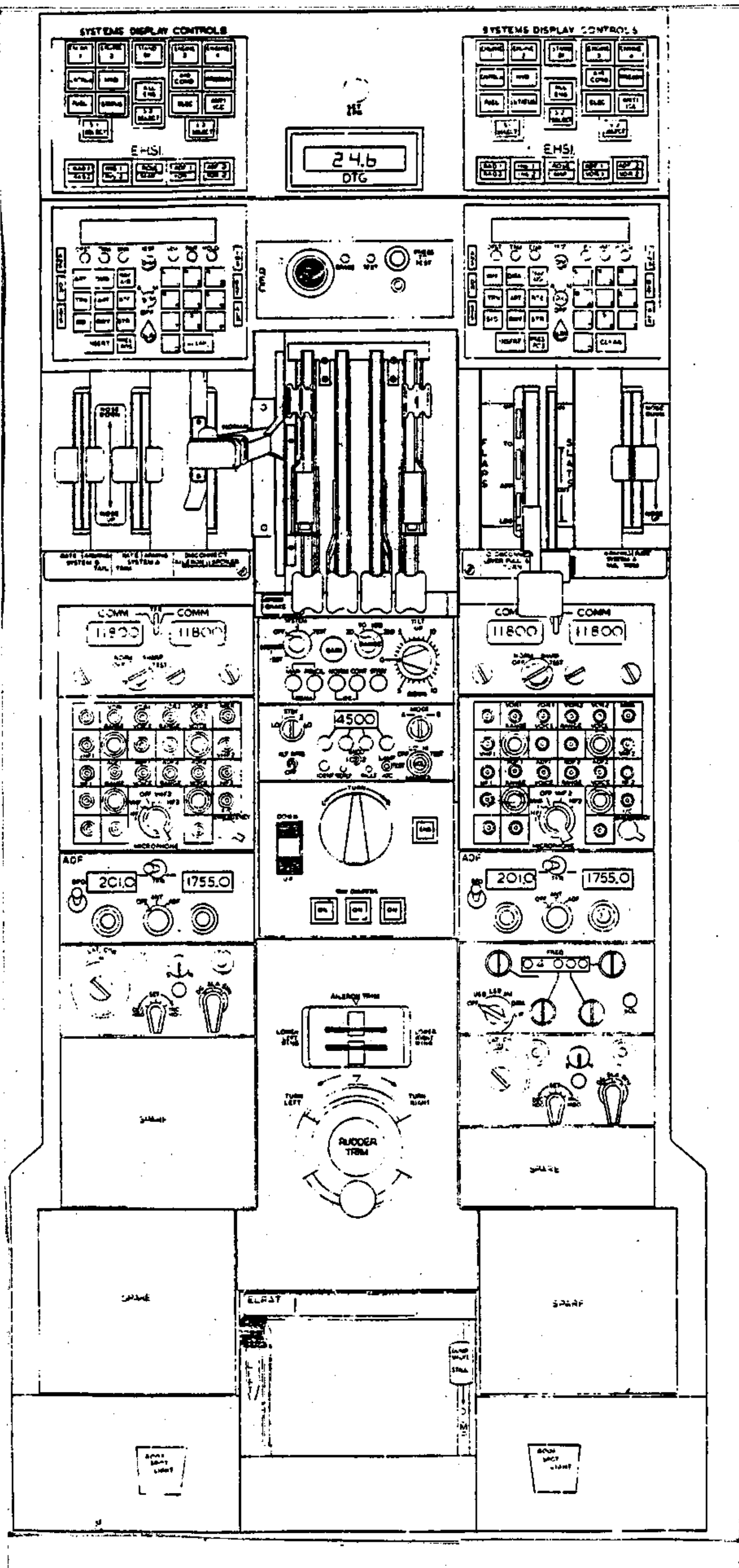


Figure 2
Pedestal

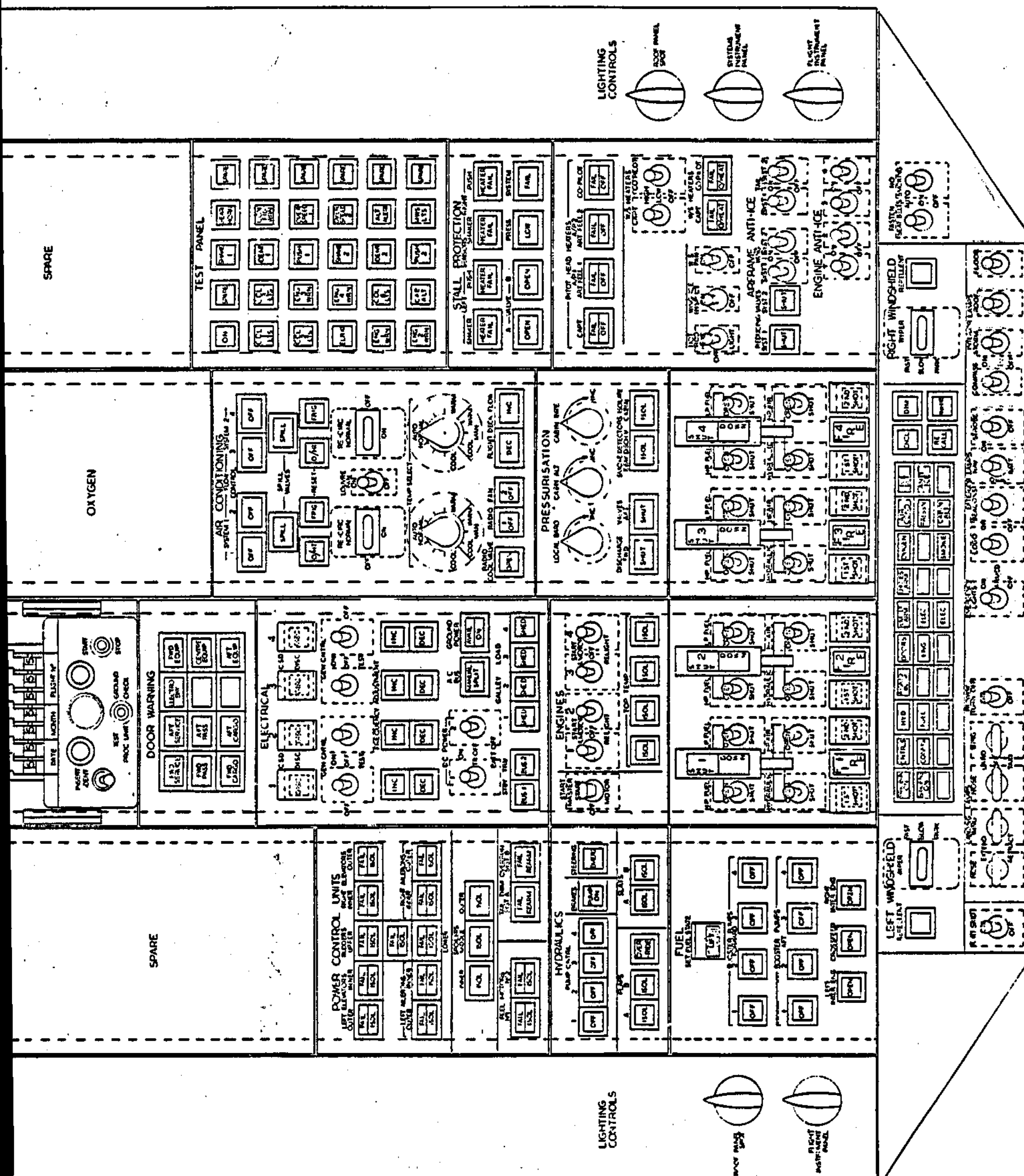


Figure 3

Roof Panel

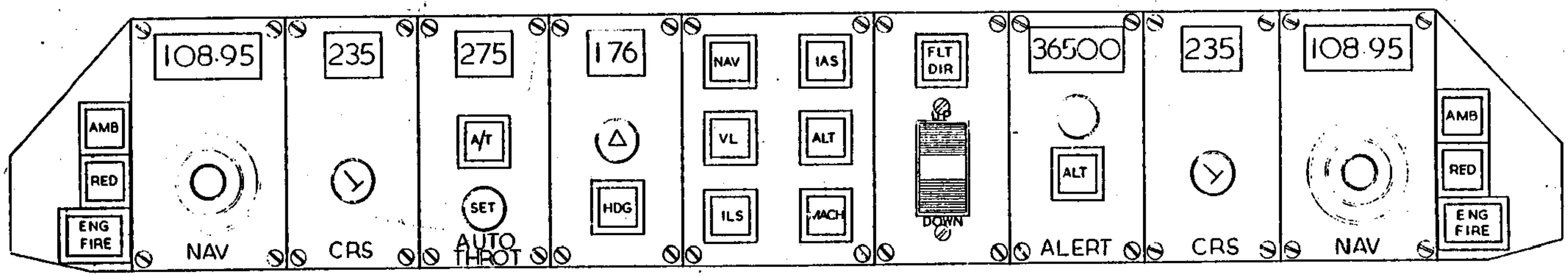


Figure 4

AFCS Controller

CHAPTER 5

DESCRIPTION OF SIMULATION

5.1. Aircraft Simulation

The aerodynamic simulation covered the normal flight envelope from brakes-off at take-off to reverser cancellation after landing.

The aircraft was, in general, difficult to fly manually with the precision and smoothness that would be achieved in reality. This was partly due to lack of motion cues and partly due to an apparent lack of speed stability, pitch stability and "stiffness". However, the simulator could be adequately controlled for the human factors tasks in manual, and easily controlled through the autopilot and autothrottle.

Trim changes due to flap/slat selection were large and some reduction was later introduced. The forward centre of gravity limit was used in order to improve stability.

The engine simulation was complete, including asymmetric effects of engine failure, and found to be entirely adequate for the tasks.

A q-dependent feel system was provided for pitch and roll force variation, with simple spring feel for the rudders.

Electric aileron trim biassed the control wheel in the normal way, electric (single-rate) pitch trim 'operated' the variable incidence tailplane and mechanical rudder trim provided the correct aerodynamic response which did not bias the rudder pedals.

Flaps, slats and airbrakes were 'operated' by the normal levers and produced the appropriate aerodynamic responses.

The parking brake lever enabled the aircraft to be held stationary on the runway until the take-off was commenced and was used to provide braking at the end of the landing run.

An undercarriage selector (electric) (see Figure 1) and normal warning lights were fitted and appropriate aerodynamic effects included.

5.2. Systems Simulation

Some changes were made to the VC-10 systems to make them more compatible with two-crew operation. These are not detailed herein as they are not relevant to the human factors assessments.

The engine, integrated air systems (air conditioning, pressurizaion, anti-icing), fuel, electric and hydraulic systems were all dynamic at the start of the assessment programme.

A flight controls display provided dynamic position information of all primary and secondary surfaces in mimic form.

Other formats were developed later in the programme and will be described in later chapters.

The flight procedures were laid out in typical airline form covering Checks and Drills. These are shown in Chapter 10. The drills were modified at intervals throughout the programme as appropriate.

A Master Warning System was also included in the simulation comprising both visual and aural warnings.

During the assessment of the systems displays the autopilot mode selection did not effect changes to the formats of the EADI and EHSI displays. Autopilot mode annunciation was introduced for the assessment of the EFIs.

Conventional pitch and bank control, heading select and course select facilities were provided in addition to the ability to lock-on to an existing altitude, airspeed and mach number. Altitude capture was not implemented.

With the exception of the pitch and bank control the autopilot modes were available on the flight director which also incorporated a pitch datum control.

An autothrottle system was simulated which was usable throughout the flight envelope, although generally it was only engaged below 200 knots. The simulation avoided the need to drive the throttles by operating the autothrottle as an independent system so that, when engaged, the throttle levers were disconnected from the engine control mechanism. A means of matching throttle position with engine power selected by autothrottle was devised using the EPR command and power bugs shown on the ALL ENGINES format (see para 6.7), so avoiding large power transients at autothrottle disconnection. As for airspeed lock, with which it was mutually exclusive, autothrottle could lock-on only to the speed existing at engagement.

5.3. Simulator Validation

The London Heathrow to Paris Charles de Gaulle route as described in Chapter 11 was used to validate the aerodynamic, engine and systems simulation as set out above. Superimposed on the aircraft management and flight path navigation tasks was an ATC communication load, including the tuning of appropriate frequencies on a dual COMM controller located on the aft pedestal, and the logging and transmission of waypoint ETAs.

The availability of all the aircraft systems in a dynamic form for control and display, the load imposed by a short, fast route with representative navigation and ATC functions, and the development of typical check lists and drills together, produced a standard of simulation which was more than adequate for the Familiarization exercises referred to later.

The basis of validation was whether the standard achieved was suitable for the evaluation of the electronic displays, not whether the handling of the simulator was representative of the VC-10 aircraft.

CHAPTER 6

DESCRIPTION OF FORMATS AND CONTROLS

6.1. Introduction

The Familiarization Assessment was concerned only with the assessment of the systems formats although some general aspects were included. The formats use are described in this chapter. Also included is a brief reference to the EADI and the EHSI formats as these were essential for the pilots to do the exercises.

6.2. EADI and EHSI

The formats for the EADI and the EHSI were identical to those used in a previous evaluation of electronic displays at the British Aircraft Corporation, Filton Division and completed in June 1975. (for further details see reference by B.J. Bleach in para. 3.2.). The formats are illustrated in Figures 5, 6 and 7.

6.3. Systems Formats

6.3.1. Character Font

The character sizes and library available for the Familiarization Assessment were not ideal, but were constrained by the equipment available. The character sizes were 2.9 mm. high and 3.7 mm. high using the RAE "Huddleston" font. A test card was drawn to the exact font with elements 0.1 in. square, reduced photographically and placed in a flying spot scanner. This was connected with a display head on the flight deck placed in the lower right position. The test card was thus reproduced as nearly as possible to actual pilot viewing conditions. Evaluation of this display showed that the larger font was just adequate for parts of the displays giving changing or digital information and failure warnings. The smaller font was judged to be sufficiently large for static parts of the formats (i.e. fixed legends such as valve titles) provided the letters were adequately spaced. The formats were designed accordingly.

6.3.2. Format Design Guidelines

In designing the formats the main guidelines used were:

(i) to present the information clearly and concisely, using a mimic format where possible.

(ii) to make the information as self-evident as possible.

(iii) to avoid placing reliance on the pilots' memories for the interpretation of information.

(iv) to avoid clutter, particularly in the part of the display conveying changing information.

Item (iv) led to the grouping of the permanent legends on the left of the displays, using the smaller characters. These were spaced so that the larger characters could have been introduced if it had been necessary.

6.3.3. Warnings

The conventional "amber" warnings were given by an appropriate word being shown "inverted" (i.e. black letters on a white flag). Under high ambient light these could be difficult to read so only standard warning legends, "FAIL", "LP", etc., were shown this way. Where a parameter value was out of limits and had to be readable the warning was given by a white flag beside the number.

The "red" warnings were presented in a similar manner, but the flags flashed.

6.3.4. Valve and Switch Indications

Several possible formats that were available within the character library were evaluated and a line in a rectangular box was finally chosen. This box was 20% larger than a large character.

6.3.5. Lines

Because of limitations on the number of lines which could be generated on certain displays vertical lines were generated using characters. These gave the appearance of unbroken lines. Lines were broken at cross-over points where there was no physical connection in the system.

Thick lines were not available, but double lines were used in some instances to denote "red" area tolerance limits.

6.4. Systems Displays Control Panels

The Systems Displays Control Panels were located on each side of the forward part of the pedestal. One panel was provided for each pilot.

The method of operation was to select the display (S1, S2, S3) on which the format was to be put and then to select the format. This required two buttons to be pressed.

The Panel used for the Familiarization Exercises is illustrated in Figure 9.

6.5. Systems Control Panels

The two crew philosophy made it inevitable that all the systems controls required in flight had to be mounted on the Roof Panel (see Figure 3). To facilitate fitting and interchangeability, a standard 5.75 in. ARINC panel spacing was adopted. This philosophy did not cause any space problems.

6.5.1. Push-button Switches

Where switches had only two states illuminated push-buttons were introduced. In general these only illuminated to indicate an abnormal condition (i.e. no switches should have been illuminated when the aircraft was in the cruise condition with all systems functioning normally).

Some switches had independently illuminated split legends (viz. Power Control Units - see Figure 17). Standard commercial grade switches were used.

6.5.2. Toggle Switches

Where switches had more than two states toggle switches were retained. In general these were similar in action to standard aircraft switches, but were again of a standard commercial grade.

The use of push-buttons in these cases would have led to an increase in complexity and workload.

6.5.3. Special Switches

Special switches were designed to be similar in action to the corresponding airborne switch, but in order that standard parts could be used to ease programming, some simplifications were introduced. For example, the temperature selectors utilized a 12-way wafer switch in place of a continually variable control.

6.5.4. Layout of Panels

As far as possible mimic presentations corresponding to the systems arrangements were used.

6.6. Switch and Control Convention

For a definition of directions refer to Figure 10

6.6.1. Toggle Switches

	Throttle Box	Main Inst. Panels	Roof Panels
"ON"	Forward	Upward	Rearward
"OFF"	Rearward	Downward	Forward

For special switches, e.g. Manual/Auto, the "ON" position was the mode selected for normal flight conditions.

Switches operating in a lateral direction were avoided where possible (one exception was the EADI/EHSI changeover switch), but where they had to be fitted the convention adopted was "ON" to the right and "OFF" to the left.

6.6.2. Push-buttons

All push-buttons had a means for defining their selected state or mode. Where an illuminated switch was used for mode definition the light was extinguished for normal flight.

6.6.3. Rotary Switches

"ON" - Clockwise

"OFF" - Anti-clockwise

6.6.4. Rotary Controls

Rotary controls increased a parameter when turned clockwise and decreased a parameter when turned anti-clockwise.

6.6.5. Lever Controls

	Throttle Box	Main Inst. Panels	Roof Panels
"Increase" parameter	Forward	Upward	Rearward
"Decrease" parameter	Rearward	Downward	Forward

Laterally operating levers were avoided, but if it had been essential to have fitted them, movement to the right would have increased a parameter and movement to the left would have decreased a parameter.

6.7. Digital Displays

Where moving digital displays, e.g. drums, were used the digits moved in a downward direction relative to their own base-line for increasing the readout.

6.8. Illustrations of Formats and Control Panels (Figures 11 to 21)

The illustrations have been reproduced using stencils or "Letraset" and the fonts and sizes of the characters are not representative. The paper reproductions can, and were, only used for evaluating:

a) the suitability of the information displayed in relation to the system under consideration.

b) the logic of the displayed information

c) the suitability of the arrangement of information (e.g. assessment of clutter)

d) as training aids for the pilots, and in their introductory notes.

It would have been misleading to have attempted to evaluate the readability of the controls and displays from the figures.

ELECTRONIC ATTITUDE DIRECTOR INDICATOR (EADI)

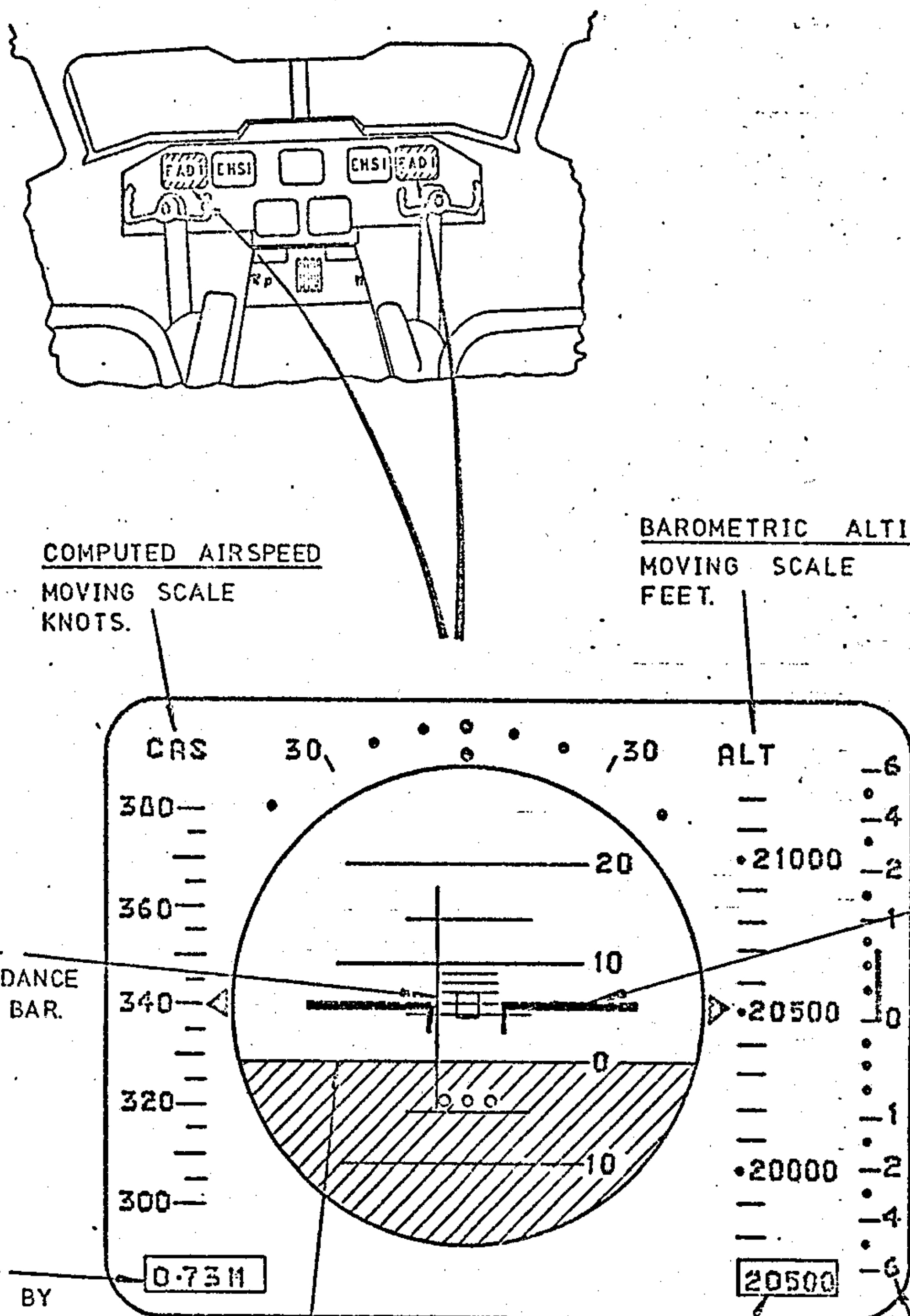


Figure 5

ELECTRONIC ATTITUDE DIRECTOR INDICATOR

(EADI)

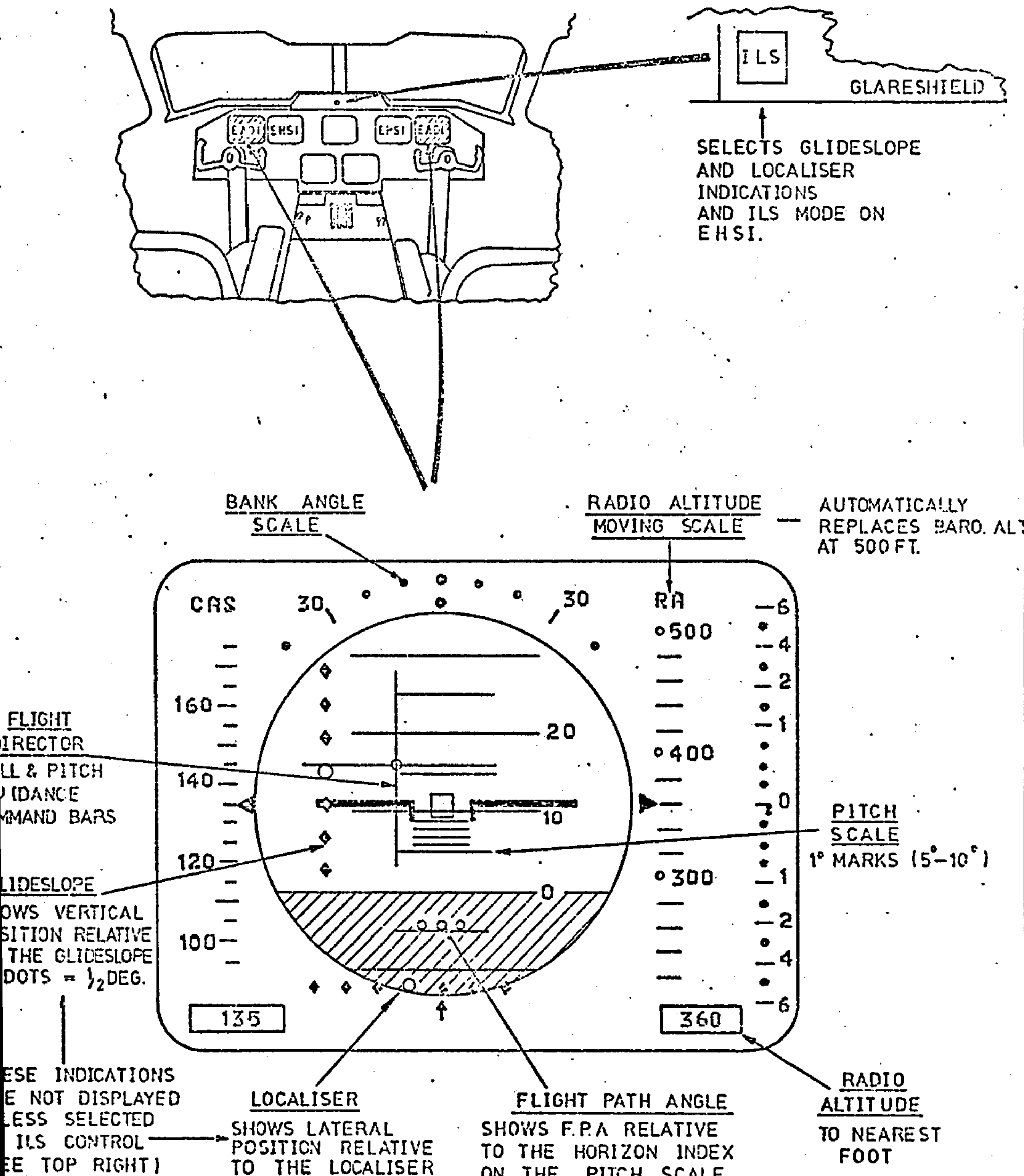
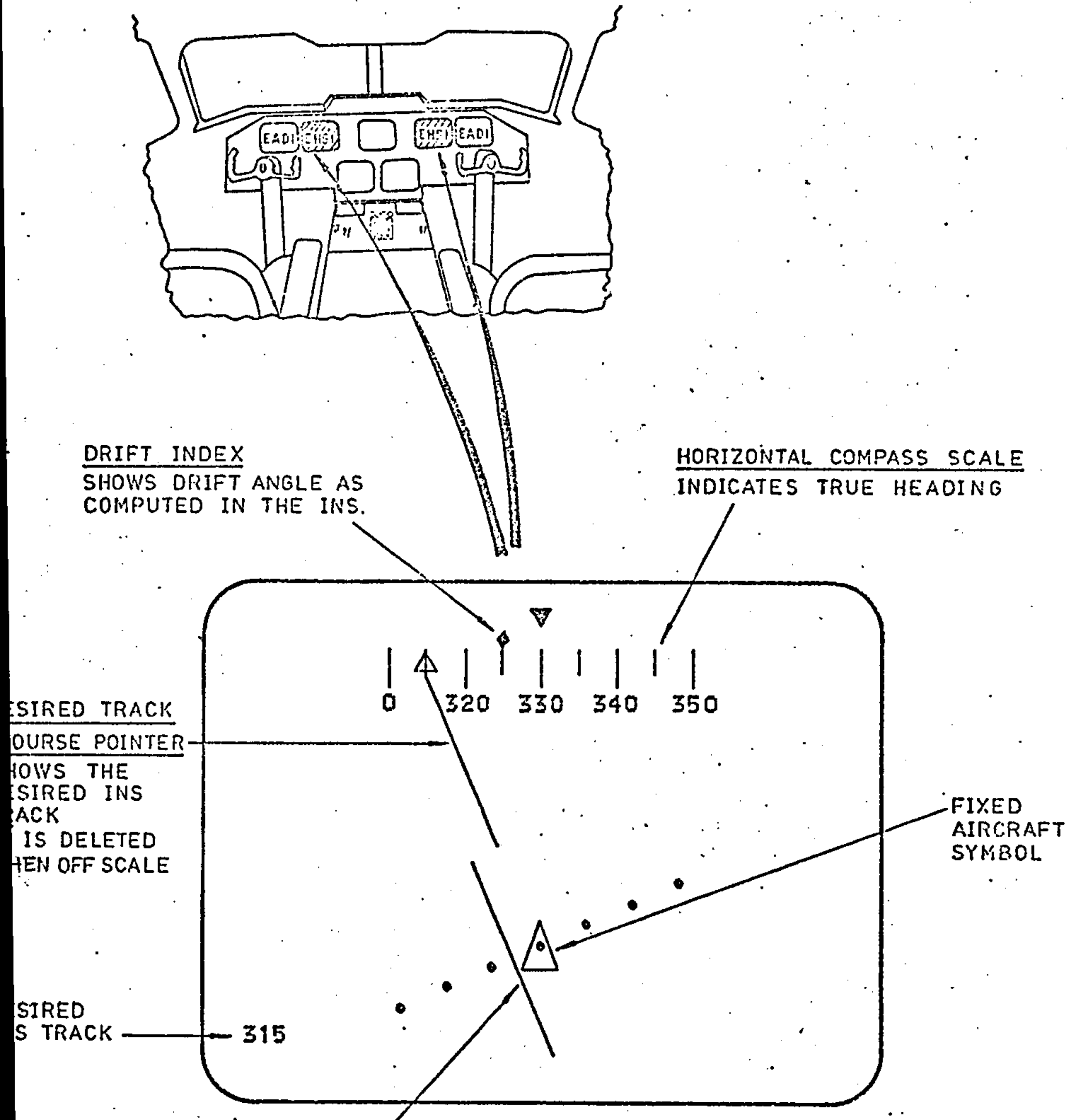


Figure 6

ELECTRONIC HORIZONTAL SITUATION INDICATOR (EHSI)



COURSE / TRACK DEVIATION

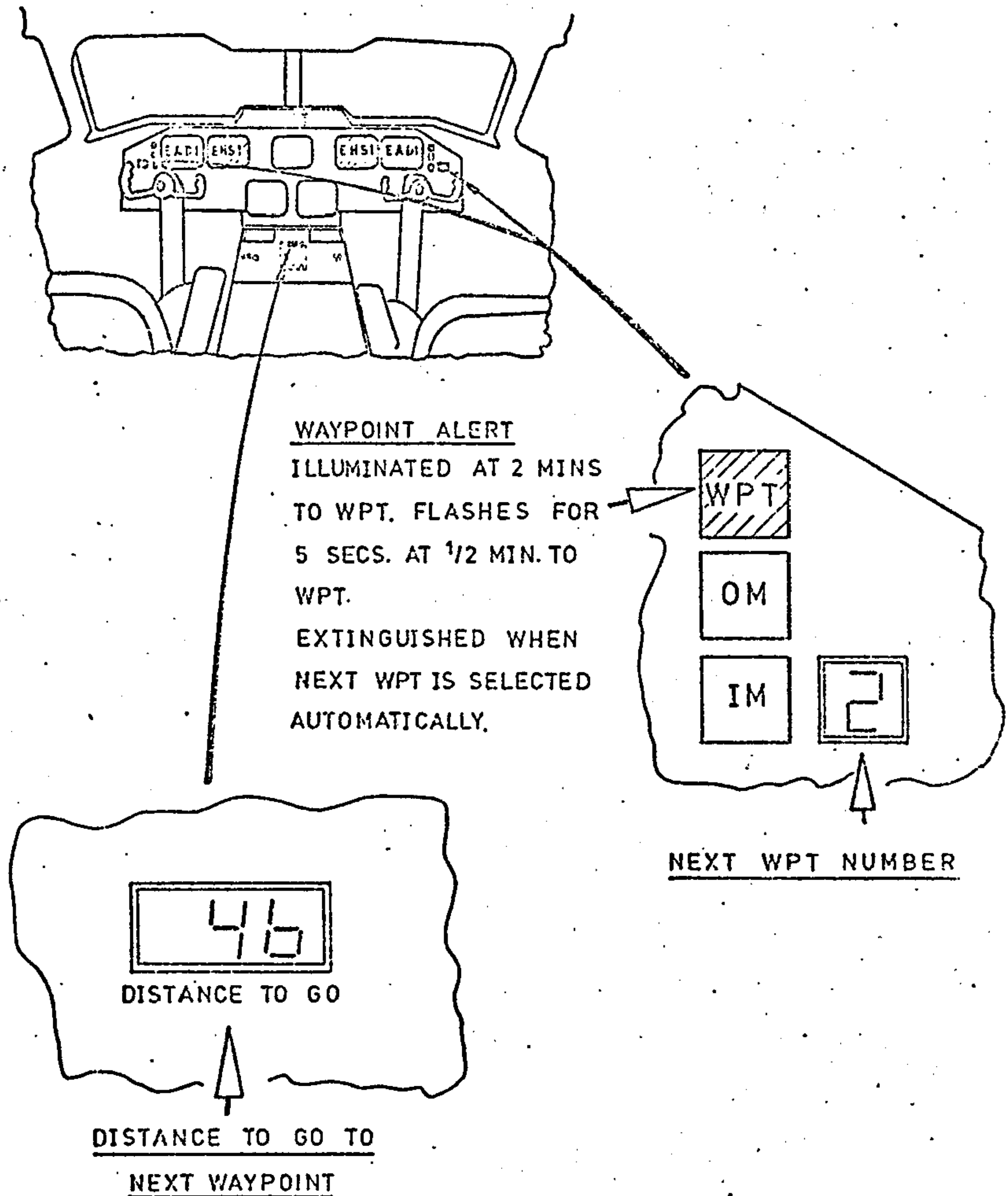
INS - THE BAR SHOWS LINEAR DISPLACEMENT FROM INS TRACK OVER THE DEVIATION SCALE - 2 DOTS = 7½ NM.

OR

ILS - THE BAR SHOWS ANGULAR DISPLACEMENT FROM ILS OVER THE DEVIATION SCALE - 2 DOTS = 2½ DEGS

Figure 7

NAVIGATION AIDS.



USED IN CONJUNCTION WITH EHSI FOR PHASE 1 SIMULATION ONLY

Figure 8

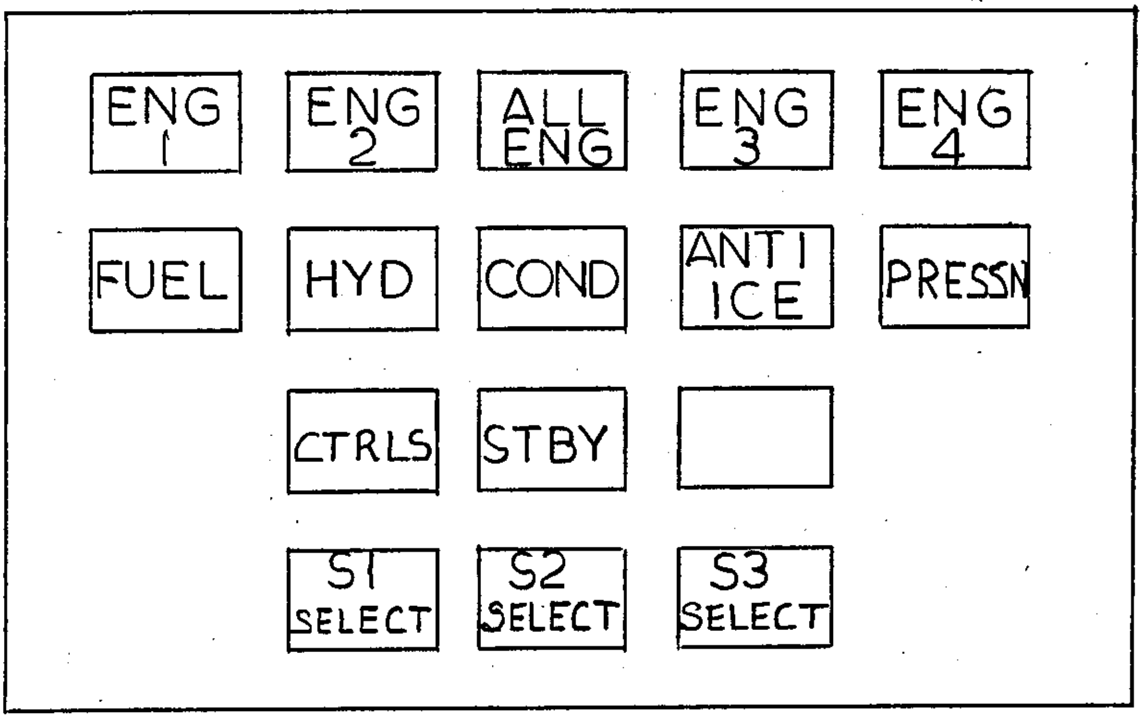


Figure 9

Systems Displays Control Panel

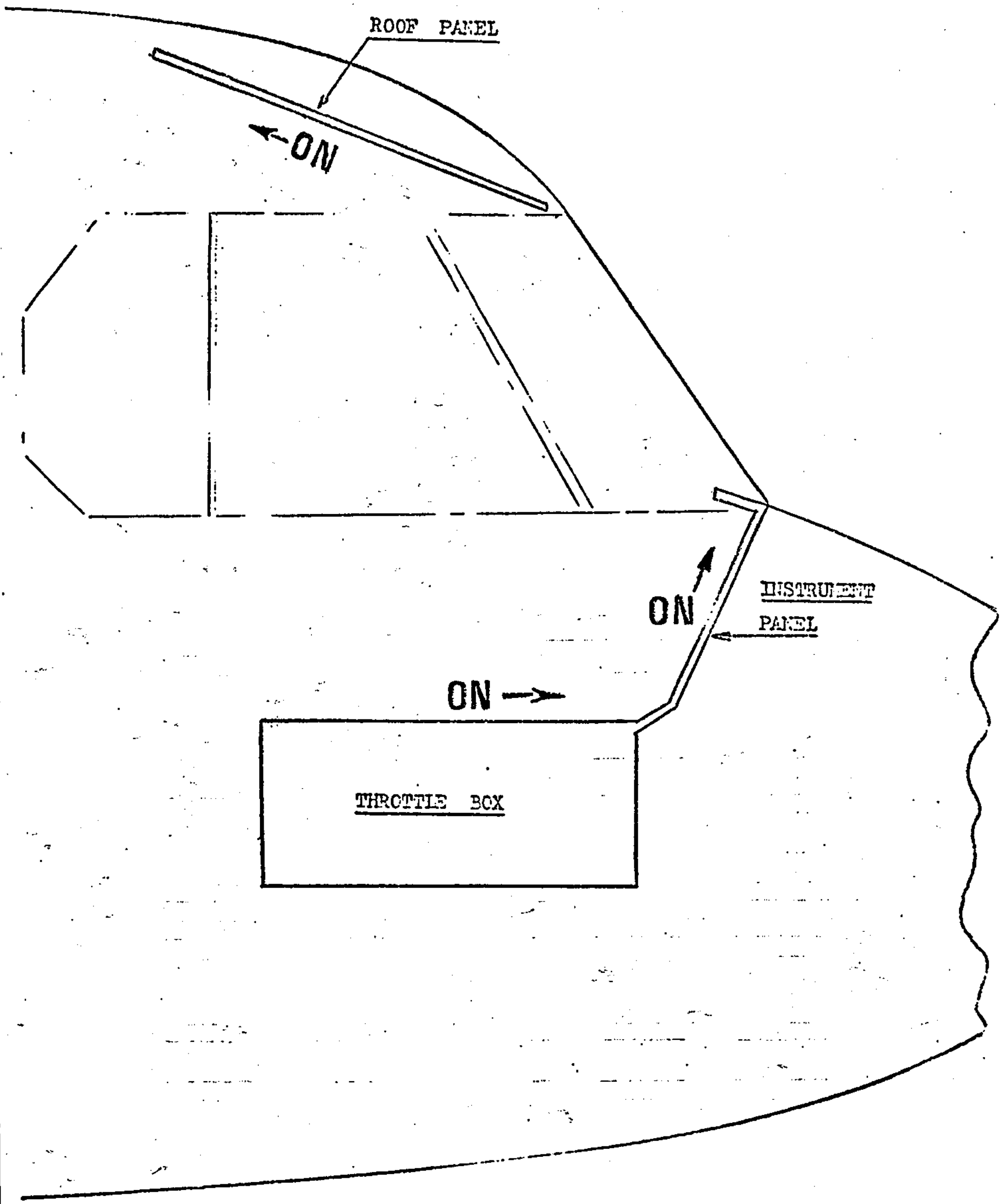
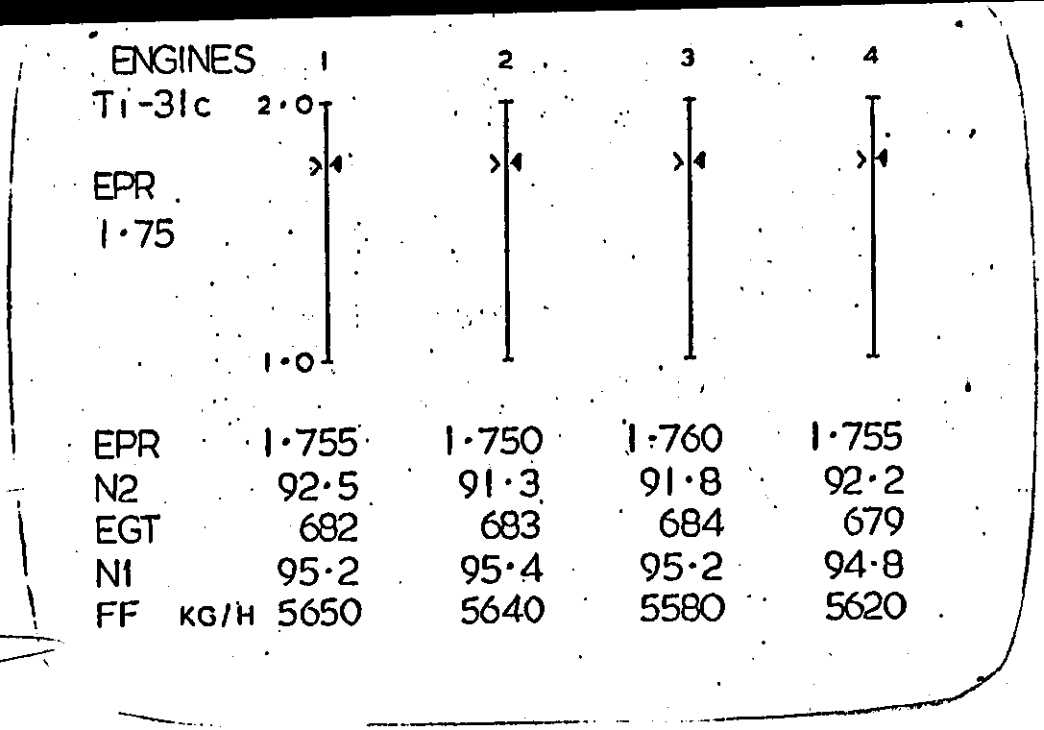


Figure 10

Switch and Control Convention



Normal Format

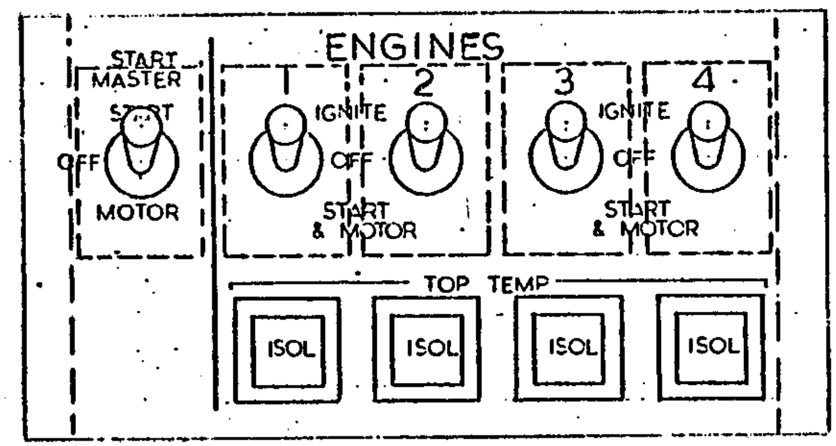
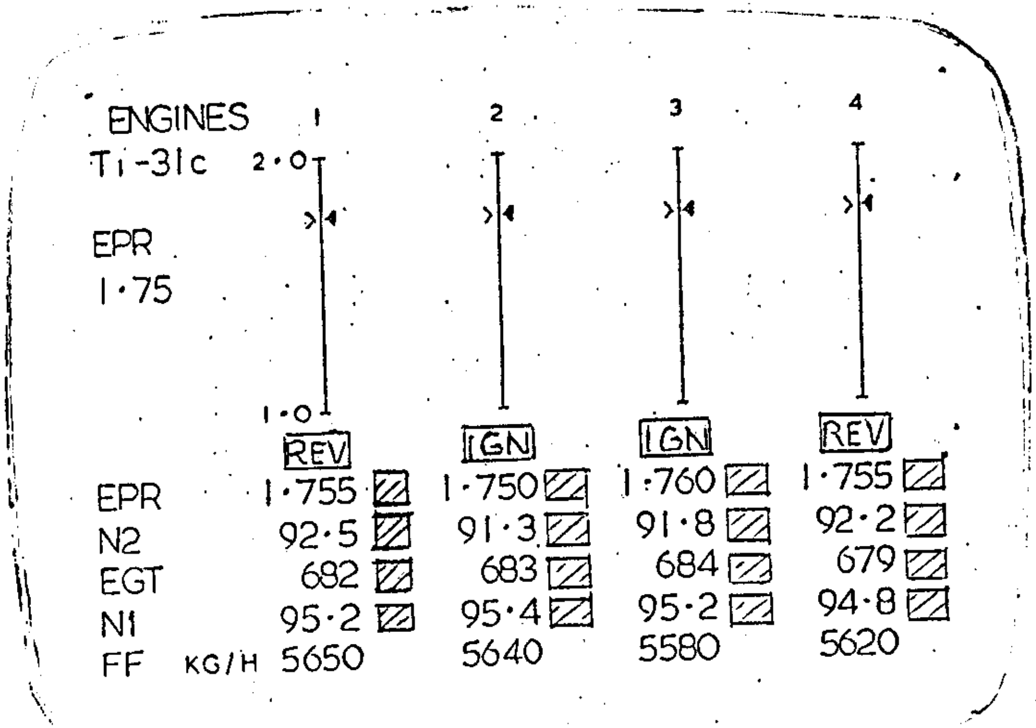


Figure 11

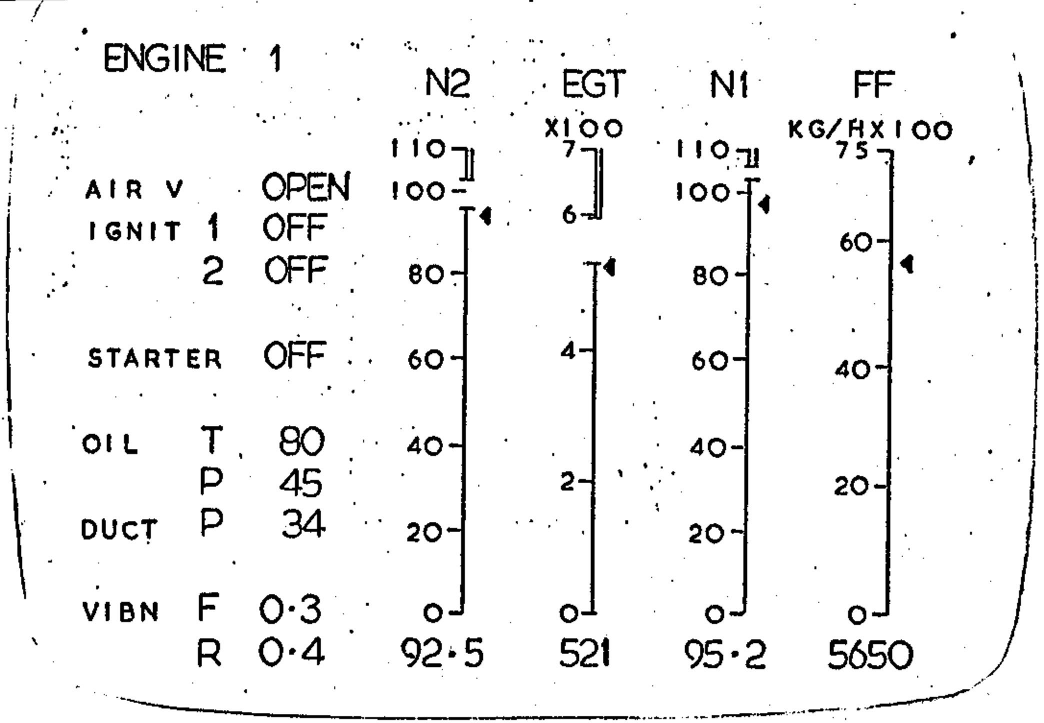
"All Engines" Format and

Engines Start Panel



Format with Warnings.

Normal Format



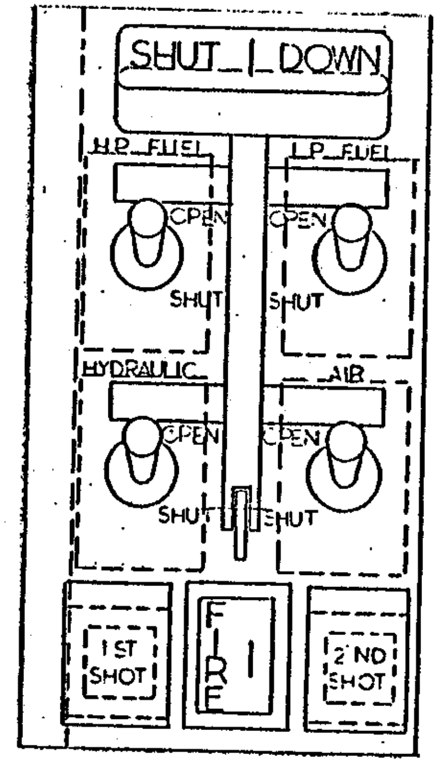
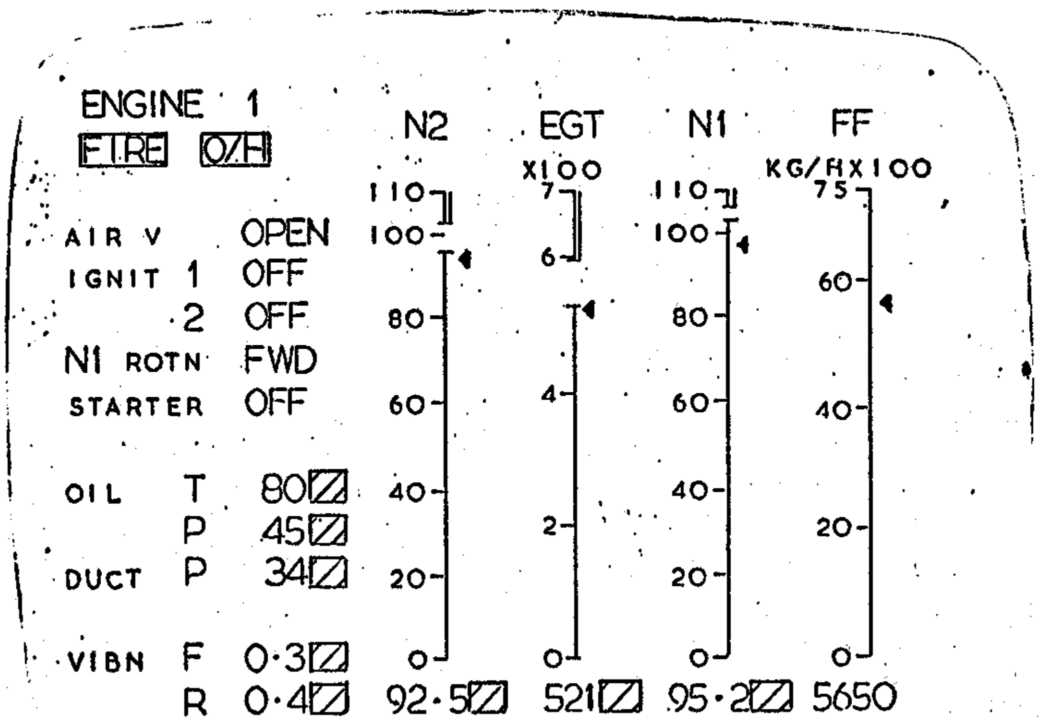


Figure 12

Single Engine Format

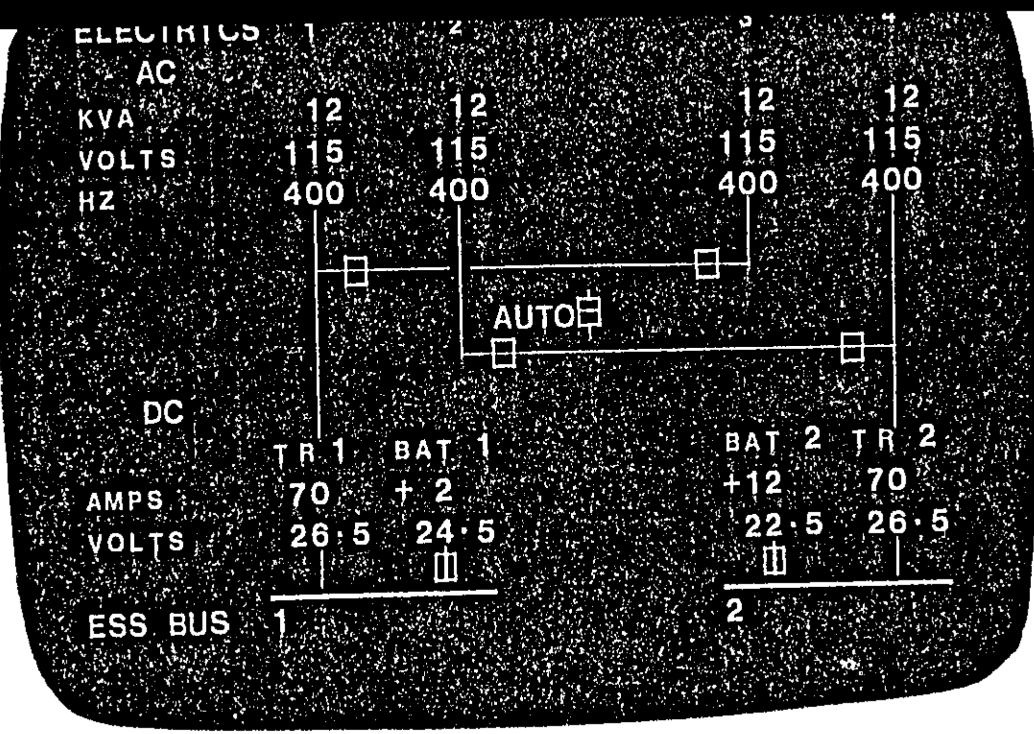
and Engine Shut-down

Panel



Format with Warnings

Normal Format



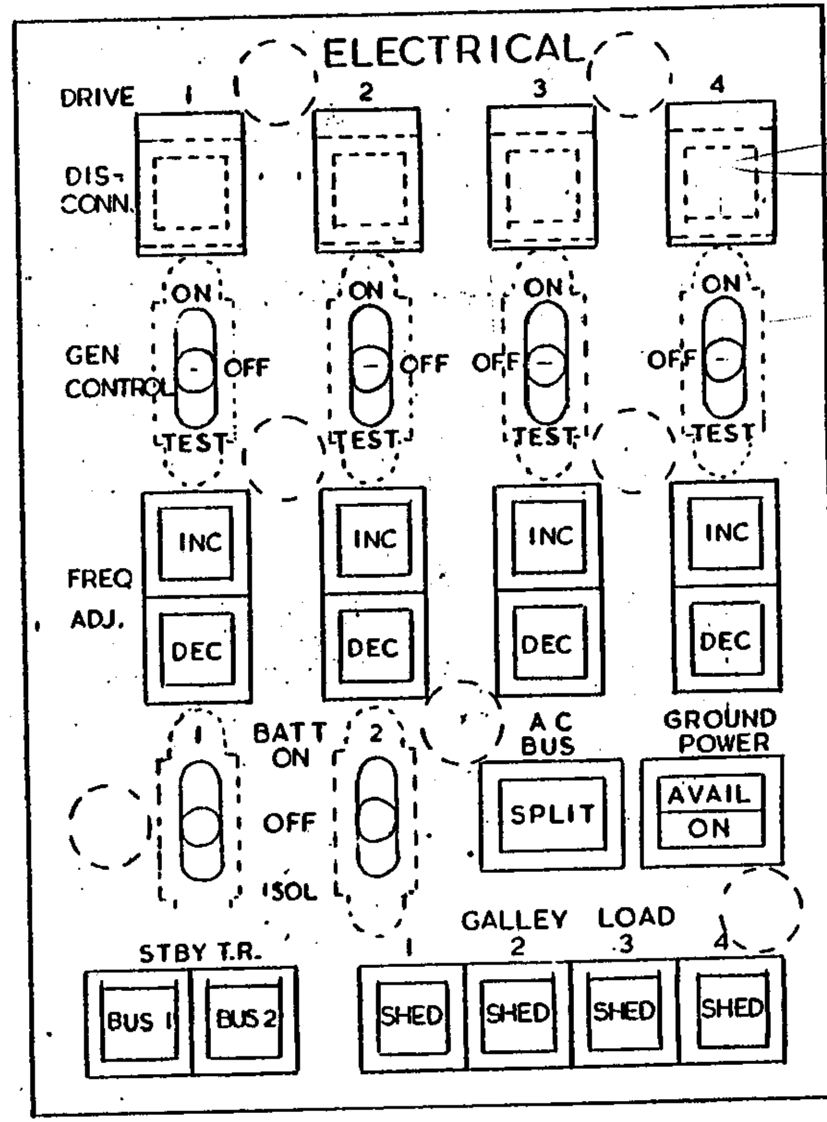
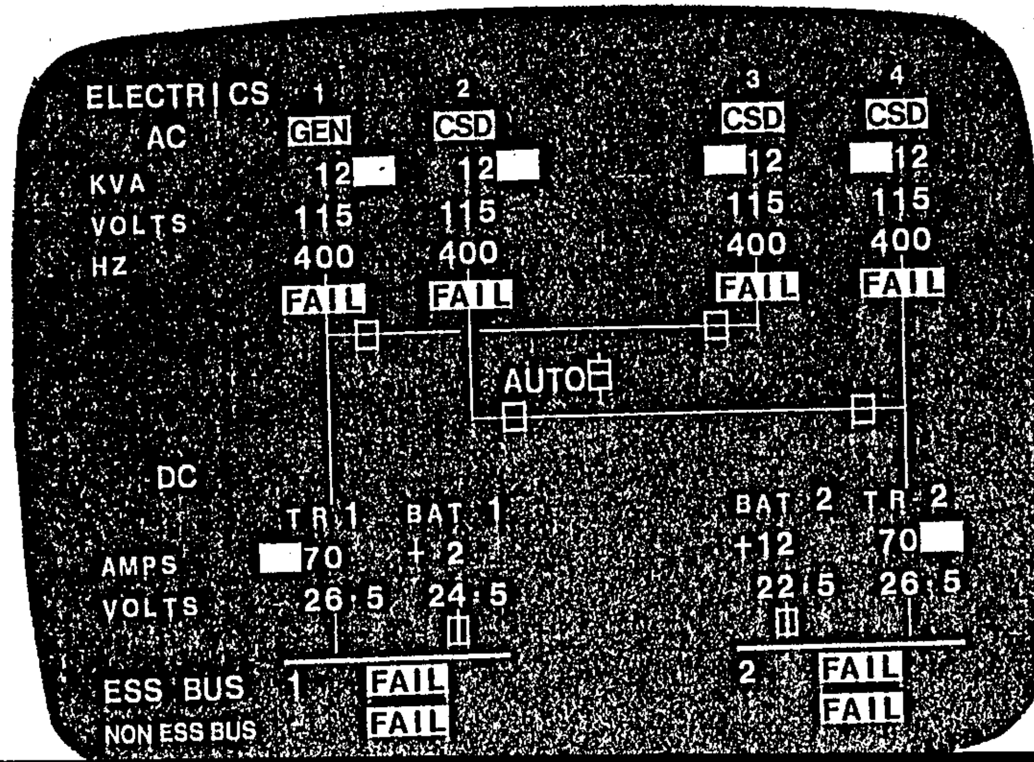
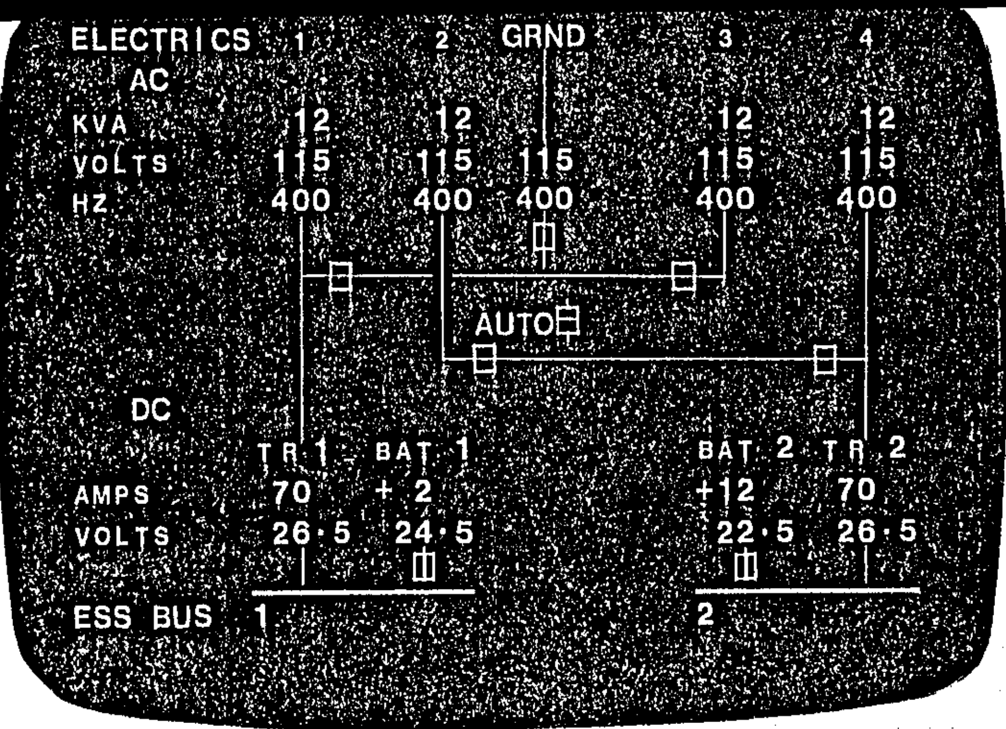


Figure 13

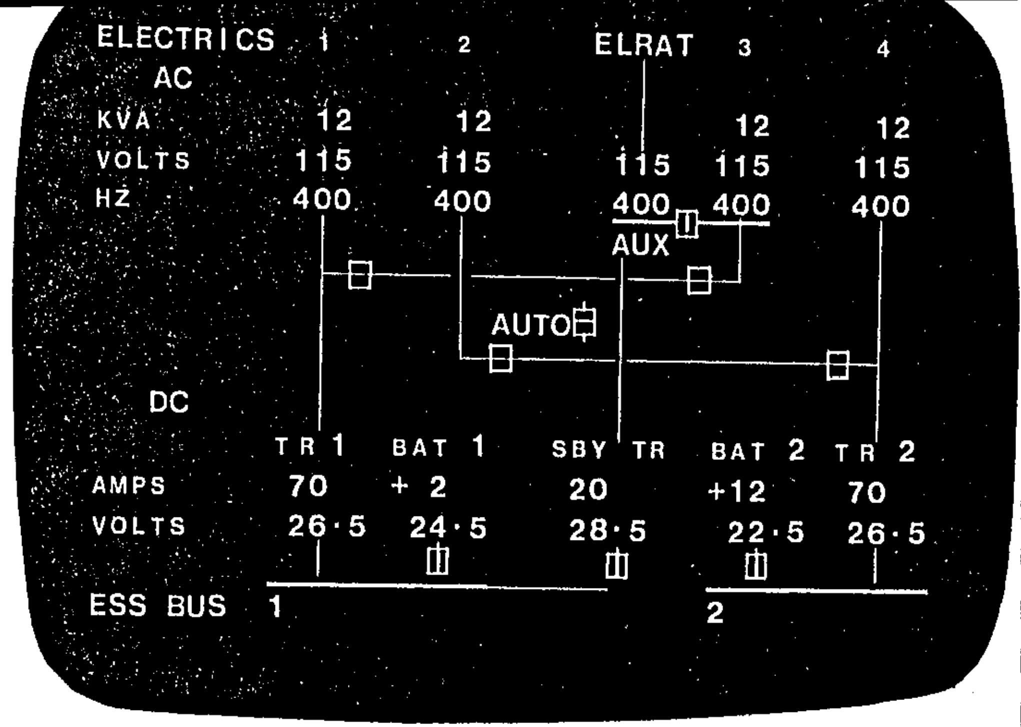
<u>Electrical System Formats and Controls</u>



Format with Warnings



with Ground Power



with Emergency Power

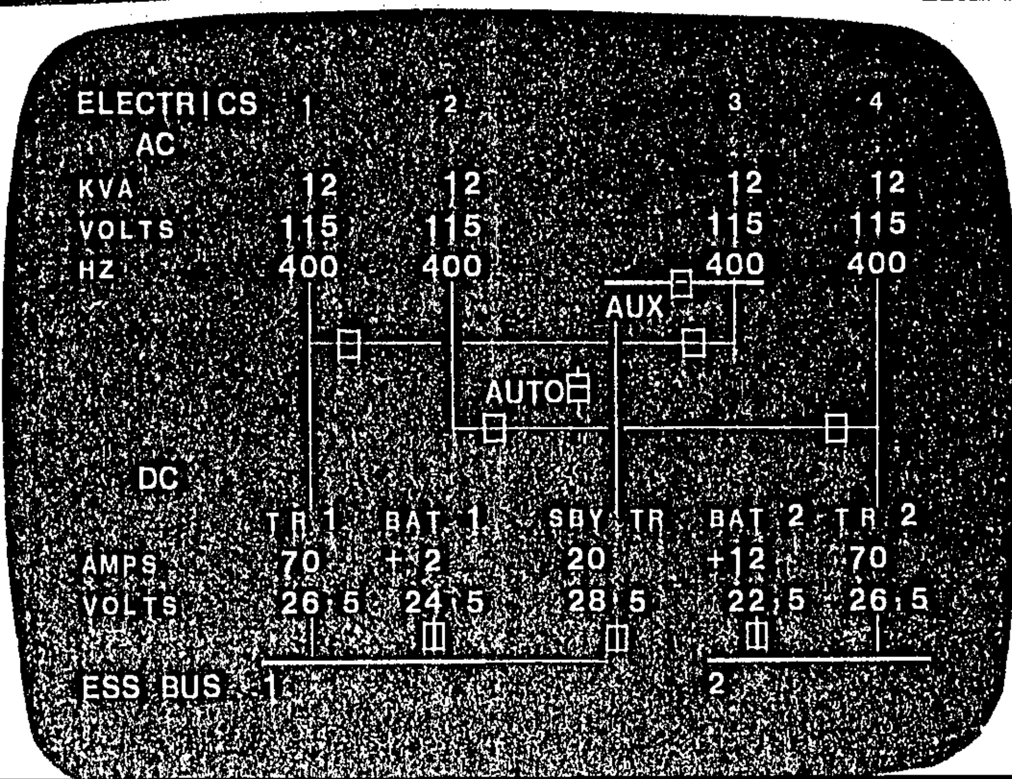


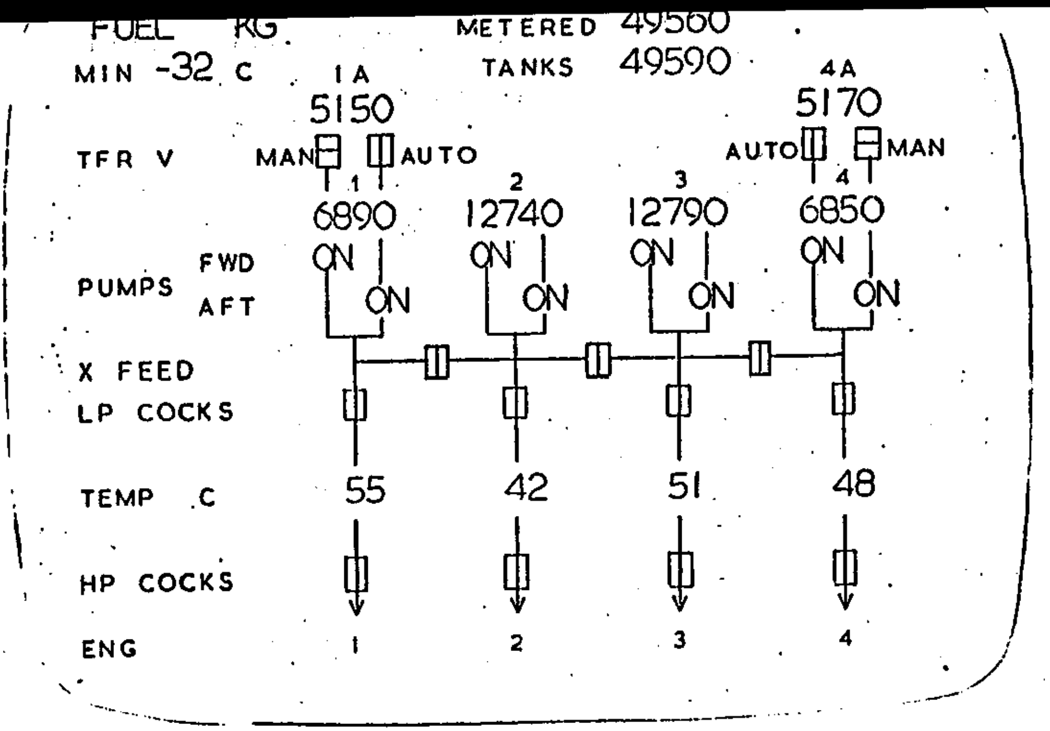
Figure 14

Various Electrics

Formats

with Auxiliary DC Power

Normal Format



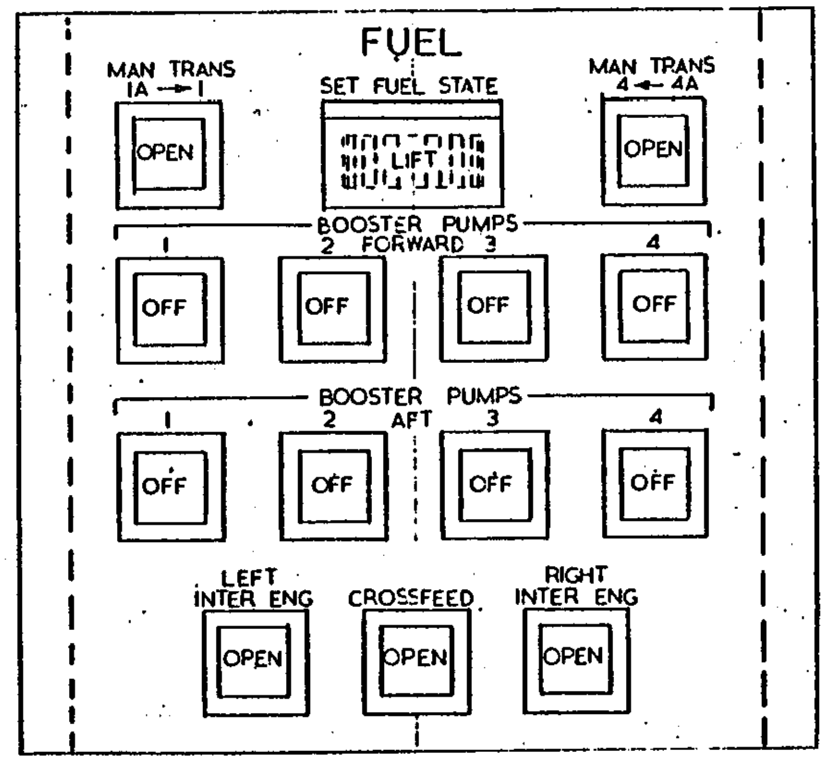
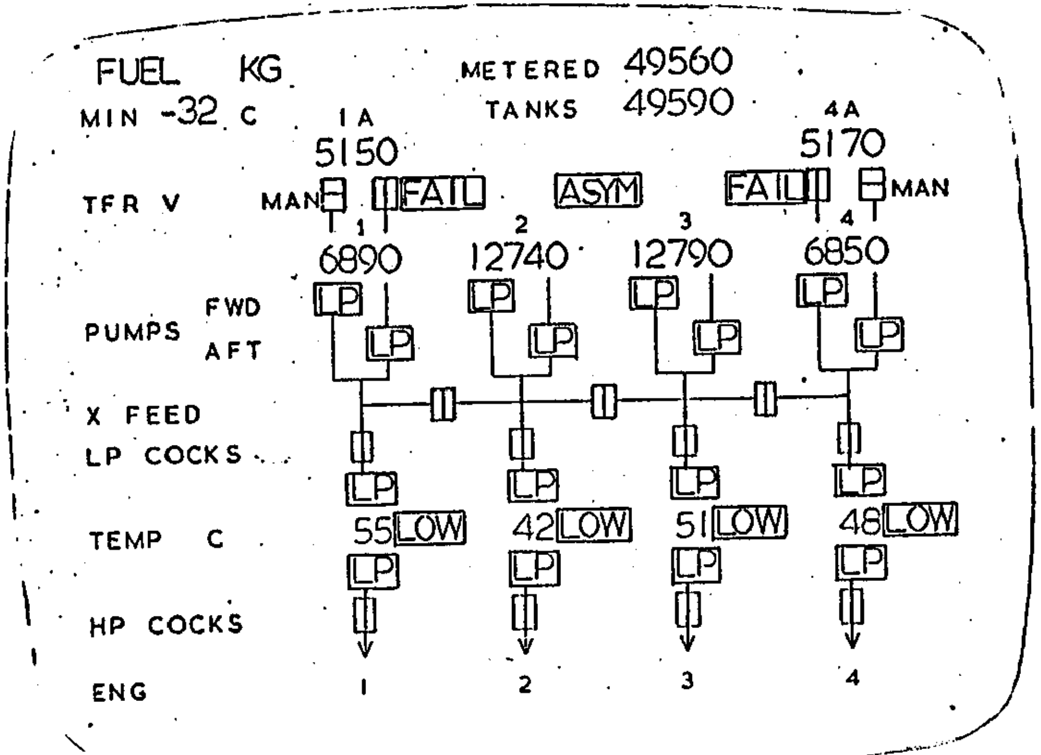


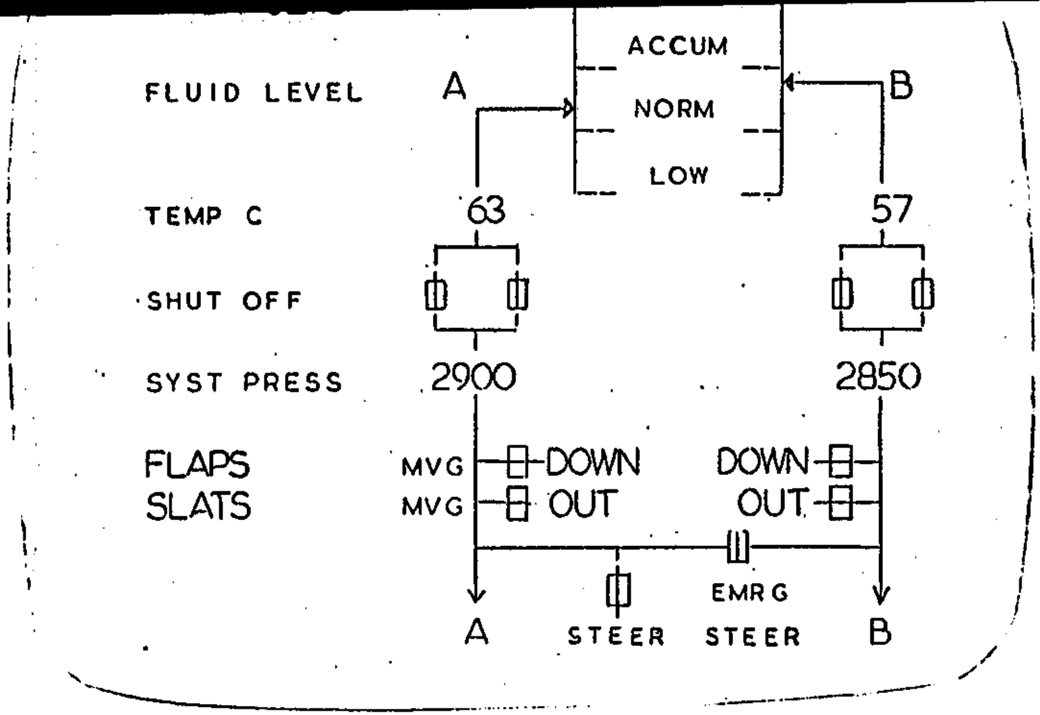
Figure 15

Fuel System Formats and Controls

Format with Warnings



Normal Format



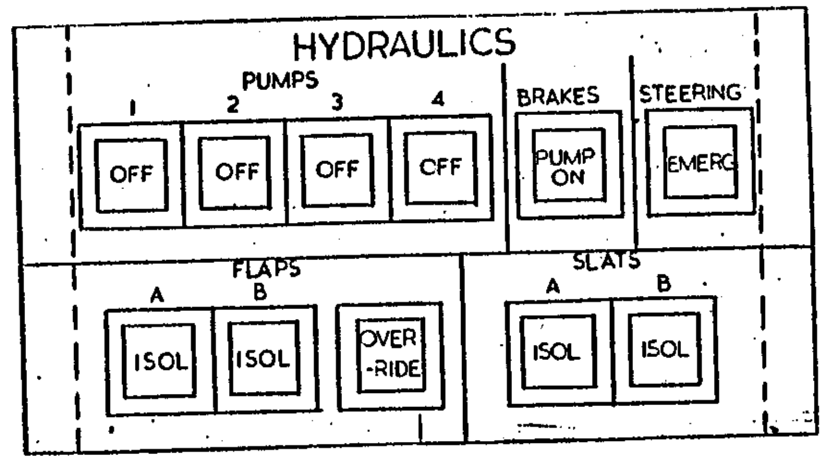
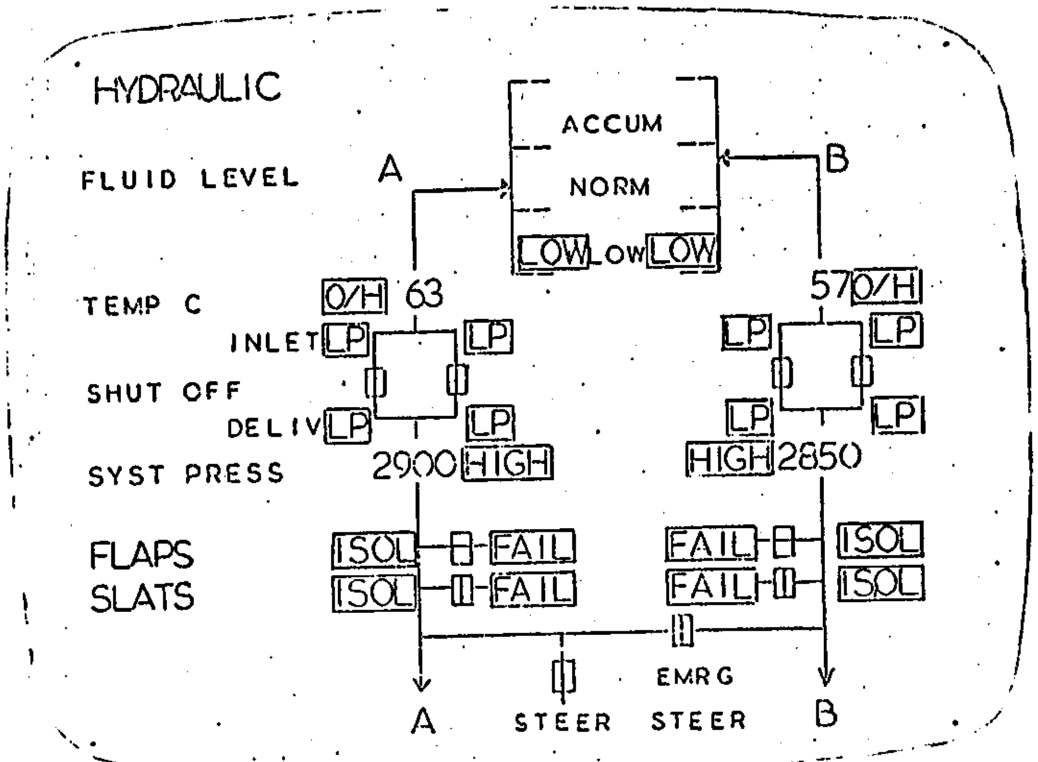
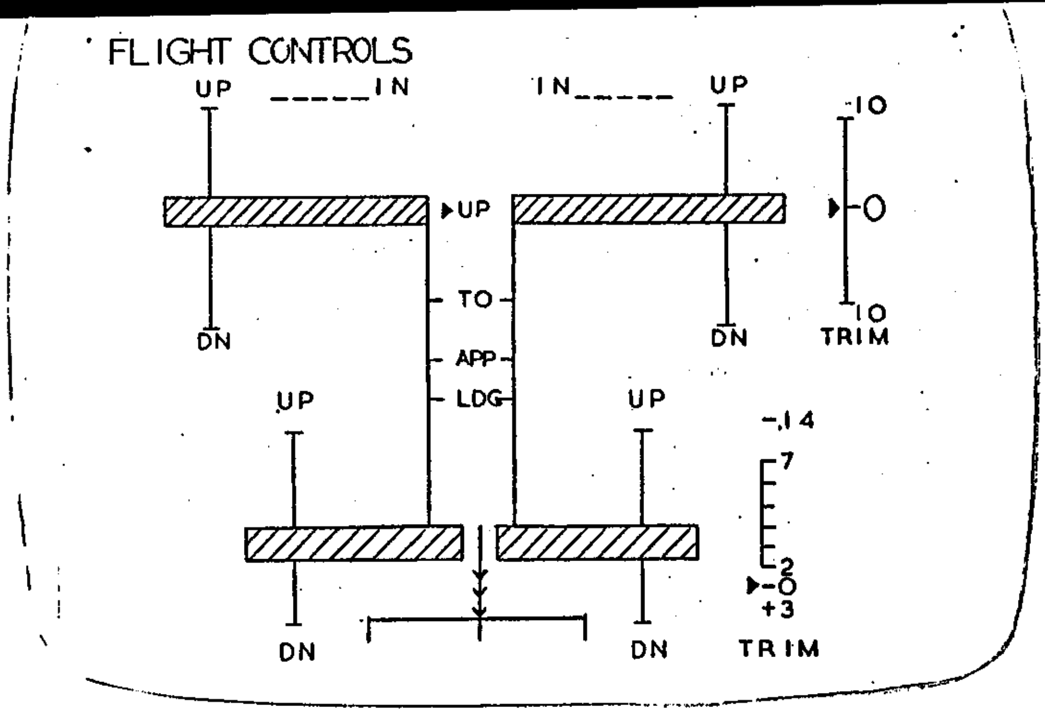


Figure 16

Hydraulics System Formats and Controls

Format with Warnings





Clean Aircraft

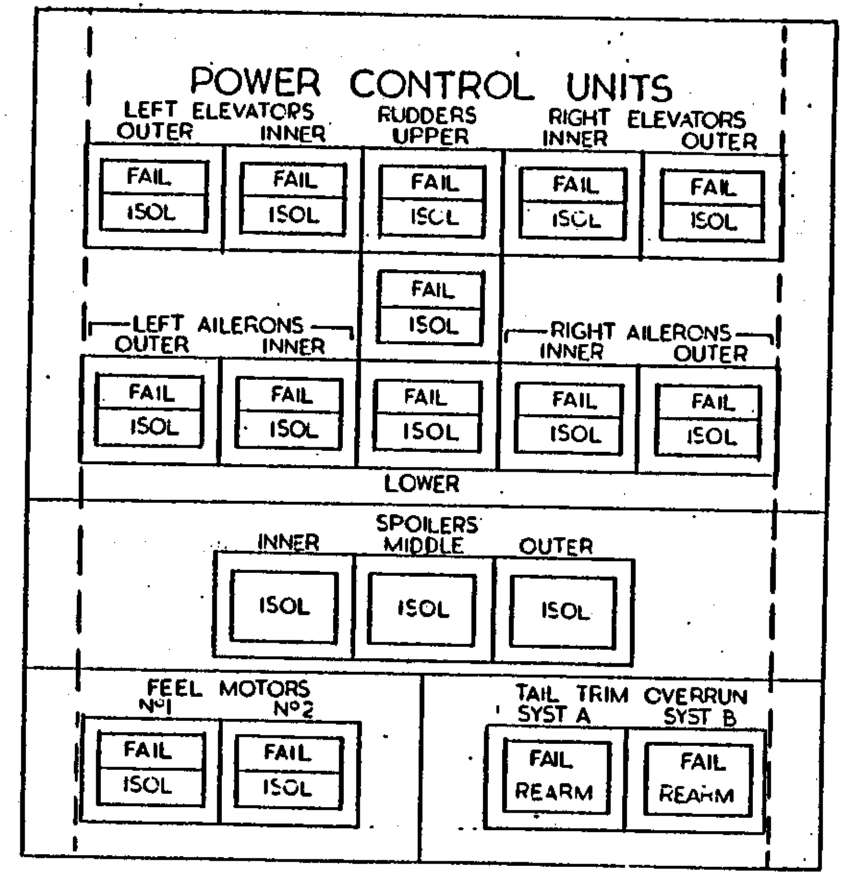
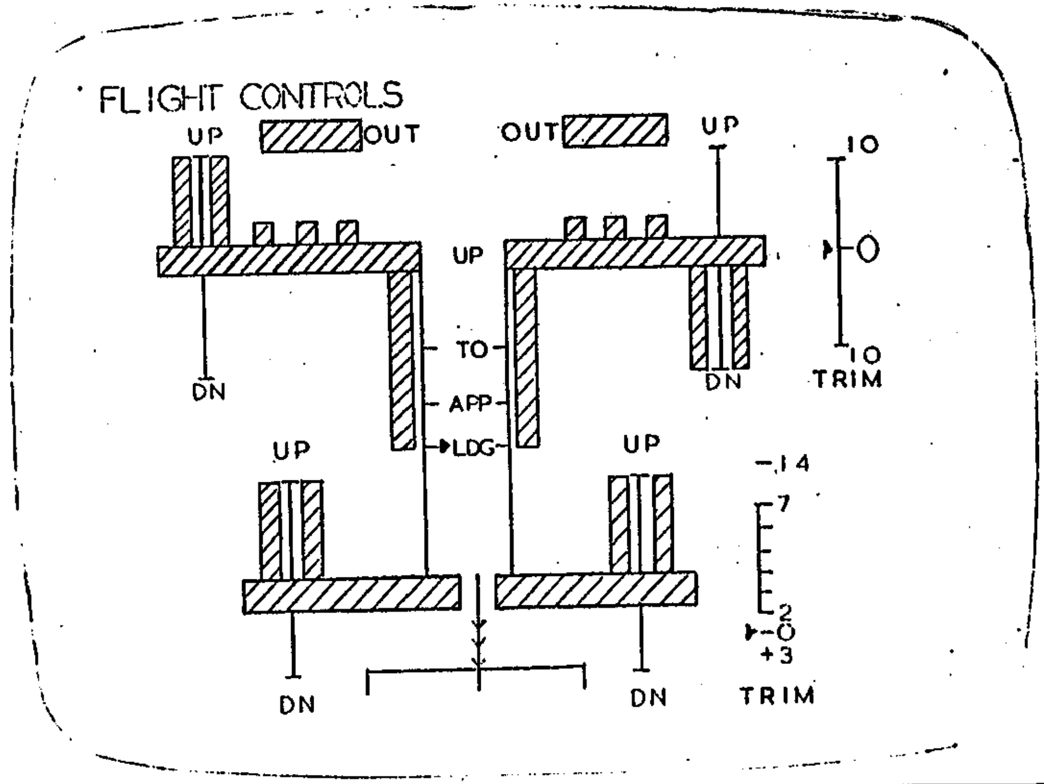


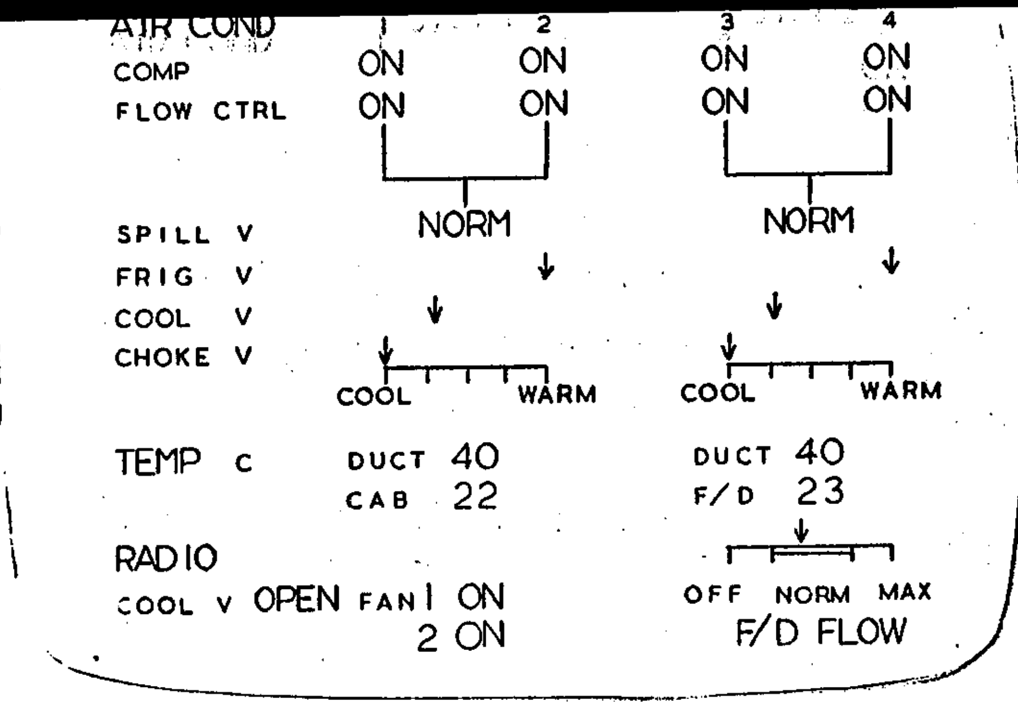
Figure 17

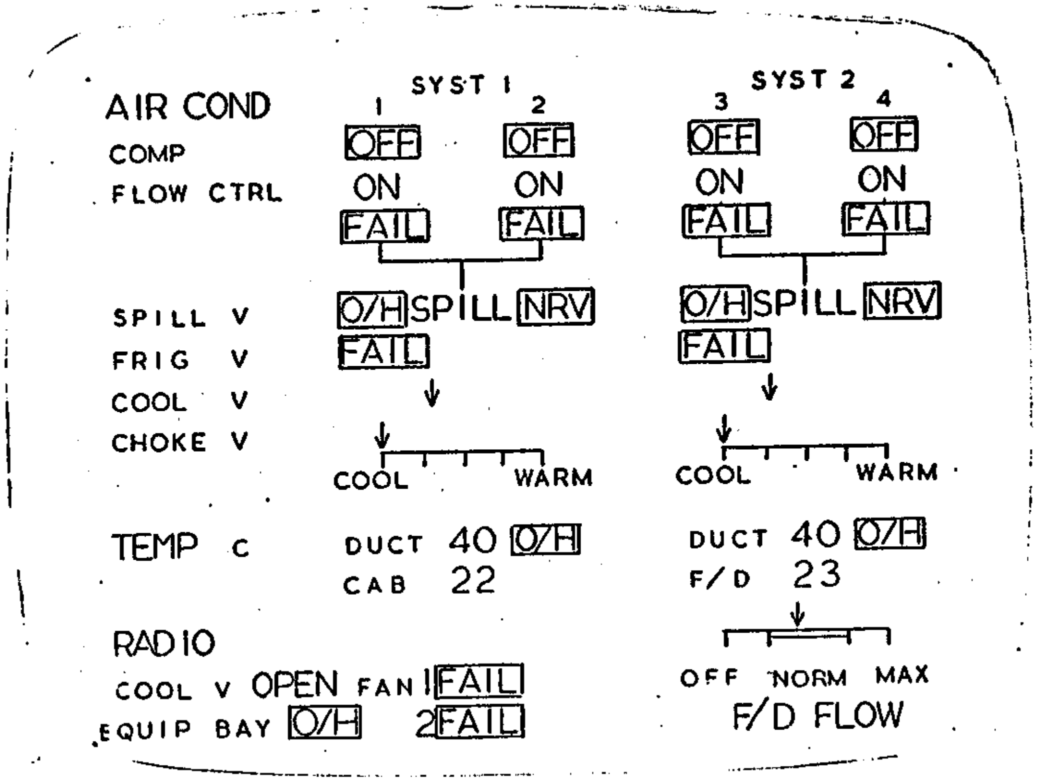
Flying Controls Fomats and Power Controls Panel

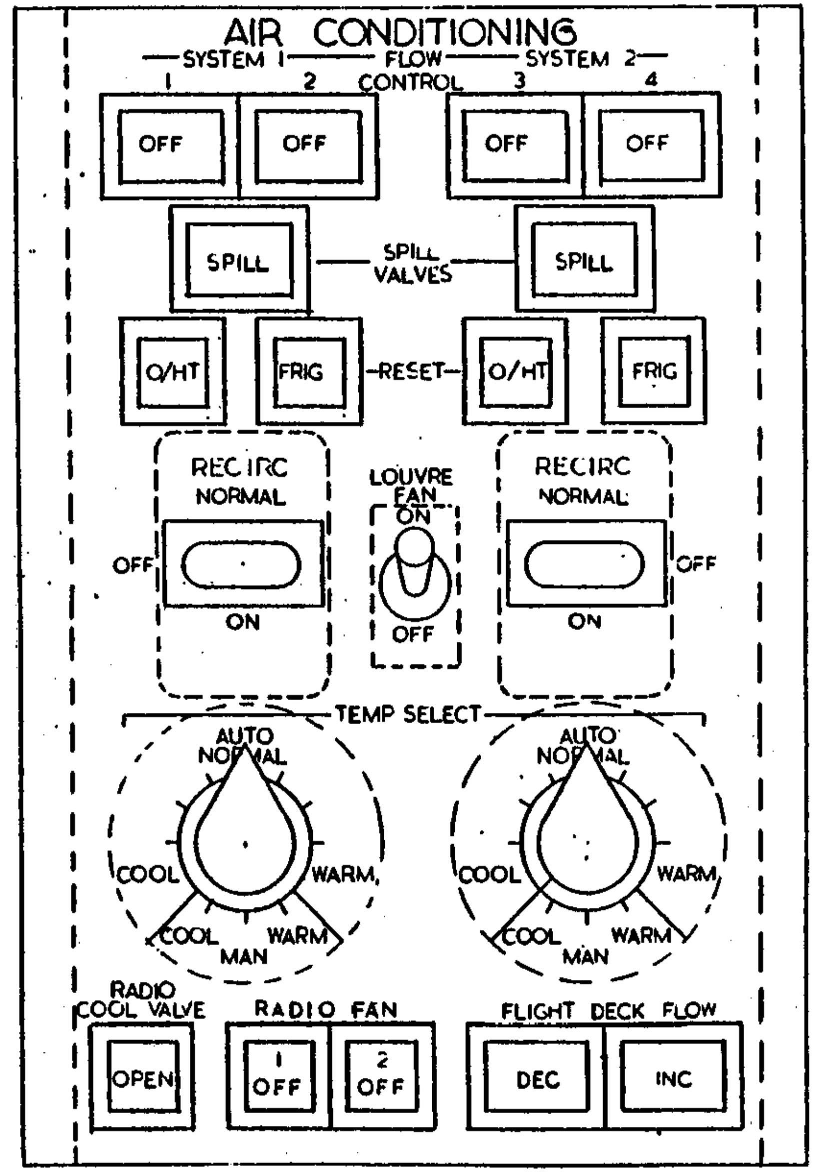


Control Surfaces at Maximum

Normal Format



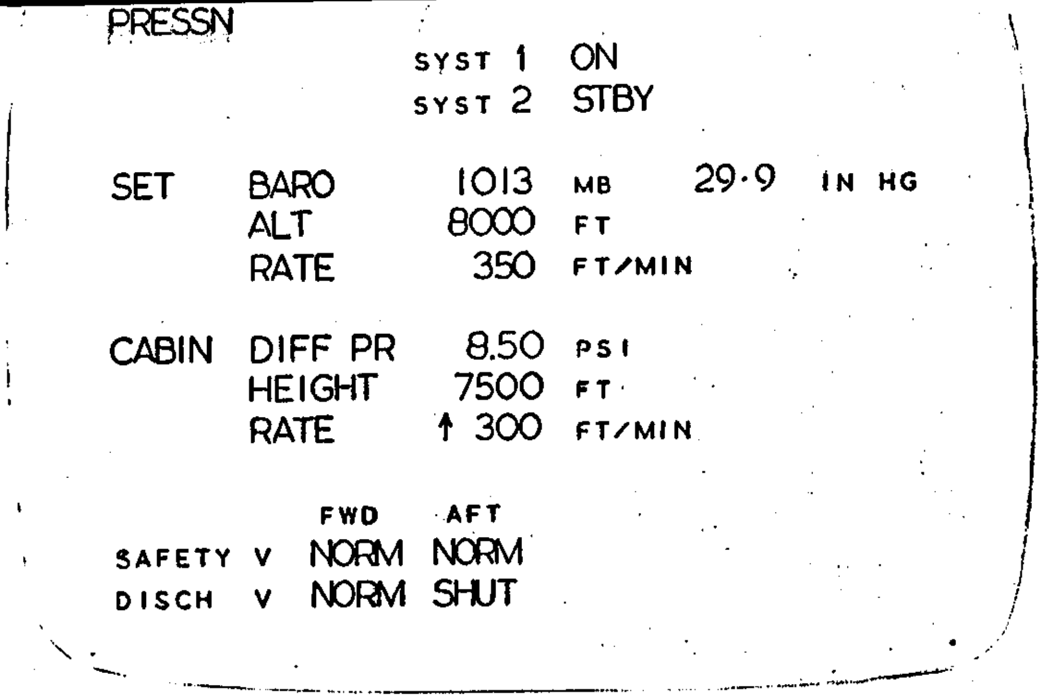




Format with Warnings

Figure 18

Air Conditioning System Formats and Controls



Normal Format

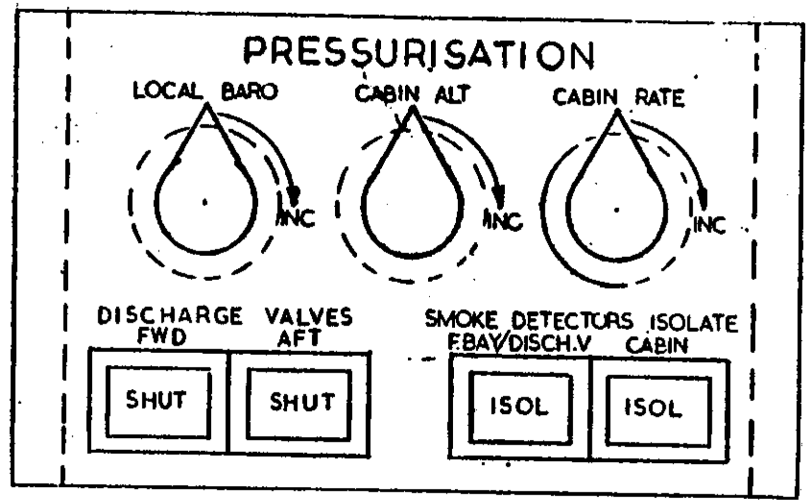
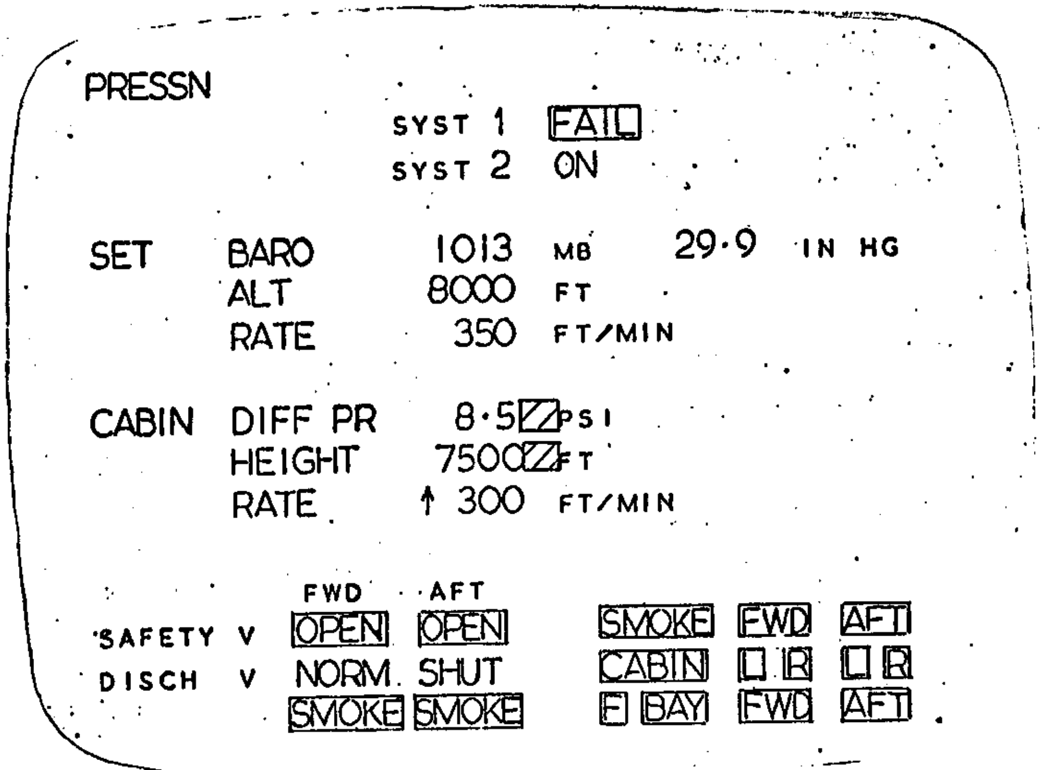


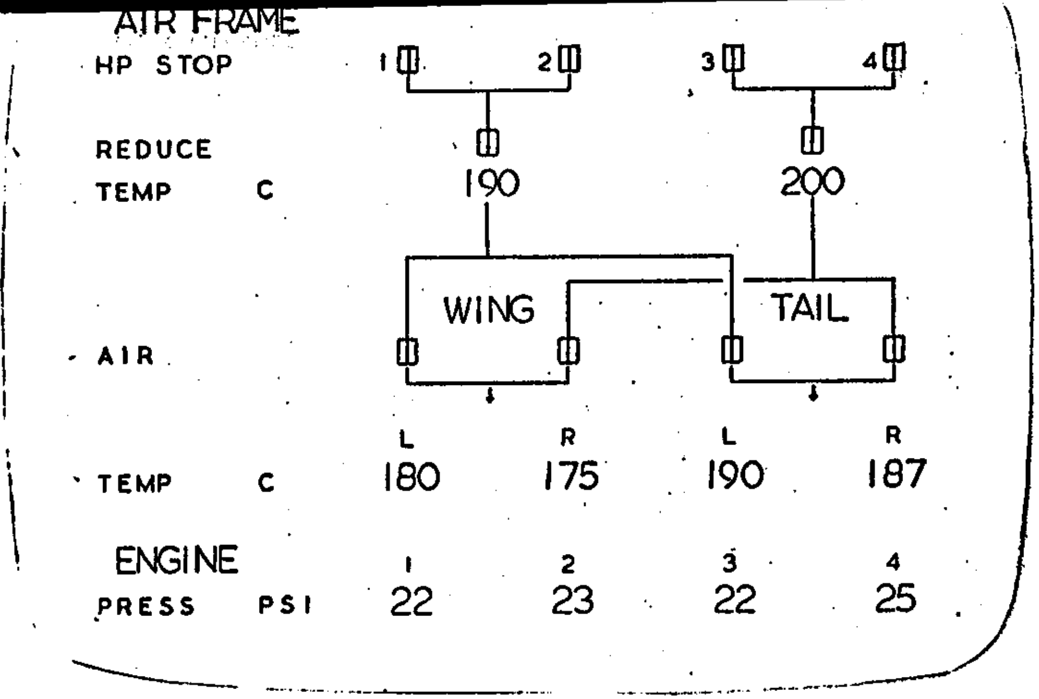
Figure 19

<u>Pressurisation System Formats and Controls</u>



Format showing Warnings

Normal Format



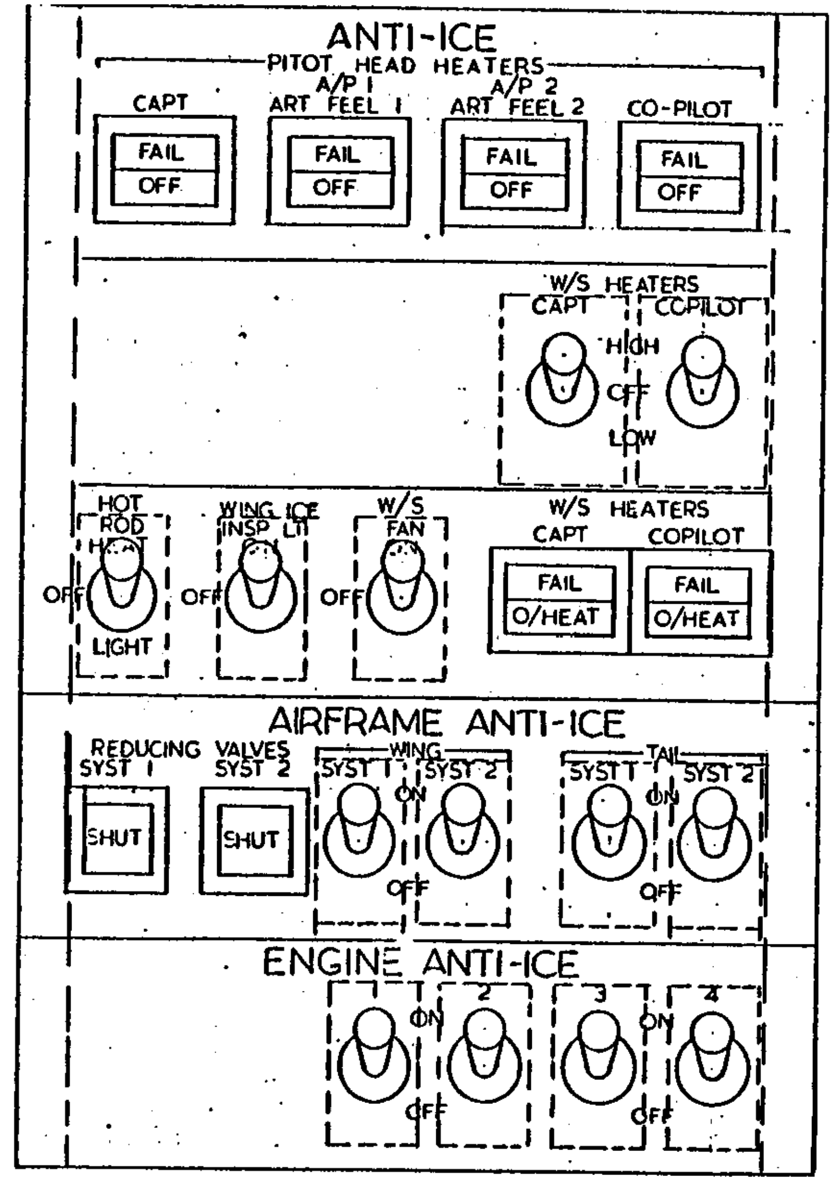
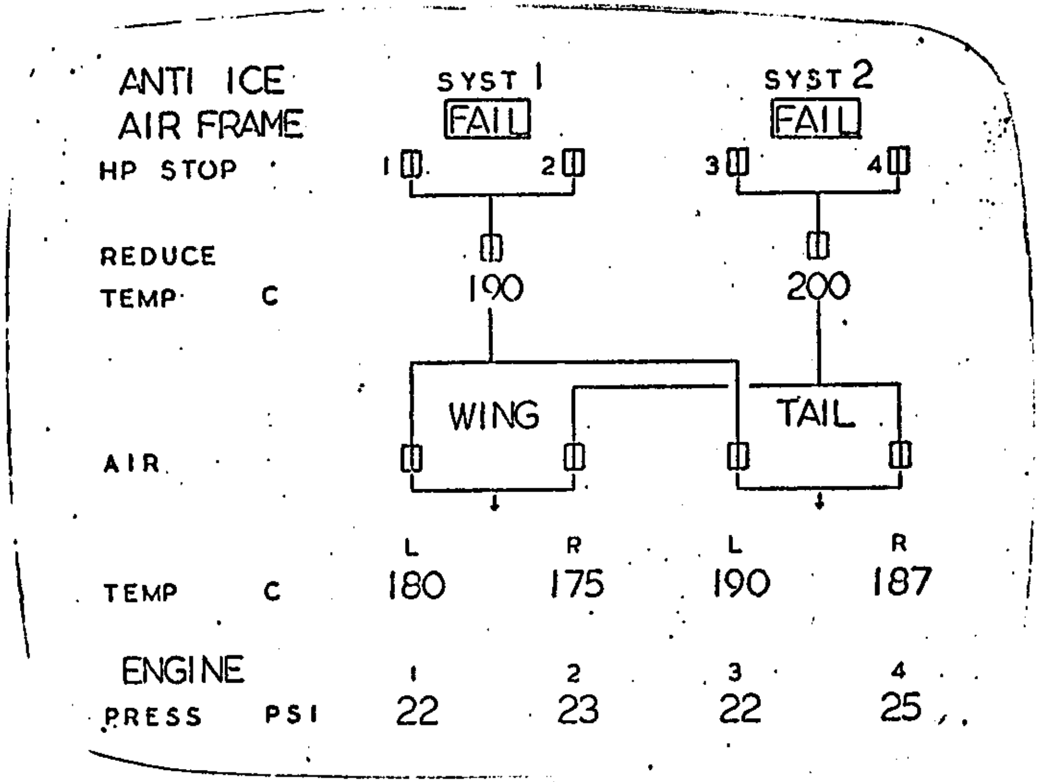


Figure 20

Anti-ice System Format and Controls



Format showing Warnings

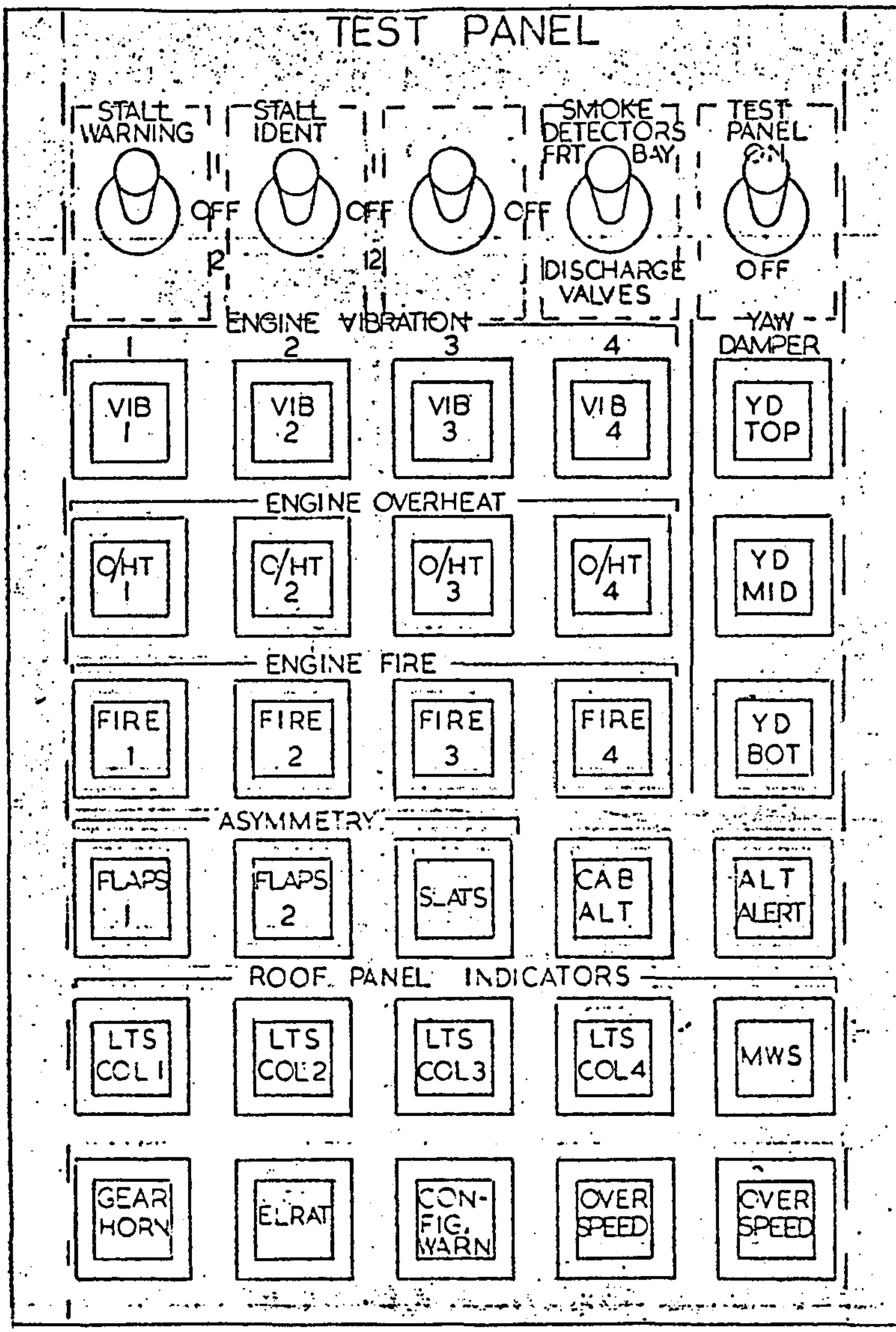


Figure 21

Systems Test Panel

CHAPTER 7

MASTER WARNING SYSTEM

7.1. Introduction

The warning philosophy employed was based on a centralised MWS and associated audible warnings.

7.2. Description

7.2.1. Warnings were classified into two classes:

(i) Red warnings requiring immediate action

(ii) Amber warnings requiring action at the earliest opportunity.

7.2.2. The pilots were alerted to a failure by one of the "Attention Getters" situated on either side of the Glareshield (see Figure 4):

(i) A red flashing light

(ii) An amber flashing light

(iii) A steady red light illuminating the caption "ENG"

The red or amber flashing lights were accompanied, when appropriate, by an audible warning. Recognition of the fault was acknowledged by one of the pilots pressing the attention-getter which resulted in the flashing light becoming steady if red and becoming extinguished if amber. The audible warning also then ceased. The pilots then determined the area of the fault from the MWS annunciator panel (see Figure 22).

The red "ENG" light was an exception to the general MWS philosophy as its illumination indicated 'Engine Fire' if a bell sounded simultaneously or 'Engine Overheat' if no bell sounded.

7.2.3. The annunciator panel was situated at the forward end of the Roof Panel (see Figure 3) and consisted of rows of captions each relating to an aircraft system.

7.2.4. Also situated on this annunciator panel were four push-buttons:

(a) CNCL (amber) to remove a persistent warning, which was useful to alert the crew to a second failure of a system.

(b) RECALL to recall a cancelled warning which was still present.

(c) INHIBIT to prevent unwanted warnings

(d) DIM for use in night flying.

7.2.5. The annunciator would, in general, direct the pilot to the relevant systems panel where a caption, the same as the MWS caption, was lit.

7.2.6. When a fault activated the MWS it "called-up" the relevant system format, if appropriate, onto a predetermined display to assist the crew to assess the actions they would need to take. For multiple failures the presentation of the systems formats was assigned a priority order:-

	S1	S2	S3
1.	FUEL	ALL ENG	ELEC
2.	HYD		ANTI ICE
3.	CTRLS		PRESSN
4.	SING.ENG		AIR COND.

Red warnings always took priority over amber warnings.

7.2.7. The audible warnings used were:

(a) Autopilot Disconnect - Lyre Bird

(b) Engine Fire - Bell

(c) Undercarriage Warning	-	Continuous Horn
(d) Overspeed	-	Continuous Horn
(e) Take-off Configuration	-	Intermittent Horn
(f) Cabin Altitude	-	Intermittent Horn

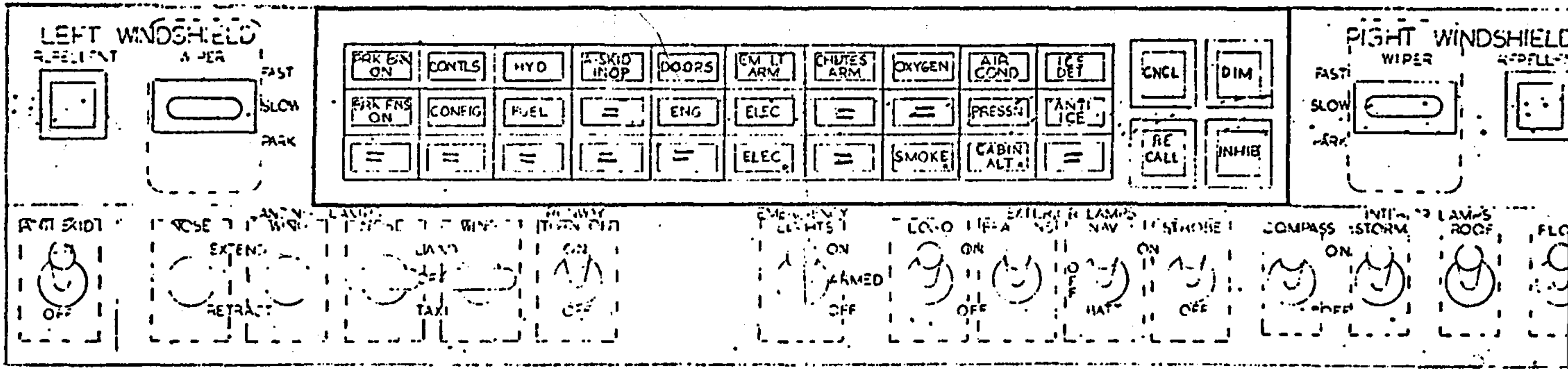


Figure 22

MWS Annunciator Panel

CHAPTER 8

DESCRIPTION OF MONITORING AND RECORDING FACILITY

8.1. Monitoring Team

During the Familiarization part of the programme each pilot was monitored by a team of four persons, each having a separate function:

8.1.1. Resident Pilot who occupied the left or right-hand pilots' seats according to the requirements of each exercise. He assisted the Assessment Pilot and shared the handling and non-handling duties as defined for each exercise.

8.1.2. Observer who was seated in a central position aft of the pedestal. His duty was to monitor each stage of the programme to check that correct procedures were followed and to record any deviations. He also instructed the Assessment Pilot, in conjunction with the Exercise Controller, on the requirements of each exercise. The Observer kept a log of each exercise and an example page is shown in Figure 23.

8.1.3. Flight Controller who was located outside the flight deck at a monitoring desk. He controlled the flights including timing, briefing on initial conditions and the requirements for each flight. He kept a log for each flight and recorded selections and indications and times at selected points. The Flight Controller also acted as Air Traffic Controller when required.

8.1.4. Exercise Controller (the rôle taken by the author) who was located outside the flight deck at the monitoring desk.

He controlled all the exercises during the flights including the instructions for the exercises and recording and timing of all selections and readings relating to the systems displays. He was also responsible for asking the questions relating to the readings taken. A log was kept of the timings for each task and analysed together with the Observer's and Flight Controller's logs.

8.2. Monitoring Facilities

The monitoring desk is illustrated in Figure 24. Both the Flight and Exercise Controllers had an intercom link with the Flight Deck and had a visual contact with the simulator engineers controlling the aircraft dynamics and navigation.

The facilities were:

8.2.1. Flight Controllers Log (item 1)

A sample page from the log is reproduced in Figure 25. The log recorded:

a) GMT - to give stage and total times

b) ATC numbers to show where ATC instructions were given

c) Route reference as a distance to go to a waypoint on the flight plan

d) WPT No. - datum positions in the navigation

e) Exercise Reference - recording when instruction from the Observer or Exercise Controller were given

f) Indications of Altitude, CAS, HDG, and vertical speed at set points

g) State of flight director and autopilot (ON or OFF)

8.2.2. Clock (Item 2)

This was a standard type electric office clock with a sweep second hand and was used for the times in the Flight Controller's log. The pilots' clock was synchronised with this clock at the start of each day.

8.2.3. EADI and EHSI Monitors (Item 3)

These were repeaters of the pilots' indications on the flight deck and were used to monitor the flight control parameters and navigation recorded in the Flight Controller's log.

8.2.4. Distance-to-Go Indicator (Item 4)

This indicated the distance to go to the next waypoint and was used as a reference for the aircraft navigation and for the questions and tasks given to each pilot.

8.2.5. Waypoint Alert Light (Item 5)

This was a yellow repeater of the pilots' warning lights.

8.2.6. Outer Marker Light (Item 6)

This was a yellow repeater of the pilots' outer marker lights.

8.2.7. Next WPT No. (Item 7)

This was a repeater of the pilots' indications.

8.2.8. Systems Displays Monitor (Item 8)

This was a single large screen (11" x 8") and was used in conjunction with Item 10 to display the systems formats. It was used by the Exercise Controller when asking questions and for monitoring the accuracy of the pilots' readings.

8.2.9. Stop Clock (Item 9)

This was a large dial electric stop clock with a one second sweep hand. It was used by the Exercise Controller to time the readings in the exercises.

8.2.10. System Display Selectors (Item 10)

These were three buttons controlling the selection of displays S1, S2 or S3 onto the Systems Displays Monitor.

8.2.11. Clock Controls (Item 11)

These were two buttons providing start, stop and reset for the Stop Clock.

8.2.12. Alarm (Item 12)

This was a button controlling a bell to attract the attention of the computer personnel should abnormalities in the operation be noticed at the control desk.

8.2.13. Observer's Cue Light (Item 13)

This was a two-way cue light between the Exercise Controller and the Observer. It was used by the Exercise Controller to inform the Observer to prepare to observe a reading. A similar facility was also provided for the Observer for him to inform the Exercise Controller that conditions on the flight deck were satisfactory for instructions to be passed.

8.2.14. Exercise Controller's Log (Item 14).

A sample page from the log is reproduced in Figure 26. The records taken were:

a) Route Reference (distance to go to next WPT)

b) Reading Required

c) Exercise Controller's Reading

d) Pilot's Reading

e) Time for pilot to take reading

f) Notes as required.

8.2.15 X-Y Plotter

This was used to monitor the pilots' accuracies in adhering to the flight plans and for monitoring the aircraft's progress.

8.3. Observer's Facilities

The Observer was situated in the third crew seat on the flight deck, aft of the pedestal. The seat had a fault injection panel attached. An illustration of this panel is shown in Figure 27. During the Familiarization Assessment only the READY ('RDY') light/button was used. A description of the other facilities is included in Chapter 15.

8.4. Method of Recording

Each parameter reading was requested by the Exercise Controller. The questions were asked in the form (e.g.) "Engine 2, N2, please". The pilots were requested to respond by stating the respective parameter reading only and not to repeat the question. The Exercise Controller's stop clock was started on the word "please" and stopped when the whole reading had been given. This gave the "Reading Time".

When, to provide the correct reading, the pilot was required to make a format selection the Exercise Controller's stop clock time then included this selection and was termed the "Total Response Time". In order to obtain the "Reading Time" the times taken by the Observer on the flight deck were used. The Observer started his stop watch at the same time as the Exercise Controller, but he stopped it as soon as the required format appeared on the appropriate display. The Observer's reading was termed the pilots' "Selection Time". i.e. "Total Response Time" minus "Selection Time" equals "Reading Time".

The reading requests were carefully interfaced with the ATC. However on each pilot's second day he was also required to perform checks and drills during flight. In order that these checks or drills did not interfere with the readings the pilots were requested to give all readings preference.

L.H. J. W. WILSON (HANDLING)	ADVANCED FLIGHT DECK - OBSERVER'S LOG	DATE (SAMPLE)
R.H. (SAMPLE) PILOT (NON HANDLG)	EXERCISE 8 - SYSTEMS CONTROL	SHEET 1

RIG DEFICIENCIES NONE.

INITIAL CONDITIONS
HT 0 IAS 0
HDG 270° POSN 0

GMT	DIST TO GO SCHED	DIST TO GO ACTUAL	READING TITLE / INSTRUCTION TO PILOT	OBSERVER'S READING	STOP REQD	WATCH TIME	NOTES	GMT	REMARKS
1150	0/0		CHECK LIST FROM ENG START (SH 6 PARA 2)						(Pilot not feeling well - heavy
								1154	Radio fans selected off instead of
1157			ENG START CHECKS COMPLETE						radio cool valve shut.
1159			BRAKES OFF				S1: FLT CTRLS S2: ALL ENG. S3: ELEC		
			AFTER TAKE OFF ENGAGE A/P	✓			F3: EHSI F4: EADI	1201	A/P IN AT 6000'
1201	WPT 1								
	15/2	15/2	ANTI ICE REQUIRED		W	4.5	CHECK TIME TO SELECT A/I TO S: 3		→ All switches on correctly.
1206	WPT 2							1204	After T/O checks completed then
	25/3	25/3	READ: A/I AIR DUCT TEMP SYST 1	199					selected to Anti Ice again
	20/3	22/3	A/I WING TEMP RIGHT	183					
	15/3	19/3	A/I TAIL TEMP LEFT	187					
	10/3	16/3	ENG 1 A/I PRESSURE	24				1210	Pilot told to switch off A/I
1211	WPT 3 47/4		S1, S3 To STBY		W	S1 1.8 S3 2.8		1212	Cruise checks commenced.
	45/4	✓	No 3 TANK CONTENTS	1577	W	2.9	TIME TO SELECT FUEL TO S: 1		
	40/4	41/4	CABIN DIFF PRESS	7.15	W	3.0	TIME TO SELECT PRESSN TO S: 3		→ Pilot adjusting AIR COND (Cabin

Figure 23

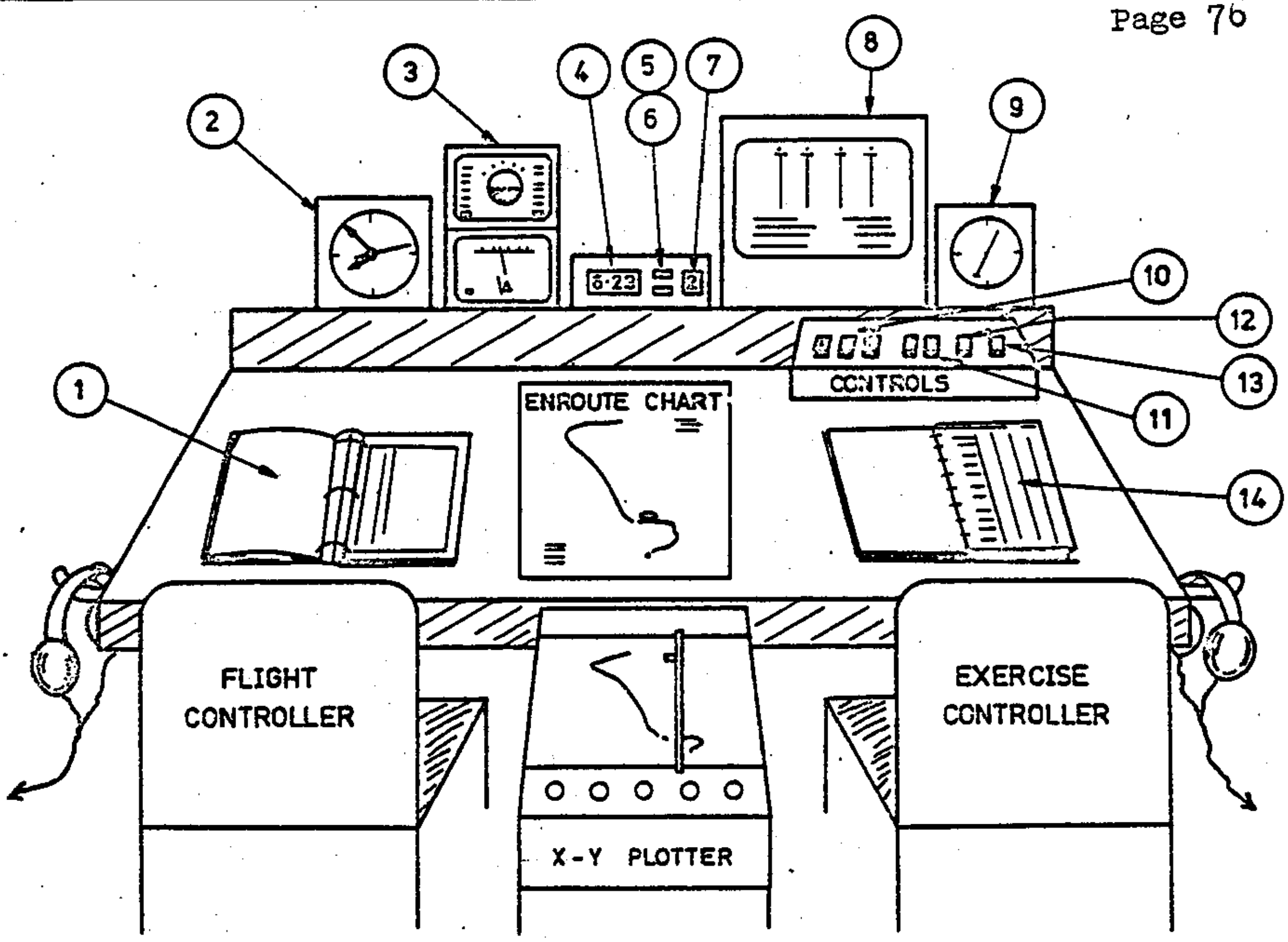


Figure 24

ARRANGEMENT OF MONITORING DESK

Item 1 - Flight Controller's Log
Item 2 - Clock
Item 3 - EADI and EHSI Monitors
Item 4 - Distance-to-Go Indicator
Item 5 - Waypoint Alert Light
Item 6 - Outer Marker Light
Item 7 - Next WPT No.
Item 8 - Systems Displays Monitor
Item 9 - Stop Clock
Item 10 - System Display Selectors
Item 11 - Clock Controls
Item 12 - Alarm
Item 13 - Observer's Cue Light
Item 14 - Exercise Controller's Log

LOG SHEET	FLIGHT Nº 8 No lidd From Take-off clearance	DATE SAMPLE PILOT CO-PILOT

SHT 8

TIME HRS	ATC Nº	ROUTE REF DTG	ROUTE REF WPT	EX Nº	EVENT	ALT	CAS	HDG	VS	FD	AP
12.07	6										
	7				AIRBORNE 07						
	8										
			1			060	258	152	–	ON	ON
.13			2	01	3 at 18						
.15				R	start	↑	277	139	3.2	ON	ON
.17		8.5		R	complete						
.18	10		3		4 26	207					
.20	11										
	12					210	328	141	–	OFF	ON
.21				02							
.22				R	start	210	338	141	–	OFF	ON
					Pilot switched to HDG mode. (upset DTG)						
				R	complete						
27	13		4	01							
		30		R	start	↓	336	146	2.8	OFF	ON
32				R	Complete						
			5		M 35						
					6 at 37 EAT 49						
38			6								
	21										
40	22	14.8							3.2		
					Pilot changeover	↓	195	118		ON	OFF
43	23		7			2070	195	118	–	–	–
.45	24				Pilot said 5 m not 3 m b	ILS					
	25										
48	26										
.50					LAND.						
.54					After land 32 complete						
					Flight 43						
					Checks. 4						
					47 min						

O = Observers Instructions R = Readings asked for

Figure 25

ADVANCED FLIGHT DECK - EXERCISE CONTROL LOG

SAMPLE

DATE 070476	EX. No. 4.	7
LH JWW	R.H. PILOT	
OBSERVER PMW	FLT. CONTROL BJB	EX. CONTROL MDL

DTG WPT	READING	EX. RDG.	PILOT RDG	TIME	NOTES
24-3	Eng.1 (EPR)	2.17	2.17	3.3	
22-3	Eng.4 (FF)	4694	4694	2.85	
20-3	Eng.3 (EGT)	498	498	1.75	
18-3	Eng.1 (EGT)	499	499	2.2	
16-3	Eng.2. (EPR)	2.21	2.21	2.5	
14-3	Eng.1. (N1)	92.3	92.3	2.2	
12-3	Eng.2. (FF)	4045	4045	1.55	
10-3	Eng.4. (FF)	4056	4056	1.95	
8-3	Eng.2. (EGT).	494	494	2.3	
6-3	T_1	0	0	7.9	
40-4	Metered Fuel	5600	5600	2.9	
38-4	No.3. Tank Cnts.	1410	1410	4.1	
36-4	No.1A Tank Cnts.	578	578	2.25	
34-4	No.2. Fuel Temp.	11	11	2.5	
32-4	Total Fuel	5440	5440	2.55	
30-4	No.4. Fuel Temp	11	11	2.05	
28-4	Min.Tank Temp	10	10	1.65	
26-4	No.4 Tank Cnts	773	773	2.2	
24-4	No.4A Tank Cnts	549	549	1.15	
34-5	Eng.2 (oil Temp)	20	20	2.25	
32-5	Eng.2. (N1)	50.2	50.2	4.05	
30-5	Eng.2 (FF)	484	484	2.3	
28-5	Eng.2 (oil Press)	45	45	1.6	

Figure 26

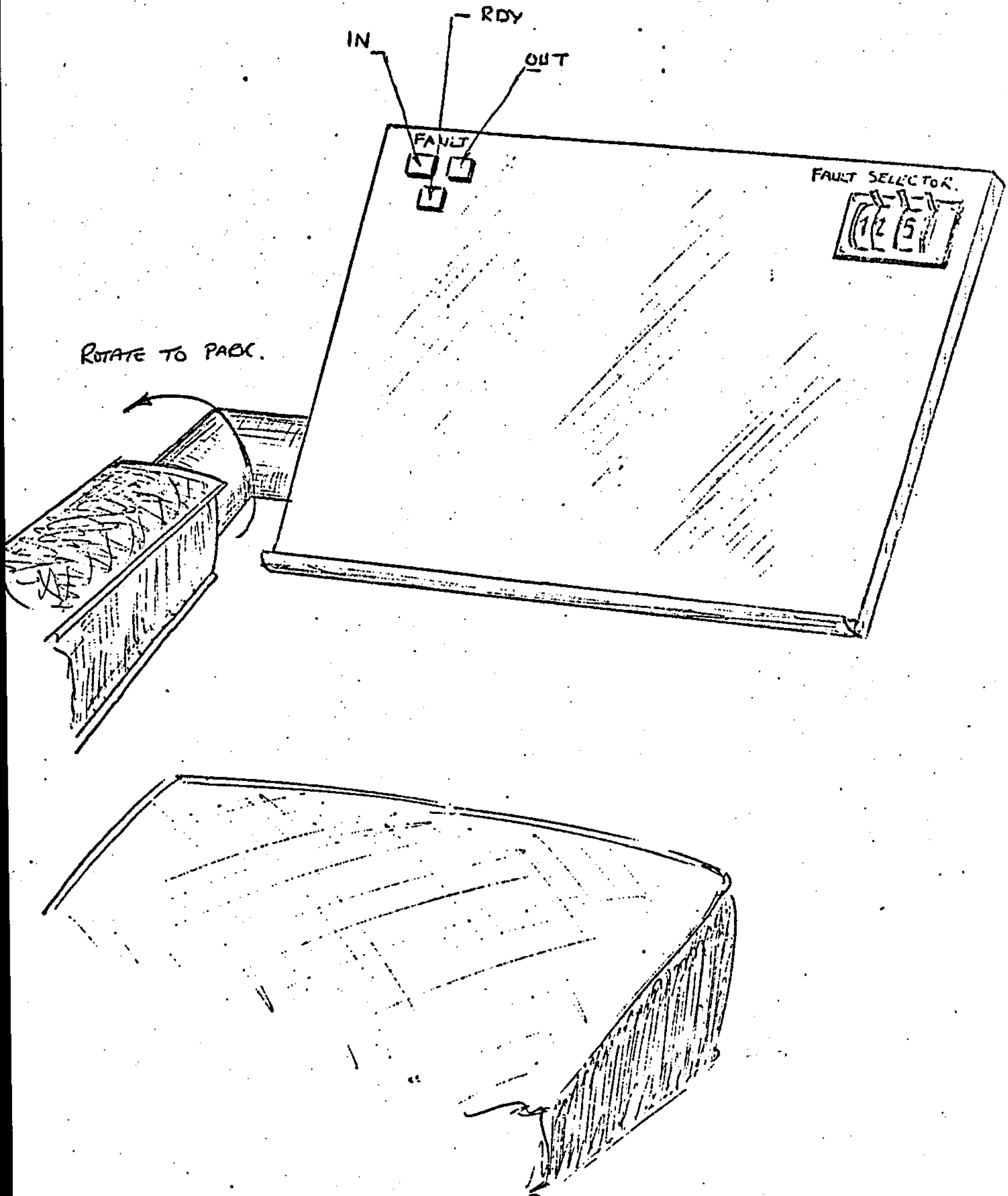


Figure 27

Observer's Monitoring Facility

CHAPTER 9

PROGRAMME AND EXERCISES

9.1. Purpose

The purpose of the Familiarization Programme was to introduce the management of the Flight Deck to the pilots and to refine the techniques used by the assessment team prior to the start of the main evaluation in August 1976. This enabled the procedures to remain unchanged throughout the assessment period. The exercises provided a valuable opportunity to respond to the significant criticism and suggestions made by the designated eleven pilots (see Chapter 13).

9.2. Programme

The Familiarization Programme commenced on 24th. March 1976 and lasted until 26th. May 1976.

Before the pilots could do the exercises an engineering evaluation was made and the Resident Pilot and Observer underwent their own familiarization programme.

The programme consisted of two consecutive days for each pilot, and in this time there were nine exercises. Briefings were given at the beginning of each day and each pilot completed a questionnaire before participating in a formal de-briefing.

9.2.1. Details of Programme

DAY 1

1015 BRIEFING on Simulator Handling, EADI & EHSI, Engine Displays and Short Flight Plan (see Chapter 11). Methods of Recording and Readings to be taken.

1045 INTRODUCTION TO SIMULATOR. Demonstration of Controls and Displays for Exercises 1 to 4. Layout of Displays, Control Column, Throttles, Flaps & Slats, Trims, EADI & EHSI switching.

1115 EXERCISE 1. - Simulator Handling

1145 EXERCISE 2. - Simulator Handling

1215 EXERCISE 3. - Displays Switching (EADI & EHSI)

1300 (Lunch)

1345 BRIEFING on Full Flight Plan (see Chapter 11), Flight Log, Autopilot, Displays Switching, Electrics Format, Single Engine Format, Fuel Format.

1415 EXERCISE 4. - Flight Plan Familiarization and Systems Displays Switching (1)

1515 EXERCISE 5. - Systems Displays Switching (2)

1600 QUESTIONNAIRE (and tea)

1620 BRIEFING (for Day 2) on Preflight checks, Check List, Test Panel, Systems Layout.

1715 DEBRIEFING on Exercises 1 to 5

DAY 2

0915 BRIEFING on Day's programme, Air Conditioning Format, Pressurization Format, Anti-ice system and Format.

0930 EXERCISE 6. - Preflight Checks and Introduction to Air System and Pressurization Formats.

1035 (Coffee)

1050 EXERCISE 7. - Use of Air Conditioning System and Pressurization Formats.

1245 (Lunch)

1345 BRIEFING Systems Displays Failures.

1355 EXERCISE 8. - Systems Controls

1450 EXERCISE 9. - Displays Failures

1550 QUESTIONNAIRE (and tea)

1625 DEBRIEFING on Exercises 6 to 10 and general items.

9.2.2. Technique

The technique employed in the programme was to start with basic exercises that were repeated and expanded until the full flight programme with pre-flight checks and drills was achieved. The emphasis was placed on the systems formats and management of the displays, with sufficient aircraft systems handling to permit checks and drills to be perfomed using the systems formats. System failures and their effect on the MWS were introduced, where relevant to preflight conditions. An assessment was made of single display head failures.

The exercises, outlined following, resulted from preliminary assessments by three pilots. A further review occurred after the first four pilots had participated, but changes were not necessary.

The same Resident Pilot and Observer participated with the Assessment Pilots in each exercise.

On the first day of the two day programme each pilot began with an introduction to the Flight Deck and was concerned with the flying of the simulator and the handling of the displays. Systems operation was not included. The pilots began by performing simple manoeuvres which were later included in the full twenty minute flight. Later in the day the flights became longer and involved additional manoeuvres together with the introduction of display failures.

The second day was mainly concerned with the systems handling and used the experience gained on the first day. The pilots preceded each flight with the Engine Start Procedure. This procedure involved the operation of all the aircraft systems. During the flights themselves only a few of the systems were operated. The details of operation are shown in paras. 9.3.1. to 9.3.5. and 9.3.7 to 9.3.10. No systems faults were introduced.

9.3. Exercise Details

9.3.1. Ex. 1. - Simulator Handling

This exercise allowed each pilot a period of "free flying" and introduced part of the flight plan which formed the basis of later exercises.

Duration: 30 min.

Plan: The pilot was allowed 10 min. free flight with manual control. After these 10 min. the pilot assumed navigation as the flight plan from DTG 4 miles to WPT 6 (abbreviated to 4/6) to landing.

Pilot: Left Seat

Readings: None.

9.3.2. Ex. 2. - Simulator Handling

This exercise had a similar purpose to Ex. 1.

Duration: 30 min.

Plan: The pilot was allowed 4 min. free flight followed by manual flying to the plan from 16/6 to landing.

Pilot: Right Seat

Readings: None.

9.3.3. Ex. 3. - Display Switching

The content of Exercises 1 and 2 was repeated but with an extended use of the flight plan. Failure of either the EADI or the EHSI and the use of the EADI/EHSI Changeover Switch (see Figure 1) was introduced. The Observer instructed the pilots when and where to operate this switch, and to simulator a failure of his displays. Towards the end of this exercise the pilots were requested to read various parameters from the ALL ENGINES display with the primary aim of directing his attention towards its format. The errors and response times were recorded and these gave an indication of the pilots' familiarity with the format. Air Traffic Control was introduced to aid the pilot in following the flight plan.

Duration: 30 min.

Plan: The pilot assumed control straight and level at 3,000 ft. at 50/1. After WPT 1 the pilot flew to WPT 3 manually and then did free flying towards WPT 4 for about 8 min. ATC was only a guide and did not require pilot response.

Pilot: Right Seat

Readings & Tasks:

40/1 the EADI and EHSI were interchanged by the pilot

20/1 F4 (EHSI) was switched off by the pilot

4/1 F4 was switched on by the pilot. The EADI/EHSI Changeover Swictch was switched to normal and the navigation assumed as per flight plan.

12/2 F3 was switched off by the pilot

20/3 F3 was switched on by the pilot. After the display had warmed up the flight director was switched off.

60/4 F4 (EADI) was switched off by the pilot

40/4 F4 and flight director were switched on by the pilot.

35/4 the following readings were requested at approximately 30 sec. intervals.

35/4	Engine	2, N2
33/4	"	4, Fuel Flow
31/4	"	1, EGT
29/4	"	3, N1
27/4	"	1, N2
25/4	"	2, EPR
23/4	"	2, N1
21/4	"	3, Fuel Flow
19/4	"	4, N1
17/4	"	4, EPR

The switching was requested by the Observer.

The readings were requested by the Exercise Controller.

9.3.4. Ex. 4. - Flight Plan Familiarization and Systems Displays Switching (1)

The complete flight plan was flown with the introduction of autopilot operation. The autopilot considerably reduced crew workload and allowed time for the pilot to concentrate on the main objectives of the exercise which were the operation of the Systems Displays Controller (see Figure 9), and the switching of the formats from one display to another. Emphasis was directed towards the FUEL and SINGLE ENGINE formats by further requests for parameter readings. The full ATC service was used, but care was taken to ensure that it did not conflict with the pilots' responses to the Exercise Controller's questions.

Duration: 45 minutes

Plan: The pilot flew the full flight on autopilot until the hold, then manually until after landing. The check list was not used.

Pilot: Right Seat

Readings: & Tasks Between WPTs 2 and 5 the following readings were requested by the Exercise Controller at approximately 30 sec. intervals.

24/3 Engine 1, EPR
22/3 " 4, Fuel Flow
20/3 " 3, EGT
18/3 " 1, EGT
16/3 " 2, EPR
14/3 " 1, N1
12/3 " 2, Fuel Flow
10/3 " 4, Fuel Flow
8/3 " 2, EGT
6/3 T1
45/4 Select FUEL to S1
40/4 Total Metered Fuel
38/4 No. 3 tank contents
36/4 No. 1A tank contents
34/4 No. 2 Engine Fuel temperature
32/4 Total fuel in tanks
30/4 No. 4 engine fuel temperature
28/4 Tank minimum temperature
26/4 No. 4 tank contents
24/4 No. 4A tank contents
22/4 Select STANDBY on S1 and S3
40/5 Select ENGINE 2 on S1
34/5 No. 2 oil temperature
32/5 No. 2 N1
30/5 Fuel Flow
28/5 Oil Pressure
26/5 Select ENGINE 1 on S1

20/5 Oil pressure

18/5 N1

16/5 EGT

14/5 EPR

12/5 Select ENGINE 2 on S1

8/5 Select STANDBY on S1 if required

9.3.5. Ex. 5. - Systems Displays Switching (2)

This was a repeat of Exercise 4, but with the emphasis directed, by requests for readings, towards the ELECTRICS and FLYING CONTROLS formats.

Duration: 45 min.

Plan: The pilot flew the full flight on autopilot. The check lists were not used.

Pilot: Left Seat

Readings: & Tasks Between WPTs 2 and 7 the following readings were requested by the Exercise Controller at approximately 30 sec. intervals:

25/3 Select ELECTRICS on S3

20/3 Gen. 1 volts

18/3 Batt 1 volts

16/3 TR2 amps

14/3 Batt 2 amps

12/3 Batt 1 amps

10/3 Gen. 3 KVA

8/3 Gen. 4 frequency

6/3 Select STANDBY on S1 and S3

45/4 Engine 2, N2

43/4 T1

40/4 Batt. 1 volts

35/4 Total metered fuel

30/4 Engine 1, Oil pressure

25/4 Batt. 1 volts

20/4 Select STANDBY on S1 and S3

40/5 Tank 1A fuel contents

35/5 TR2 amps

30/5 Engine 1, EGT

25/5 Engine 1, oil temperature

20/5 Tail trim position

15/5 Total fuel in tanks

10/5 Engine 4, N2

5/5 Select STANDBY to S1 and S3

15/6 Engine 2 inlet temperature

10/6 Batt. 1 volts

5/6 Select STANDBY to S1 and S3 if required

14/7 T1

12/7 Engine 2, N1

10/7 Mimumum fuel temperature

6/7 STANDBY if required

9.3.6. A questionnaire was completed by each pilot as a termination to the first day of his assessment.

9.3.7. <u>Ex. 6. Preflight Checks and Introduction to Air System and Pressurization Formats</u>

During this exercise an introduction was given to the philosophy and layout of the roof panel systems controls, and their relationship to the formats presented on the displays. This was achieved by involving the pilots in both preflight and inflight checks.

Duration: 65 mins.

Plan: The pilot went through the complete check list including the engine start procedure. A 20 min.

flight was flown, the autopilot being engaged at the datum altitude. The flight was a climb to 8,000 ft. and a descent and landing.

Pilot: Right Seat

Readings & Tasks: During the cruise the pilot was requested by the Observer to select and study the Air Conditioning format. After 1 minute to select and study the Pressurization format, and after a further minute to select and study the Anti-ice format.

9.3.8. Ex.7 - Use of Air Conditioning System and Pressurization Formats

A flight was made from London (Heathrow) to Paris using all the defined checks and drills. Operation of the anti-ice system and air conditioning system was required. During this exercise the emphasis was directed towards the air-conditioning, pressurization and anti-ice systems formats.

Duration: 65 min.

Plan: The pilot started with preflight checks, did the engine start procedure and followed the full flight on autopilot. The check list was used throughout.

Pilot: Right Seat

Readings & Tasks: At 15/2, the anti-ice system was used and the anti-ice format was selected to S3 by the pilot. The pilot was requested by the Exercise Controller to read:

25/3 Air Duct. Temp.

20/3 Right Wing temp.

15/3 Left Tail temp

10/3 Engine 4 pressure

At 45/4 the pilot selected the Air Conditioning format on S3 and was requested by the Exercise Controller to read:

40/4 Cabin temp.

38/4 Adjust flight deck temperature to 3 degrees above shown value

34/4 Flight deck duct temp.

32/4 System 1 cool valve position

30/4 Flight deck temp.

At 40/5 the pilot selected Pressurization on to S3 and was requested to read:

35/5 Cabin differential pressure

30/5 Cabin rate of descent

25/5 Flight Deck temp.

20/5 Cabin height

15/5 System 2 cool valve position

10/5 Cabin temp.

6/5 STANDBY was selected to S3 if required.

9.3.9. <u>Ex. 8. - Systems Controls</u>

This exercise was designed to allow consolidation of the experience gained in the previous exercises. The complete flight plan was flown with the autopilot managed by the Resident Pilot. Requests were made for the reading of parameters from different systems thus calling for the use of the Systems Displays Controllers.

Duration: 55 min.

Plan: The pilot started with the engine start procedure and followed with the full flight on autopilot.

Pilot: Right Seat

Readings & Tasks: At 15/2 the anti-ice system was used and the anti-ice format selected on S3 by the pilot. He was asked to read:

25/3 Air Duct temp. system 1

20/3 Right wing temp.

15/3 Left tail temp.

10/3 No. 1 Engine Pressure

45/4 No. 3 fuel tank contents

40/4 Cabin differential pressure

35/4 Cabin temperature

30/4 Adjust cabin temperature to 3° below shown value

25/4 Total metered fuel

20/4 Air conditioning system 1 cool valve position

40/5 Flight deck temp.

35/5 minimum fuel temperature

30/5 Cabin height

9.3.10. Ex. 9. - Display Failures

During this exercise simulated systems display failures were introduced. Initially the remedial action was demonstrated to the pilots, but subsequently they were expected to determine the appropriate action themselves.

Duration: 60 min.

Plan: The flight plan was as for Ex. 8 from take-off, but there was no hold pattern included. The flight finished with an overshoot and landing. The Resident Pilot handled the aircraft up to 15/5, after which the Assessment Pilot took over.

Pilot: Left Seat

Readings & Tasks: 15/2 Pilot switched on anti-ice system and selected the anti-ice format on to S3

5/2 Anti-ice switched off by the pilot and electrics format selected onto S3.

WPT 2 S2 switched off by the Resident Pilot

(The Observer noted where the pilot put the ALL ENGINES format)

15/3 The Resident Pilot switched on S2

55/4 The Resident Pilot switched off S1

50/4 Pilot selects Single Engine format for Eng. 2.

(The Observer noted where this format appeared)

40/4 The Resident Pilot switched on S1

40/5 The Resident Pilot switched off S3

35/5 The pilot was asked to set the cabin temperature 3^{o} below the value shown

(The Observer noted on which display this format appeared)

25/5 The Resident Pilot switched on S3

After all displays were on the pilot reselected STANDBY to S1 and S3 as required.

16/6 S2 was failed by the simulator engineer.

(The Observer noted where the pilot placed the ALL ENGINES format and any other actions taken by the pilot, e.g. use of Standby Instruments)

9.3.11. The assessment was terminated by each pilot completing a further questionnaire covering the full two-day programme and a debriefing.

CHAPTER 10

CHECK LISTS AND DRILLS

10.1. Introduction

The check lists and drills covered all functional controls and some items which were non-functional.

The lists were divided as follows:

1. Preflight Checks
2. Starting Drill
3. Taxi Checks
4. Take-Off Checks
5. After Take-Off Checks
6. Cruise Checks
7. Top of Descent Checks
8. Initial Approach Checks
9. Final Approach Checks
10. Landing Checks
11. After Landing/Shut Down Checks

Lower case letters are used for items not normally included in check lists.

The Resident Pilot read the list and the Assessment Pilot actioned the P1 or P2 as appropriate to his position.

PRE FLIGHT CHECKS

No	PILOT	TITLE	CHECK	SITUATED
1		ROOF LIGHT	ON	ENTRY DOOR
2		INTERCOM	ON	
3	P1	BRAKE PRESS	CHECK	INST. PNL. (LEFT)
4	P2	LDG. GEAR SELECTOR	CHECK DOWN & LOCKED- 3 GREENS	INST. PNL. (CENTRE)
5	P1	SHUT DOWN HANDLES	PULL (4)	ROOF (CENTRE)
6	P1	GROUND POWER	ON	ROOF (COL 2) ELEC. PNL.
7	P1/P2	PANEL LIGHTS	ON AS REQUIRED	ROOF (LEFT & RIGHT)
8	P1	P.C.U's & FEEL MOTORS	CHECK ISOL (13)	ROOF (COL 1) P.C.U.'s
9	P1	SPOILERS	NORMAL (3)	"
10	P1/P2	CRT. DISPLAYS	ON (7)	INST. PNLS (TOP)
11	P2	MWS	CANCEL	ROOF (BOTTOM) MWS
12	P2	TEST PANEL	ON	ROOF (COL 4) TEST PNL.
13	P2 P1	VIBRATION WARNINGS	TEST 1, 2, 3, 4. CHECK DISPLAY (S1)	"
14	P2 P1	ENG. O/H WARNINGS	TEST 1, 2, 3, 4. CHECK DISPLAY (S1)	"
15	P2 P1	ENG. FIRE WARNINGS	TEST 1, 2, 3, 4. CHECK DISPLAY (S1)	"
16	P2 P1 P 2	COL. 1 LTS.	TEST CHECK P.C.U., HYD., FUEL PNL. LIGHTS S1: FLT. CTLS. (3 WNGS) S2: HYD. (18 WNGS.) S3: FUEL (23 WNGS.)	ROOF (COL 4) TEST PNL. ROOF (COL 1)
17	P2	HYDRAULIC FLUID LEVEL	CHECK	HYDRAULIC DISPLAY (S2)
18	P2	HYD. PRESS. WARNINGS	CHECK (8)	"
19	P1	HYD. PUMPS	CHECK ON (4)	ROOF (COL 1) HYD. PNL.
20	P1	BRAKES & STEERING	CHECK NORMAL	
21	P1	FLAP & SLAT ISOL. SWS & OVERRIDE	CHECK NORMAL (5)	"
22	P1	FUEL STATE	SET METERED (S3)	ROOF (COL 1) FUEL PNL.

PRE FLIGHT CHECKS (CONTD)

No	PILOT	TITLE	CHECK	SITUATED
23	P1	INTER ENG & X FEED VALVES.	CHECK CLOSED	ROOF (COL 1) FUEL PNL
24	P2 P2 P1	COL 2 LTS	TEST CHECK DOOR, ENGINES, ELEC, ENG 1 & 2 PNL LIGHTS S1: ENG 1 (10 WNGS) S2: ELECTRICS (18 WNGS) S3: ENG 2 (10 WNGS)	ROOF (COL 4) TEST PNL ROOF (COL 2)
25	P1	FLIGHT DATA RECORDER	SET DATE/FLT No SELECT START CHECK WARNING DOLLS EYE SELECT INSERT IDENT	ROOF (COL 2) ELEC PNL.
26	P1	DRIVE DISCONNECTSWS	NORMAL	ROOF (COL 2) ELEC PNL
27	P1 P2	GEN CONTROL SWS	CHECK: ON 1, 2, 3, 4. GEN FAIL WNGS (4)	ROOF (COL 2) ELEC PNL S2
28	P1	BATTERIES	ON (2)	ROOF (COL 2) ELEC PNL
29	P1	A.C. BUS SW	SET TO MAN SPLIT: CHECK DISPLAY SET TO NORMAL: CHECK AUTO ON DISPLAY	" & S S2
30	P1	STAND BY T.R.U.	TEST TO BUS 1/BUS 2. CHECK DISPLAY	" S2
31	P1	1 & 2 T.R.U.	CHECK	
32	P2 P2 P1	COL 3 LTS	TEST CHECK AIR COND, PRESSN, ENG 3 & 4 PNL LIGHTS S1:ENG 3 (10 WNGS) S2: AIR COND (19 WNGS) S3: ENG 4 (10 WNGS)	ROOF (COL 4) TEST PNL ROOF (COL 3)
33	P2 P1	FLOW CONTROL	ON 1, 2, 3, 4. CHECK 4 FAIL WNGS	ROOF (COL 3) AIR COND PN AND S2: AIR COND DISPLAY
34	P2 P1 P2	SPILL VALVES	CHECK SPILL SELECTED (2) AND DISPLAYED SELECT BOTH VALVES NORMAL	
35	P2	RECIRC/LOUVRE FANS	SET L.H. TO NORMAL R.H. & LOUVRE AS REQD.	

PRE FLIGHT CHECKS (CONTD)

No	PILOT	TITLE	CHECK	SITUATED
36	P2 P1 P2	TEMP SELECT	SET TO MAN WARM (2) CHECK VALVE MOVEMENT SET TO MAN (OFF) (2)	ROOF (COL 3) AIR COND PN AND S2: AIR COND DISPLAY
37	P2	RADIO COOL VALVE	CHECK OPEN	
38	P2	RADIO FANS	CHECK FAN 1 & 2 ON	
39	P2	FLIGHT DECK FLOW	SET TO MID SCALE	
40	P2 P2 P1	COL 4 LTS	TEST CHECK: STALL PROTECTION & ANTI ICE PNL LIGHTS S1: PRESSURISATION (13WNGS) S2: ALL ENGINES (20 WNGS) S3: ANTI-ICE (2 WNGS)	ROOF (COL 4) TEST PNL ROOF (COL 4)
41	P2	PRESSURISATION	SET LOCAL BARO TO 1013 MB SET CABIN ALT TO 1000 FT SET CABIN RATE TO 300FT/MIN	ROOF (COL 3) PRESSN PNL AND S1: PRESSN DISPLAY.
42	P2 P1	DISCHARGE VALVES	SET SHUT, THEN NORM (2) CHECK DISPLAY	
43	P2 P2 P1 P2 P2 P1 P2 P2	STALL PROTECTION SYST PRESS:	CHECK LOW PRESS LIGHT OUT SET STALL WARNING TO 1 CHECK CAPTAIN'S SHAKER SET STALL IDENT TO 1 CHECK SYSTEM FAIL LT, SET WARNING & IDENT TO 1 CHECK: CAPTAIN'S PUSH VALVES A & B OPEN LTS REPEAT FOR WARNING & IDENT 2 & CHECK COPILOT'S SHAKER/PUSH	ROOF (COL 4) TEST PNL & STALL PROT. PNL " " " "
44	P2	PITOT HEATERS	ON (4) CHECK FAIL LIGHTS OUT CHECK STALL PROT HEATER FAIL LIGHTS OUT (4)	ROOF (COL 4) ANTI ICE PNL " " STALL PROT PNL
45	P2	WIND SCREEN HEATERS	ON - LOW (2) CHECK FAIL-O/H LTS OUT (2)	" ANTI ICE PNL
46	P2	WINDSCREEN FAN	AS REQUIRED	" "
47	P2	REDUCING VALVES	NORMAL (OPEN) (2)	" "
48	P2 P1	WING & TAIL L.P. AIR VALVES	OFF (4) CHECK DISPLAY (S3)	" "
49	P2	ENGINE ANTI ICE	OFF 1, 2, 3, 4	" "

1. PRE FLIGHT CHECKS (CONTD)

No	PILOT	TITLE	CHECK	SITUATED
50	P2	GEAR HORN	TEST CHECK HORN & GEAR UNSAFE LT.	ROOF (COL 4) TEST PNL INST PNL (CENTRE)
51	P2	ELRAT	TEST CHECK ELECTRICS DISPLAY	ROOF (COL 4) TEST PNL. S3
52	P2	CONFIG WNG	TEST CHECK AUDIO	ROOF (COL 4) TEST PNL
53	P2	OVER SPEED	TEST (2) CHECK AUDIO	"
54	P2	M.W.S.	TEST CHECK ANNUNCIATOR & GLARE SHIELD LTS.	"
55	P2 P1	ALT. ALERT	TEST CHECK AUDIO & MWS.	"
56	P2 P1	CAB ALT WARNING	TEST CHECK AUDIO & MWS	"
57	P2	SEAT BELTS NO SMOKING	)AUTO)	ROOF PNL (BOTTOM)
58	P2	ROOF LAMP	AS REQUIRED	"
59	P2	NAV LAMP	AS REQUIRED	"
60	P2	EMERGENCY LIGHTS	ARMED	"
61	P2	Radio check & weather	See flight plan.	
62	P2	Route Clearance		

STARTING DRILL

No	PILOT	TITLE	CHECK	SITUATED
1	P2	Start-up Clearance	See flight plan	
2.	P2	BEACON	ON	ROOF PNL (BOTTOM)
3.	P2	GROUND CLEARANCE	CALL GROUND CREW	(Intercom)
4	P1	DOOR WARNING LIGHTS	OUT	ROOF (COL 2)
5	P1/P2	SEATS & HARNESS	ADJUSTED	
6	P1	THROTTLES	CHECK CLOSED	PEDESTAL
7	P2	DISPLAYS	SELECT S1: FUEL S2: ANTI ICE S3: HYDRAULICS	PEDESTAL - SYST. DISPL.CON
8	P1	LP FUEL, HP AIR & HYDRAULIC COCKS	OPEN 1, 2, 3, 4.	ROOF SHUT DOWN PNLS
9	P1 P2	BOOSTER PUMPS	ALL ON (8) CHECK DISPLAY S1	ROOF (COL 1) FUEL PNL
10	P2	RADIO COOL VALVE	CLOSE	ROOF (COL 3) AIR COND PNL
11	P1	ENGINE TOP TEMP.	ISOL. 1, 2, 3, 4.	ROOF (COL 2) ENG. PNL
12	P1	START MASTER SW.	START	"
13	P2	DISPLAY	SELECT: S2: ALL ENG	PEDESTAL SYST. DISPL.CONT
14	P2	START ENG 3	SELECT: S1: ENG 3 CHECK : START AIR VALVE OPEN DUCT P: NO WARNING	" S1 S1
15	P1 P2	APPROPRIATE START SW.	START & MOTOR CHECK: IGNIT 1 ON 2 ON N1 ROTN FWD STARTER ON	ROOF (COL 2) ENGINE PNL ENG 3 DISPLAY (S1)
16	P1	HP FUEL SW.	OPEN AT N2= 10 - 12%	ROOF ENG 3 SHUT DOWN PNL.
17	P2	ABOVE N2 = 40%	CHECK IGNIT 1,2 OFF STARTER - OFF OIL P - NO FLAG HYD SYST B-NO FLAGS	ENG 3 DISPLAY (S1) HYDRAULICS DISPLAY (S3)
18	P1/P2	START ENG 4	SELECT ENG 4 TO S1 AS FOR ITEMS 14 - 17	PEDESTAL - SYST DISPL. CO

STARTING DRILL (CONTD)

No	PILOT	TITLE	CHECK	SITUATED
19	P1/P2	START ENG 2	SELECT ENG 2 TO S1 AS FOR ITEMS 14 - 17	PEDESTAL-SYST DISPL. CONTR.
20	P1/P2	START ENG 1	SELECT ENG 1 TO S1 AS FOR ITEMS 14 - 17	"
21	P1	START MASTER	OFF CHECK ENG 1 AIR VALVE SHUT	ROOF (COL 2) ENGINE PNL ENG 1 DISPL (S1)
22	P1	TOP TEMP	NORMAL (4)	ROOF (COL 2) ENGINE PNL
23	P 2	GROUND SERVICES	REMOVE AIR TRUCK	
24	P2	ENGINE CHECK	CHECK ALL ENGINES-IDLE POWER EPR : 1.110 N2 : 58.9 EGT : 280 N1 : 31.9 FF 576	ALL ENG DISPLAY (S2)
25	P2	HYDRAULIC CHECK	CHECK HYDRAULICS NORMAL	S3
26	P2	ELECTRICS	SELECT ELECTRICS DISPLAY TO S3 CHECK DISPLAY NORMAL	PEDESTAL-SYST DISPL. CONTR. S3
27	P 2	GROUND SERVICES	REMOVE ELECTRICAL POWER TRUCK	
	P2		CHECK AVAIL LIGHT OUT & DISPLAY NORMAL	ROOF (COL 2) ELEC PNL
28	P 2	M.W.S.	PRESS RECALL BUTTON	ROOF-MWS PNL
29	P2	CONTROLS DISPLAY	SELECT FLIGHT CTRLS TO S1	PEDESTAL-SYST DISPL CONTR.
30	P1	P.C.U's & FEEL MOTORS	ON (13) CHECK ISOL & FAIL LTS OUT	ROOF (COL 1) P.C.U. PNL
31	P 2 P2	YAW DAMPERS	ENGAGE 1, 2, 3 TEST: TOP, MID, BOTTOM. DISENGAGE Y/D 3	PEDESTAL ROOF (COL 4) TEST PNL PEDESTAL
32	P2	TEST PANEL	OFF	ROOF (COL 4) TEST PNL
33	P 2 P1 P2 P2	AUTOPILOT	ENGAGE PRESS CAPTAIN'S DISENGAGER CONFIRM A/P DISENGAGED & AUDIO RE-ENGAGE A/P PRESS COPILOT'S DISENGAGER CONFIRM A/P DISENGAGED. & AUDIO	PEDESTAL CAPT'S CONTROL COLUMN PEDESTAL COPILOT'S CONTROL COLUMN
34	P1	SPEED BRAKES	OPERATE LEVER-RETURN TO ZERO CHECK SPOILERS CLOSED	PEDESTAL S1
35	P1	AIL/SPOILER DISCONN.	CHECK LEVER IN NORMAL POSN.	PEDESTAL
36	P 2	AILERON/RUDDER/TAIL TRIMS	CHECK TRIMS-SET FOR TAKE OFF (TAIL TRIM: -7^{0})	"
37	P2 P1	FLAPS & SLATS	SELECT: FLAPS T.O. SLATS OUT CHECK DISPLAY	PEDESTAL " S1

STARTING DRILL (CONTD)

No	PILOT	TITLE	CHECK	SITUATED
38	P1	FLIGHT CONTROLS	CHECK FOR FULL MOVEMENT AND CORRECT SPOILER OPERATION	S1 "
39	P1	BRAKES	CHECK AVAILABLE PRESSURE	INST PANEL (LEFT)

TAXI CHECKS

1	P2	Taxi Clearance	See flight plan	
2	P1 P2	TAKE OFF SPEEDS & POWER	CHECK V_1 V_R V_2 V_{FI} PLACARDED SET EPR INDEX TO 2.6	INSTRUMENT PANEL
3	P2	ENGINE ANTI ICE	AS REQUIRED	ROOF (COL 4) ANTI ICE PNL
4	P1	RELIGHT SWITCHES	AS REQUIRED	ROOF (COL 2) ENGINES
5	P2	M.W.S. PANEL	CLEAR	M.W.S.
6	P1	REVERSERS	CHECK (IDLE POWER)	PEDESTAL/S2
7	P2	TEMP SELECTORS	AUTO NORMAL (2)	ROOF (COL 3) AIR COND PNL
8	P2	WINDSCREEN HEATERS	HIGH (2)	ROOF (COL 4) ANTI ICE PNL
9	P2	ROOF PANEL	CHECK ALL LIGHTS OUT	ROOF

TAKE OFF

1	P2	Take off Clearance	See flight plan	
2	P1	CONTROLS	CHECK	
3	P1	POWER	OPEN THROTTLES TO EPR = 2.60	
4	P2	STOP WATCHES	START	
5	P1	BRAKES	PRESSURE ZERO	
6	P2	ENGINE PARAMETERS	CHECK: EPR: 2.60 N2 : 95% EGT: 485 N1 : 89% FF : 5000	S2
7	P2	CALL	100 KTS, V_1, V_R	
8	P2	GEAR	UP - CHECK LIGHTS	

AFTER TAKE OFF

No	PILOT	TITLE	CHECK	SITUATED
1.	P2	Confirm Airborne	See flight plan	
2	P2	AIRFRAME ANTI-ICE	AS REQUIRED	ROOF (COL 4) ANTI-ICE PNL
3	P1/P2	ALTIMETERS	SET Q.N. H. OR 1013	
4	P2	FLAPS/SLATS	UP AT 200 KTS CHECK RETRACTION	PEDESTAL FLT CTRLS DISPLAY (S1)
5	P2	POWER	NORMAL CLIMB (EPR = 2.5)	
6	P2	PRESSURISATION	SELECT PRESSN TO S3 SET CABIN ALT: 2000 ft SET CABIN RATE 300 ft/ min.	PEDESTAL-SYST. DISPL. CON' ROOF (COL 3) PRESSN PNL. " "
7	P2	AIR COND.	SELECT AIR COND. TO S3 CHECK DISPLAY NORMAL FLIGHT DECK FLOW AS REQD. (MID. SCALE).	PEDESTAL-SYST. DISPL. CON' S3 ROOF (COL 3) AIR COND PNL & S3.
8	P2	RELIGHT SWITCHES	OFF (4)	ROOF (COL 2) ENGINES PNL.
9	P2	ELECTRICS	SELECT ELEC. DISPL. TO S3 CHECK NORMAL OPERATION	PEDESTAL-SYST. DISPL. CON' S3
10	P2	FUEL	SELECT: FUEL TO S1 CHECK: AUTO TRANSFER & NORMAL OPERATION	PEDESTAL SYST. DISPL. CON' S1
11	P2	HYDRAULICS	SELECT HYDRAULICS TO S3 CHECK NORMAL OPERATION	PEDESTAL-SYST. DISPL. CO[illegible] S3
12	P2	DISPLAYS	SELECT S1, S3 TO STANDBY	PEDESTAL-SYST. DISPL. CON'

CRUISE CHECKS

1	P2	AIR COND / PRESSN.	MONITOR CABIN TEMP & PRESSURE PERIODICALLY. RESELECT CABIN ALT AS NECESSARY	
2	P2	FUEL	MONITOR FUEL SYMMETRY & TRANSFER PERIODICALLY. COMPARE METERED & TANK CONTENTS WITH FUEL REQUIRED AT REGULAR INTERVALS.	
3	P2	AIRFRAME ANTI ICE	IF REQUIRED: SELECT ANTI ICE TO S3 CHECK HP STOP VALVES OPEN REDUCE VALVES OPEN SELECT WING/TAIL SYST 1/2 } AS REQD	 S3 S3 ROOF (COL 4) ANTI ICE PNL

TOP OF DESCENT

No	PILOT	TITLE	CHECK	SITUATED
1	P2	HYDRAULICS	SELECT HYDRAULICS TO S3 CHECK CONTENTS & TEMPS.	" S3
2	P2	FUEL	SELECT FUEL TO S3 CHECK ALL BOOSTER PUMPS ON INTER ENG. V's SHUT CROSSFEED V SHUT TOTAL FUEL	" S3
3	P2	PRESSURISATION	SELECT PRESSN TO S3 SET: LOCAL BARO. AIRFIELD HEIGHT CABIN RATE	" ROOF (COL 3) PRESSN PNL " "
4	P1/P2	SEATS/HARNESS	ADJUSTED	
5	P1/P2	ALTIMETERS	SET TO QNH WHEN CLEARED	
6	P2	DISPLAYS	S1 & S3 TO STANDBY	

INITIAL APPROACH

No	PILOT	TITLE	CHECK	SITUATED
1	P2	DISPLAYS	SELECT FLIGHT CONTROLS TO S1 HYDRAULICS TO S3	
		After Tourly (WPT 5) and at 200 kts:		
2	P2	FLAPS & SLATS	SELECT T.O. CHECK DISPLAYS	PEDESTAL S1/S3
3	P2	ELECTRICS	SELECT ELECTRICS TO S3 CHECK DISPLAY	 S3
		At Meru (after hold if applicable)		
4	P2	Weather at De Gaulle	Call Paris Control on 131.35	

FINAL APPROACH (After Gaully (WPT 7))

No	PILOT	TITLE	CHECK	SITUATED
1	P2	FLAPS	SELECT APPROACH (AT 170 kts)	PEDESTAL
2	P1/P2	ALTIMETERS	SET QFE	
3	P2	ENGINE ANTI ICE	AS REQUIRED	ROOF (COL 4) ANTI ICE PNL
4	P2	RELIGHT SWITCHES	AS REQUIRED	ROOF (COL 2) ENGINES PNL
5	P1	AUTOTHROTTLE & ILS	ENGAGE	GLARESHIELD
6	P2	GEAR	DOWN - 3 GREENS STEERING CENTRAL BRAKE PRESSURE ZERO	INST PNL (CENTRE) "
		When established on Localiser		
7	P2	SPEEDBRAKES	IN	PEDESTAL
8	P2	FLAPS	SELECT LAND	"
9	P1/P2	THRESHOLD SPEED(V_{AT})	SET 134 KTS	
10	P2	RUDDER & AIL TRIM	CHECK	"
11	P2	AIRFRAME ANTI ICE	WING (SYST 1 & 2) OFF TAIL (SYST 1 & 2) OFF	ROOF (COL 4) ANTI ICE PNL "
12	P1	AUTOTHROTTLES	OUT AT 200 ft	GLARE SHIELD
13	P1	AUTOPILOT	OUT AT 100 ft	CONTROL HAND WHEEL

0. LANDING

No	PILOT	TITLE	CHECK	SITUATED
1	P2	REVERSE THRUST	SELECT (2)	1 & 4 THROTTLES
2	P1	BRAKE PRESSURES	CHECK	INST PNL (LEFT)

1. AFTER LANDING / SHUT DOWN

1	P1	FUEL BOOSTER PUMPS	ALL OFF (8)	ROOF (COL 1) FUEL PNL
2	P1	RELIGHT SWITCHES	OFF (4)	ROOF (COL 2) ENGINES PNL
3	P2	SPILL VALVES	SPILL (2)	ROOF (COL 3) AIR COND PNL
4	P2	RECIRC FANS	OFF (2)	"
5	P2	TEMP SELECT	MAN (OFF) (2)	"
6	P2	FLIGHT DECK FLOW	MAX. CHECK AIR COND DISPLAY	 S3
7	P2	PITOT HEATERS	OFF (4)	ROOF (COL 4) ANTI ICE PNL
8	P2	WINDSCREEN HEATERS	LOW (2)	"
9	P2	ENGINE ANTI ICE	OFF (4)	"
10	P2	FLAPS/SLATS	SELECT UP & IN, CHECK DISPLAY	PEDESTAL/S1
11	P1	SPEEDBRAKES	CHECK IN	"
12	P1	T.P.I.	ZERO	"
13	P1	P.C.U.'s & FEEL UNITS	ISOLATE (13)	ROOF (COL 1) P.C.U.'s
14	P2	YAW DAMPERS	OFF (3)	PEDESTAL
15	P1/P2	FLT DIRECTOR	OFF (1)	GLARE SHIELD
16	P1	PARKING BRAKE	ON	LEFT OF PEDESTAL
17	P2	NOTICES	OFF (2)	ROOF (BOTTOM)
18	P1	ENGINE SHUT DOWN	PULL SHUT DOWN HANDLES - 1,2,3 ONLY	"
19	P2	GROUND POWER	SELECT ELECTRICS TO S3 CHECK AVAIL LIGHT ON SELECT GROUND POWER ON CHECK DISPLAY	PEDESTAL,SYST DISPL CONTR. ROOF (COL 2) ELEC PNL " S3
20	P1	ENGINE 4	PULL SHUT DOWN HANDLE	ROOF (BOTTOM)
21	P2	LANDING LAMPS	RETRACTED AND OFF	"
22	P2	BEACON	OFF	"
23	P2	NAV LAMPS	AS REQUIRED	"
24	P1	FLIGHT DATA RECORDER	OFF	ROOF (COL 2) F.D.R.
25	P1	GENERATOR CONTL SWS	OFF (4)	" ELEC PNL
26	P1	BATTERIES	OFF (2)	"
27	P2	FLOW CONTROL SWS	OFF (4)	ROOF (COL 3) AIR COND PNL
28	P2	LOUVRE FAN	OFF	"
29	P2	RADIO COOLING VALVE	OPEN	"
30	P2	WINDSCREEN HEATER	OFF	ROOF (COL 4) ANTI ICE PNL
31	P1/P2	DISPLAYS	OFF (7)	INST PANEL
32	P1/P2	FLIGHT DECK LIGHTS	AS REQD	ROOF (SIDES)

CHAPTER 11

NAVIGATION AND AIR TRAFFIC CONTROL

11.1. Navigation

11.1.1. Flight Plan

A route from London (Heathrow) to Paris (Charles de Gaulle) was selected and is illustrated in Figure 28.

For the assessment no navigation controllers were fitted on the Flight Deck and only the EHSI format shown in Figure 7 was available. VOR & DME indications could therefore not be used. The Flight Plan was designed to cater for this.

Departure from London called for a left turn to intercept the LONDON 245° VOR radial and to maintain this heading until a further left turn between LONDON 5 and 6 DME fix onto track 159°. For the purposes of the simulation a WPT was created at the intersection of radial 245 and track 159 and named LONGLY (WPT 1).

Similarly from DIEPPE the track was a VOR radial from PONTOISE and a left turn was required at the intersection of this radial and the radial from CREIL. A WPT was created at this intersection and named TOURLY (WPT 5).

The approach to Paris required a right turn from track 125 at the radial 060° from CDG VOR onto track 240°. These two tracks were extended to an intersection and named GAULLY (WPT 7).

With this arrangement the complete route was flown as a simulated pre-programmed INS with approach to the WPTs indicated by an Alert Light (see Figure 8) which flashed prior to an automatic change to the next track. This change of track was displayed on the EHSI. The flight director and autopilot, when engaged, responded accordingly. A Distance-to-Go Indicator (see Figure 8) was fitted to give the pilots additional information and to provide a datum for monitoring purposes.

The route was based on standard AERAD charts, but the named beacons and VORs were replaced by WPTs. The magnetic headings were converted to true headings by assuming the variations which are shown in Figure 28.

The MERU holding pattern used in Exercises 4,7 and 8 involved radial 022 from PONTOISE and DME fixes from CREIL. These were replaced by ATC instructions to turn left at DTG 16 and to carry out a one minute left-hand racetrack holding pattern.

Standard approach procedures to Paris were used and ILS, Middle and Outer Markers (see Figure 8) were available.

The left turn after departure was made by following the flight director which was automatically switched on at 500 ft. and using the beam-bar on the

EHSI (see Figure 7) to line up with WPT 1.

A Go-around pattern was used in Exercise 9 and this is shown in Figure 29.

11.1.2. Vertical Profile

The vertical profile and some initial aircraft performance data are shown in Figure 30. The cruise altitude of FL 260 was selected to provide a flight duration of about 45 min.

The data shown in Figure 30 were used as a basis for estimating the duration of flight shown in Figure 31. These data assumed a VC-10 type performance and were only preliminary. Some modifications were made during the flying programme.

11.1.3. Short Flights

To suit the requirements of the various exercises, parts of the Flight Plan were used according to the duration and type of flight required. This provided the pilots with progressive familiarization with the Flight Plan and simplified the navigation computation for the simulator.

11.1.3.1. Short Take-off and Landing

Exercise 6 consisted of a flight of 20 min. (see Figure 32) starting with an initial climb, with flight director and navigation off, to an altitude of 8,000 ft. This was maintained for free flying for 10 min. The aircraft was then flown at this altitude at a speed of 210 kt. and the navigation and flight director switched on. The Flight Plan from WPT 6 to landing completed the exercise.

11.1.4. Go-Around Pattern with Landing

This plan had a duration of about 12 min. and was deliberately not included in the navigation computation of the Flight Plan. It was flown manually to ATC instructions until the localiser was re-established. The Go-around was used in Exercise 9.

11.2. Air Traffic Control

Simulated ATC was used in conjunction with the Flight Plan, but was limited by the lack of radio controllers fitted on the Flight Deck.

The ATC consisted of:

a) A single operator representing all the different ATC stations.

b) A script based on the Flight Plan as a guide to step-by-step communication with the pilot. (This script was not directly relevant to the human factors study so is not described herein).

c) A functional dummy VHF controller to enable the pilots to have the workload involved with selecting the rquired VHF frequencies.

The ATC script covered:

Ground Checks	- London Ground Control
Start Clearance	- London Ground Control
Taxy Clearance	- London Ground Control

Airways Clearance	- London Ground Control
Take-off Clearance	- London Tower
Route Clearances	- London ATC
Airways Vectors	- London Radar
Upper Airways Clearances	- London Control
Route Clearance	- France Control
Descent Clearance	- France Control
Meru Hold (if required)	- Paris Radar
Descent Clearance	- Paris Approach
Approach Clearance	- Paris Approach
Landing Clearance	- Paris Tower
Go-Around (if required)	- Paris Radar

ENROUTE CHART SIMULATED FLIGHT LONDON TO PARIS

0	LONDON	N51° 28·7 W00 27·9	0	WPT5	TOURLY SIMULATION ONLY	N49 15·0 E01 53·0	FL 080
WPT1	LONGLY SIMULATION ONLY	N51° 25·5 W00 37·4	3000 FT	DTG15 WPT6	MERU HOLD	N49 15·0 E02 07·0	FL 080
WPT 2	DUNSFOLD	N51 07·9 W00 22·9	FL 080	WPT 6	CREIL	N49 15·0 E02 31·0	FL 080
WPT 3	SEAFORD	N50 45·6 E00 07·4	FL 210	WPT7	GAULLY SIMULATION ONLY	N49 05·8 E02 55·5	2000FT
WPT4	DIEPPE	N49 56·0 E01 11·0	FL 210	WPT8	BRAY SIMULATION ONLY	N48 59·0 E02 39·0	—

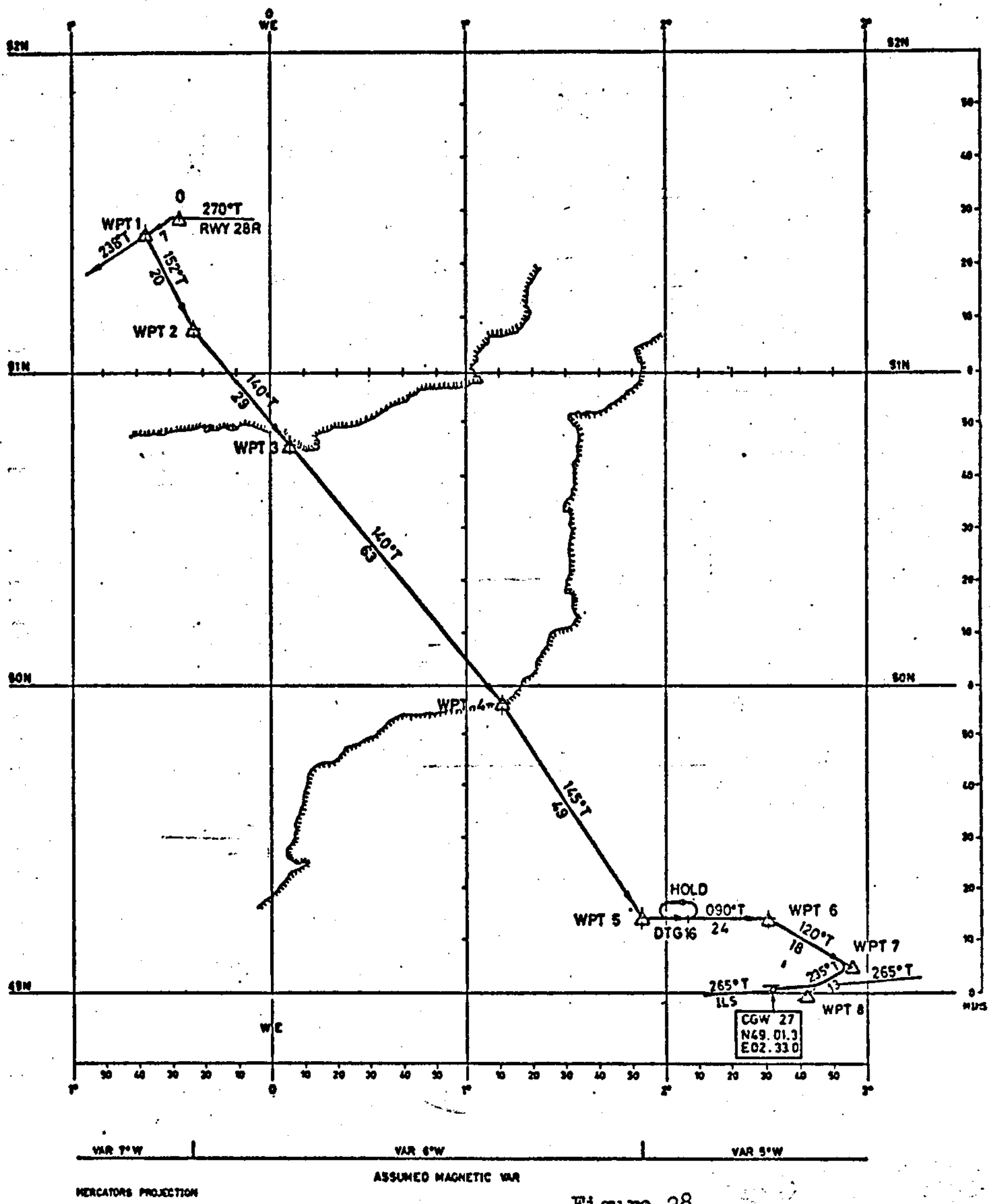


Figure 28

GO AROUND PLAN - ATC USE ONLY

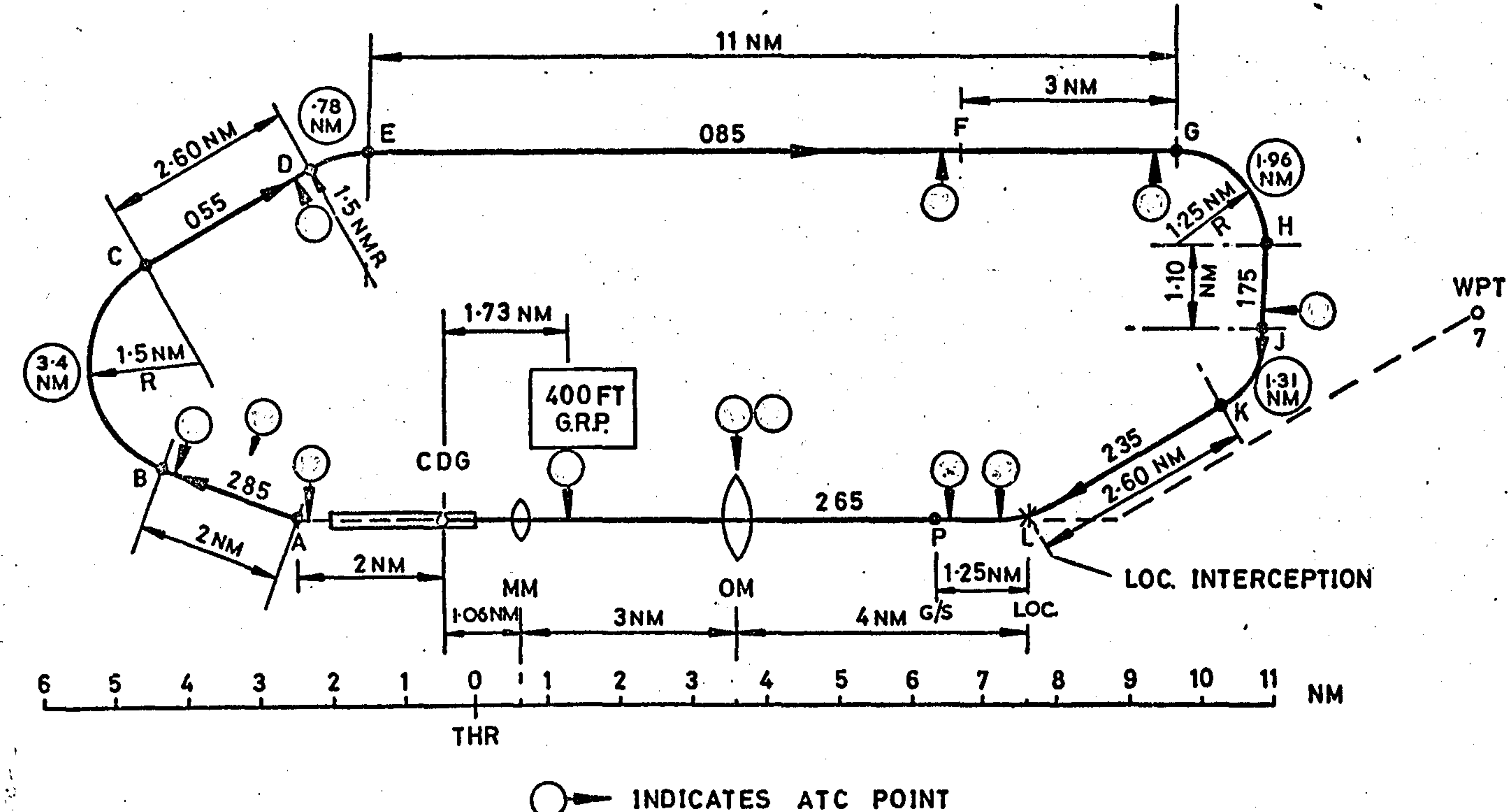


Figure 29

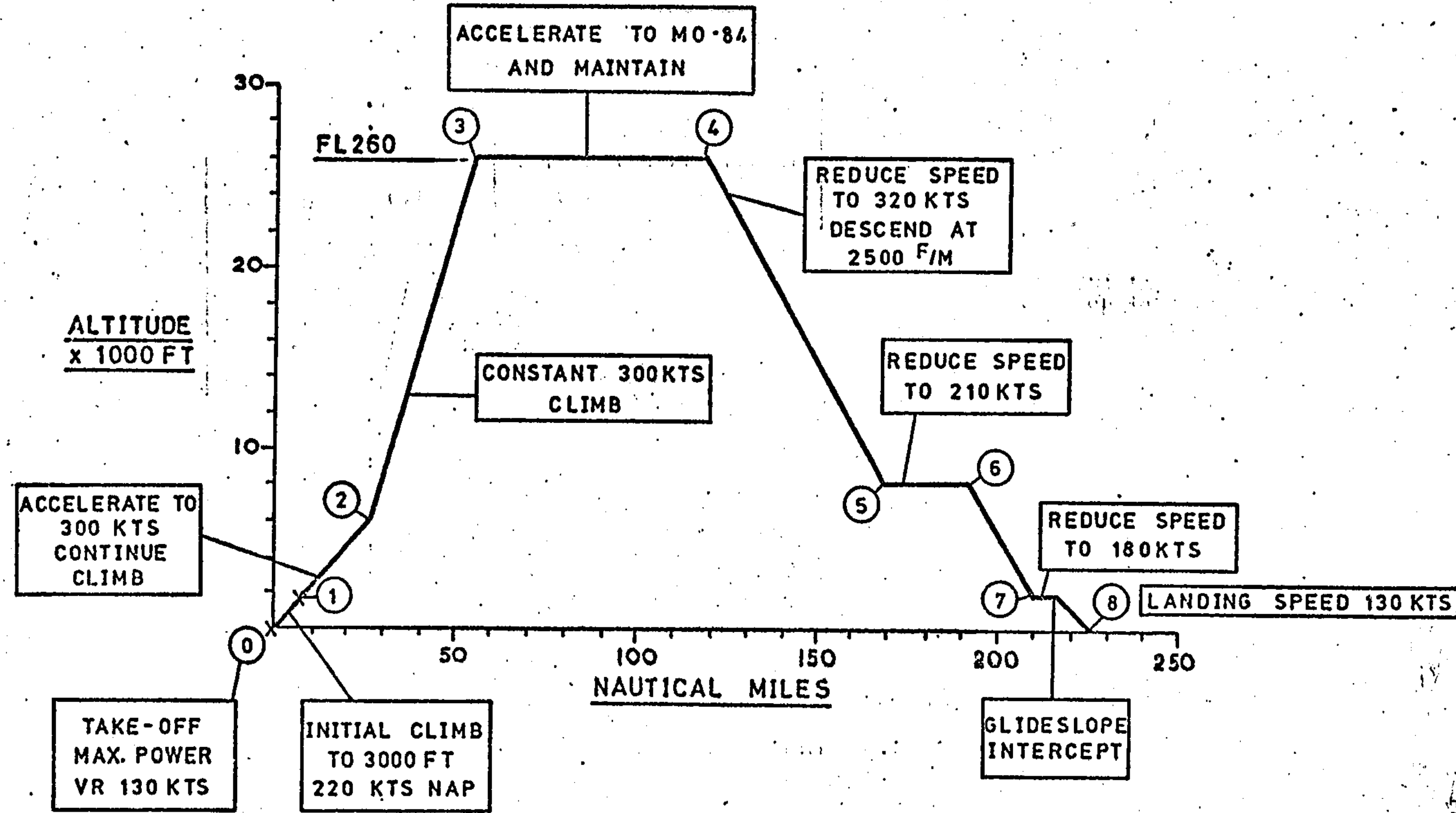


Figure 30

VERTICAL PROFILE WITH AIRCRAFT PERFORMANCE DATA
FOR SIMULATED ROUTE LONDON TO PARIS

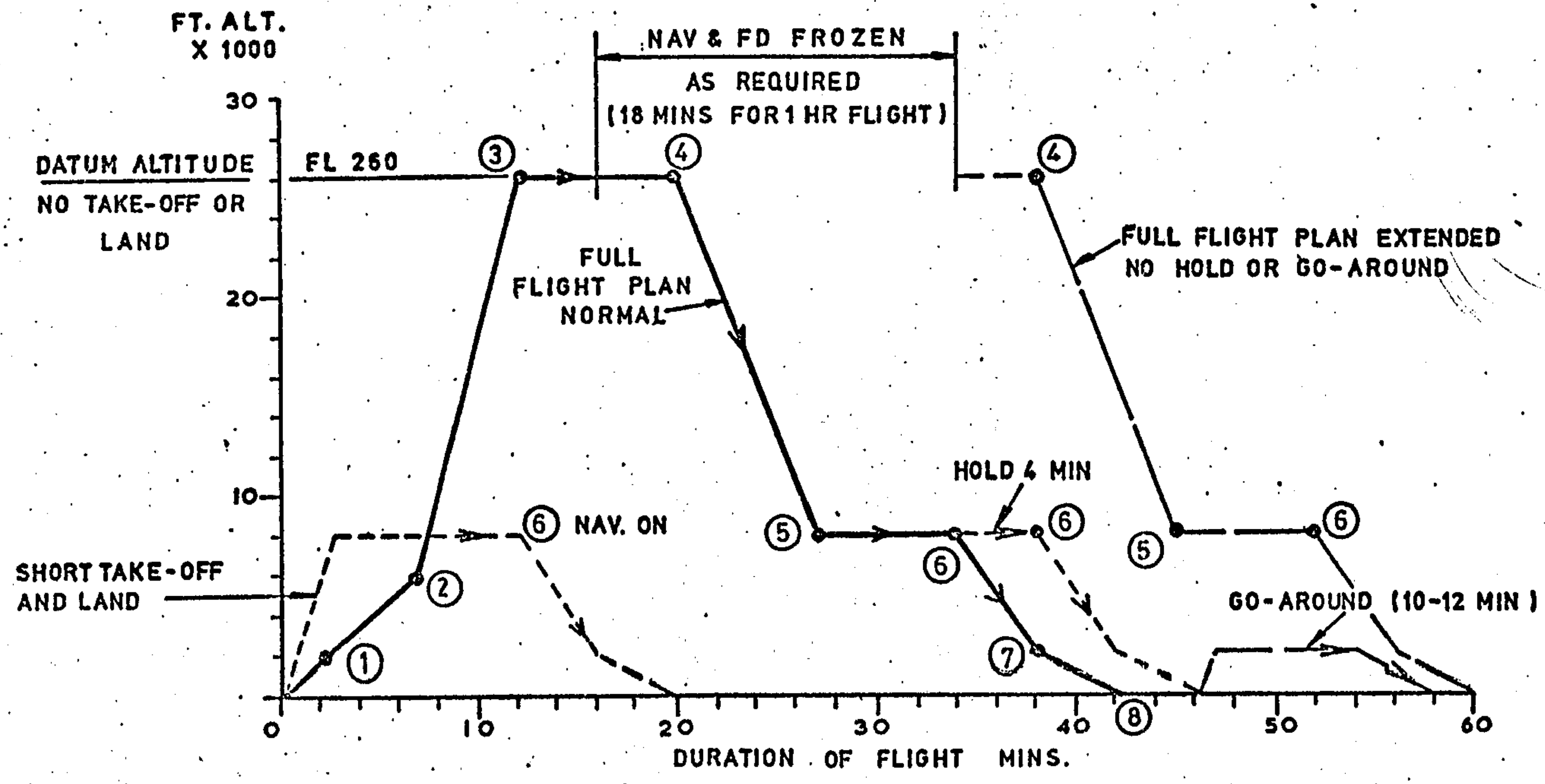
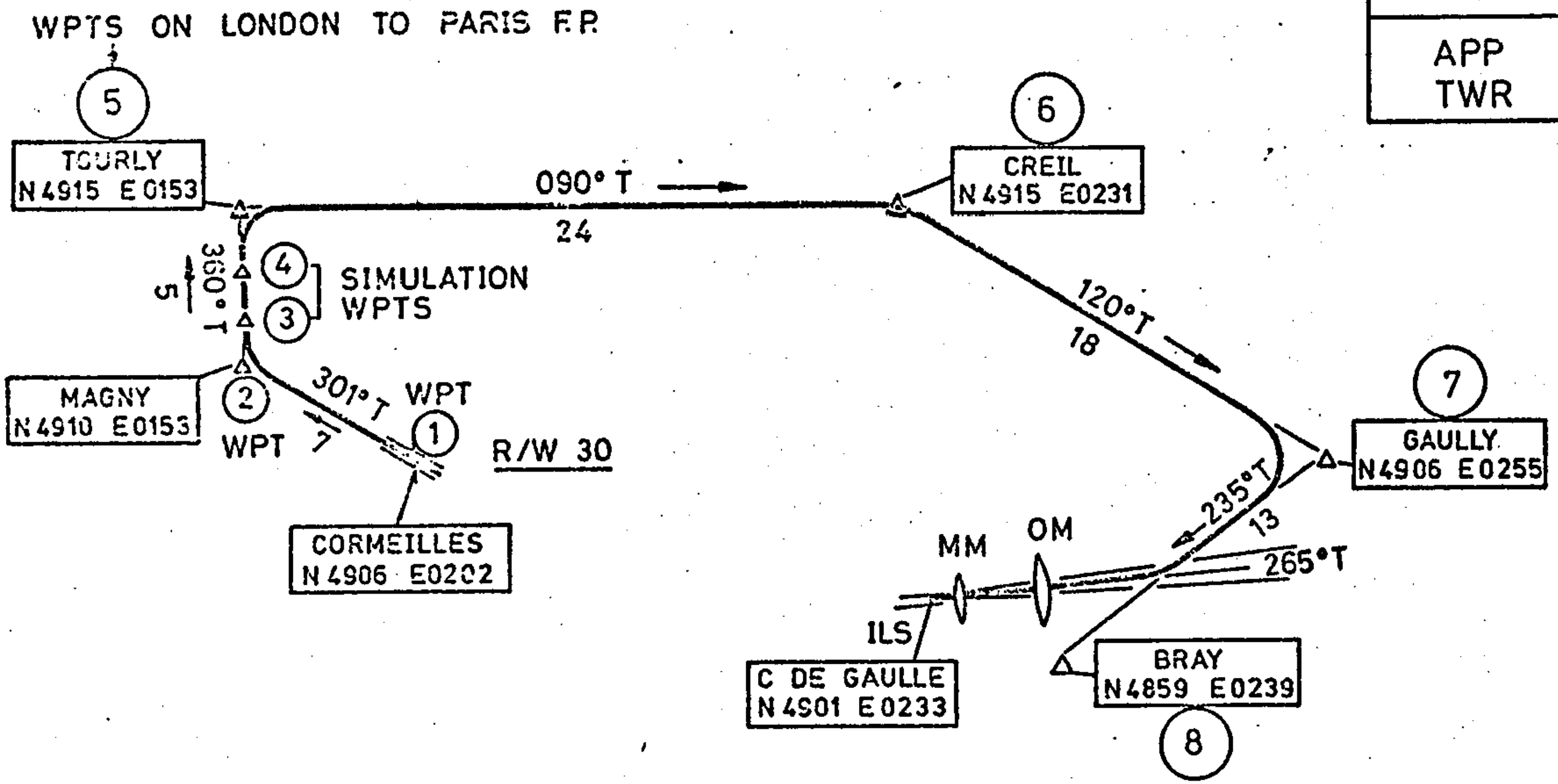


Figure 31

ESTIMATED DURATION OF FLIGHT. FOR SIMULATED ROUTE LONDON TO PARIS.
SHOWING VARIATIONS TO SUIT EXERCISES

PARIS
CHARLES DE GAULLE
CGW 27

APP 118.15
TWR 119.25



PONTOISE
(CORMEILLES-EN-VEXIN)
TO
CHARLES DE GAULLE

CORMEILLES AIRPORT
TWR 119.70

Figure 32

FLIGHT PLAN FOR SHORT FLIGHT

AS LONDON TO PARIS FLIGHT PLAN FROM TOURLY

CHAPTER 12

QUESTIONNAIRES

12.1. Introduction

Two sets of questions were used in the Familiarization Programme, one at the end of the first day and the other at the end of the second.

The first questionnaire was aimed mainly at initial subjective impressions and the second at a more qualitative assessment.

The questionnaires were completed in a conference room adjacent to the Flight Deck. A book of illustrations was provided to assist the pilots. (The simulator was needed at this time by the computer personnel)

12.2. Rating Scales

All except two of the questions included a rating scale which was designed to enable the pilots to give a quantitative indication of their feelings about any one topic. Where a comparison with a conventional display was possible a simple scale was used with the two end positions marked and a neutral position shown in the middle. However, because the pilots were from both military and civil aviation backgrounds they had a variety of experience and a meaningful comparison was not always possible. For most of the questions a six-point rating scale was introduced which deliberately avoided a neutral position where the majority of pilots with a "Don't Know" opinion would probably have indicated. It was felt that an equal interval assumption between the rating positions would be invalid so a non-linear scale similar to that suggested by Duncanson (see reference in para 3.2.) for telephone evaluation was adopted.

12.3. Day 1 Questionnaire

The first questionnaire was aimed at obtaining the pilots' initial impressions and began with the overall flight deck layout, autopilot and the handling of the simulator. The positions of the EADI and the EHSI and their changeover switch were covered, but questions about the formats on these displays were intentionally avoided. Included were questions about the Systems Displays Controllers and the systems displays themselves. The questions on the systems formats were restricted to the ALL ENGINES format and the FLYING CONTROLS format. The alphanumerics on the formats were also included.

12.4. Day 2 Questionnaire

During the second day the pilots had more time to make their assessments of the Flight Deck and the second questionnaire was designed to reflect this. Questions about the systems displays and the associated Systems Displays Control Panel were again included. Questions were also included about the systems controls (Roof Panel) and their relationship with the formats, particularly with respect to their remoteness from the displays. There were questions relating to the systems formats which were not covered in the Day 1 Questionnaire. Also included was more detail about the symbology used. Questions about the use of pushbuttons and the checks and drills performed by the pilots were also included. To complete the list of questions a few general topics were covered relating to eye fatigue, display flicker and the conduct of the exercises.

12.5. Debriefing

Following each questionnaire there was a debriefing session. The questionnaires were used as a basis for the debriefing to ensure that all the topics were covered. The debriefing was tape-recorded for future reference.

12.6. List of Questions

The numbers in parentheses following each question refer to the type of rating scale used. For the key to the rating scales see Figure 33. A sample page from the questionnaires is shown in Figure 34.

Day 1

1.1. After considering the exercises that you have done, what are your impressions of the Flight Deck as shown? (The pilots were required to tick a box corresponding to one of the following categories: Most Unfavourable, Unfavourable, Neutral, Favourable, Most Favourable).

1.2. How would you rate the acceptability of the Flight Deck layout as presented for two crew operation? (1)

1.3. How would you rate the acceptability of the manual handling (feel) of the simulator? (1)

1.4. How would you rate the position of the AFCS Controller on the Glareshield with respect to sight and reach? (1)

1.5. How would you rate the sizes and shapes of the alphanumerics as presented on the three centre displays? (1)

1.6. How would you rate the acceptability of the layout of the three centre displays? (1)

1.7. How do you regard the normal position of the EHSI format? (Criticism of the format itself is not required.) (1)

1.8. How would you rate the acceptability of the EADI in its alternative position? (Criticism of the format itself is is not required.) (1)

1.9. How would you rate the acceptability of the EADI/EHSI Changeover Switch? (1)

1.10. How would you rate the position of the Systems Displays Control Panels? (1)

1.11. How would you rate the layout and operation of the Systems Displays Control Panels? (1)

1.12. How would you rate the information content of the Multi-Engines format? (3)

1.13. How would you rate the presentation and layout of the Multi-Engines format? (1)

1.14. How would you rate the presentation of the Flying Controls format? (1)

1.15. The brilliance and contrast levels of the displays have been set for this exercise only. How would you rate their acceptability? (1)

Day 2

2.1. How would you rate the acceptability of the layout of the three Centre Displays for carrying out the exercise you have done? (1)

2.2. How would you rate the positions of the three Centre Displays relative to your normal eye position? (2)

2.3. Do you consider the number of Displays shown to be adequate for the tasks you have performed during the last two days? (YES or NO)

2.4. Now that you have had more experience in operating the Systems Displays Control Panels, how would you rate their layout and operation? (1)

2.5. How would you rate the philosophy of the operation of the Systems Displays Control Panels? (3)

2.6. How would you rate the acceptability of the Systems Controls with respect to their remoteness from their respective displays? (1)

2.7. How would you rate the layout and position of the Systems Control Panels with respect to your normal eye position? (1)

2.8. How would you rate the layout and position of the Engine Shut-down controls with respect to your normal eye position? (1)

2.9. How would you rate the acceptability of the operation of the Engine Shut-down controls? (1)

2.10. How would you rate the acceptability of the illuminated Pushbuttons for the Systems Controls? (1)

2.11. How would you rate the presentation of the Single Engine formats compared with using conventional engine instruments? (5)

2.12. How would you rate the presentation of the Fuel System format? (6)

2.13. How would you rate the presentation of the Air Conditioning format? (6)

2.14. How would you rate the presentation of the Anti-ice format? (6)

2.15. How would you rate the acceptability of the Pressurization format, as only digital information is presented? (1)

2.16. How would you rate the presentation of the symbols for Pumps and Valves as shown on the Fuel and Air Conditioning formats? (1)

2.17. In general how would you rate the information content of the SYSTEMS formats as presented? (7)

2.18. How would you rate the presentation of the Flying Controls format? (1)

2.19. How would you rate the presentation of the scales as shown on the SINGLE ENGINE formats? (1)

2.20. Although you have not used the Master Warning System you have seen the warning symbols presented on the formats. How would you rate the readability of the warning indications compared with conventional Instrument Failure Flags? (5)

2.21. You have been introduced to the Preflight Checks and

Inflight Checks. How would you rate them with regard to complexity? (8)

2.22. After prolonged viewing, how would you rate eye fatigue from your experience? (9)

2.23. Did you notice any flicker associated with the Displays? (10)

2.24. When looking at any one display did you find any distraction by information changing on an adjacent display? (11)

2.25. How did you regard the realism of the simulation for the exercises you have done in these two days? (12)

2.26. How did you regard the realism of the ATC for the exercises you have done in these two days? (12)

2.27. How would you rate the conduct of the exercises? (13)

(1)

Unacc- eptable	Bad	Poor	Fair	Good	Excel- lent

(2)

Very difficult to see	Satisfactory	Very easy to see

(3)

Too little	Satisfactory	Too much

(4)

Too complicated	Neutral	Very simple

(5)

Very much worse	Comparable	Very much better

(6)

Too complicated	Neutral	Very clear

(7)

Too much presented	Satisfactory	Much more could be included

(8)

Very complex	Neutral	Very clear

(9)

Very bad	None at all

(10)

Very noticeable	Barely noticeable	Unnoticeabl

(11)

Very distracting	None at all

(12)

Totally Inadequate	Adequate	More than Adequate

(13)

Very poor	Satisfactory	Very good

Figure 33

Key to Questionnaire Rating Scales

PILOTS QUESTIONNAIRE	QUESTION No. 1.2

HOW WOULD YOU RATE THE ACCEPTABILITY OF THE FLIGHT DECK LAYOUT AS PRESENTED FOR TWO CREW OPERATION?

RATING

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT

COMMENTS

DE-BRIEFING NOTES (NOT FOR PILOT USE)

SUPPLEMENTARY NOTES

PILOT No.

Figure 34

CHAPTER 13

RESULTS, DISCUSSION AND CONCLUSIONS

13.1. Results

13.1.1. Objective Measurements

A full list of the readings taken is given in Chapter 9. This chapter summarizes the results obtained.

Both the Reading Times and the Format Selection Times have been plotted as histograms (see Tables 1(a) to 1(h) and 2(a) to 2(c)) each with a class-interval of 0.5 sec. The average reading times can easily be seen and no "learning curve" is apparent. No attempt has been made to produce "means" and "standard deviations" as their values would, in all instances, depend on whether or not the unusually long Reading Times were included (the sample sizes being too small). The longer Reading Times can usually be related to the errors made and these are shown in Table 3. Histograms have only been produced for the Selection Times where at least one result for each parameter has been recorded for each pilot.

13.1.2. Subjective Ratings

The questionnaire ratings are included here in graphical form (see Tables 4(a) to 4(c)).

It will be seen that fairly satisfactory ratings were recorded for all the questions except those relating to aircraft handling (Q 1.3.), pumps and valves symbology (Q 2.16) and the scales on the Single Engines formats (Q 2.19).

In each of these unsatisfactory cases significant changes were made before the Systems Evaluation (Part B) took place. The handling characteristics were changed several times during the programme, but an optimum could not be achieved. This unsatisfactory situation, however, did not have any significant effect on the main object of the exercises - the evaluation of the systems displays and controls.

13.2. Discussion of Pilots' Comments

The most useful data collected which were relevant to the development of the Flight Deck were the comments made by the pilots. These were related to their experience of flying with conventional instruments and controls.

The following paragraphs summarise the comments made by the eleven pilots in both the questionnaires and in the debriefing sessions. The comments relating to each question are discussed sequentially and followed by the more important general points which were discussed in the debriefing.

13.2.1. Day 1 Questionnaire

Q 1.1. After considering the exercises that you have done - what are your impressions of the Flight Deck as shown?

Generally the pilots were impressed with the Flight Deck as presented and thought that the basic philosophy seemed promising. Most, however, did not wish to commit themselves regarding detailed impressions as they were, obviously, very much at the beginning of their learning curves. Most pilots thought that they would become more impressed as their familiarity increased. All the pilots found the EADI, EHSI and feel characteristics required improvement, and some felt that these factors may have influenced their overall impressions, but not significantly.

(As described in Chapter 6 the EADI and EHSI were to an early standard limited by computer capacity. See Part C for the assessment of these displays. The feel characteristics were continually being improved.)

Q 1.2. How would you rate the acceptability of the Flight Deck layout as presented for two crew operation?

Four pilots felt that the controls on the pedestal including the throttles were not in their optimum position. However, the pilots generally felt that the Flight Deck layout was good for two crew operation, bearing in mind that they had not dealt with systems failures at this time.

Q 1.3. How would you rate the acceptability of the manual handling (feel) of the simulator?

The pilots unanimously found the feel forces too high and the aircraft to heavy to control with one hand. The flying was unrealistic because of the lack of feedback when trimming the tailplane and it was difficult to relate control movement to control effect, particularly in pitch.

Q 1.4. How would rate the position of the AFCS Controller on the Glareshield with respect to sight and reach?

Almost all the pilots thought that the AFCS was in a good position, but most found the logic of its operation difficult to assimilate and required considerable improvement.

(A redesigned AFCS Controller was used in the evaluation of the EADI and EHSI and is described in Chapter 22)

Q 1.5. How would you rate the sizes and shapes of the alphanumerics as presented on the three centre displays?

Most pilots thought that the sizes of the alphanumerics were the minimum acceptable and that the shapes were satisfactory. There was a significant variation of opinion as to the relative ease of reading. In addition many pilots commented that the pointers on the analogue scales were far too small. The slashed zero (Ø) was commented on by several pilots and the stroke thought to be unnecessary. Some pilots though that consideration should be given to a larger size for data requiring greater emphasis.

(All character sizes used were limited by the constraints imposed by the use of military equipment. The recommended sizes relating to military applications were not practical for civil use and needed reassessing)

Q 1.6. How would you rate the acceptability of the layout of the three centre displays?

All the pilots agreed that the three CRTs were arranged satisfactorily (see Q 2.1.).

Q 1.7. How do you regard the normal position of the EHSI format?

Only one pilot said that he did not like the EHSI in the position shown, but all agreed that they were able to use the display in that position quite easily. Some pilots, however, did comment that this position altered their normal scan pattern and this would require re-learning (see also Chapter 26).

Q 1.8. How would you rate the acceptability of the EADI in its alternative position?

All the pilots agreed that the EADI was perfectly acceptable in the alternative position for the failure case. Several pilots said that it did not matter which way round the EADI/EHSI were and one pilot preferred the alternative arrangement as this improved the scan pattern with EHSI and engines either side of the EADI.

Q 1.9. How would you rate the acceptability of the EADI/EHSI Changeover Switch?

Two pilots thought that the switch should be more robust and two though it should move horizontally, but the rest found it acceptable. One pilot had inadvertently switched off a CRT when asked to operate the Changeover Switch.

(The CRT ON/OFF switches were guarded for Part B)

Q 1.10. How would you rate the position of the Systems Displays Control Panels?

It was generally felt that there would be conflict between the systems displays control panels and the positioning of any INS controllers. The first seven pilots unanimously agreed that the control panels needed to be moved aft and/or tilted to improve reach. Resulting from this opinion the panels were tilted upwards, but this then caused problems of the under-glareshield lighting reflecting on the buttons causing the next four pilots to request improved lighting. The position was, however, thought to be good for reach.

Q 1.11. How would you rate the layout and operation of the Systems Displays Control Panels?

Many of the pilots felt that they had not had sufficient exposure to the control panels on the first day to be able to offer sufficient constructive comments. (Further comment is included in Q 2.5.)

Q 1.12. How would you rate the information content of the Multi-Engines format?

There was a mixture of feeling as to the information content of this format. Some pilots felt that there was just sufficient whereas others thought there was too much, particularly of the digital data. Some pilots felt that there was no need for both N2 and N1 and that EPR was not the primary parameter for the engines simulated.

(N2 was later to become the primary parameter, see Part B)

Q 1.13. How would you rate the presentation and layout of the Multi-Engines format?

Most pilots rapidly learned the positions of the various digital parameters although N1 and N2 were sometimes confused. Suggestions included improved spacing between the lines of digital data and putting the legends for the digits on both sides of the format. Generally the pilots did not use the analogue scales as they were not familiar with using EPR. Two pilots commented that the scale calibration needed improvement. Some pilots found it difficult to relate the throttles position to the EPR pointers on the scales. Only one pilot specifically suggested that more than one parameter should have been in analogue form on this format.

(The Multi-Engines format was modified for the Systems Evaluation in response to these comments (See Chapter 15)).

Q 1.14. How would you rate the presentation of the Flying Controls format?

There was almost unanimity that the important parameters were difficult to see whereas the least important areas, the representation of the wing and tail, were overstressed. The tail trim was found to be unclear by almost all pilots and the majority also felt that the aileron trim should have been presented laterally. Some pilots also criticised the slats presentations and felt that these should have been linked to the wings (see also Q 2.18).

(The Flying Controls format was modified in response to the above comments, see Chapter 15).

Q 1.15. The brilliance and contrast levels of the displays have been set for this exercise only. How would you rate their acceptability?

The brilliance levels as set were generally found to be acceptable for the exercises. Some pilots, however, did notice differences between the displays from time to time.

13.2.2. Day 2 Questionnaire

Q 2.1. How would you rate the acceptability of the layout of the three Centre Displays for carrying out the exercises you have done?

The comments did not change from Q 1.6.

Q 2.2. How would you rate the positions of the three centre Displays relative to your normal eye position?

Only one pilot found difficulty in reading the furthest of the three centre displays. He suggested that this may have been due to the display curvature, another pilot felt that the cross-cockpit vision was improved over conventional instruments as there were no problems of parallax.

Q 2.3. Do you consider the number of displays shown to be adequate for the tasks you have performed during the last two days?

Many pilots found two systems displays to be adequate (without systems failures). Some form of systems status was requested by several pilots to reduce repetitive display selection.

(A Status Display was provided for Part B, see Chapter 15).

Q 2.4. Now that you have had more experience in operating the Systems Displays Control Panels, how would you rate their layout and operation?

Most of the comments were the same as for Q 1.11, i.e. lengthy reach. The detail comments made on the layout involved separating the "Standby" button, improving the arrangement and separation of the S1, S2 and S3 buttons. Several pilots suggested improved grouping and colour coding. However, although there were many criticisms it should be noted that some pilots found the layout satisfactory and had no problem with the operation.

(In response to the above comments the layout of the panels was modified for Part B, see Chapter 15.).

Q 2.5. How would you rate the philosophy of the operation of the Systems Displays Control Panels?

The most frequest comment concerned the fact that two buttons had to be pressed for each format selection. Most pilots felt that too many selections were required for normal monitoring, thus justifying a Systems Status presentation. Several pilots, however, did feel that two buttons were not a hardship. One suggested making selections in the reverse order, i.e. format before display.

(A significant reduction of manual switching was achieved in Part B by the use of the Status format).

Q 2.6. How would you rate the acceptability of the Systems Controls with respect to their remoteness from their respective displays?

Most pilots found the separation of displays and controls acceptable, three considered it a disadvantage.

Q 2.7. How would you rate the layout and position of the Systems Control Panels with respect to your normal eye position?

Generally there were no problems with visibility or reach.

Q 2.8. How would you rate the layout and position of the Engine Shut-down Controls with respect to your normal eye position?

Almost all the pilots found the toggle switches difficult to see and operate. The HP cock switches could have been more distinctive. One pilot expressed reservations about the shut-down handles in that they were too close together and it was easy to select the wrong one.

Q 2.9. How would you rate the acceptability of the operation of the Engine Shut-down Controls?

One pilot thought that by using the shut-down handles for normal operation as well as an emergency control the pilots might acquire a "Light-hearted" attitude towards these controls. Another pilot suggested incorporating the fire extinguisher controls into the handles. All other comments are contained in Q 2.8.

Q 2.10. How would you rate the acceptability of the illuminated Pushbuttons for the Systems Controls?

The majority of pilots approved of pushbutton controls (subject to a full lighting evaluation). One felt that similarity of buttons could lead to confusion, another felt that raised buttons prevented fingers being braced on the panel.

Q 2.11. How would you rate the presentation of the Single Engine format compared with using conventional instruments?

This format was criticised by all pilots. The fundamental philosophy of separate engine displays was thought to be wrong. They thought that two Multi-engines formats each presenting different parameters would be preferable. The most frequent comment was that the digital information down the left side was difficult to find. This was substantiated by the reading exercises given. Although the EPR parameter was not part of this format and not missed by many pilots it was felt that any future primary parameter should be included. The scales were generally only used for the engine start. There was a mixture of feeling as to whether or not this format was better or worse than conventional instruments.

Q 2.12. How would you rate the presentation of the Fuel System format?

From the pilots who commented on the Fuel format it would appear that the main problem was that the top was "too crowded" making the figures difficult to read. One pilot questioned whether the transfer valves should have been symmetrical and also thought that fuel flow should also have been on this format. Another pilot felt that it was easier to detect fuel imbalance and equal feed rate by comparing needles rather than digits.

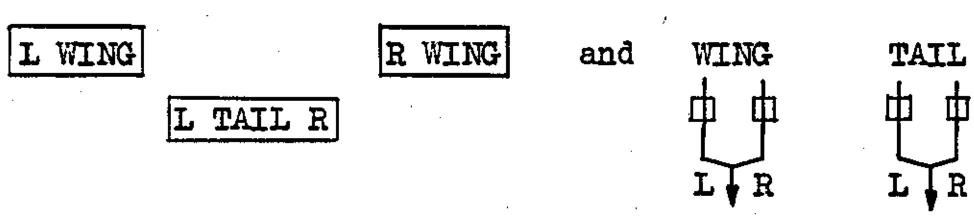
(The VC-10 fuel system used in the simulation was modified to reflect the then current practices thus resulting in a less complex fuel display for Part B, see Chapter 15.)

Q 2.13. How would you rate the presentation of the Air Conditioning format?

Most pilots found the air system too complicated for present day aircraft and as such the format was not the optimum. They felt that the important data should have been highlighted.

Q 2.14. How would you rate the presentation of the Anti-ice format?

There were two criticisms of this format, each made by several pilots. These were that a clearer indication of the valves in the shut position should have been shown and that the presentation of the wing and tail temperatures should have been improved. Two suggestions for the latter were made:-



Some pilots did however have no problems with this format and one thought it was the best shown.

Q 2.15. How would you rate the acceptability of the Pressurization format, as only digital information is presented?

Opinions varied, though most considered that the more important data required emphasis. Two pilots would have preferred analogue scales for cabin height and rate of change. At the suggestion of the earlier pilots the gearing between the controls and display readout was improved during the evaluation.

Q 2.16. How would you rate the presentation of the symbols for Pumps and Valves as shown on the Fuel and Air Conditioning formats?

At the commencement of the Familiarisation stage the pumps were shown to be on by the word 'ON' and off by a blank space. This philosophy was criticised immediately and the word "OFF" was then inserted. There were no further criticisms of the pump indications. The first few pilots all commented on the small size and lack of clarity of the valve symbology. The symbol for a closed valve, , was particularly thought to be worthy of improvement with the result that as soon as the hydraulics format became partially operational the symbol, , was introduced. Most of the later pilots preferred for shut, for transit and for open. One pilot still preferred for closed and another wanted . One of the later pilots found the symbols to be too small.

(See Q 1.5.)

Q 2.17. In general how would you rate the information content of the Systems formats as presented?

All the pilots agreed that sufficient systems information was presented for the exercises carried out.

Q 2.18. How would you rate the presentation of the Flying Controls format?

For most of the comments see Q 1.14. Two pilots found the bold outline of the wings and tail a little distracting.

Q 2.19. How would you rate the presentation of the scales on the SINGLE ENGINE formats?

It appears from the evaluation that the scales on the Single Engine formats were not used, except by one pilot for start-up, the digital information being of far more benefit. There was mixed feeling about the scales as presented, generally the bugs were not dominant enough and several pilots thought the scales were inferior to conventional strip instruments. One pilot suggested that the scales would be better if they were non-linear, thus devoting more of the scales to the critical areas of operation for each parameter.

(The Single Engine formats were redesigned for Part B, see Chapter 15).

Q 2.20. Although you have not used the Master Warning System you have seen the warning symbols presented on the formats. How would you rate the readability of the warning indications compared with conventional Instrument Failure Flags?

Most of the pilots felt that due to lack of colour and contrast the failure indications presented on the CRTs were not as good as their conventional counterparts. Tolerance limits also needed careful definition.

(These comments are more signifiacnt when related to the detection of systems faults, see Part B).

Q 2.21. You have been introduced to the Preflight and Inflight Checks. How would you rate them with regard to complexity?

Only one pilot liked the checks as presented, all the others thought they were far too complicated for two crew operation. The Test Panel philosophy, subject to minor detail changes, was liked by every pilot. The last three pilots also used the check list presented on a CRT for their preflight checks. All three agreed that this was a good presentation. Several ideas for detail changes were offered.

(The Check list was rewritten for Part B, see Chapter 17).

Q 2.22. After prolonged viewing, how would you rate eye fatigue from your experience?

All pilots agreed that they did not suffer any abnormal eye fatigue, but considered the effects to be similar to the same exposure in a conventional simulator.

Q 2.23. Did you notice any flicker associated with the displays?

Most of the pilots did not notice any flicker, but they noticed striations and symbols varying in size due to computer idiosyncracies. One pilot claimed that he noticed flicker, which apparently disappeared when his workload increased.

Q 2.24. When looking at one display did you find any dustraction by information changing on an adjacent display?

Most pilots noticed information changing in their peripheral vision, but only one thought it was a slight distraction. Several pilots noticed the lights momentarily illuminate on their Systems Displays Control Panels when the Resident Pilot was making selections.

Q 2.25. How do you regard the realism of the simulation for the exercises you have done in these two days?

Although adequate for the assessment most pilots commented on the undue level of workload caused by the poor control dynamics, poor EADI, poor EHSI and poor AFCS logic. The realism of the Flight Deck task was generally well managed.

Q 2.26. How did you regard the realism of the ATC for the exercises you have done in these two days?

Not all the pilots commented on the ATC, but of those that did most agreed that the instructions were adequate for the purpose and that the background tape (used for the last four pilots only) added to the realism, but needed careful editing.

Q 2.27. How would you rate the conduct of the exercises?

Few pilots commented on the exercises. They generally felt that they were well organised, but some areas were mentioned by the first pilots were the briefing needed improving. Generally the pilots felt that the objective of familiarisation had been achieved.

13.2.3. General Comments

There were no specific questions concerning the electrics and hydraulics formats as these were not dynamic or only partially dynamic for the exercises. Opinions were sought during the debriefing. The flexibility of the electrics format was liked, but several pilots found the DC part not well presented and suggested various improvements. The hydraulics format was found to be satisfactory, although some confusion did arise due to the lower part being a static presentation only.

The first few pilots highlighted areas where the briefing needed improving and this was duly done.

Specific areas which were noted as requiring improvement were the position of the Engine Start Panel, a better identification of the Engine Start Master Switch and the order ofthe Test Panel. The Start Switch was improved for the last few pilots. (These improvements were made for Part B)

More than half of the pilots said there was a higher mental workload required due to display switching and this could be reduced if a Status Display was used. The control dynamics also produced a workload which was far too high when flying manually.

The identification of the correct Single Engine format was found to be not sufficiently obvious, particularly for emergency use. However, several pilots commented that the sudden "arrival" of a format was in itself a good "Attention-getter".

Many pilots mentioned the use of colour and thought it would offer significant advantages.

All the pilots commenced at least one flight with their EADI and EHSI interchanged to the alternative positions without being told of the arrangement. The times varied before each pilot noticed this change, and when questioned most admitted that the alternative position was satisfactory, and one pilot even thought the positions an improvement.

The convenience and practicability of the systems presentations were commented on and most pilots thought the priorities to be about the optimum. When questioned as to whether or not they were conscious of looking at CRTs most admitted that they had soon got used to them and used them merely as devices for presenting the data they required.

13.3. Conclusions

Most pilots agreed that the objective of initial familiarisation with the Flight Deck had been achieved. In many areas the Flight Deck had been easier to assimilate than some conventional designs.

The pilots' enthusiasm for the potential of electronic displays increased as each two-day period proceeded.

Most pilots became accustomed to the horizontal layout of the EFIs and their reversionary positions more easily than they had expected.

Although most of the formats were readily accepted there were some parameters that appeared more difficult than the majority to read (see Tables 1 and 3). These parameters were:-

T1

Engine Oil Pressure

Engine Fuel Pressure

Fuel Temperature

Fuel Tank Contents

Air Duct Temperature

Air Cool Valve Position

Cabin Temperature

Anti-ice Wing Temperature

Cabin Height

Some of the difficulties can be attributed to unfamiliarity. This was definitely the case for T1 an Fuel Temperature. The phrasing of the questions can also have an effect on the Reading Times and this was particularly noticeable for Fuel Temperature which was asked as "Engine No.X Fuel Temperature, please". Many pilots confused this parameter as being present on the Engines format instead of the Fuel Format. Many of the reasons for the other difficulties are apparent from the pilots' comments in paras. 13.2.1. and 13.2.2.

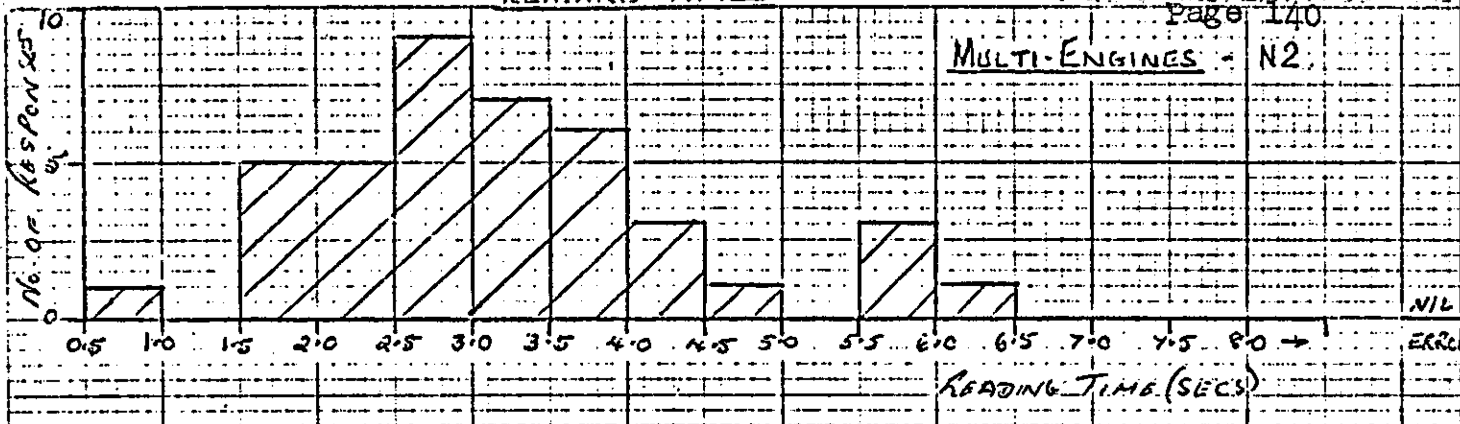
The Checks and Drills were considered by all pilots to be too long for a short to medium range aircraft, but these were adequate for the exercises given.

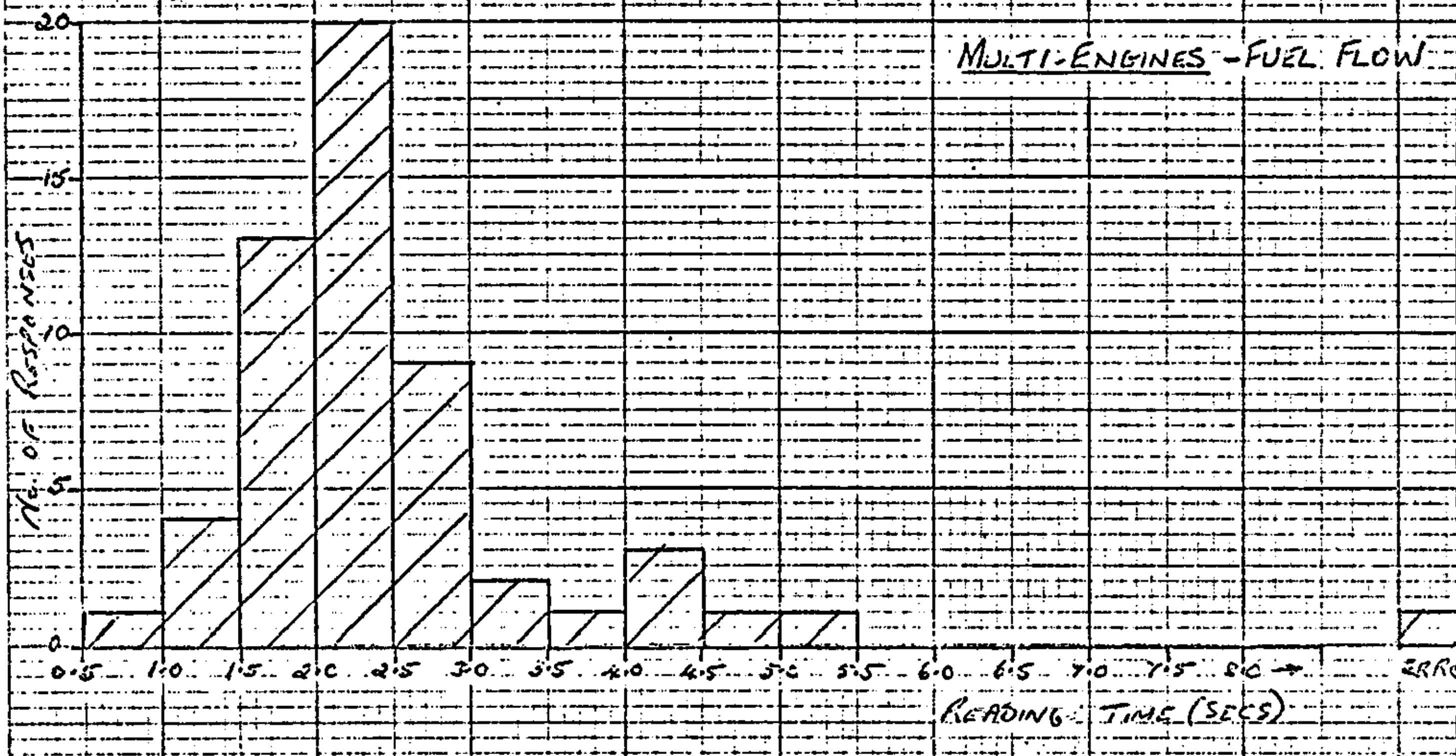
Judgements on displays failures were reserved until the pilots could appreciate these in a more realistic navigation situation, see Part B.

The use of illuminated pushbutton controls remote from their associated displays, which were also used as "fault identifying", was accepted.

The simulator was very difficult to fly manually and required more effort than any known aircraft. Nevertheless this did not influence the pilots' opinions of the displays, formats and systems controls.

READING TIMES





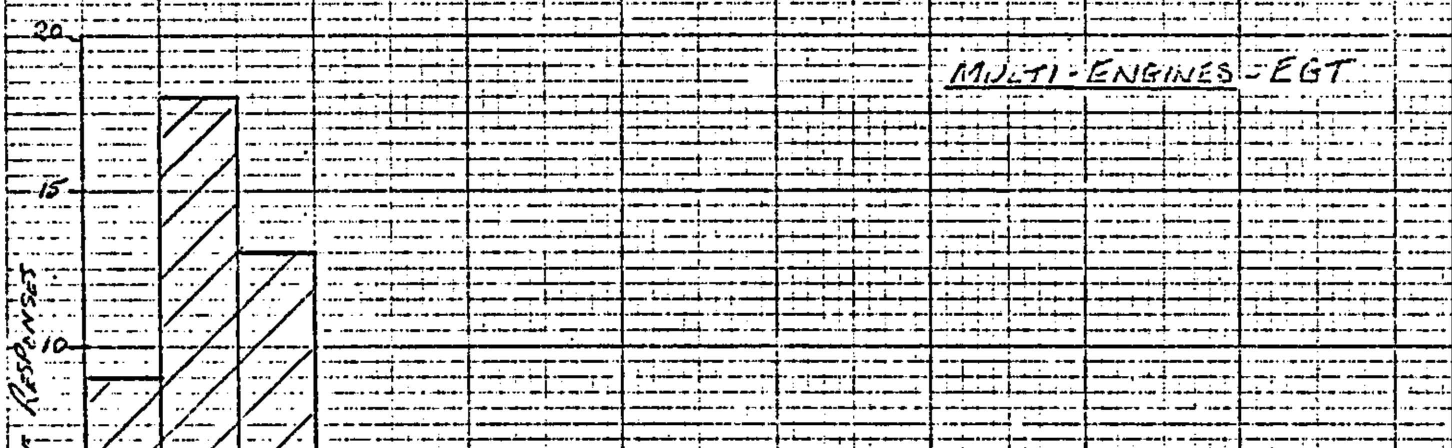


Table 1(a)

READING TIMES

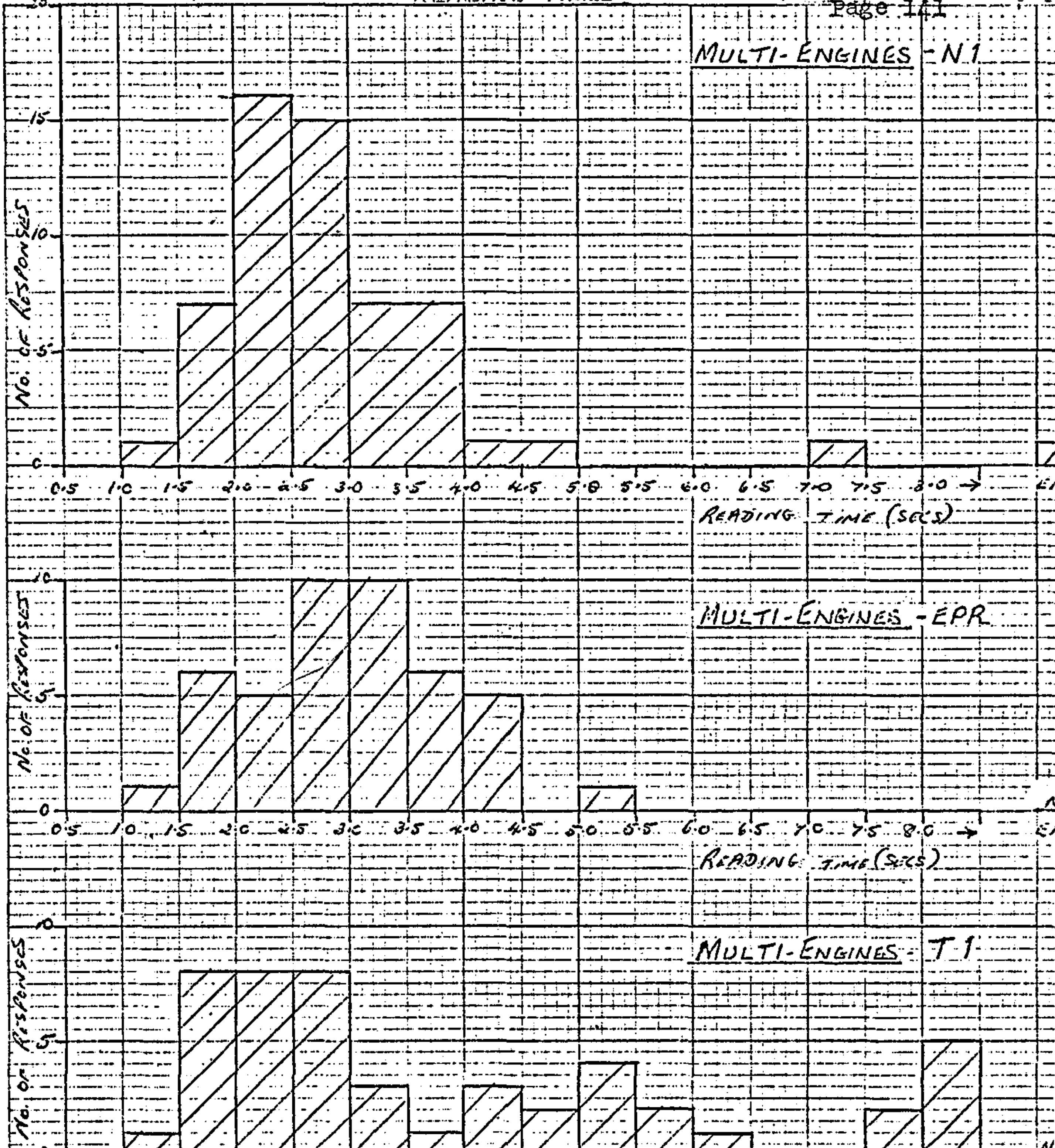


Table 1(b)

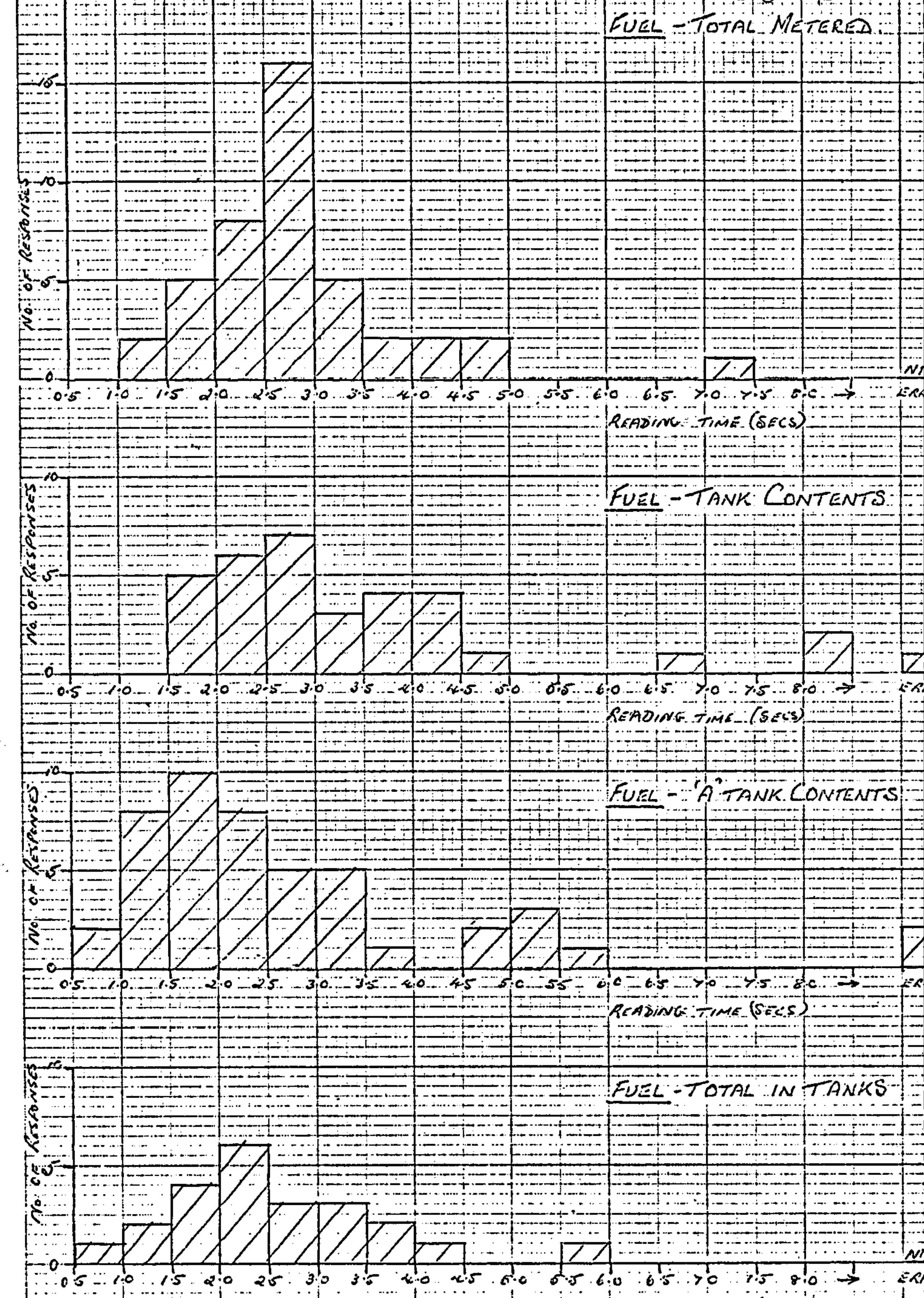
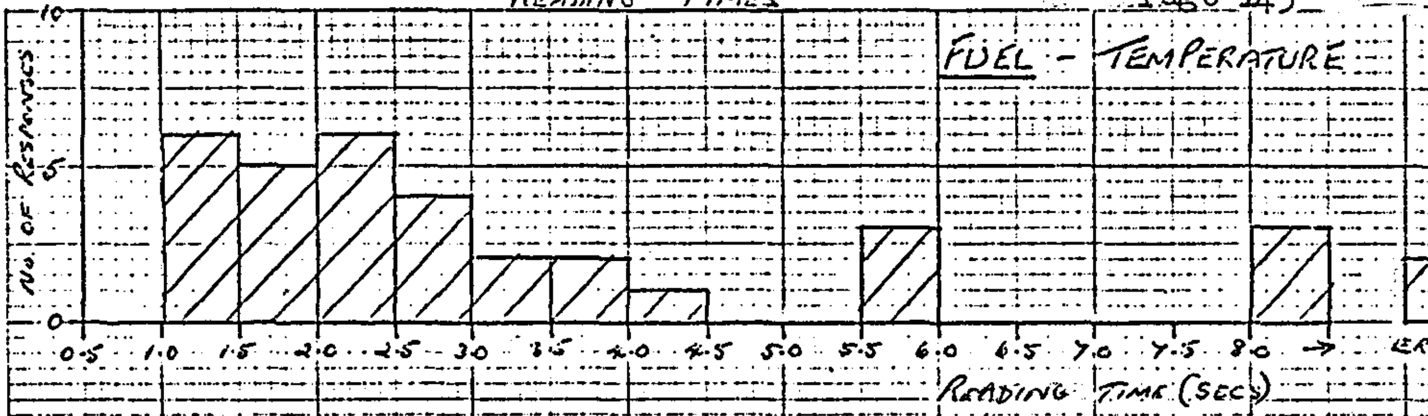
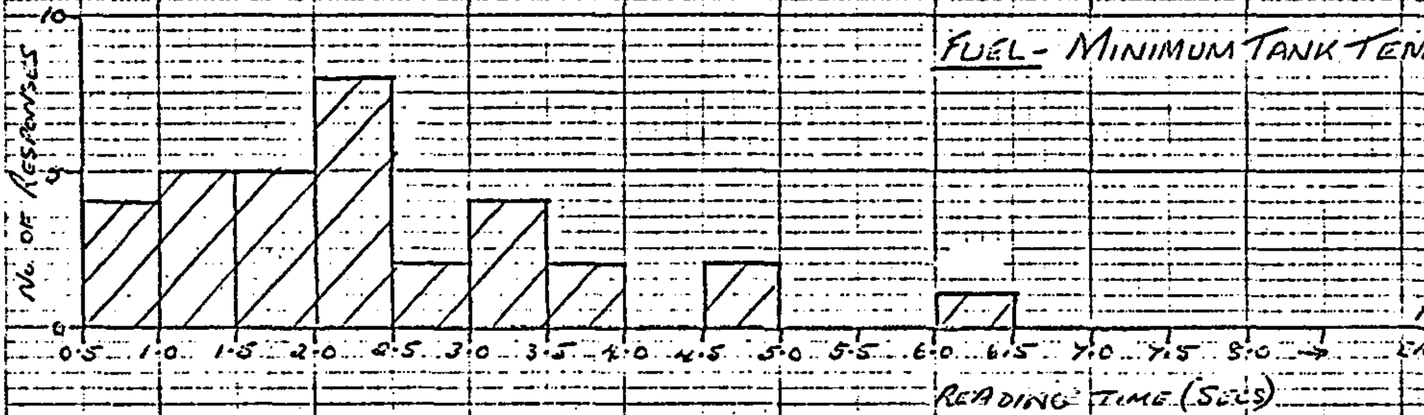
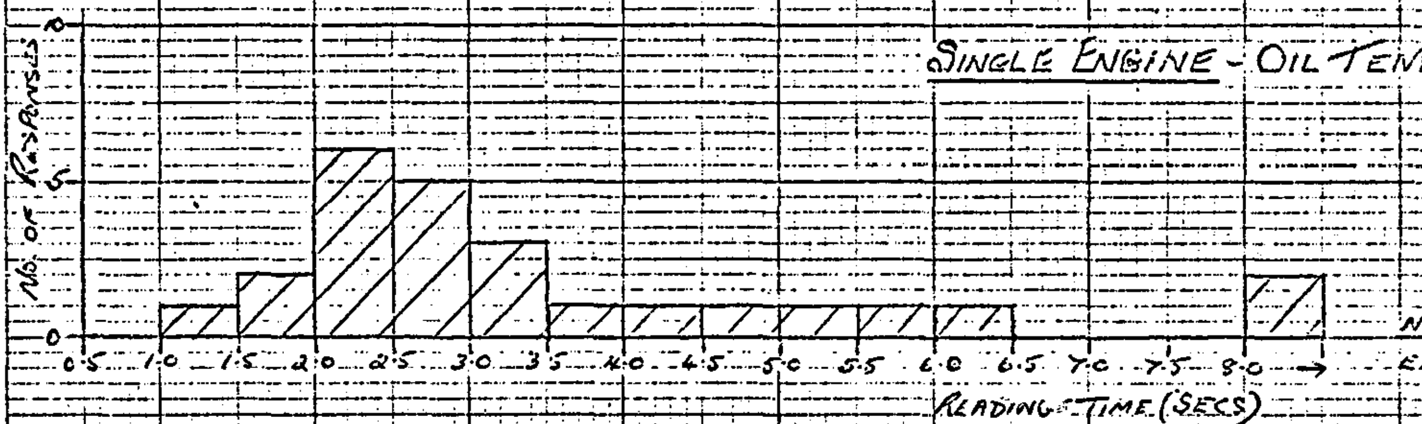
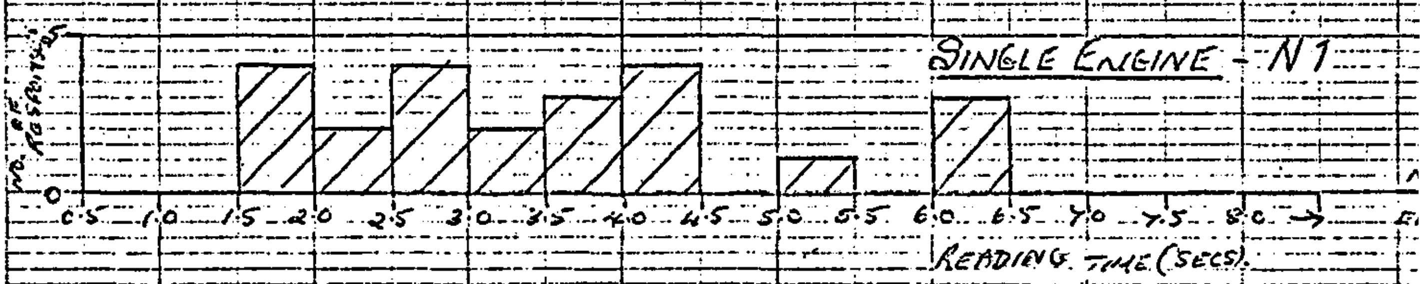

FUEL - TOTAL METERED
No. OF RESPONSES
READING TIME (SECS)
FUEL - TANK CONTENTS
No. OF RESPONSES
READING TIME (SECS)
FUEL - 'A' TANK CONTENTS
No. OF RESPONSES
READING TIME (SECS)
FUEL - TOTAL IN TANKS
No. OF RESPONSES
READING TIME (SECS)

Table 1(c)


FUEL - TEMPERATURE
No. OF RESPONSES
10
5
0
0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 →
READING TIME (SECS)


FUEL - MINIMUM TANK TEM
No. OF RESPONSES
10
5
0
0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 →
READING TIME (SECS)


SINGLE ENGINE - OIL TEM
No. OF RESPONSES
10
5
0
0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 →
READING TIME (SECS)


SINGLE ENGINE - N1
No. OF RESPONSES
5
0
0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 →
READING TIME (SECS).

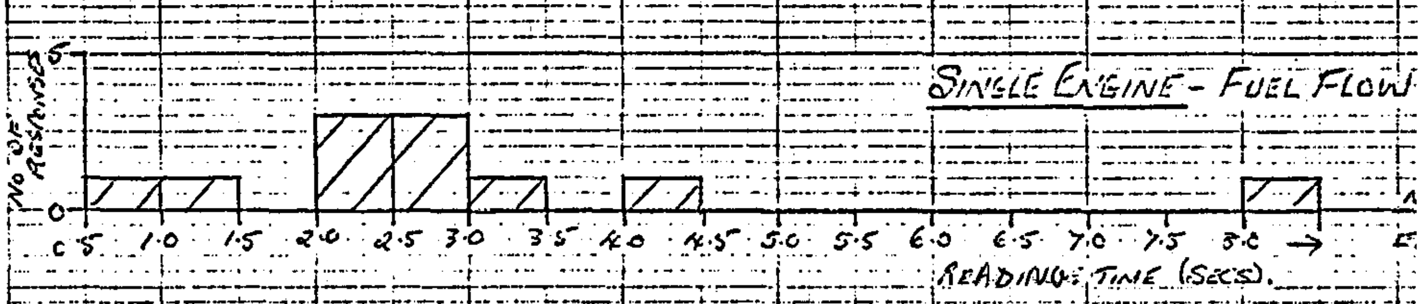

SINGLE ENGINE - FUEL FLOW
No. OF RESPONSES
5
0
0·5 1·0 1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0 5·5 6·0 6·5 7·0 7·5 8·0 →
READING TIME (SECS).

Table 1(d)

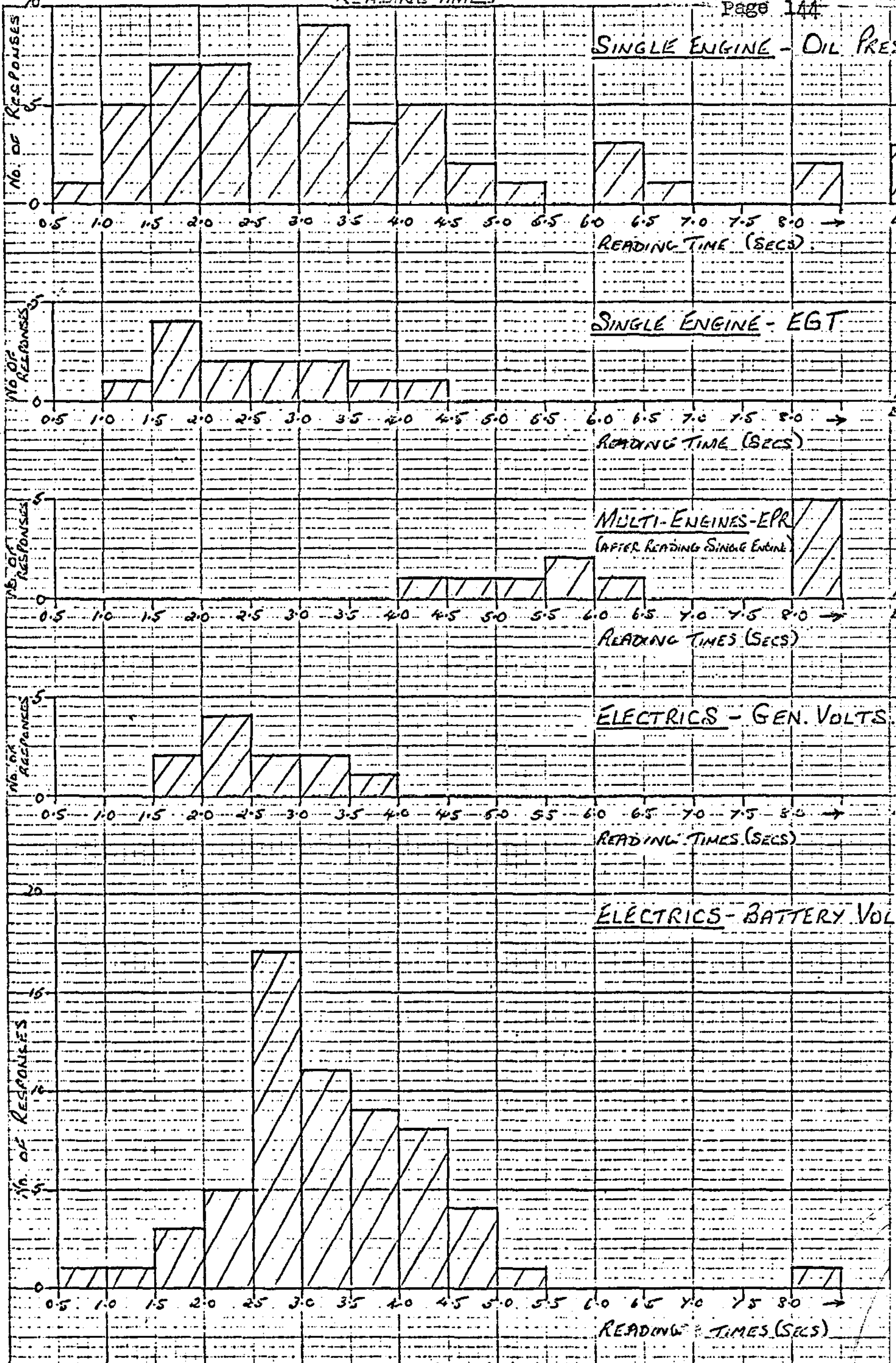
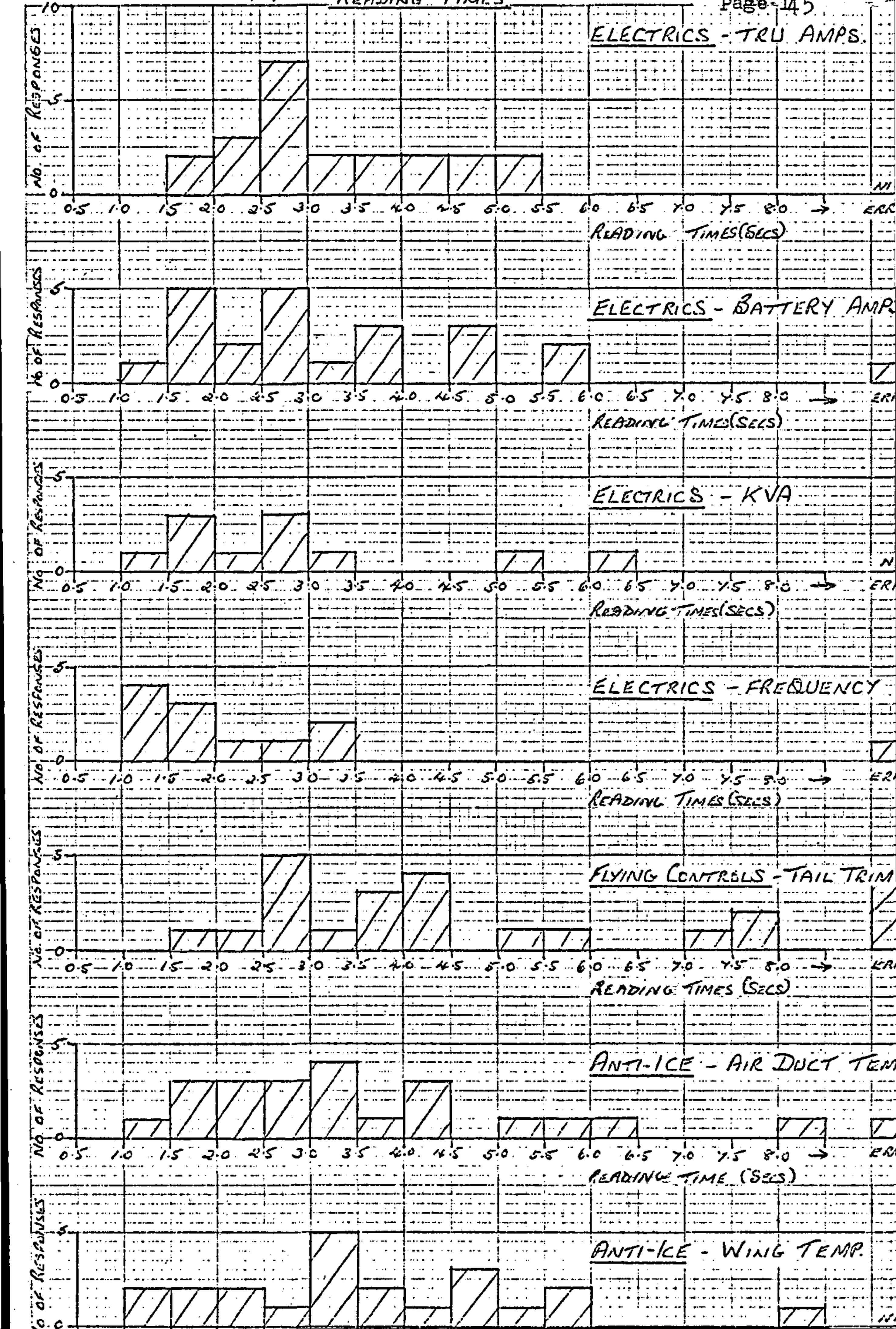

SINGLE ENGINE - OIL PRES
No. OF RESPONSES
READING TIME (SECS)
SINGLE ENGINE - EGT
No. OF RESPONSES
READING TIME (SECS)
MULTI-ENGINES-EPR
(AFTER READING SINGLE ENGINE)
No. OF RESPONSES
READING TIMES (SECS)
ELECTRICS - GEN. VOLTS
No. OF RESPONSES
READING TIMES (SECS)
ELECTRICS - BATTERY VOL
No. OF RESPONSES
READING TIMES (SECS)

Table 1(e)

Table I(i) READING TIMES



READING TIMES

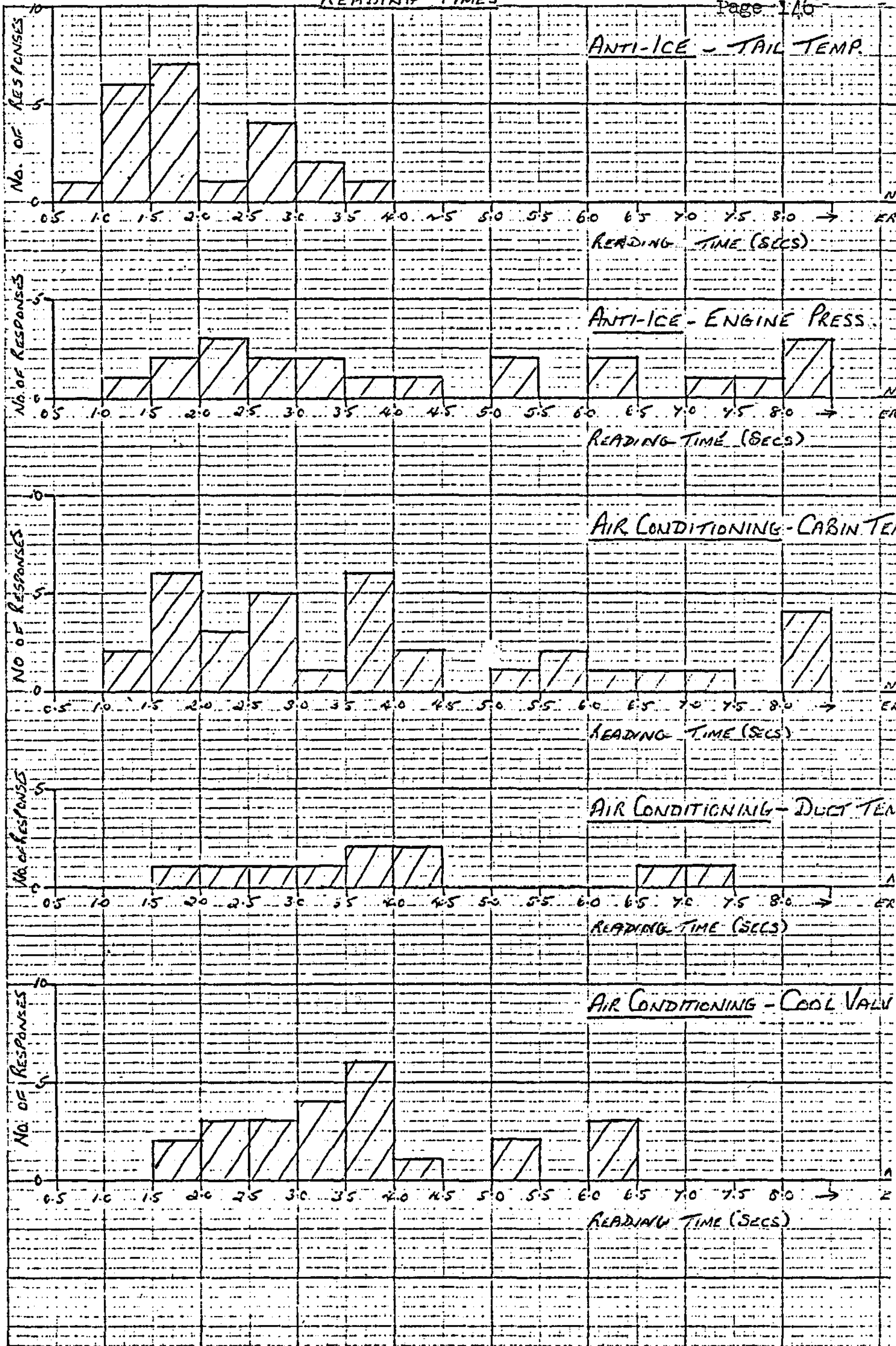


Table 1(g)

READING TIMES

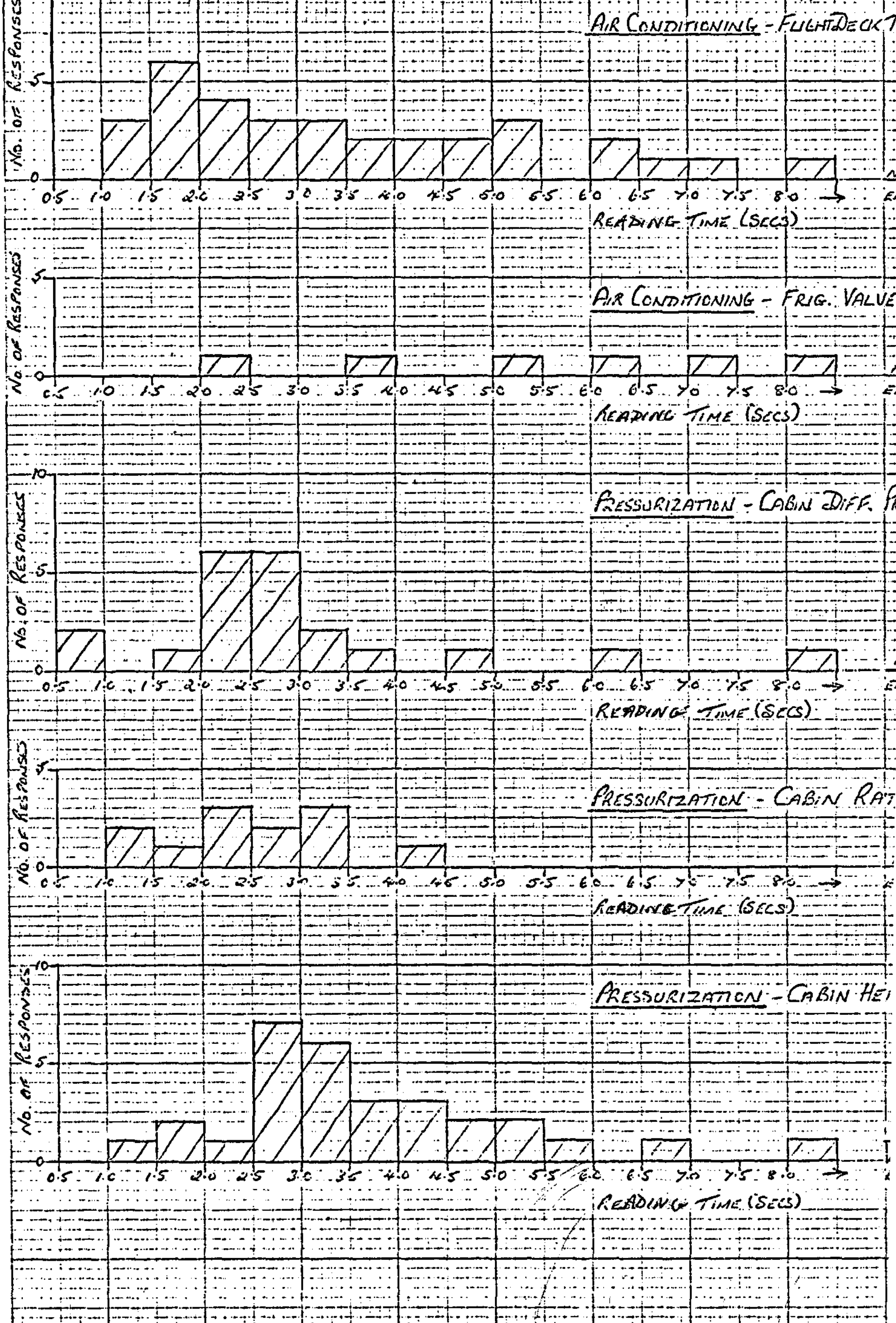


Table 1(h)

SELECTION TIMES.

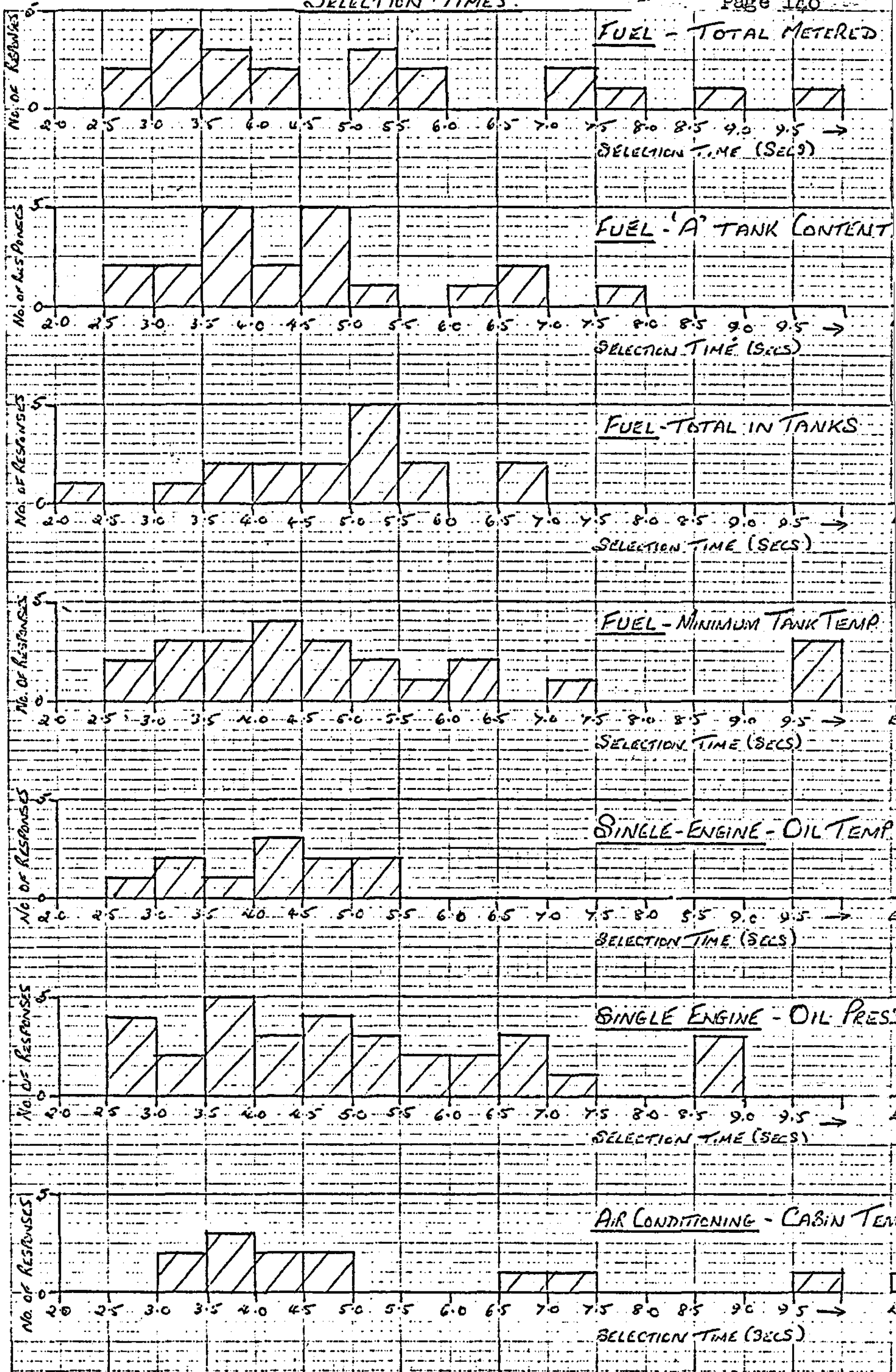
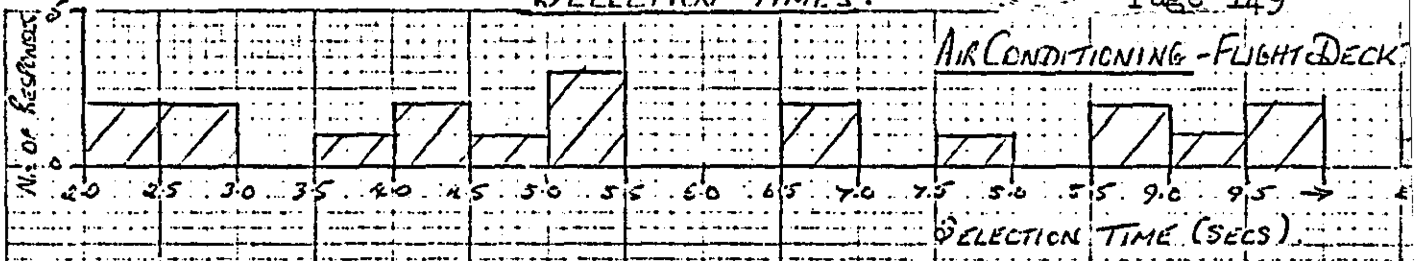
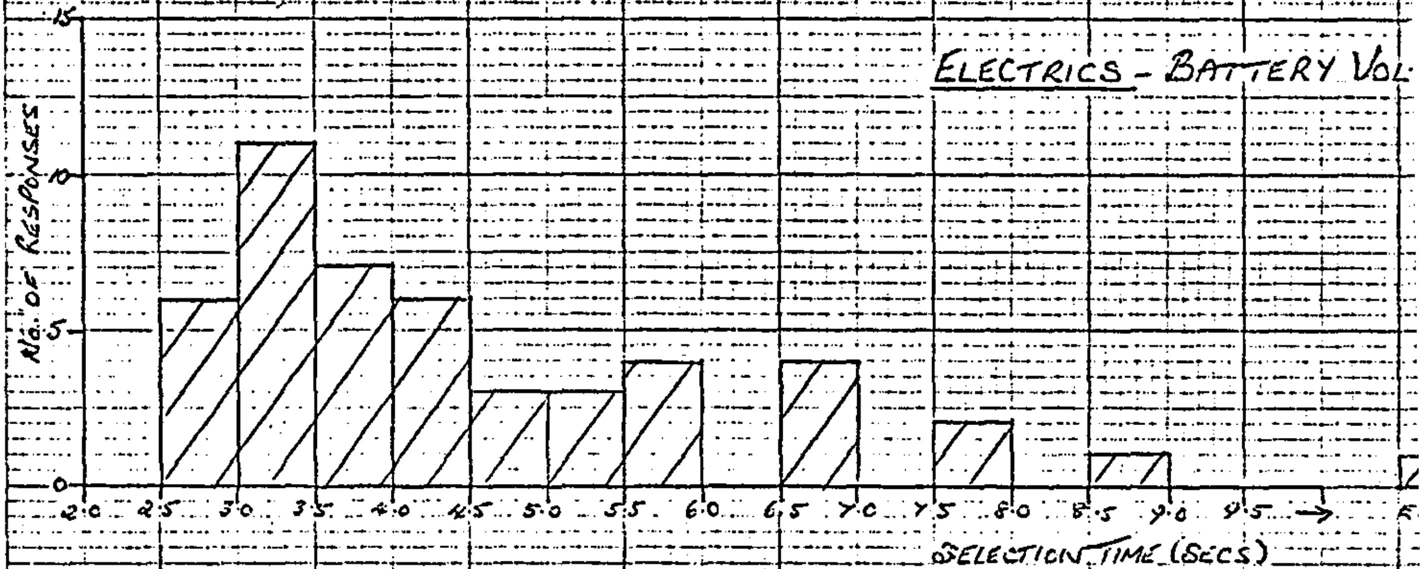
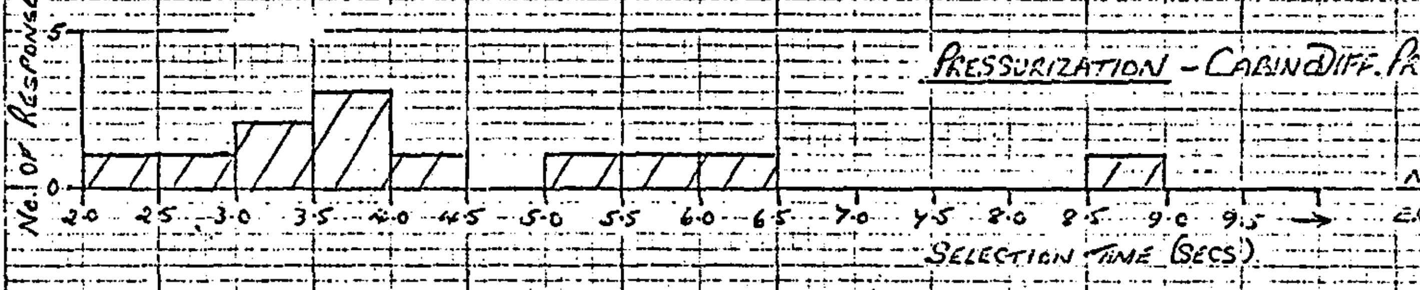
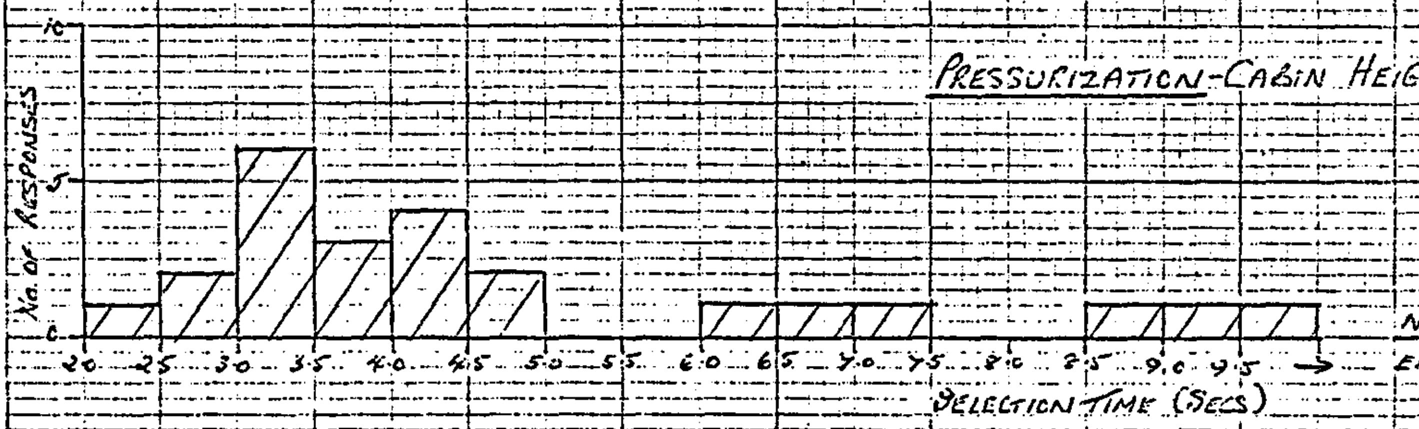


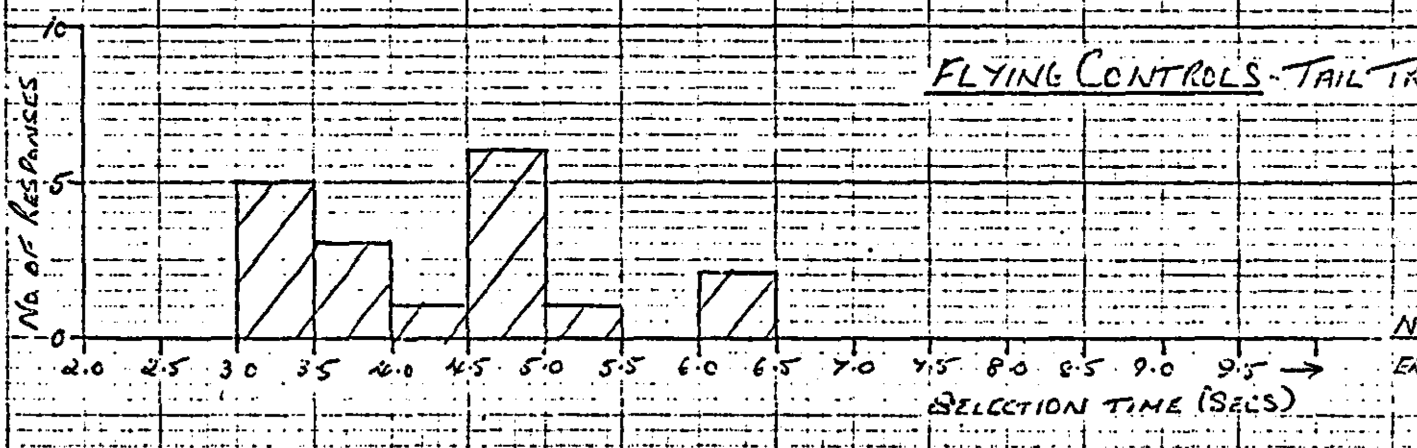
Table 2(a)


AIR CONDITIONING - FLIGHT DECK
No. OF RESPONSES
SELECTION TIME (SECS)

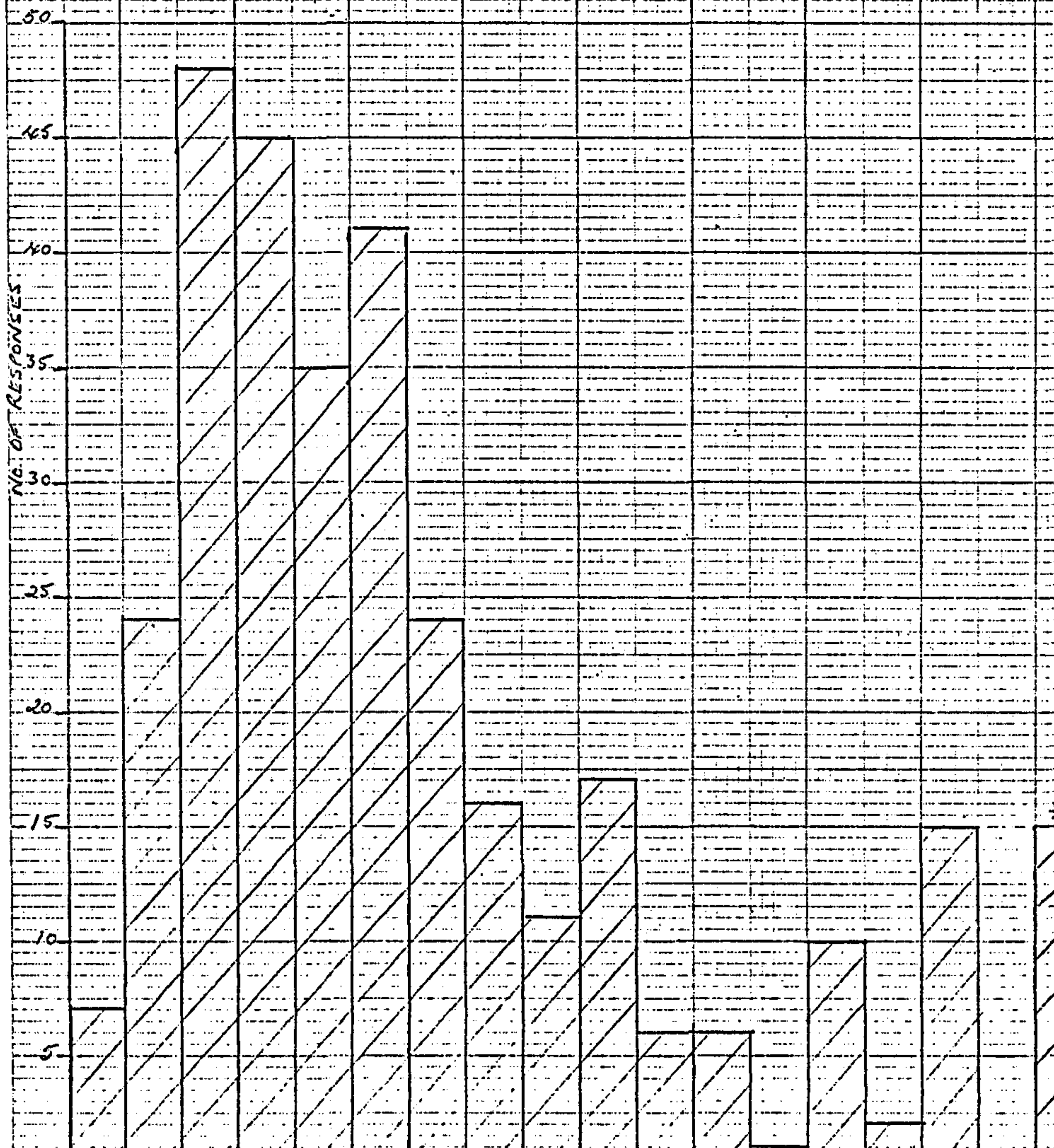

ELECTRICS - BATTERY VOL
No. OF RESPONSES
SELECTION TIME (SECS)


PRESSURIZATION - CABIN DIFF. PR
No. OF RESPONSES
SELECTION TIME (SECS)


PRESSURIZATION - CABIN HEIG
No. OF RESPONSES
SELECTION TIME (SECS)


FLYING CONTROLS - TAIL TR
No. OF RESPONSES
SELECTION TIME (SECS)

TOTAL SELECTION TIMES



*NOTE: 9 OF THESE 15 ERRORS ARE DUE TO CONFUSION AS TO WH
FORMAT THE ENGINE FUEL TEMPERATURES APPEAR. IN THESE
9 INSTANCES AN ENGINE FORMAT WAS SELECTED INSTEAD OF
FUEL.

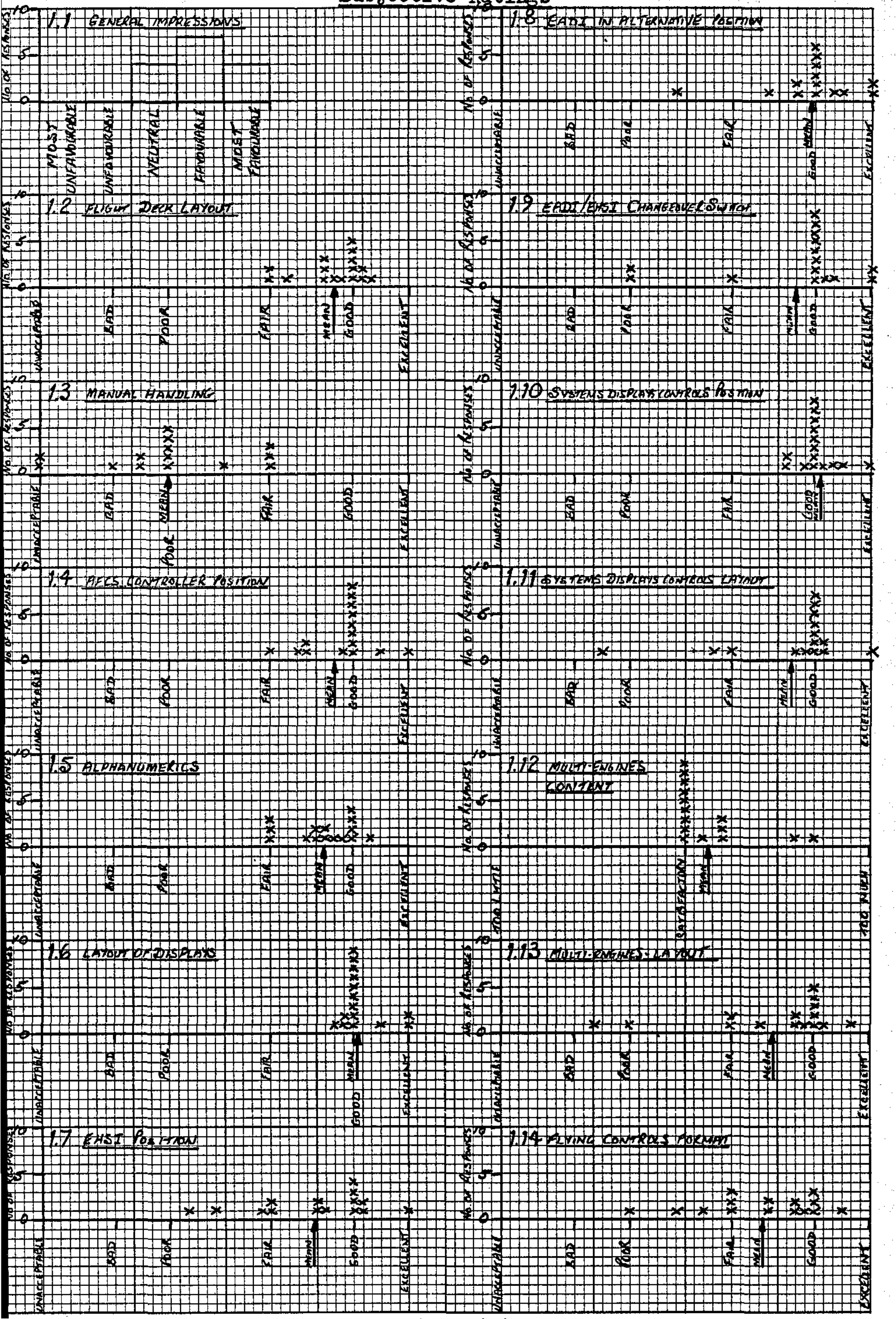
Table 2(a)

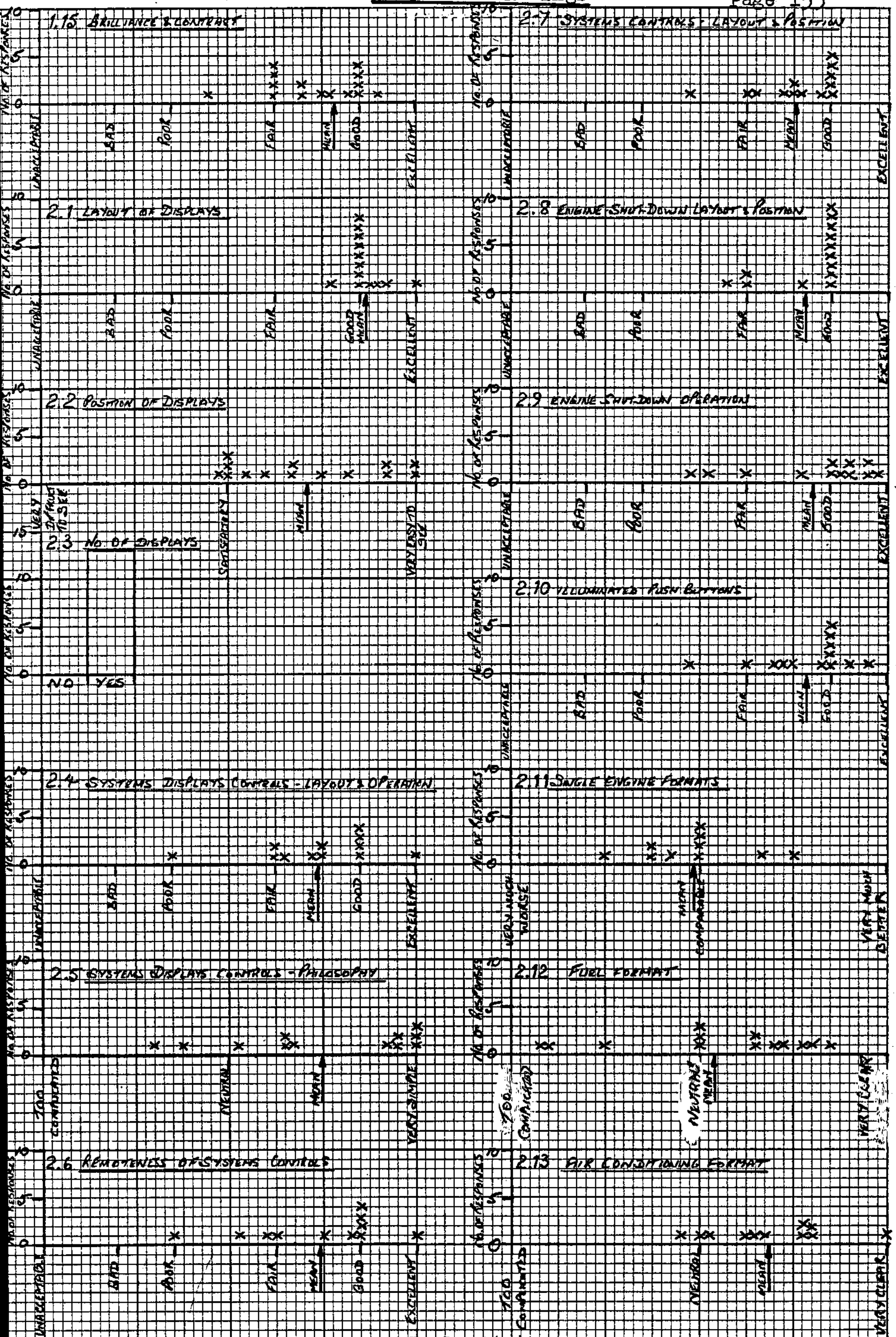
Table 3

PARAMETER READING ERRORS

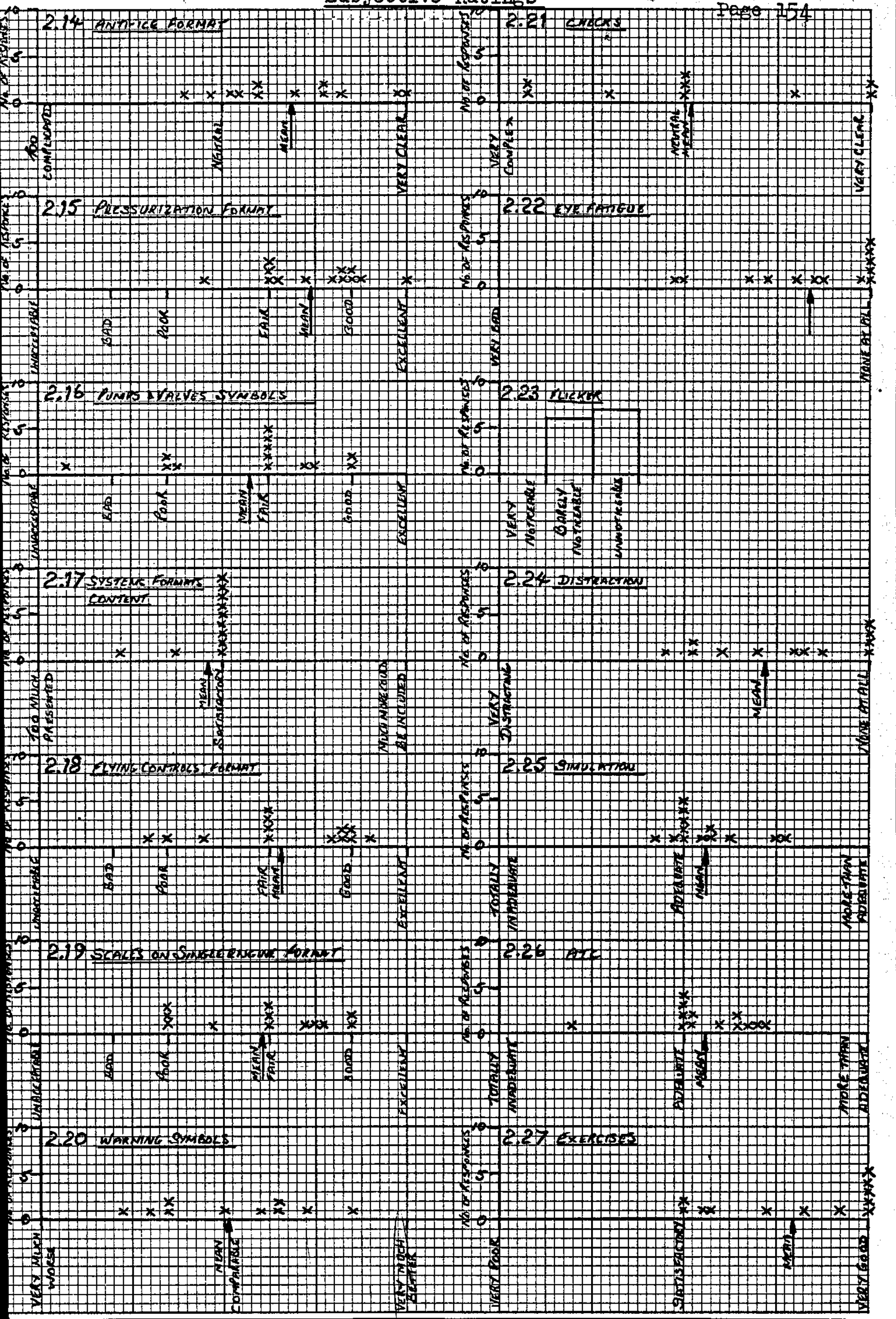
	No. of Errors
ALL ENGINES format:	
Read N1 for Fuel Flow	1
Unable to find T1 (unfamiliarity)	5
Read N2 for N1	1
SINGLE ENGINE format:	
Read Oil Temperature for Oil Pressure	3
ELECTRICS format:	
Read Battery Amps for Batt. Volts	1
Read KVA instead of Frequency	1
FUEL format:	
Read wrong engine for Fuel Temp.	2
Unable to find Fuel Temp. (unfamiliarity)	2
Confused Fuel Temp. with Single Engine form.	8
Misread Tank Contents	3
Unable to find Metered Fuel	1
HYDRAULIS format:	
None	
FLYING CONTROLS format:	
Confused sense of Tail Trim	4
AIR CONDITIONING format:	
Confused Cool Valve for Press. format	1
Confused Flight Deck Temp. for Anti-ice form.	1
Confused Cabin Temp. with Pressure	1
PRESSURIZATION format:	
Almost confused Cabin Ht. with Diff. Press.	1
ANTI-ICE format:	
Read wrong figure for Air Duct Temp.	1

Subjective Ratings




1.15 BRILLIANCE & CONTRAST
2.1 LAYOUT OF DISPLAYS
2.2 POSITION OF DISPLAYS
2.3 NO. OF DISPLAYS
2.4 SYSTEMS DISPLAYS CONTROLS - LAYOUT & OPERATION
2.5 SYSTEMS DISPLAYS CONTROLS - PHILOSOPHY
2.6 REMOTENESS OF SYSTEMS CONTROLS
2.7 SYSTEMS CONTROLS - LAYOUT & POSITION
2.8 ENGINE SHUT-DOWN LAYOUT & POSITION
2.9 ENGINE SHUT-DOWN OPERATION
2.10 ILLUMINATED PUSH BUTTONS
2.11 SINGLE ENGINE FORMATS
2.12 FUEL FORMAT
2.13 AIR CONDITIONING FORMAT
NO. OF RESPONSES
UNACCEPTABLE
BAD
POOR
FAIR
MEAN
GOOD
EXCELLENT
VERY DIFFICULT TO SEE
SATISFACTORY
VERY EASY TO SEE
NO
YES
VERY MUCH WORSE
COMPARABLE
VERY MUCH BETTER
TOO COMPLICATED
NEUTRAL
VERY SIMPLE
VERY CLEAR

Subjective Ratings



PART B

SYSTEMS EVALUATION

CHAPTER 14

CHANGES TO SIMULATOR

14.1. The following changes were made to the simulator for the Systems Evaluation as a result of the pilots' criticisms recorded during the Familiarization Programme (see Chapter 13).

14.2. Simulator Stability and Control

Although manual flying was not a major part of the programme the instability of the simulator could have lead to an unrealistic workload particularly when systems failures were introduced. The feel and trim systems were redesigned to give improvements.

14.3. Systems Displays

The All Engines format was changed to make the primary control parameter N2, consistent with that of the Conway engine. The bugs indicating individual engine power were made more dominant (see Figure 35).

The Single Engine formats were redesigned to reduce clutter and make the bugs more effective (see Figure 36).

The Fuel System format was made more appropriate to that of a long-range aircraft (see Figure 37).

On the Flying Controls format the representation of the aircraft was made less dominant as it had been too "eye catching" in the Familiarization Programme. The trim indications were made clearer (see Figure 38).

The valve symbols on the Hydraulics, Fuel and Anti-ice Systems were improved to make their identification more positive.

The EADI/EHSI Changeover switches were moved to operate in a horizontal direction with the toggle pointing in the direction of the display showing the EADI format.

14.4. Status Format

To relieve workload associated with displays monitoring for routine flying a new "Status" format providing summary data from the Flying Controls, Anti-ice, Hydraulics, Electrics and Pressurization systems was introduced. This is illustrated in Figure 39. No failure warnings were given on the Status Display. Any parameter going outside normal limits caused the normal MWS warning, accompanied by an automatic recall of the appropriate system format to the appropriate display head. The Status format was displaced if it was selected to the same display head, since it had the lowest priority in the hierarchy.

14.5. Systems Displays Control Panels.

The Systems Display Control Panels were revised to incorporate the Status select button. The panel was also tilted to improve reach and inhibit the reflections referred to in Chapter 13. The new panel is illustrated in Figure 40.

14.6. Centre Pedestal

The throttles had been too far aft when power was reduced for cruise and descent, so the aft throttle limit was adjusted to enable idling power to be reached at a position previously corresponding to cruise power.

Pitch trim loads were reduced and trim rate made a function of trim control displacement. A similar improvement was also made for the selection and setting of reverse thrust.

14.7. Roof Panel

Small improvements were made to the Systems Control Panels, including:

Re-location of the Engine Start Panel to a position as shown in Figure 4.

Re-design of the Test Panel to achieve greater compatibility with system checking. (See Figure 41)

Introduction of more pushbuttons to replace toggle switches.

Accurate labelling of switch functions.

14.8. Check Lists

The paper Check List was reduced in content and set out in a style compatible with the electronic check list displays. They are fully described in Chapter 17.

A CRT Check List Display was installed in the right-hand quarter panel and partway through the programme a Ferranti back-projected Check List Display was put in a similar position of the left-hand side. The positions are illustrated in the photograph at the beginning of this thesis. An example of the format layout is shown in Figure 4 . Each display had its controls located immediately below the display with the exception of the "Line Advance" buttons which were in the boss of each control column.

The Documentation Displays received a more thorough assessment in conjunction with the evaluation of the EFI's and are described in Part C.

14.9. Fault Injection

As part of the assessment it was necessary for the crew to evaluate the effectiveness of:-

(a) the Master Warning System to alert to failures or out of tolerance conditions,

(b) electronically displayed information for undertaking fault diagnosis,

(c) initiating appropriate remedial actions on the relevant control.

The ability of the crew to fly the aircraft and operate its systems in a variety of reversionary situations following gross failures was also a necessary part of the assessment.

14.9.1. Fault Definitions

Three general types of faults were assessed:-

(a) Failure of CRT(s)

(b) System failures and excursions outside acceptable limits.

(c) Emergency power conditions.

Table 5 lists the fault conditions which were available for assessment.

14.9.2. Failure of CRT(s)

Reliability figures provided by the manufacturers of display heads indicated a "mean time between failures" of 3,000 hours. These infer a remote probability of two displays failing in one flight. The programme therefore involved an assessment of managing the presentation of information following single or double display failures.

For the assessment the flight and systems data were segregated. The flight information was presented on the four outboard displays and the systems information on the three centre displays (see Figure 1). When the failure of a CRT was detected by the pilot it was acknowledged by switching it off using the button under the Glareshield. This button illuminated when OFF. The lost flight information was available on one of the other flight displays by manual operation of the Changeover Switch. Lost systems information could be selected onto the remaining Systems Displays when under manual control. When under automatic control a logic signal initiated by switching OFF a faulty head reallocated the hierarchy of Systems Formats between the remaining System heads.

Two modes of display failure were available:-

(a) Simulation of faults such as loss of Hold or Synchronisation,

(b) Loss of Video Signal.

14.9.3. <u>System Failures and Excursions outside acceptable limits</u>

The Flight Deck was designed to ensure that the pilots were alerted to a fault or out of limit condition via a visual and audible warning system. Where appropriate the relevant system format would automatically be presented to aid the pilots in their fault diagnosis (see Chapter 7). The simulation permitted all relevant faults listed in Table 5 to be presented on the systems displays, which were further modified when the pilots selected the appropriate systems controls.

Faults were injected via a panel on the Observer's Control Console (see Figure 27). All fault injections were managed by the PDP 11E10 computer which initiated the appropriate action, such as activation of "Attention Getters" and audible warnings, illumination of the MWS and control panel captions, modification of the system dynamics and called the relevant systems format to a predetermined display. The correct crew action to be taken following a fault condition was specified in the Check Lists and Drills (see Chapter 17). The MWS is described in Chapter 7.

The were also a number of failures not included in Table 5 for which additional data is required:-

(a) Landing-gear not down or spoilers out in the landing configuration, and V_{MO} + 6 kt. or M_{MO} + 0.01 caused a continuous horn to sound.

(b) Take-off Configuration Warning - an intermittant horn.

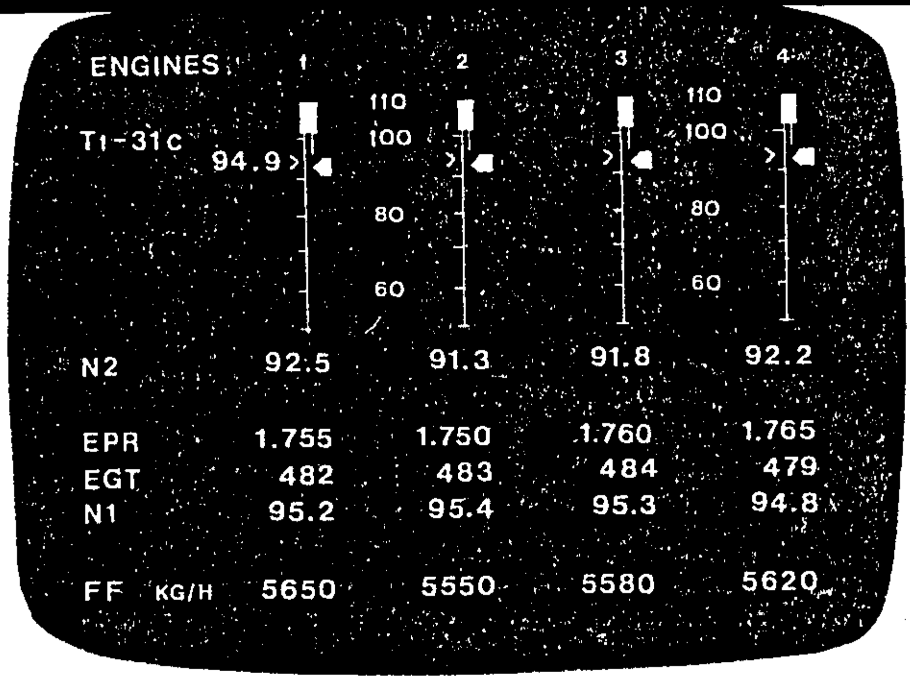
(c) When autopilot disconnect occurred there was a flashing autopilot disconnect caption accompanied by a continuous "Lyrebird" sound. These continued until the autopilot disconnect button was pressed.

14.9.4. Emergency Power Conditions

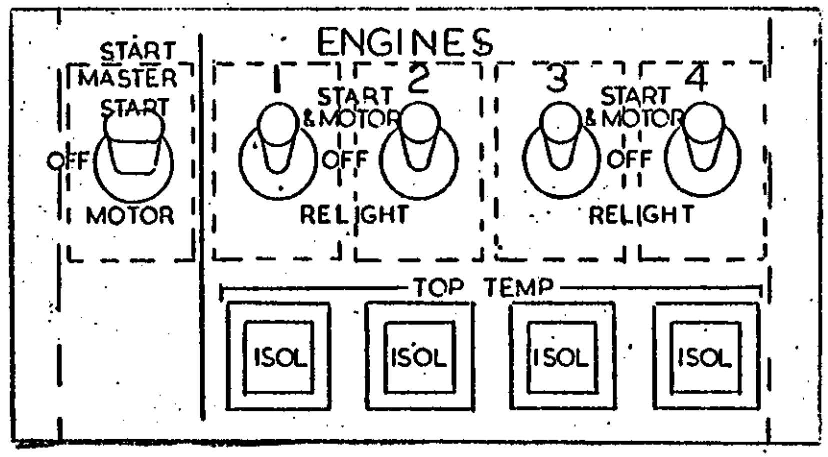
In order to comply with the CAA requirement for dissimilar redundancy for aircraft systems totally dependant on electrical supplies, the Flight Deck was furnished with standby instruments. The two-engine instruments showing two different engine parameters were available for selection to any engine, or an off position.

14.9.5. Method of Fault Injection

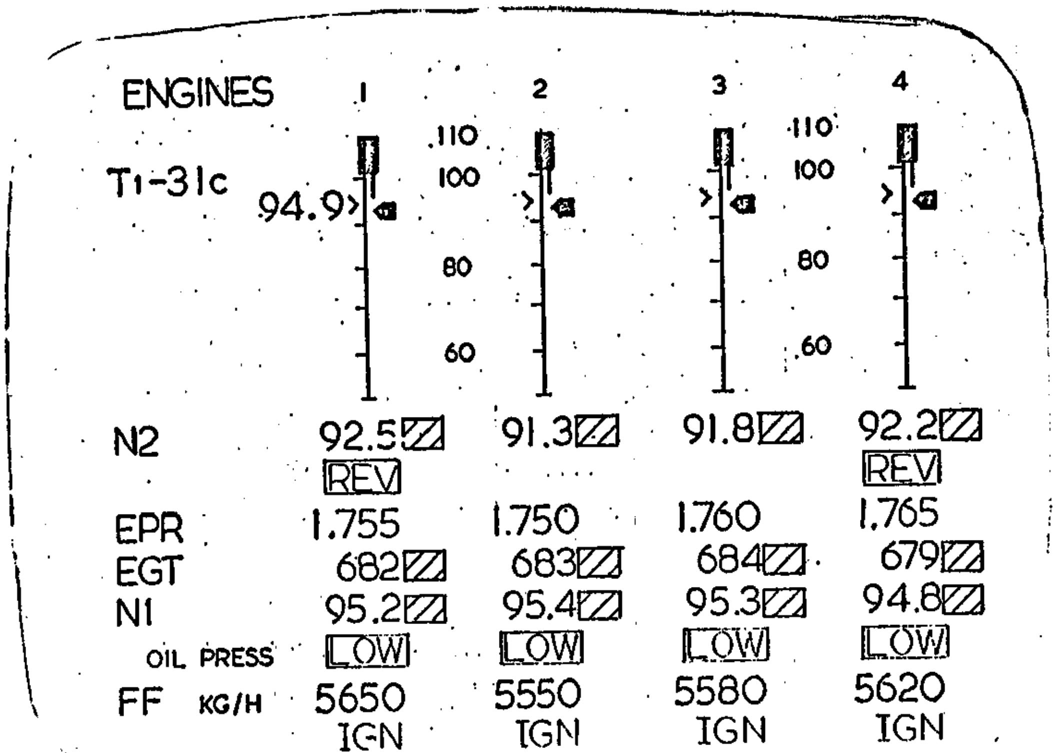
A small console mounted on the Observer's seat (see Figure 27) allowed predetermined faults to be simulated. All faults were implemented by the PDP 11E10 computer and each had an associated three digit octal code number. Injection of a fault involved the Observer making a code selection on the three digit wheel-switches and pressing the INJ button. A fault was removed by selecting the code and pressing the REM button.



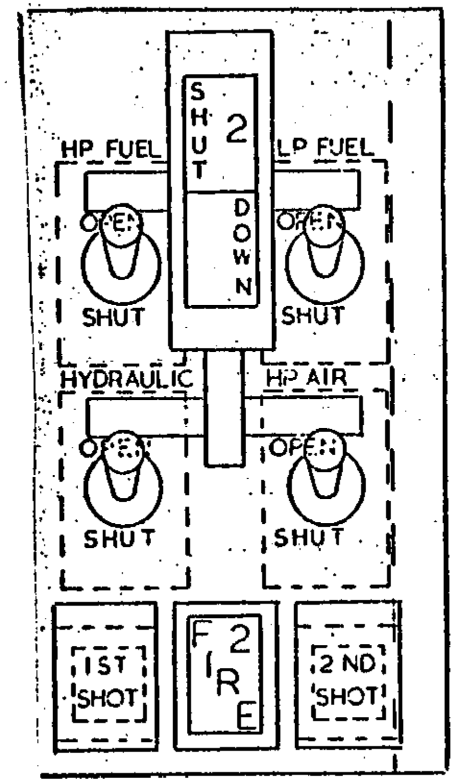
Normal Format



Start Panel



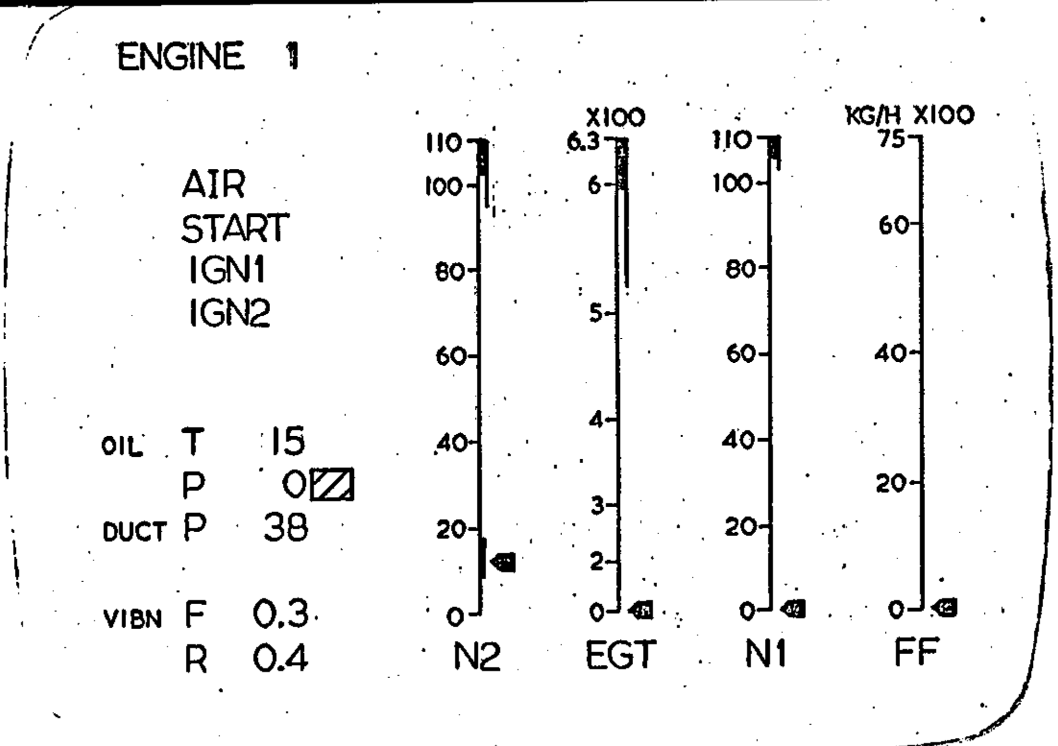
Format with Warnings



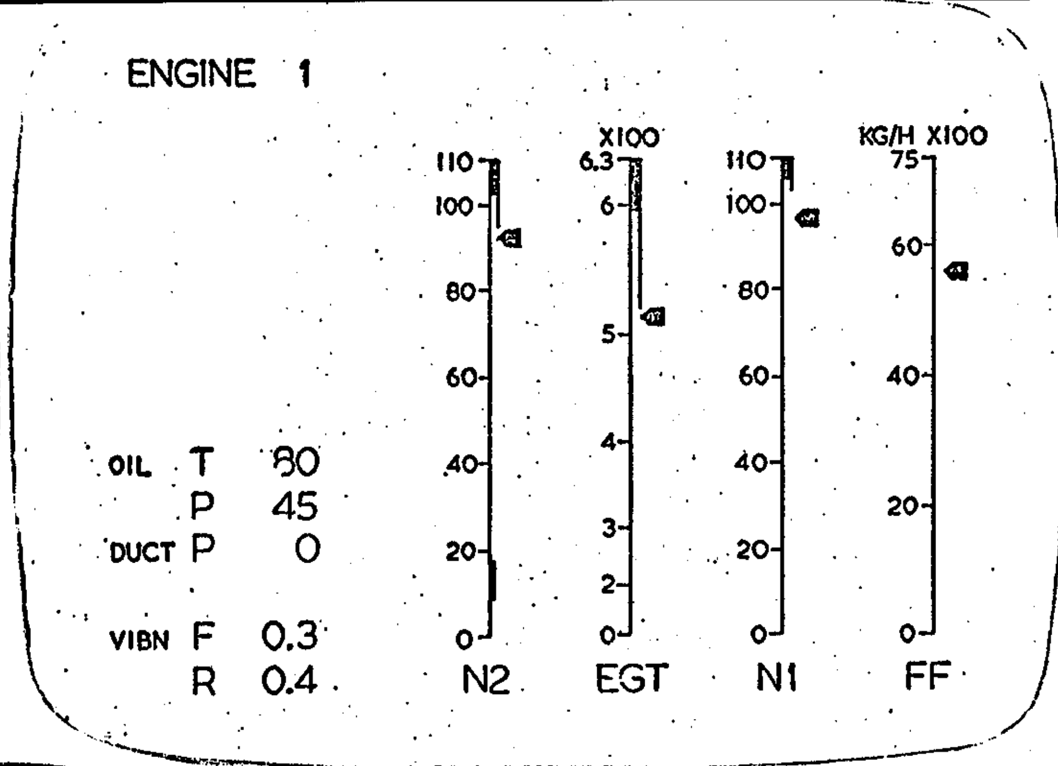
Shut-down Panel

Figure 35

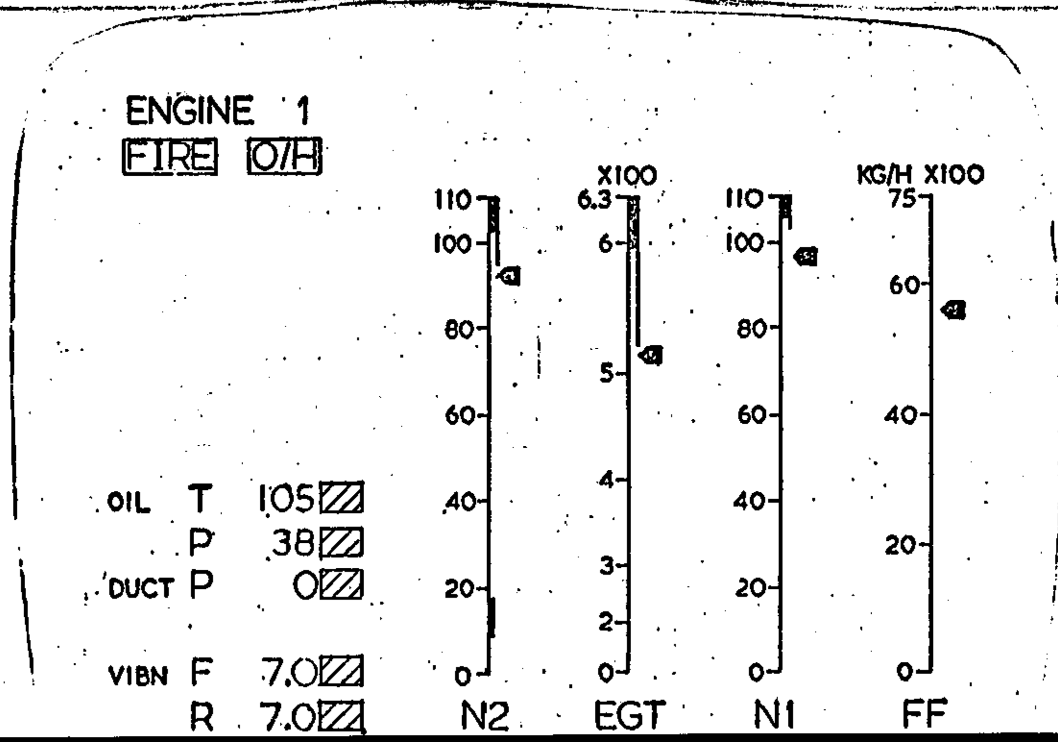
All Engines Formats, Start Panel & Shut-Down Panel



Engine Start



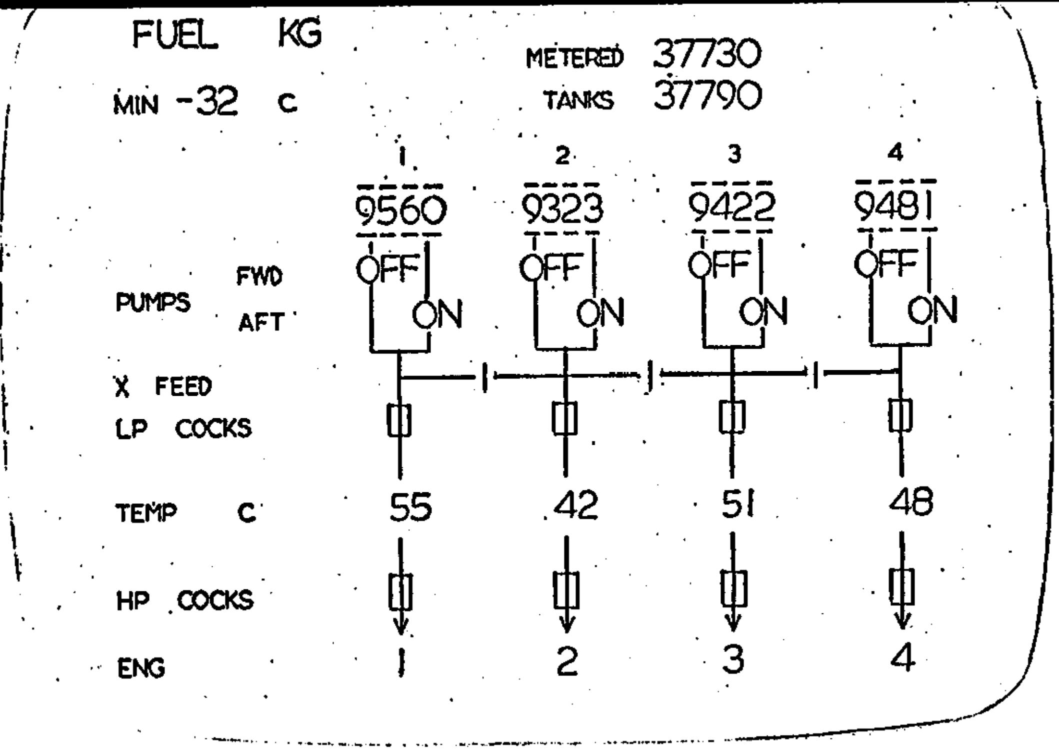
Normal Flight



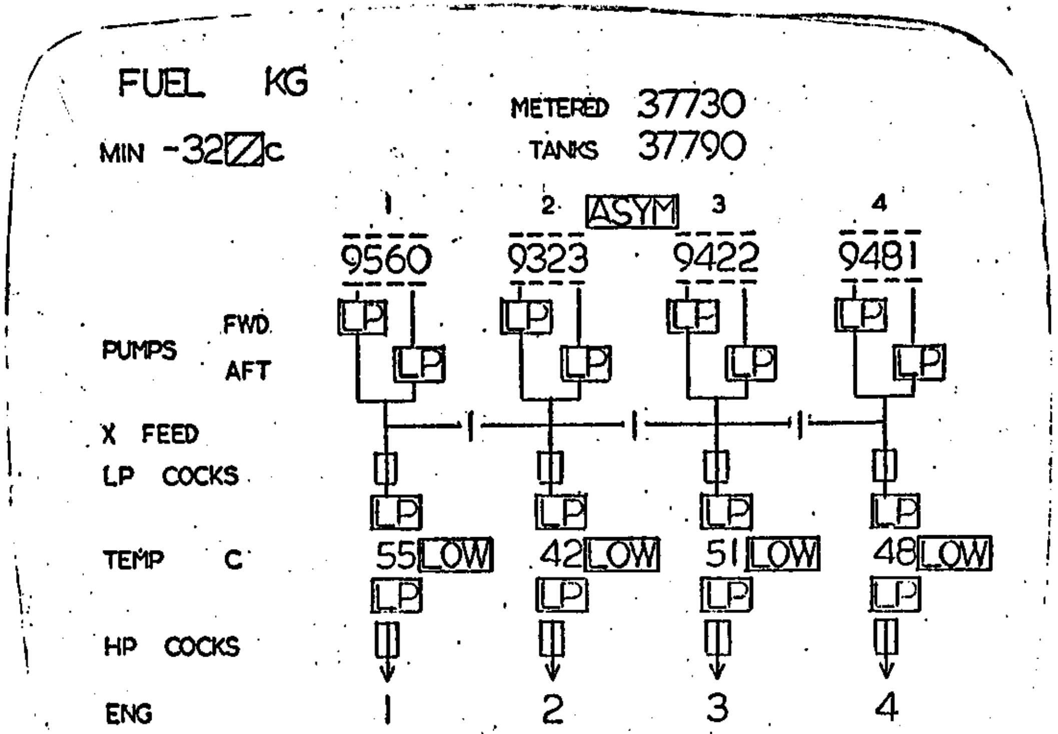
With Warnings

Figure 36

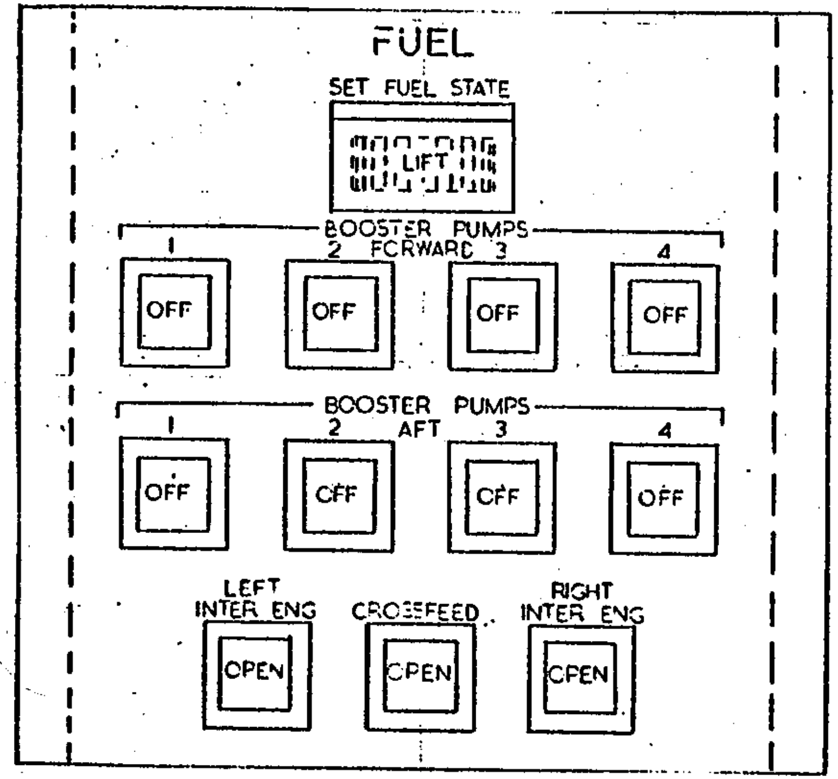
Single Engine Formats



Normal Format



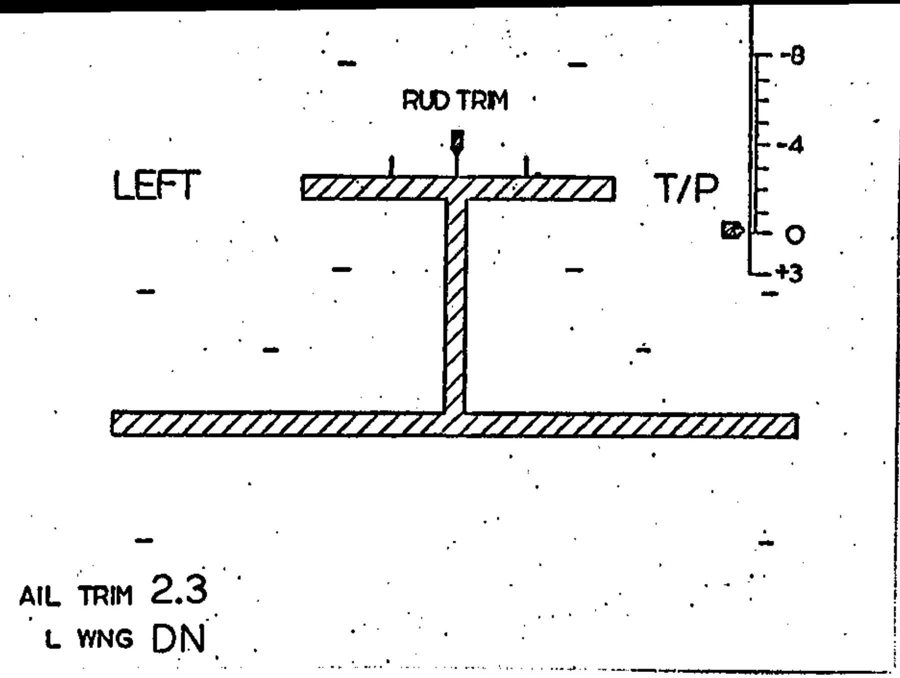
With Warnings



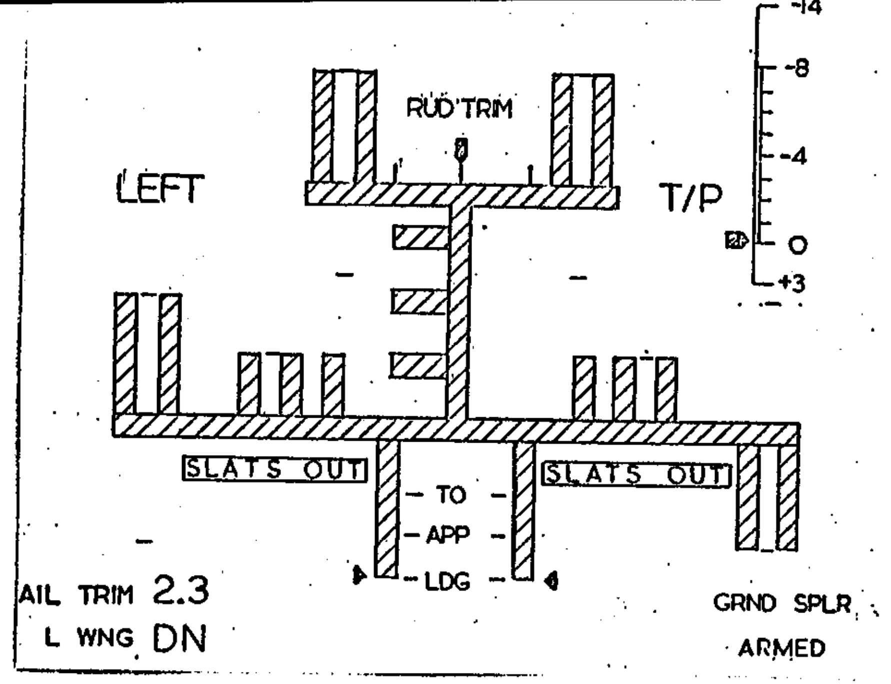
Control Panel

Figure 37

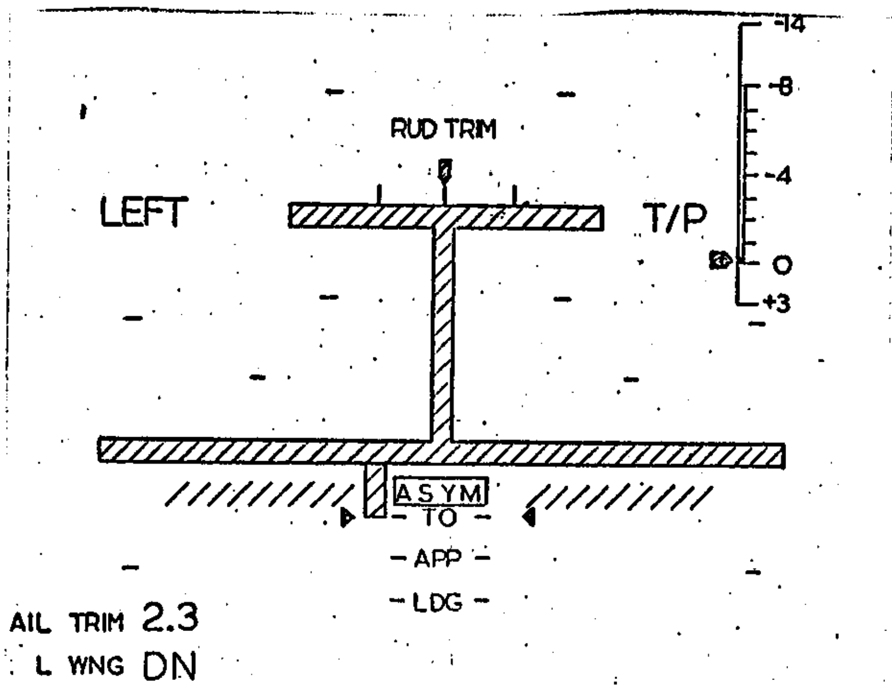
Fuel System Formats and Controls



Clean Aircraft



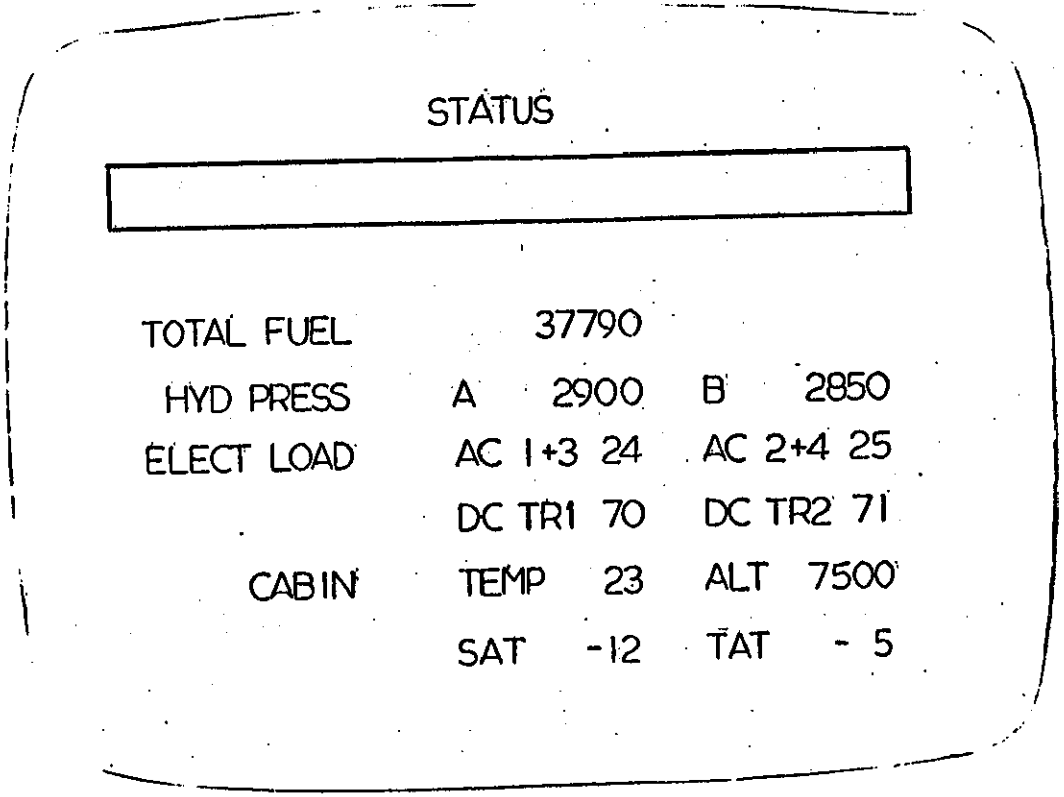
Controls at Maximum



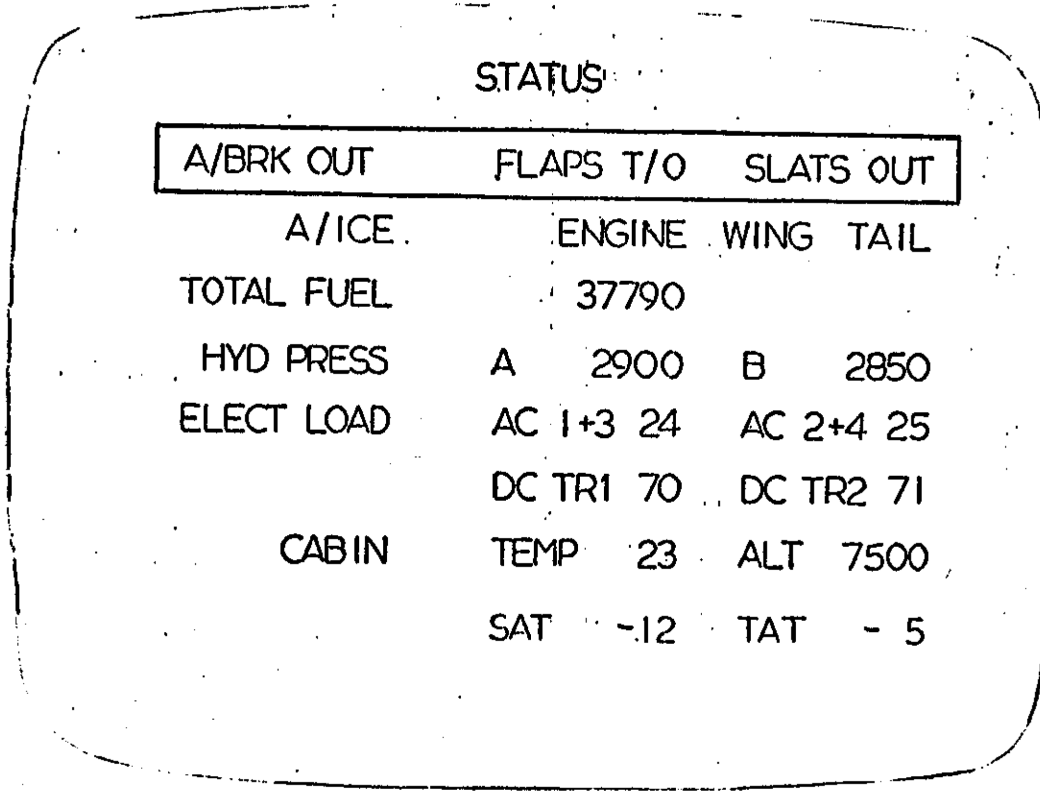
With Warnings
& Slats Moving

Figure 38

Flying Controls Formats



In Cruise



All Parameters

Figure 39

Status Formats

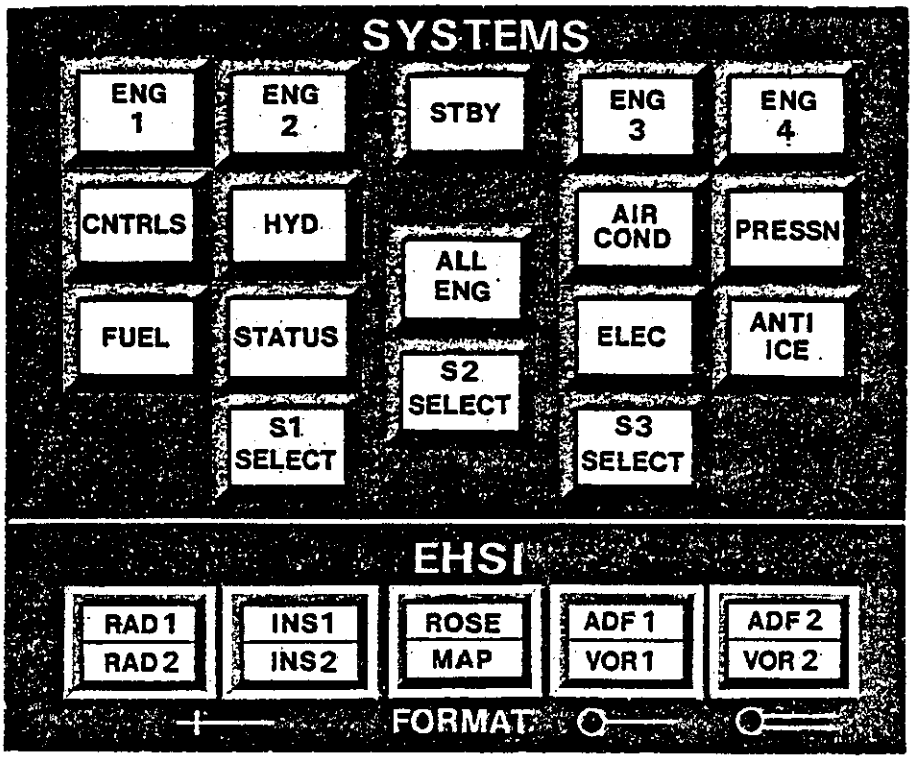


Figure 40

Systems Displays Control Panel

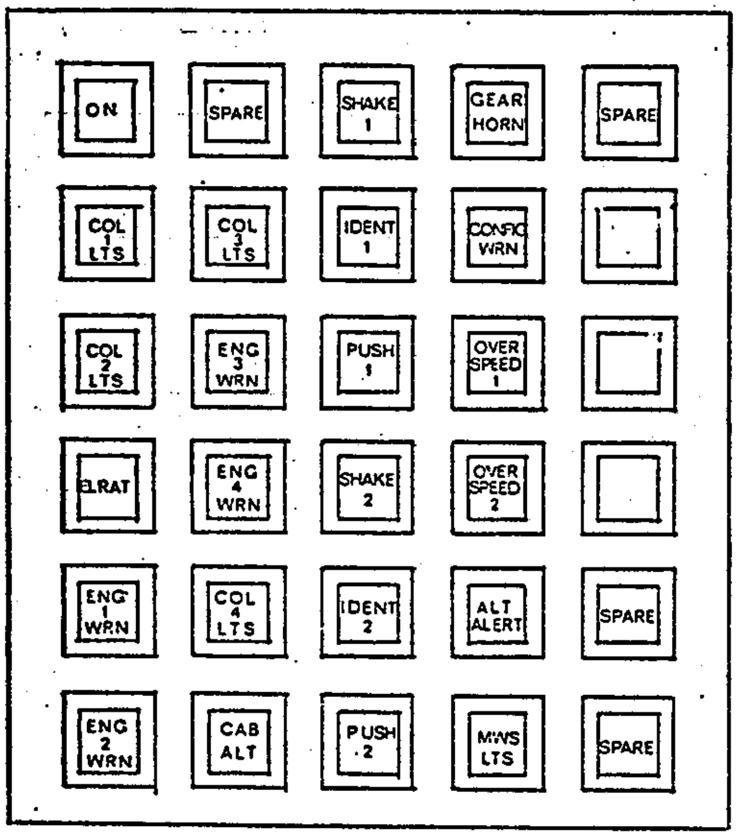


Figure 41

Systems Test Panel

List of Systems Faults

System	Fault		Warning	Fault Category
Engine	(1) Reverser unlocked	No.3 Eng.	Amber	(b)
"	(2) Vibration	No.3 Eng.	Amber	(c)
"	(3) Oil low pressure	No.3 Eng.	Amber	(c)
"	(4) Fire warning	No.3 Eng.	Red & Bell	(b)
"	(5) Overheat warning	No.3 Eng.	Red	(c)
Air Condit:	(1) Duct overheat	System 1	Amber	(c)
"	(2) Radio fan fail	No.1	Amber	(b)
"	(3) Fridge Fail	System 1	Amber	(b)
Pressurisation	(1) Excess cabin diff: Pressure	System 1	Amber	(c)
"	(2) Excess cabin altitude	System 1	Red & Int.Horn	(c)
Ice Protection	(1) Overheat/Overpressure	System 1	Amber	(c)
"	(2) Pitot Head heater fail	Feel & A/P.2	Amber	(b)
"	(3) W/S Heater Fail	Captain	Amber	(b)
"	(4) W/S Heater Overheat	Co-pilot	Amber	(c)
Ice Detection	(1) Ice detected		Amber	(c)
Fuel	(1) Transfer Valve fail	1A	Amber	(b)
"	(2) Booster Pump fail	Tank 3 Fwd.	Amber	(b)
Hydraulics	(1) Fluid Pressure Low	B System	Amber	(c)
"	(2) Fluid Overheat	B System	Amber	(c)
Controls	(1) P.C.U. Oil L.P.	Elev. Rt.Outer	Amber	(b)
"	(2) Feel Motor Fail	No.2	Amber	(c)
Electrics	(1) C.S.D. Oil O/Heat or L.P.	No.3	Amber	(c)
	(2) Excess KVA	No.3	Amber	(c)
	(3) TRU Fail	No.1	Amber & Red	(b)
	(4) Main A.C. failure	All	Red	(d)
Configuration	(1) Flap Asymmetry	Diff.	Amber	(c)
	(2) Gearnot down	Landing Config.	Amber + Cont.Horn	(c)
	(3) Configuration incorrect	T/O	Amber + Int. Horn	(c)
Smoke	(1) Detected at Discharge Valve	Aft	Red	(b)
	(2) Detected in freight bay	Aft	Red	(b)
Autopilot	(1) Disconnect		Light + Lyre bird	(b) or (c)
Displays	(1) Any single failure	ADI,HSI,System	Pilot observed	(a)
	(2) Any two flight displays	EADI or EHSI	"	(a)
	(3) Any two system displays	S_1/S_2 or S_2/S_3 or S_1/S_3	"	(a)

Table 5

CHAPTER 15

MONITORING AND RECORDING

15.1. Introduction

The monitoring and recording facility in the Familiarization part of the programme (see Chapter 8) used four persons in addition to the Assessment Pilot. Arrangements were changed for the Systems Evaluation to make more effective use of the persons available.

15.2. Monitoring Team

15.2.1. General

The monitoring team was reduced to only two persons, the Resident Pilot and the Observer, both of whom were on the Flight Deck for each flight.

15.2.2. Resident Pilot

The Resident Pilot occupied the left-seat for most of the flying and perfomed the following tasks:-

(a) In conjunction with the Observer he briefed the pilots before each day's exercise on the Flight Deck controls and systems controls to be used.

(b) He acted as handling pilot on all but one of the exercises except for certain take-offs and landings.

(c) He carried out the P1 duties as defined in the Check Lists (see Chapter 17).

(d) He controlled the pre-programmed inertial navigation system.

(e) He controlled the pre-recorded ATC messages to the Flight Deck

(f) He did not assist the Assessment Pilots in the identification, diagnosis or correction of fault conditions. In an actual aircraft these would normally be shared between the two pilots, but for the purposes of the evaluation these were left to the Assessment Pilot.

15.2.3. <u>Observer</u>

The Observer's seat was moved onto a raised plinth behind the right-hand pilot's seat. The Observer performed the following tasks:-

(a) He gave a general briefing to each Assessment Pilot and aided the Resident Pilot in the detailed briefing on systems and demonstrations of faults and drills.

(b) He controlled the start and the progress of the exercises and introduced the faults and failures as defined in Chapter 16 by the methods described in Para. 14.7.3. The Observer exercised his discretion in modifying the programme as to when faults were injected to be compatible with any variations in the flights.

(c) He requested display selections and readings as listed in Chapter 16 and checked visually for the correct responses.

(d) He timed the selections and responses for the readings and faults using a two-handed stop-watch.

(e) He maintained a writted log of these times and other pilot actions and the comments. A tape recorder was also used as in the Familiarization

Programme (see Para. 15.3.3.).

(f) He conducted a debriefing at the end of each day's exercises.

(g) He was responsible for ensuring that the correct ATC tapes were fitted for each exercise.

15.3. Monitoring Facilities

15.3.1. General

The logs kept by the Flight Controller and the Exercise Controller in the Familiarization Assessment were effectively replaced by computer monitoring and print-outs, and by an increase in the information recorded by the Observer.

15.3.2. Timing

The Observer's watch was used as the master time for the scheduling and monitoring of the exercises. The two Flight Deck clocks and the computers were synchronised with it at the start of each day. A clockwork stop-watch, with two hands, was used by the Observer to time the pilots' responses.

15.3.3. Observer's Log

The log was kept in written form and supplemented by the use of a tape recorder. Sample pages of the written log are shown in Figures 42(a) and 42(b). The tape recorder could be switched on or off from the Observer's console to record either the intercom or the Observer's remarks. The latter could not be heard by the pilots. During the insertion of the faults the intercom conversation was recorded with additional comments from the Observer as necessary. There were a few problems with the system as described. Some pilots were seen to react to the faint 'pop' as the Observer's microphone was isolated from, or connected to, the intercom and changes of procedure were adopted to avoid distortion of the pilots' reaction times. The loss of intercom recording while the Observer was recording could have led to important comments made by the pilots at crucial moments during failures going unrecorded. Every care was taken to ensure these were minimized and it is not thought any were lost.

After each exercise the tape recorder was left running to record pilots' immediate comments.

15.3.4. Computer Print-outs

15.3.4.1. PDP 11E10 (Exercise Log)

The times of most switching actions by the pilots were recorded on a log printed out during each exercise. A sample of the information collected is illustrated in Figures 43(a) to 43(d). The explanation of the meaning of each line is very long and complex and, as such, only a brief description is included in this thesis.

15.3.4.1.1. Most events were timed (hours: mins: secs ± 1 sec) and some were also accompanied by the current aircraft position (DTG to next WPT, i.e. miles to next waypoint).

15.3.4.1.2. Logging of Pilot Actions

System VDU Selection

[VDU 3AIR] @ 11:23:34

The pilot has selected the air conditioning format on S3. Note that [VDU 3 is printed when the AIR]format button was pressed i.e. @ 11:23:34. Hence [VDU2[VDU3AIR @ 11:23:34 would indicate an incorrect selection of S2 which was later corrected by pressing S3.

Test Panel Buttons

[TEST 037]

The pilot has pressed and released the button corresponding to test No.37, i.e. Col. 1 Lights (see Figure 44 for Test Codes). Note that the trailing bracket was not printed until button release and could therefore have been preceded by other log messages.

Roof Panel Actions

Logic signals from the Flight Deck entered the PDP 11E10 in twelve 16-bit interface cards (KIT 1 - KIT 12). A change in the content of a KIT word, due to Roof Panel switching/button pushing, was detected and caused the following printout:

"Kit No. (octal) content of Kit Altered bits @ time" which can be interpreted by reference to Figure 45, e.g.

004 003770 000030 @ 11:00:13

indicates that fuel booster pumps 4 FWD and 4AFT were turned on at 11:00:13. The booster pumps on tanks 1,2 and 3 were already on at the time.

Check List

Progress through the CRT Check List was logged by printing a document identifier in acute brackets when a document picture was first built, e.g. <PFA 377> indicated the arrival of the first page of the Pre-flight Checks. The number following the document mnemonic was only of interest to the computer personnel and can be ignored.

15.3.4.1.3. Logging of Observer induced events

Ident Marker

The Observer could mark any event in time and corresponding aircraft position by pressing an IDENT button on his panel. The computer printed a numbered log marker, e.g.

MARK 002 @ 1.4/6 @ 11:23:33

The marker number was incremented each time to allow unambiguous interpretation when cross-checked against the Observer's Exercise Log. The PDP 11-45 was also informed whenever the Ident marker was used.

Fault Injection/Removal

The Observer's Injection/removal of an aircraft systems fault was accompanied by a timed print-out of the fault code (see para 14.7.5.) e.g.

[INJ 041]@ 11:23:39

[REM 041]@ 11:26:04

Special 'fault' codes were printed as a six digit number.

15.3.4.1.4. Logging of Non-pilot/Non-Observer Events

MWS Display Selection

The PDP 11E10 would announce the seizure of a system display by the MWS, e.g.

ELE → S3 @ 11:35:07

The MWS has forced the Electrics format onto S3.

Waypoint Marking

Arrival at a waypoint was announced and timed.

e.g. WAPNT 7 @ 11:37:22

Miscellaneous Switch Activity

Lower case messages embedded in the Exercise Log were only of interest to the computer engineers and can be ignored.

e.g. mws(f)?

stuv

....

15.3.4.2. PDP 11-45 (Flight Log)

During each exercise the progress of the navigation with certain other information, listed below, was printed out at take-off, at each waypoint, at localiser and glide-slope acquisition and at each landing. Additional print-outs (e.g. at certain heights) were initiated by the Observer's "IDENT" button when required. A deficiency of this print-out was its poor accuracy in timing and the lack of a buffer store to ensure that all the information was extracted at one time. The printing speed was approximately one inch per second and a delay of up to eight seconds could have been introduced before the next print-out began. This would have been particularly noticeable if a waypoint print-out coincided with an Ident print-out.

The information printed out was (see Figure 46):

Date

Time (hours:minutes:seconds to the nearest whole second)

Identification (e.g. waypoint or Ident Marker Number)

Airspeed (in knots to two decimal places)

Height (in Feet to two decimal places)

Height Rate (Vertical Speed) (in feet/second to two decimal places)

Distance to Go (in nautical miles to two decimal places)

Track (in degrees true to nil decimal places)

15.3.5. Fault Injection

A prime task in the exercises was the observation of the pilots' reactions to fault conditions injected via the Observer's console. The method of injecting these faults and the list of failures are given in Para. 14.9.5. and Table 5.

15.3.6. Alarm Button

A button on the Observer's console rang a bell in the computer area where an engineer was on call in the event of a simulator malfunction.

15.3.7. Simulator Serviceability Record

The Observer's written log also recorded simulator malfunctions that influenced the conduct of the exercises. These notes were passed to the engineers for attention as necessary.

15.4. Questionnaires

Preprinted questionnaires were given to each pilot at the end of each day's exercises, while he was still on the flight deck. The simulator was kept running while the pilots completed these so that they could "call-up" actual formats, etc. to help them answer the detailed questions. The questionnaires are described in Chapter 19.

15.5. Debriefing

At the end of each day, after completion of the questionnaires, a debriefing was conducted. During the debriefings the questionnaires were discussed, together with points from the Observer's logs. An attempt was made to cover all the relevant points of the day's exercises. The proceedings were recorded on tape.

L.H. J. W. WILSON CAPT R.H. [SAMPLE] PILOT	ADVANCED FLIGHT DECK - OBSERVER'S LOG EXERCISE 12 LONDON TO PARIS	DATE ../../76 SHEET 1
RIG DEFICIENCIES Red cover on No2 Shut down handle light loose.		CHECK LIST IN USE: CRT ATC SCRIPT NO: 1

TIME	DIST TO GO SCHED	DIST TO GO ACTUAL	OBSERVER'S ACTION	IDENT	RDG CONFD	TIMES REQD	TIMES	TIMES	TIME	REMARKS
1040			TIME ON DECK							Flight director modified for this flight to delete pitch line.
			774R LOG ✓							
			775R REFUEL ✓							
			TAPE ON (DATE & TIME) "THIS IS EXERCISE NO.12 - LONDON TO PARIS USING CRT CHECK LIST FOR NORMAL PROCEDURES & PAPER DRILLS FOR FAILURES. BEGIN AT PREFLIGHT CHECK NO. 1							
EXACTLY 1041-30			EX 12 BEGINS NOW"	X ✓						
			TAPE OFF							
47			PREFLIGHT CHECKS COMPLETE							Pilot called "Preflight checks complete" after item 23 (end of test panel che
			770G GROUND POWER							Pilot selected HP fuel cocks open instead of HP Air.
54½			ENGINE START CHECKS COMPLETE							
55½			TAXI CHECKS COMPLETE							Pilot doing take off to power reduction (1500')
										F3: EHSI F4: EADI
.58			AIRBORNE							EXTRA IDENTS AT 1000' ✓ 1600' ✓
	WPT1									3000' ✓ 6000' ✓

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Figure 42 (a)

L.H. J.W. WILSON CAPT R.H. SAMPLE. PILOT	ADVANCED FLIGHT DECK - OBSERVER'S LOG EXERCISE 12	DATE ../../76 SHEET 2
RIG DEFICIENCIES NIL.		CHECK LIST IN USE: CRT

TIME	DIST TO GO SCHED	DIST TO GO ACTUAL	OBSERVER'S ACTION	IDENT	RDG CONFD	TIMES REQD	TIMES TO NOTICE WARNING	TIMES TO 1st CORRECT ACTION	TIME	REMARKS
	17/2	✓	TAPE ON							
	15/2	-	12.1. 252R ICE WARNING			✓✓	2·6	7·3		
			TAPE OFF							
1121	WPT2									
	22/3	✓	TAPE ON							
	20/3	-	12.2. 250R (A/I SYST 2 FAIL)			✓✓	3·5	24·0		
1126	~~FL180~~	-	252G ICE WARNING CANCEL			✓✓	No reaction	before		next failure
									1128	Pilot noticed ice det off.
	5/3	-	12.3. 773R S3 FAIL			✓✓	10·0	12·5	1128½	Actioned.
			TAPE OFF				Pilot	may	have	noticed before this time
	WPT3									
	42/4		TAPE ON (TIME)							
	41/4		"PREPARE FOR READINGS"				TO SELECT DISPLAY	TO SELECT & READ		
	40/4	-	12.4. GEN 3 KVA	X		✓✓	-	6·2		Elec display already selected.
	35/4	-	12.5. ENG 1 OIL TEMP	X		✓✓	4·4	6·5		

Figure 42(b)

Ex 9 BEGINS.

TID DOC	
<MEL 017>	
TID ENC	
[INJ 000752] @ 7.7/1 @ 15:36;02	
[INJ 000774] @ 10.0/1 @ 15:40:48	
[INJ 000775] @ 10.0/1 @ 15:40:50	
[VDU3STA] @ 15:41:29	
[VDU1STA] @ 15:41:30	
[VDU1[VDU1PRE][VDU1PRE] @ 15:41:36	
[VDU1FUE] @ 15:41:48	
[VDU1HYD] @ 15:42:00	
[VDU1PRE] @ 15:42:08	
[VDU1[VDU1[VDU1MARK 001 @ 10.0/1 @ 15:44:32	
012 020360 020000 @ 15:44:45	TEST PANEL ON
<CDX 000001> @ 15:44:50	
[VDU1<TRA 077>	
PRE]<TRB 037>	
[VDU3ICE] @ 15:45:26	PILOT SELECTED S3 TO ANTI-ICE
<CDX 000004> @ 15:45:29	
<STA 177>	ENGINE START CHECKS (1)
[VDU1HYD] @ 15:47:26	PILOT SELECTED S1 TO HYDRAULICS
[VDU2FUE] @ 15:47:29	" " S2 TO FUEL
004 003007 003000 @ 15:47:52	No. 1 BOOSTER PUMPS ON
004 003607 000600 @ 15:47:53	No. 2 " " "
004 003747 000140 @ 15:47:54	No. 3 " " "
004 003777 000030 @ 15:47:55	No. 4 " " "
<STB 077>	START CHECKS (2)
006 102214 000010 @ 15:48:04	ENG 1 LP FUEL ON
006 106214 004000 @ 15:48:07	" 2 " " "
007 102214 000010 @ 15:48:09	" 3 " " "
007 106214 004000 @ 15:48:11	" 4 " " "
006 106314 000100 @ 15:48:18	ENG 1 AIR ON
006 146314 040000 @ 15:48:20	" 2 " "
007 106314 000100 @ 15:48:23	" 3 " "
007 146314 040000 @ 15:48:24	" 4 " "
006 146354 000040 @ 15:48:30	ENG 1 HYDRAULICS ON
006 166354 020000 @ 15:48:32	" 2 " "
007 146354 000040 @ 15:48:34	" 3 " "
007 166354 020000 @ 15:48:36	" 4 " "
[VDU1ENC] @ 15:48:46	S1 TO ENG 3 (BY PILOT)
[VDU2ENG] @ 15:48:50	S2 TO ALL ENG " "
[VDU3ELE] @ 15:48:54	S3 TO ELECS. " "
<STC 377>	START CHECKS (3)
004 103777 100000 @ 15:48:58	ENG START MASTER ON
007 166356 000002 @ 15:49:03	ENG 3 START & MOTOR ON
007 166354 000002 @ 15:49:04	" " " " " OFF
007 166374 000020 @ 15:49:14	" 3 HP FUEL ON
[VDU1END] @ 15:49:35	S1 TO ENG 4 (BY PILOT)
007 167374 001000 @ 15:49:37	ENG 4 START & MOTOR ON
007 166374 001000 @ 15:49:38	" " " " OFF
007 176374 010000 @ 15:49:48	" " HP FUEL ON
[INJ 055] @ 10.0/1 @ 15:50:05	INSERT HOT START (BY OBSERVER)
[VDU1ENB] @ 15:50:08	S1 TO ENG 2 (BY PILOT)
006 167354 001000 @ 15:50:12	ENG 2 START & MOTOR ON
006 166354 001000 @ 15:50:13	" " " " " OFF
006 176354 010000 @ 15:50:23	" " HP FUEL ON
006 166354 010000 @ 15:50:30	" " " " OFF
[VDU1ENA] @ 15:50:51	S1 TO ENG 1 (BY PILOT)
[REM 055] @ 10.0/1 @ 15:50:52	REMOVE HOT START
006 166356 000002 @ 15:50:54	ENG 1 START & MOTOR ON
006 166354 000002 @ 15:50:55	" " " OFF
006 166356 000002 @ 15:51:16	" " " ON
006 166354 000002 @ 15:51:17	" " " OFF
004 003777 100000 @ 15:51:22	START MASTER OFF
004 103777 100000 @ 15:51:28	" " ON
006 166356 000002 @ 15:51:30	ENG 1 START & MOTOR ON

Figure 43(a)

006 166354 000002 @ 15:51:31	ENG 1 START & MASTER OFF
006 166374 000020 @ 15:51:41	" 1 HP FUEL ON
[VDU1ENB] @ 15:51:57	S1 TO ENG 2 (BY PILOT)
006 167374 001000 @ 15:52:02	ENG 2 START & MASTER ON
006 166374 001000 @ 15:52:03	" " " " OFF
006 176374 010000 @ 15:52:13	" " HP FUEL ON
004 003777 100000 @ 15:52:31	START MASTER OFF
<STD 037>	START CHECKS (4)
[REM 000770] @ 10.0/1 @ 15:52:53	
012 000360 020000 @ 15:52:58	TEST PANEL OFF
012 000360 040000 @ 15:53:02	MWS RECALL
003 142037 000200 @ 15:53:11	CABIN AIR OFF
003 142017 000020 @ 15:53:13	FLIGHT DECK AIR OFF
<STE 077>	START CHECKS (5)
[VDU1SUR] @ 15:53:16	S1 TO FLYING CONTROLS (BY PILOT)
<CDX 000010> @ 15:54:03	
MARK 002 @ 10.0/1 @ 15:54:04	START CHECKS COMPLETE (BY OBSERVER)
<TAX 037>	TAXI CHECKS (1)
<TBX 037>	" " (2)
<CDX 000020> @ 15:55:21	
<ATO 177>	AFTER TAKE-OFF CKS
MARK 003 @ .0/1 @ 15:55:50	" " " " COMPLETE (BY OBSERVER)
[VDU1PRE] @ 15:57:07	S1. TO PRESSURIZATION (BY PILOT)
WAYPNT 1 @ 15:59:07	
[VDU1TAT] @ 15:59:19	S1 TO STATUS (BY PILOT)
[VDU3STA] @ 15:59:29	S3 TO STANDBY " "
[INJ 123] @ 28.4/2 @ 16:01:26	INSERT No.1 FEEL MOTOR FAIL
012 000360 000400 @ 16:01:30	AMBER FLASHER CANCELLED
005 177760 000010 @ 16:01:42	No.1 FEEL MOTOR ISOLATE
[INJ 141] @ 17.8/2 @ 16:03:40	CSD No.4 FAIL
ELE->S3 @ 16:03:40	S3 TO ELECTRICS (AUTOMATICALLY)
012 000360 000400 @ 16:03:43	AMBER FLASHER CANCELLED
<CDX 000400> @ 16:03:52	
011 013331 000002 @ 16:03:56	AIR FLIGHT DECK SPILL VALVE OPEN
011 013330 000001 @ 16:04:02	" " " O/HEAT " "
[INJ 131] @ 7.2/2 @ 16:06:00	RIGHT INBOARD AILERON PCU FAIL.
012 000360 000400 @ 16:06:03	AMBER FLASHER CANCELLED
[VDU1SUR] @ 16:06:12	S1 TO FLYING CONTROLS (BY PILOT)
005 176760 001000 @ 16:06:18	NO.3 AILERON PCU ISOLATE
WAYPNT 2 @ 16:07:35	
[VDU1TAT] @ 16:08:21	S1 TO STATUS
[INJ 000773] @ 36.1/3 @ 16:08:25	S3 FAIL
[VDU3ELE] @ 16:08:31	S3 TO ELECTICS } UNSUCCESSFULLY
[VDU3ICE] @ 16:08:33	" " ANTI-ICE } UNSUCCESSFULLY
[VDU3HYD] @ 16:08:37	" " HYDRAULICS } UNSUCCESSFULLY
[VDU3 001 004773 004000 @ 16:08:44	S3 OFF
[INJ 206] @ 23.5/3 @ 16:10:22	No.3 HYD PUMP LOW PRESS
HYD->S1 @ 16:10:23	S1 TO HYDRAULICS AUTOMATICALLY
012 000360 000400 @ 16:10:26	AMBER FLASHER CANCELLED.
002 000015 000002 @ 16:11:22	No.3 HYD PUMP OFF
[VDU1TAT] @ 16:11:36	S1 TO STATUS (BY PILOT)
[VDU1FUE] @ 16:12:13	S1 " FUEL "
004 003773 000004 @ 16:12:25	FUEL CROSSFEED LEFT INTER ENG CLOSE
004 003770 000003 @ 16:12:26	" " RIGHT " " & X FEED CLOSE
004 000770 003000 @ 16:12:40	No1 FWD & AFT BOOSTER PUMPS OFF
004 003770 003000 @ 16:12:44	" " " " " ON
004 003600 000170 @ 16:12:45	Nos3&4 FWD & AFT " " OFF
004 003140 000740 @ 16:13:09	Nos 3 FWD & AFT BOOSTERS ON, No.2's OFF
004 003000 000140 @ 16:13:11	" 2 " " " "
004 003030 000030 @ 16:13:22	" 4 " " " "
004 003770 000740 @ 16:13:25	Nos 3&4's OFF
004 003774 000004 @ 16:13:30	FUEL XFEED LEFT INTER ENG OPEN
004 003777 000003 @ 16:13:31	RIGHT " " & X FEED OPEN
WAYPNT 3 @ 16:13:38	
[VDU1TAT] @ 16:14:16	S1 TO STATUS (BY PILOT)
[INJ 163] @ 49.0/4 @ 16:15:35	No.4 FWD BOOSTER FAIL

Figure 43(b)

FUE->S1 @ 16:15:36	S1 TO FUEL (AUTOMATICALLY)
[INJ 164] @ 48.7/4 @ 16:15:38	No. 4 AFT BOOSTER FAIL
012 000360 000400 @ 16:15:39	AMBER FLASHER CANCELLED
004 003776 000001 @ 16:15:52	FUEL X FEED: RIGHT INTER ENG. CLOSE
012 000760 000400 @ 16:15:54	AMBER FLASHER PUSHED
012 000360 000400 @ 16:15:55	" " CANCELLED
004 003746 000030 @ 16:16:22	No.4 BOOSTERS OFF
004 003744 000002 @ 16:16:32	X FEED CLOSE
004 003740 000004 @ 16:16:33	LEFT INTER ENG. CLOSE
<DES 037>	DESCENT CHECKS
[VDU1PRE] @ 16:18:42	S1 TO PRESSURIZATION (BY PILOT)
[VDU1TAT] @ 16:18:58	S1 TO STATUS (BY PILOT)
<CDX 001000> @ 16:19:14	
<APA 037>	APPROACH CHECKS (1).
MARK 004 @ 28.8/4 @ 16:19:18	
[INJ 000771] @ 25.7/4 @ 16:19:48	S1 FAIL
[VDU1FUE] @ 16:19:52	S1 TO FUEL] UNSUCCESSFULLY
[VDU1HYD] @ 16:19:55	" " HYDRAULICS]
[VDU1 001 005771 001000 @ 16:20:06	S1 OFF
[VDU2TAT] @ 16:20:17	S2 TO STATUS
MARK 005 @ 20.0/4 @ 16:20:42	
[VDU2ENG] @ 16:20:45	S2 TO ALL ENGINES
[VDU2FUE] @ 16:20:56	S2 TO FUEL
[VDU2MARK 006 @ 17.1/4 @ 16:21:10	S2 TO ALL ENGINES
ENG] @ 16:21:10	
[VDU2FUE] @ 16:21:20	S2 TO FUEL
004 003741 000001 @ 16:21:33	RIGHT INTER ENG OPEN
FUE->S2 @ 16:21:33	S2 TO FUEL (AUTOMATICALLY)
012 000360 000400 @ 16:21:36	AMBER FLASHER CANCELLED
012 000360 100000 @ 16:21:54	MWS AMBER CANCELL
004 003740 000001 @ 16:23:20	RIGHT INTER ENG CLOSE
004 000740 003000 @ 16:23:22	No.1 BOOSTERS OFF
004 000140 000600 @ 16:23:25	No.2 " "
WAYPNT 4 @ 16:23:45	
[VDU2TAT] @ 16:24:25	S2 TO STATUS (BY PILOT)
MARK 007 @ 32.9/5 @ 16:24:40	
[VDU2ENG] @ 16:24:40	S2 TO ALL ENGINES (BY PILOT)
MARK 010 @ 29.6/5 @ 16:25:13	
[INJ 202] @ 24.7/5 @ 16:26:03	HYDRAULICS 'B' SYSTEM O/HEAT
HYD->S2 @ 16:26:04	HYDRAULICS TO S2 (AUTOMATICALLY)
012 000360 000400 @ 16:26:07	AMBER FLASHER CANCELLED
012 000360 000400 @ 16:26:08	
002 000014 000001 @ 16:26:46	No 4 HYD PUMP OFF
[VDU2TAT] @ 16:27:48	S2 TO STATUS (BY PILOT)
[INJ 367] @ 14.7/5 @ 16:28:10	DROP TEMP OUTSIDE 10°
[INJ 367] @ 13.7/5 @ 16:28:26	" " " "
[REM 367] @ 13.4/5 @ 16:28:31	REMOVE " " 10° DROP
[INJ 367] @ 13.3/5 @ 16:28:32	DROP TEMP OUTSIDE 10°
[INJ 252] @ 10.9/5 @ 16:29:10	ICE WARNING
012 000360 000400 @ 16:29:15	AMBER FLASHER CANCELLED
002 006014 006000 @ 16:29:22	ANTI-ICING WING ON
002 007414 001400 @ 16:29:23	" " TAIL "
002 177414 170000 @ 16:29:24	" " ENGINES ON
006 176775 000401 @ 16:29:50	ENGINES 1&2 IGNITERS ON
007 176775 000401 @ 16:29:51	" 3&4 "
<APB 007>	APPROACH CHECKS (2)
[VDU2FUE] @ 16:31:19	S2 TO FUEL (BY PILOT)
004 000740 000600 @ 16:31:29	No. 2 BOOSTERS ON
004 000600 000140 @ 16:31:34	" 3 " OFF
WAYPNT 5 @ 16:31:47	
[INJ 071] @ 9.2/6 @ 16:33:07	ENG. 3 O/HEAT
ENG->S2 @ 16:33:07	S2 TO ALL ENGINES (AUTOMATICALLY)
..<MEO 017>	EMERGENCY O/HEAT CHECKS.
012 000360 002000 @ 16:33:27	FIRE LIGHT CANCEL
007 176605 000170 @ 16:33:40	ENG3 SHUT-DOWN HANDLE PULLED
011 013310 000020 @ 16:33:49	ENG 3 GENERATOR OFF

Figure 43(c)

012 000760 000400 @ 16:33:51	AMBER FLASHER PUSHED
012 000360 000400 @ 16:33:52	" " CANCELLED
[REM 071] @ 13.6/6 @ 16:34:01	ENG 3 O/HEAT REMOVED
003 142013 000004 @ 16:34:01	No3 FLOW VALVE OFF (AIR)
[VDU2FUE] @ 16:34:44	S2 TO FUEL (BY PILOT)
004 000604 000004 @ 16:35:06	LEFT INTER ENG VALVE OPEN
004 003604 003000 @ 16:35:07	No.1 BOOSTERS ON
004 003606 000002 @ 16:35:08	X FEED OPEN
FUE->S2 @ 16:35:08	S2 TO FUEL (AUTOMATICALLY)
004 003607 000001 @ 16:35:10	RIGHT INTER ENG OPEN (ALREADY ON)
012 000360 000400 @ 16:35:12	AMBER FLASHER CANCELLED
<CDX 000001> @ 16:35:50	
002 171414 006000 @ 16:37:03	WING ANTI-ICE OFF
002 170014 001400 @ 16:37:04	TAIL " "
004 003604 000003 @ 16:38:39	X FEED CLOSE & RIGHT INTER ENG CLOSE
[VDU2PRE] @ 16:39:33	S2 TO PRESSURIZATION (BY PILOT)
<FIN 377>	FINAL APPROACH CHECKS
[VDU2ENG] @ 16:39:46	S2 TO ALL ENGINES (BY PILOT)
<CDX 004000> @ 16:39:57	
<ALA 177>	AFTER LAND CHECKS
[VDU2TAT] @ 16:40:01	S2 TO STATUS (BY PILOT)
[VDU2PRE] @ 16:40:15	S2 TO PRESSURIZATION (BY PILOT)
[VDU2ENG] @ 16:40:41	S2 TO ALL ENGINES (BY PILOT)
[REM 252] @ 12.6/6 @ 16:41:32	ICE CONDITIONS REMOVED
006 176774 000001 @ 16:42:20	ENG. 1 IGNITERS OFF
006 176374 000400 @ 16:42:21	" 2 " "
007 176604 000001 @ 16:42:21	" 3 " "
007 176204 000400 @ 16:42:22	" 4. " "
[VDU2TAT] @ 16:42:26	S2 TO STATUS (BY PILOT)
003 142213 001600 @ 16:42:33	CABIN AIR COOL - OFF
003 142233 000060 @ 16:42:35	FLIGHT DECK AIR WARM - OFF
<CDX 010000> @ 16:42:39	
MARK 011 @ 12.6/6 @ 16:42:41	
[VDU2ENG] @ 16:42:47	S2 TO ALL ENGINES (BY PILOT)
<SHA 177>	SHUT DOWN CHECKS (1)
006 176204 000170 @ 16:42:53	ENG 1 SHUT DOWN
HYD->S2 @ 16:42:53	S2 TO HYDRAULICS (AUTOMATICALLY)
006 102204 074000 @ 16:42:54	ENG 2 SHUT DOWN
ELE->S2 @ 16:42:57	S2 TO ELECTRICS (AUTOMATICALLY)
001 007770 002000 @ 16:42:58	S2 ON.
[INJ 000770] @ 12.6/6 @ 16:43:11	GROUND POWER INSERTED
001 005770 002000 @ 16:43:13	S2 OFF
012 000360 000001 @ 16:43:13	GROUND POWER ON
012 000360 000400 @ 16:43:17	AMBER FLASHER CANCELLED
007 102204 074000 @ 16:43:44	ENG. 4 SHUT DOWN
004 000004 003600 @ 16:43:49	No.1 & 2 BOOSTERS OFF
004 000007 000003 @ 16:43:53	X FEED & RIGHT INTER ENG OPEN
012 000760 000400 @ 16:43:55	AMBER FLASHER PUSHED
012 000360 000400 @ 16:43:56	" " CANCELLED
<SHB 377>	SHUT-DOWN CHECKS (2).
002 140014 030000 @ 16:44:06	ENG 1 & 2 ANTI-ICE OFF
002 000014 140000 @ 16:44:07	" 3 & 4 " " "
<CDX 000001> @ 16:44:17	
MARK 012 @ 12.6/6 @ 16:44:18	← Ex. 9. ENDS
ENG] 012 000360 100000 @ 16:44:54	
012 020360 020000 @ 16:44:59	
[VDU2ENG] @ 16:45:00	
[TEST 030VDU#1 DEAD	
]	
001 004770 001000 @ 16:45:10	
001 000770 004000 @ 16:45:11	
[REM 000771] @ 12.6/6 @ 16:45:14	
[REM 000773] @ 12.6/6 @ 16:45:16	
TAT][TEST 030]	
[VDU1ENC] @ 16:46:18,	
[VDU2STA] @ 16:47:23	

Figure 43(d)

TEST	CODE
COL 1 LTS	37
COL 2 LTS	36
ELRAT	35
ENG 1 WRN	34
ENG 2 WRN	33
SPARE	32
COL 3 LTS	31
ENG 3 WRN	30
ENG 4 WRN	27
COL 4 LTS	26
CABIN ALT	25
SHAKE 1	24
IDENT 1	23
PUSH 1	22
SHAKE 2	21
IDENT 2	20
PUSH 2	17
GEAR HORN	16
CONFIG WRN	15
OVERSPEED 1	14
OVERSPEED 2	13
ALT ALERT	12
MWS LTS	11
SPARE	10
SPARE	7
SPARE	6
SPARE	5
SPARE	4
SPARE	3

Figure 44 TEST PANEL CODES

LOGIC INPUT

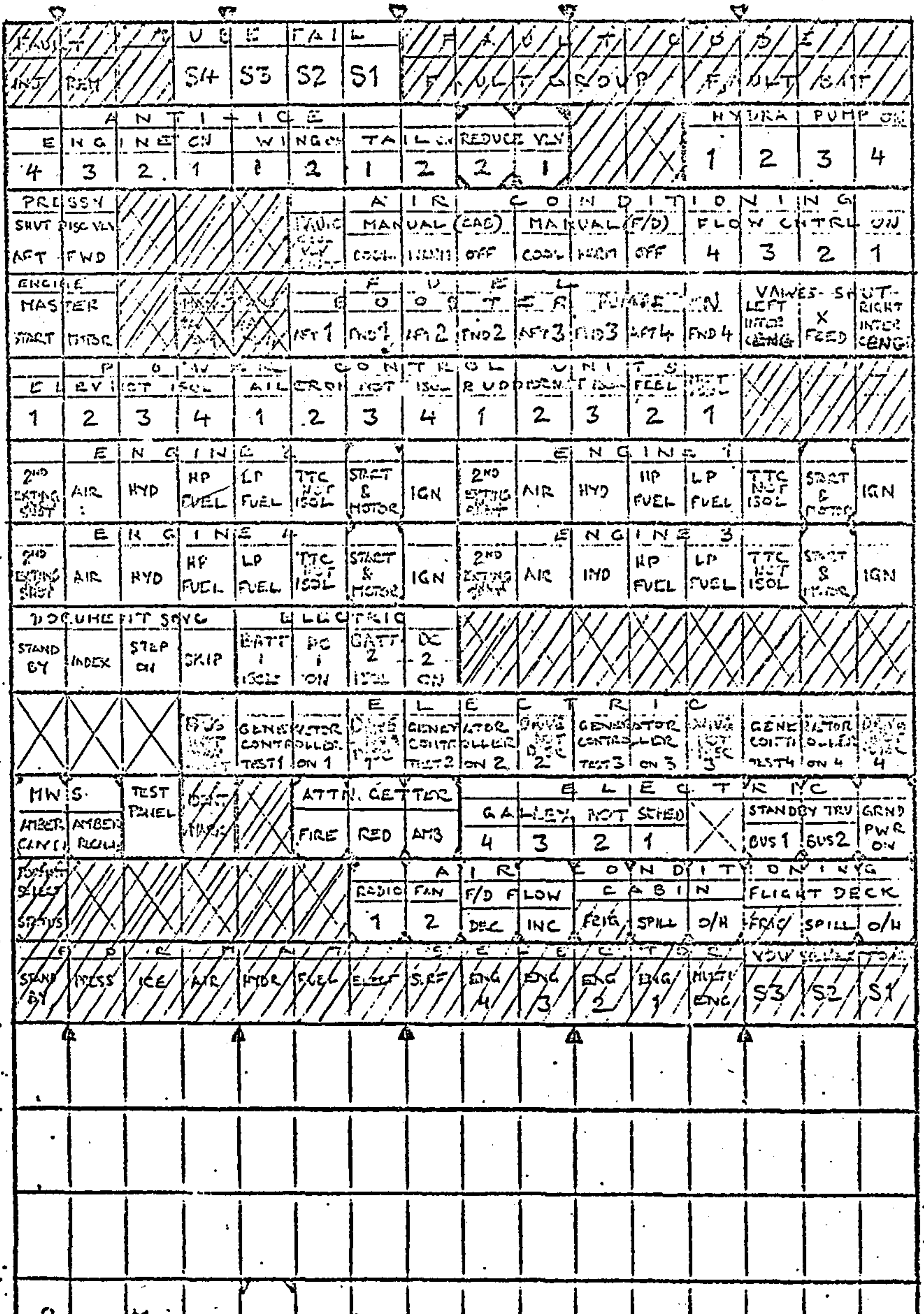

Figure 45

ADVANCED FLIGHT DECK FLIGHT LOG
DATE 29-SEP-76TIME 10:18:31

PILOT:
....

TIME	LEG NO.	AIRSPEED	HEIGHT	HEIGHT RATE	D.T.G	TRACK
10:18:43		0.06	6.57	-0.00	7.61	-124.34

1

TIME	WPT ~~LEG NO.~~	AIRSPEED	HEIGHT	HEIGHT RATE	D.T.G	TRACK
11:50:44	TAKE-OFF	161.7635	194.0859	2065.1866	6.6405	-124.3361
11:52:34	1	172.0611	3345.2993	640.2515	19.8063	152.3460
11:57:16	2	252.6259	6615.3423	-2.7352	30.2734	139.4419
12:02:23	3	326.3563	21149.9746	31.2885	65.1786	140.7720
12:10:39	4	343.4207	20990.6934	31.9664	50.2504	146.3581
12:19:07	5	238.7758	8033.2173	0.4637	26.1418	90.0066
12:25:11	6	195.2546	8015.3984	100.4275	19.1116	117.9633
12:29:47	7	192.7460	2749.4868	-880.4524	11.9415	-124.0268
12:32:19	LOC	170.2975	2117.3564	-147.7519	9.0489	-124.0268
12:33:14	G/S	169.9145	2110.4827	265.1114	6.4739	-124.0268
12:35:55	LAND	124.3410	9.3667	78.1132	0.0733	-124.0268

2

TIME	WPT ~~LEG NO.~~	AIRSPEED	HEIGHT	HEIGHT RATE	D.T.G	TRACK
14:38:16	T/OFF	152.8766	369.9116	4011.3066	1.6151	-92.8600
14:40:07	1	206.4712	2655.1313	577.7741	31.3066	13.0696
14:45:43	2	296.0176	18950.1523	598.0573	47.8390	-35.1889
14:52:10	3	336.0823	20014.5586	-0.3984	62.1880	-43.5455
15:06:20	4	326.2644	20003.9941	-5.5945	38.6420	-43.8136
15:07:08	5	244.7242	7085.7466	-3.9986	14.2600	-28.5312
15:09:42	LOC	208.7628	5659.2358	-2446.4519	12.6803	-28.5312
15:10:54	G/S	154.9297	3103.7668	-2423.7773	9.5588	-28.5312
15:11:22	G/S	141.5081	2721.3271	18.9086	8.3992	-28.5312
15:14:23	LAND	132.3748	9.1761	99.0464	0.0845	-28.5312
15:14:31	LAND	116.4332	9.1795	24.0448	0.2107	-28.5312

3

TIME	LEG NO.	AIRSPEED	HEIGHT	HEIGHT RATE	D.T.G	TRACK
15:58:00	TAKE-OFF	162.6333	209.4739	1730.3324	6.9560	-124.3361

TIME	WPT LEG NO.	AIRSPEED	HEIGHT	HEIGHT RATE	D.T.G	TRACK
15:58:16	9	179.6103	902.4849	2951.9033	6.4593	-124.3361
15:59:42	1	199.2739	2991.1243	795.4532	19.9281	152.3460
16:04:16	2	251.3923	5996.4355	-5.5463	30.2654	139.4419
16:09:20	3	322.8776	21088.7637	-10.0963	65.1162	140.7720
16:17:53	4	327.0943	21017.7930	-0.9037	50.2276	146.3581
16:25:52	5	261.1923	8820.3281	-18.6304	26.4049	98.0066
16:31:44	6	197.5606	8099.1626	-284.7534	19.1243	117.9633
16:36:36	7	172.0581	1980.1128	0.4617	12.0992	-124.0268
16:39:12	LOC	170.8563	2041.0580	-19.9505	9.0684	-124.0263
16:40:19	G/S	139.4937	1976.6398	-17.0017	6.0577	-124.0268
16:43:01	LAND	126.9586	11.2783	-166.6012	0.2827	-124.0268

Figure 46

CHAPTER 16

PROGRAMME AND EXERCISES

16.1. General

The Systems Evaluation programme was from mid-August to mid-December, 1976. The pilots were shown formats and panel layouts which had been amended as a result of the comments made by the pilots during the Familiarization Programme. The emphasis this time, however, was on the handling of the aircraft systems under a selection of simulated fault conditions.

16.2. Programme

The programme was divided into two pairs of two consecutive days. Those faults which were simpler to compute were included in the first pair of days and the remainder in the second session. Three or four exercises were perfomed on each day. The first exercises on Days 1 and 3 were refreshers. The refresher on Day 1 summarised the exercises of the Familiarization Programme. The refresher on Day 3 comprised a selection of the faults introduced on Days 1 and 2 of the Evaluation Programme. Each pilot was provided with a comprehensive set of notes several week before he was required for the exercises.

The timing of the exercises that was aimed for was:-

Day 1

1000 Briefing 1 with a demonstration on the Flight Deck

1130 Exercise 1 (Refresher)

1230 (Lunch)

1330 Demonstration of Failures

1430 Exercise 2

1545 Exercise 3

1645 Questionnaire 1

1715 Debriefing

Day 2

0900 Briefing 2 with demonstration of failures

0945 Exercise 4

1100 Exercise 5

1215 (Lunch)

1315 Exercise 6

1430 Exercise 7

1530 Questionnaire 2

1615 Debriefing

Day 3

1000 Briefing 3

1030 Demonstration of failures

1130 Exercise 8 (Refresher)

1230 (Lunch)

1330 Exercise 9

1445 Exercise 10

1600 Questionnaire 3

1700 Debriefing

Day 4

0900 Briefing 4

0930 Exercise 11

1045 Exercise 12

1215 (Lunch)

1315 Exercise 13

1430 Exercise 14

1530 Questionnaire 4

1615 Debriefing

16.3. Flights

Each flight commenced with Preflight Checks (using either the Paper Check List or the CRT display - see Chapter 17) and lasted approximately 45 minutes in the air. The flights were from London to Paris and from Paris to London on the flight plans described in Chapter 18.

16.4. Briefing and Demonstrations

Day 1. Briefing 1: General briefing with particular reference to Status format and other changes since the Familiarization Programme.

Day 1. Demonstration of Failures: for Engines, Flight Controls, Ice Protection, Electrics.

Day 2. Briefing 2: Air Conditioning, Fuel, Displays, Anti-icing.

Day 3. Briefing 3: Summary of Briefing 1 with emphasis on Hydraulics and Power Control Units.

Day 4. Briefing 4: Summary of Briefing 2 with emphasis on Pressurization.

16.5. Exercises

The Assessment Pilots sat in the right-hand seat for all but one of the flights. The flights used the same navigation aids as for the Familiarization Programme, but did not include a hold pattern (see Chapter 18). The anti-ice system was used only as stated. All In-flight checks were normally performed using the paper Check Lists. Paper Check Lists were also used for all emergencies and abnormal procedures.

16.5.1. Exercise 1

Duration: 60 min.

Preflight Checks: Paper

Flight: London to Paris

Plan: Normal flight with no failures.

Readings & Tasks:
22/3 - Eng.4 Fuel Flow
17/3 - No.4 Fuel Tank Contents
12/3 - Gen. 3 KVA
7/3 - Hydraulic Press. 'A' system
50/4 - Total fuel remaining
45/4 - Batt. 2 amps
40/4 - Cabin temp.
35/4 - Eng. 2 EGT
30/4 - Cabin altitude
25/4 - Min. fuel temp.
20/4 - T1
15/4 - TR1 amps
40/5 - Cabin Diff. Press.
35/5 - Eng. 2 Fuel Temp.
30/5 - Anti-ice Left wing temp.
25/5 - Total Metered Fuel
20/5 - Eng. 1 EGT
15/5 - Ice Warning introduced.

16.5.2. Exercise 2

Duration: 70 mins.

Preflight Checks: CRT

Flight: Paris to London

Readings Climb: 15/2 Ice Warning
& Tasks:

10/3 Radio No.1 Fan Fail

Cruise:

50/4 TR 2 fail

25/4 Standby TR amps (reading)

18/4 Engine No.1 Oil L.P. falls below 33 psi.
- shut engine down using Fire Drill

Descent:

30/5 CSD No.3 Fail

16.5.3. Exercise 3

Duration: 60 mins.

Preflight Checks: Turnround Checks only, on Paper.

Flight: London to Paris

Tasks: Climb: (Readings - Power Plant and Status Displays)

20/3 - Eng. 3 Oil Press.

15/3 - Hyd. 'A' Press.

10/3 - DC 1 load

5/3 - Eng. 2 Oil Temp.

Cruise:

50/4 Engine 1 Reverser Unlocked.
Precautionary Shutdown Drill.

25/4 Adjust Cabin Temp. to 21°

Descent:

30/5 Co-pilot's windsreen heater fail
Switch off and follow drill not to
exceed 200 knots below FL 80

15/6 Hyd 'B' Contents (Reading)

10/6 Cabin Temp. "

10/7 Cabin Altitude "

16.5.4. Exercise 4

Duration: 65 mins.

Preflight Checks: CRT. Pilot in left seat for preflight checks
and engine start, Right seat for taxi, etc.

Flight: Paris to London

Tasks: Climb:
25/2 Ice Warning
35/3 Ice Warning Off
25/3 Min. fuel temp. (reading - Fuel)
20/3 Total Fuel Remaining " "
15/3 Total metered fuel " "
10/3 No.4 Tank contents " "

Cruise:
50/4 Eng.4 vibration - to drop below 7 on throttling back. Fly on reduced power.
15/4 No.3 Fuel Temp. (Reading)
10/4 Eng.3 Fuel Flow "

Descent:
30/5 Eng.4 Fire - to be extinguished on 1st. shot.
12/5 Flaps (Reading)
8/5 Total fuel remaining (Reading)

16.5.5. <u>Exercise 5</u>

Duration: 60 min.

Preflight Checks: CRT

Flight: London to Paris

Tasks: Climb:
10/2 Air System 1 Duct overheat. Reset to be ineffective

Cruise:
55/4 Fuel LP No. 4 engine. Both booster pumps failed (engine continues) Observer to note cross-feed and balance.
35/4 Cabin Temp. (Reading)
30/4 Instruct to maintain Cabin Temp.21°
25/4 Air Cond. No.2 Duct Temp (Reading)
20/4 No. 4 fuel tank contents (Reading)

Descent:
40/5 No. 3 fuel tank contents (Reading)
35/5 Cabin temp. (Reading)
30/5 Flight Deck temp. (Reading)

25/5 Ice Warning

15/5 Anti-ice System No.1 fail

16.5.6. <u>Exercise 6</u>

Duration: 70 mins.

Preflight Checks: Paper

Flight: Paris to London

Tasks: Climb: 25/3 Eng. 2 Vibration

Cruise: 50/4 S2 poor synch.- pilot to switch off

40/4 S1 poor synch.- pilot to switch off

Observer to note pilot's reactions and the frequency of use of the engine standby instruments and the status format.

Descent: 30/5 Eng. 3 overheat - Shut down drills.

Note use of standby engine insts.

13/5 Gen. 3 KVA (Reading)

9/5 A.C. 2 + 4 load (Reading)

5/5 TR 1 Volts (Reading)

16.5.7. <u>Exercise 7</u>

Duration: 60 mins.

Preflight Checks: CRT (from Turnround if short of time)

Flight: London to Paris

Tasks: Climb: 15/2 Co-pilots windscreen overheat. To be on more than 10 mins.

20/3 No.4 Fwd fuel booster pump fail

Cruise: WPT 3 S3 out of synch. - pilot to switch off Observer to record switching

40/4 S1 out of synch.-pilot to switch off Observer to record switching.

Descent: 40/5 Eng.2 N2 (Reading)

30/5 Eng.1 Fuel Flow "

25/5 Eng.1 N2 "

20/5 Eng.3 EGT (Reading)

10/5 Eng. 4 Reverser Unlocked. Precautionary Shutdown Drill. Pilot to use standby insts only, for monitoring

8/6 Air System 1 Duct Overheat (below FL 80)

16.5.8. Exercise 8

Duration:		60 mins
Preflight Checks:		Paper
Flight:		London to Paris
Tasks:	Climb:	20/3 Eng.2 Vibration
	Cruise:	50/4 S2 poor synch. - pilot to switch off
		40/4 S1 poor synch. - pilot to switch off Observer to note pilot's actions
	Descent:	42/5 Instruct pilot to put STATUS on S3 if not already there. Note frequency of use of engine standby insts.
		40/5 No.3 Fuel Tank Contents (Reading)
		35/5 Cabin Temp. (Reading)
		25/5 Ice Warning
		15/5 Anti-ice System 1 fail
		10/6 Anti-ice left wing temp. (Reading)

16.5.9. Exercise 9

Duration:		70 min.
Preflight Checks:		CRT
Flight:		Paris to London
Tasks:	Climb:	15/2 No.1 feel motor fail
		5/2 S3 out of synch. - pilot to switch off
	Cruise:	40/4 S1 out of synch. - pilot to switch off Instruct pilot to put STATUS on S2 and use standby engine insts.
		25/4 Eng.3 N2 (Reading)
		21/4 Eng.4 Fuel Flow (Reading)

17/4 Eng.4 EGT (Reading)

13/4 Eng.1 EGT "

9/4 Eng.1 N1 "

25/5 Hydraulics 'B' system overheat - temp. to fall after 2nd pump has been switched off.

Descent: 10/5 Ice Warning

6/6 Engine 3 overheat. Pilot to shut engine down. Observer to note use of standby instruments.

16.5.10. <u>Exercise 10</u>

Duration: 70 min.

Preflight Checks: CRT (from Turnround) Pilot in Left seat flying manually throughout.

Flight: London to Paris

Tasks: Climb: 19/2 S2 Fail

16.5.11. <u>Exercise 11</u>

Duration: 70 mins.

Preflight Checks: CRT

Flight: Paris to London

Tasks: Start & Climb: No.2 engine Hot Start

25/2 Ice Warning

25/3 Anti-ice System 1 Fail. Switch off anti-ice at cruise altitude.

Cruise: 40/4 CSD Fail

30/4 PCU Fail

15/4 S2 Fail

10/4 Oil Low Pressure on Eng.2 (fault to be removed by WPT 4)

Descent: 12/5 Hydraulics 'B' pump fail

16.5.12. Exercise 12

Duration: 70 min.

Preflight Checks: CRT

Flight: London to Paris

Tasks: Climb:

15/2 Ice Warning

20/3 Anti-ice System 2 Fail
Anti-ice off at FL80

5/3 S3 out of synch. - pilot to switch off

Cruise:

40/4 Gen.3 KVA (Reading)

35/4 Eng.1 Oil Temp "

30/4 Highest EGT "

40/5 S1 out of synch. pilot to switch off and put STATUS on S2, but to use S2 for all the following Engine Readings:-

25/5 Eng.3 N2

21/5 Eng.4 Fuel Flow

17/5 Eng.4 EGT

13/5 Eng.1 EGT

9/5 Eng.1 N1

Compare readings with Ex.9)

Descent:

14/6 Eng.1 Reverser Unlocked. Precautionary Shutdown.

16.5.13. Exercise 13

Duration: 70 min.

Preflight Checks: CRT (from Turnround)

Flight: Paris to London

Tasks: Climb:

25/3 Hydraulics 'A' System overheat above 90°C
Both pumps to be left off.

5/3 S2 out of synch.-pilot to switch off.

45/4 Eng.4 runs down after double booster pump failure. Engine Relight Drill.

10/4 CSD No.1 Fail (coincides with Relight)

Cruise: 30/5 TR2 Fail

5/5 Air System 1 Duct Overheat.
Reset to be effective.

16.5.14. Exercise 14

Duration: 60 min.

Preflight Checks: CRT (from Turnround)

Flight: London to Paris

Tasks: Climb: 20/3 CSD No.2 Fail

Cruise: (Readings)

45/4 Highest Fuel Flow Rate

40/4 Total Fuel Remaining

35/4 Tail Trim Position

30/4 Eng.1 EGT

25/4 Hydraulics 'A' Contents

20/4 Cabin Differential Pressure

15/4 Hydraulics 'B' Pressure

10/4 Cabin Temp.

Descent: 35/5 Engine No.4 Fire - Extinguished on 2nd shot.

10/5 Ice Warning

14/7 Engine No.3 Overheat
Two-engine Approach Procedure.

CHAPTER 17

CHECK LISTS AND DRILLS

17.1. Introduction

The Check Lists and Drills used in the Familiarization Programme were described in Chapter 10. These were criticised as being too long so a complete revision took place for the Systems Evaluation Programme. The Normal Procedures (Section A) were presented either:

a) by electronic means on a separate CRT display (S4) on the right-hand quarter panel (see Frontispiece), or

b) (for the last two pilots only) by back-projection on a special display unit on the left-hand quarter panel (see Frontispiece), or

c) on paper at the size shown herein.

Sections B and C cover emergency and abnormal procedures, and have been added for use with the simulated failures described in Chapter 16.

A copy of the paper check list was available on the Flight Deck with the pages marked with coloured tabs for easy reference.

A full evaluation of the back-projected check list presentation took place in Phase 2 (see Chapter 27).

17.2. Paper Check List

The full paper check lists and drills are shown on the next seven pages:-

ADVANCED FLIGHT DECK

CHECKLISTS

INDEX

1. PRE-FLIGHT CHECKS

		PILOT	
1	BRAKE PRESSURE	1	CHECK
2	GEAR	2	DOWN - 3 GREENS
3	SHUTDOWN HANDLES	1	PULL 1, 2, 3, 4.
4	GROUND POWER	1	ON
5	TEST PANEL	2	ON
6	COLUMN 1 LIGHTS	2	TEST ALL LIT S1: FLIGHT CONTROLS-1 WARNING S2: HYDRAULICS - 22 WARNINGS S3: FUEL - 22 WARNINGS
7	HYDRAULIC LEVEL	2	CHECK
8	COLUMN 2 LIGHTS	2	TEST ALL LIT S1: ENGINE 1 - 7 WARNINGS S2: ELECTRICS - 18 WARNINGS S3: ENGINE 2 - 7 WARNINGS
9	ELRAT	2	TEST
10	STANDBY TR	1	ON 1, 2. SET OFF.
11	ENGINE 1 WARNINGS	2	TEST FIRE + O/H + VIBRATION
12	ENGINE 2 WARNINGS	2	TEST FIRE + O/H + VIBRATION
13	COLUMN 3 LIGHTS	2	TEST ALL LIT S1: ENGINE 3 - 7 WARNINGS S2: AIR CONDIT - 19 WARNINGS S3: ENGINE 4 - 7 WARNINGS
14	ENGINE 3 WARNINGS	2	TEST FIRE + O/H + VIBRATION
15	ENGINE 4 WARNINGS	2	TEST FIRE + O/H + VIBRATION
16	COLUMN 4 LIGHTS	2	TEST ALL LIT S1: PRESSN - 19 WARNINGS S2: ALL ENGINES - 18 WARNINGS S3: ANTI-ICE - 6 WARNINGS
17	CABIN ALTITUDE	2	TEST AUDIO AND MWS
18	STALL PROTECTION	2	CHECK 1, 2 - SHAKE AND PUSH
19	GEAR	2	TEST HORN AND LIGHT

20	CONFIGURATION	2	TEST AUDIO AND MWS
21	OVER SPEED WARNING	2	TEST AUDIO 1 AND 2
22	ALTITUDE ALERT	2	TEST AUDIO
23	MWS	2	TEST ANNUNCIATOR + GLARE/S LTS
24	PRESSURISATION	2	SET BARO + CABIN ALT + RATE
25	PITOT HEATERS	2	ON (4)
26	WINDSCREEN HEATERS	2	ON HIGH 1, 2
27	WING + TAIL ANTI-ICE	2	ALL OFF (4)
28	ENGINE ANTI-ICE	2	ALL OFF (4)
29	NOTICES	2	AUTO
30	NAVIGATION LAMPS	2	AS REQUIRED
31	EMERGENCY LIGHTS	2	ARMED
32	CALL	2	"CHECKS COMPLETE"

2. <u>TURN ROUND</u>

1	TEST PANEL	2	ON
2	PRESSURISATION	2	SET BARO + CABIN ALT + RATE
3	PITOT HEATERS	2	ALL ON (4)
4	WINDSCREEN HEATERS	2	ON HIGH 1,2
5	WING + TAIL ANTI-ICE	2	ALL OFF (4)
6	ENGINE ANTI-ICE	2	ALL OFF (4)
7	NOTICES	2	AUTO
8	NAVIGATION LAMPS	2	AS REQUIRED
9	EMERGENCY LIGHTS	2	ARMED
10	DISPLAY	2	S3: ANTI-ICE
11	CALL	2	"CHECKS COMPLETE"

3. <u>START DRILLS</u>

1	BEACON	2	ON
2	FLT. RECORDER	1	SET
3	DOOR WARNINGS	1	OUT
4	SEATS AND HARNESS	BOTH	ADJUST 1,2.
5	DISPLAYS	2	S1 HYD. S2 FUEL
6	FUEL	1	SET METERED
7	FUEL BOOSTER PUMPS	1	ALL ON (8)
8	THROTTLES	1	ALL SHUT
9	ALL ENGINES	1	OPEN LP FUEL COCKS HP AIR COCKS HYDRAULIC COCKS
10	DISPLAYS	2	S1: REQUIRED ENGINE, S2: ALL ENG S3: ELEC.
11	START MASTER	1	START
12	ENGINE 3	1	START
13	ENGINE 4	1	START
14	ENGINE 2	1	START
15	ENGINE 1	1	START
16	START MASTER	1	OFF
17	ENGINES	2	CHECK N2, EGT.
18	ELEC.	2	CHECK AC + DC + BATT
19	GROUND SERVICES	2	REMOVE
20	TEST PANEL	2	OFF
21	MWS	2	RECALL
22	AUTOPILOT	BOTH	ENGAGE/DIS 1 + 2
23	TEMP SEL	2	AUTO NORMAL (2)
24	DISPLAY	2	S1: CONTROLS

25	YAW DAMPERS	1	ON 1, 2.
26	TRIMS	1	SET AILERON + RUDDER + TAIL PLANE
27	FLAP/SLAT	2	SET FLAP TAKE OFF, SLAT OUT
28	FLIGHT CONTROLS	1	CHECK CONTROLS
29	CALL	2	"DRILLS COMPLETE"

4. TAXI CHECKS

1	BRAKES	1	CHECK PRESSURES
2	V1, VR, V2	BOTH	CHECK
3	ENGINE ANTI-ICE	2	AS REQUIRED
4	RELIGHT	2	AS REQUIRED
5	MWS	2	CHECK CLEAR
6	REVERSERS	1	CHECK AT IDLE POWER
7	N2 BUG	2	SET
8	ROOF PANEL	2	ALL LIGHTS OUT
9	COMPASS	BOTH	CHECK ALIGNED
10	CALL	2	"CHECKS COMPLETE"

5. AFTER TAKE OFF DRILLS

1	GEAR	2	UP, LIGHTS OUT
2	ANTI-ICE	2	AS REQUIRED
3	ALTIMETERS	2	SET QNH OR 1013
4	FLAP/SLATS	2	UP AT 200 KTS. CHECK IN
5	DISPLAYS	2	S1: STATUS, S3: STANDBY
6	RELIGHT	2	AS REQUIRED
7	CALL	2	"DRILLS COMPLETE"

1	FUEL	2	CHECK
2	PRESSURISATION	2	SET
3	ALTIMETERS	BOTH	SET
4	SEATS AND HARNESS	BOTH	ADJUST 1, 2.
5	CALL	2	"CHECKS COMPLETE"

7A. INITIAL APPROACH DRILL

1	DISPLAYS	2	STATUS AND STANDBY
2	FLAP/SLATS	2	SELECT TAKE OFF
3	ALTIMETERS	BOTH	SET
4	ENGINE ANTI-ICE	2	AS REQUIRED
5	RELIGHT	2	AS REQUIRED

7B. FINAL APPROACH DRILL

6	AUTOTHROTTLE + ILS	1	ENGAGE
7	FLAP	2	SELECT APPROACH
8	CALL	2	"CHECKS COMPLETE"

8. LANDING CHECKS

1	GEAR	2	DOWN - 3 GREENS
2	BRAKES	1	PRESSURE ZERO
3	SPEED BRAKE	1	IN
4	FLAPS	2	SELECT LAND
5	THRESHOLD SPEED	1	SET BUG
6	AIRFRAME ANTI-ICE	2	OFF
7	CROSS FEEDS	1	NOT OPEN
8	CALL	2	"CHECKS COMPLETE"

9 AFTER LAND CHECKS

1	REVERSERS	2	CHECK CANCELLED 1 AND 4
2	BRAKE PRESSURES	1	CHECK
3	RELIGHT	2	ALL OFF (4)
4	FLAP/SLATS	2	UP. CHECK IN
5	SPEEDBRAKE	1	CHECK IN
6	TEMP SEL	2	MAN (OFF) (2)
7	CALL	2	"CHECKS COMPLETE"

10. SHUTDOWN CHECKS

1	PARKING BRAKE	1	ON
2	SHUT DOWN HANDLES	1	PULL ONLY 1,2,3.
3	GROUND POWER	1	CHECK AVAILABLE. SELECT ON
4	SHUT DOWN HANDLE	1	PULL NO. 4
5	BOOSTER PUMPS	1	ALL OFF (8)
6	LANDING LIGHTS	1	RETRACT AND OFF
7	EMERGENCY LIGHTS	2	OFF
8	BEACON	2	OFF
9	NAVIGATION LAMPS	2	AS REQUIRED
10	SEAT BELTS	2	OFF
11	ENGINE ANTI-ICE	2	ALL OFF (4)
12	WINDSCREEN HEATERS	2	OFF (2)
13	PITOT HEATERS	2	ALL OFF (4)
14	FLT. RECORDER	1	OFF
15	CALL	2	"CHECKS COMPLETE"

ENGINE FIRE

1.	CALL FIRE ACTION	P1	
2.	SHUT DOWN HANDLE	P2	PULL
3.	BOOSTER PUMPS	P1	BOTH OFF
4.	CROSSFEED VALVES	P1	NOT OPEN
5.	EXTING.	P2	1st SHOT
	-after 30 secs if fire lit		
6.	EXTING.	P2	2nd SHOT
7.	HYD. CONTROL	P2	OFF
8.	GEN. CONTROL	P2	OFF
9.	FLOW CONTROL	P2	OFF
10.	ENGINE ANTI-ICE	P2	OFF
11.	DISPLAY	P2	SELECT FUEL
12.	FUEL COCKS	P2	CHECK SHUT

Maintain fuel balance
within 1000 kg.

ENGINE O/HEAT

USE ENGINE FIRE DRILL
DO NOT USE EXTINGUISHERS

ENGINE OIL LOW PRESS.

USE ENGINE FIRE DRILL
DO NOT USE EXTINGUISHERS

ELEC - DC ESSENTIAL BUS FAIL

1. STANDBY TR	P2	SELECT TO FAILED BUS
2. ELEC DISPLAY	P2	STBY TR CONNECTED
3. DC SUPPLY	P2	26v 80 AMPS BATTERY ON

CABIN ALT.

1. DISCHARGE VALVES	P2	SHUT
2. RADIO COOL VALVE	P2	NOT OPEN
3. SPILL VALVES	P2	NOT SPILL
4. FLOW CTRL VALVES	P2	NOT OFF

EMERGENCY DESCENT

1. THROTTLES	P1	IDLE
2. SPEEDBRAKES	P2	FULL
3. SPEED	P1	M .84/360 KT
4. NOTICES	P2	ON
5. TRANSPONDER	P2	A 7700

ENGINE VIBRATION

1. CLOSE THROTTLE SLOWLY TO REDUCE BELOW 7.0
2. N2 ABOVE 65% — USE ENGINE - KEEP VIB BELOW 7.0
3. N2 LESS THAN 65% — ENGINE SHUT DOWN

ENGINE OIL LOW PRESS.

1. LOW PRESS CONFIRMED — ENGINE SHUT DOWN

ENGINE REVERSER UNLOCKED

1. ATTEMPT TO STOW
2. UNLOCK CONFIRMED — ENGINE SHUT DOWN

ENGINE SHUT DOWN

1. HYD. CONTROL	P2	OFF
2. GEN. CONTROL	P2	OFF
3. FLOW CONTROL	P2	OFF
4. SHUT DOWN HANDLE	P2	PULL
5. FUEL	P1	MAINTAIN BALANCE

ENGINE RELIGHT

Immediate

1.	START/MOTOR	P1/P2	RELIGHT
	If no relight in 20 secs:		
2.	SHUT DOWN HANDLE	P2	PULL

Normal

1.	SHUT DOWN HANDLE	P2	PULL
2.	ENGINE ANTI-ICE	P2	OFF
3.	THROTTLE	P1	SHUT
4.	DISPLAY	P2	SELECT FUEL
5.	BOOSTER PUMPS	P1	ON
6.	INTER ENGINE VALVE	P1	SHUT
7.	L.P. FUEL COCK	P2	OPEN
8.	H.P. AIR COCK	P2	OPEN
9.	HYDRAULIC COCK	P2	OPEN
10.	START MASTER	P2	START
11.	DISPLAY	P2	ENGINE
12.	ENGINE	P2	START
13.	START MASTER	P2	OFF
14.	HYD. CONTROL	P2	ON
15.	GEN. CONTROL	P2	ON
16.	FLOW CONTROL	P2	ON

ELEC - CSD FAIL

1.	DISPLAY	P2	CHECK LOADS
2.	GEN CONTROL	P2	OFF
3.	DRIVE	P2	DISCONNECT

ELEC - NON ESS BUS FAIL

1.	STBY TR	P2	SELECT
2.	DISPLAY	P2	STBY TR CONNECTED ABOVE 26 V BELOW 80 A

FUEL - PUMP FAIL

1.	FAILED PUMP	P1	OFF

FUEL - 2 PUMPS FAIL (SAME TANK)

1.	FAILED PUMPS	P1	OFF
	If engine runs down		
2.	INTER ENGINE VALVE	P1	OPEN
3.	ENGINE	P2	RELIGHT

AIR COND - DUCT O/H

1.	RECIRC FAN	P2	ON
2.	TEMP SELECT	P2	MAN COOL
3.	MATCH VALVES TO GOOD SYSTEM		
	Duct temp below 65°		
4.	O/HT	P2	RESET
5.	SPILL VALVE	P2	NOT SPILL
6.	TEMP SELECT	P2	USE IN MANUAL SECTOR
	Duct O/H recurs:		
7.	FLOW CONTROL	P2	BOTH OFF
8.	O/HT	P2	RESET
9.	SPILL VALVE	P2	SPILL

AIR COND - RADIO FAN FAIL

1.	FAILED FAN	P2	OFF

HYD. - O/H

1.	HYD PUMP CTRL (1 + 2) or (3 + 4)	P1	OFF
	Temp below 90°		
2.	(1) or (3)	P1	ON
	Temp rising:		
3.	(1) or (3)	P1	OFF
4.	(2) or (4)	P1	ON
	Temp rising:		
5.	(2) or (4)	P1	OFF

HYD - L.P.

1.	PUMP	P1	OFF

ICE DET.

1. ENGINE ANTI-ICE	P2	ON
2. AIRFRAME ANTI-ICE	P2	ON
3. DISPLAY	P2	VALVES OPEN

ANTI-ICE FAIL

1. REDUCING VALVE	P2	SHUT (1) or (2)
If FAIL remains:		
2. HP AIR VALVES	P2	SHUT (1 + 2) or (3 + 4)

W/S HEATER FAIL OR O/HEAT.

1. W/S HEATER	P2	LOW
2. SPEED		200 KTS MAX BELOW 8000 FT

FEEL MOTOR FAIL

1. FEEL MOTOR	P1	ISOLATE

POWER CTRL UNIT FAIL

1. P.C.U.	P1	ISOLATE
2. DISPLAY	P1	FLT CTRLS
3. ISOL SURFACE	P1	TRAILING

SINGLE DISPLAY FAILURE

1. DISPLAY	CHANGE FORMAT
If format degraded:	
2. DISPLAY	OFF
If format not degraded:	
3. DISPLAY	AS REQUIRED

DOUBLE DISPLAY FAILURE

1. DISPLAYS	CHANGE FORMATS
If formats degraded:	
2. DISPLAYS	OFF
3. STBY N2 + EGT	ON

17.3. CRT Check List Display

17.3.1. Controls

The controls associated with the CRT method of Check List Display were:

a) A guarded CRT power ON/OFF switch.

b) A STBY mode pushbutton for use when the power was on and the Check Lists not required.

c) An EHSI XFD pushbutton to permit presentation of the Check Lists in both the normal EHSI positions (F2 and F3). This was principally used when the EHSI was not required, i.e. Preflight, Engine Start, Afterland, Shutdown.

d) An INDEX pushbutton which caused presentation of the index for entry to the Check Lists.

e) The SKIP pushbutton to move the window either to the item required in the index, or to by-pass a check that currently could not be undertaken.

The above controls and pushbuttons were all mounted on an ARINC width panel immediately below S4.

f) The GO button mounted in the centre of the control column was used to select the index item contained within the window, or to acknowledge the completion of a check item contained within the window. The window was a computer generated box that could be positioned around any line on the Check List Display. (see Figure 46).

17.3.2. Operation

i) Switch ON the power to the CRT (this switch was guarded to be normally left on, to be powered when ground power was available).

ii) INDEX was selected

iii) With the SKIP button the window was positioned, say around Checks & Drills.

iv) The GO button was pressed on the control column, which brought the list of checks and drills onto the CRT.

v) The SKIP button was used to place the window around the appropriate check, say Preflight.

vi) The GO button was pressed and the first page of the Preflight Checks would be presented on the CRT., with the window positioned around the first check item.

vii) Each line contained a tag consisting of an inverted 1,2 or space which identified the pilot (i.e. P1, P2 or both) who should perfom the check. When the first check was completed the GO button was pressed, which progressed the window from the first to the second check item, and removed a tag from the first item indicating that that check had been acknowledged as completed.

viii) If it was not convenient to complete a check in its normal order it could be by-passed using the SKIP button. The tag remained to indicate that the check had not been undertaken. At this stage in the development the next page would not automatically be presented until all the checks on the current page had been acknowledged as completed.

ix) When the Preflight Check was completed the Checks and Drills page would automatically appear with the window incremented to the next set of checks, i.e. Start of Engines. If that check was appropriate the GO button was pressed and the Start of Engines check list would be presented. If not, the SKIP button was used to progress to the appropriate check. If a check was not required, the STBY could be selected.

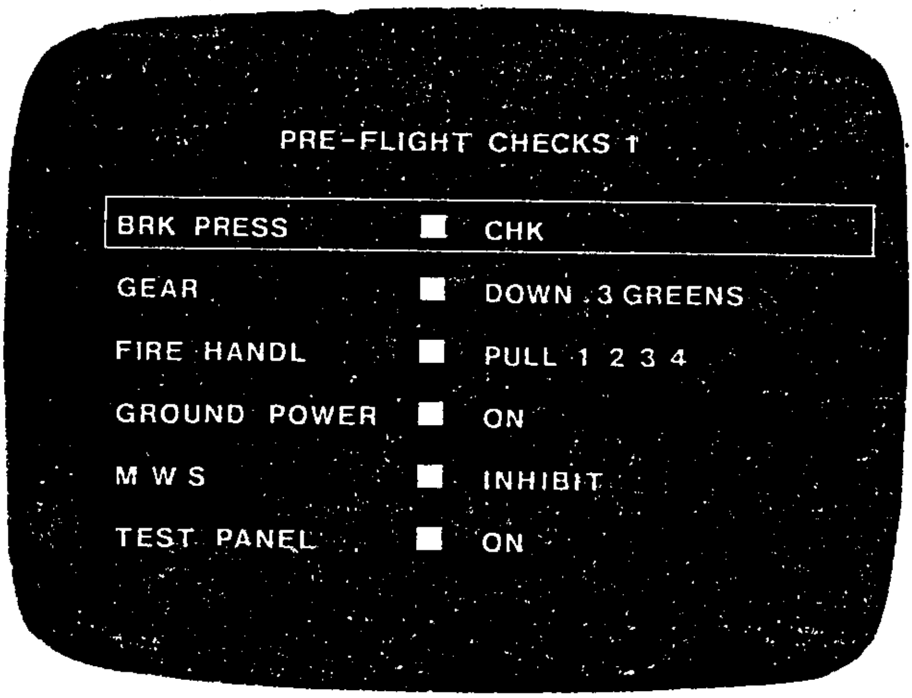

Figure 47

Example of Check List Format

17.3.3. CRT Check Lists Formats

The Check Lists and Drills in the format used on the CRT are shown on the next eleven pages.

PRE-FLIGHT CHECKS 1

BRK PRESS	1	CHK
GEAR	2	DOWN 3 GREENS
SHUT HANDL	1	PULL 1 2 3 4
GRND POWER	1	ON
TEST PANEL	2	ON

PRE-FLIGHT CHECKS 2

COL 1 LTS	2	TEST ALL LIT	
	2	CHK S1 FLT CNTRL	1 WRN
	2	S2 HYD	22 WRN
	2	S3 FUEL	22 WRN
HYD LEVEL	2	CHK	

PRE-FLIGHT CHECKS 3

COL 2 LTS	2	TEST ALL LIT	
	2	CHK S1 ENG 1	7 WRN
	2	S2 ELECT	18 WRN
	2	S3 ENG 2	7 WRN
ELRAT	2	TEST	
STBY TRU	1	ON 1 2	SET OFF
ENG 1 WRN	2	TEST VIB+O/H+FIRE	
ENG 2 WRN	2	TEST VIB+O/H+FIRE	

PRE-FLIGHT CHECKS 4

COL 3 LTS	2	TEST ALL LIT	
	2	CHK S1 ENG 3	7 WRN
	2	S2 AIR COND	19 WRN
	2	S3 ENG 4	7 WRN
ENG 3 WRNS	2	TEST VIB+O/H+FIRE	
ENG 4 WRNS	2	TEST VIB+O/H+FIRE	

PRE-FLIGHT CHECKS 5

COL 4 LTS	2	TEST ALL LIT	
	2	CHK S1 PRESSN	19 WRN
	2	S2 ALL ENG	18 WRN
	2	S3 A/ICE	6 WRN
CBN ALT	2	TEST AUDIO AND MWS	
STALL PROT	2	CHECK 1 2 SHAKE+PUSH	

PRE-FLIGHT CHECKS 6

GEAR	2	TEST HORN AND LT
CONFIG WRN	2	TEST AUDIO AND MWS
OVER SPD	2	TEST AUDIO 1 AND 2
ALT ALERT	2	TEST AUDIO
MWS	2	TEST ANN/GLRSHLD LTS
PRESSN	2	SET BARO+CBN ALT+RATE

PRE-FLIGHT CHECKS 7

PITOT HTRS	2	ALL ON <4>
W/SCRN HTR	2	ON HIGH 1 2
WNG/TAIL	2	ALL OFF <4>
ENG A/ICE	2	ALL OFF <4>
NOTICES	2	AUTO
NAV LAMPS	2	AS REQD
EMRG LTS	2	ARMED
CALL	2	**CHECKS COMPLETE**

TURNROUND CHECKS 1

TEST PANEL	2	ON
PRESSN	2	SET BARO+CBN ALT+RATE
PITOT HTRS	2	ALL ON <4>
W/SCRN HTR	2	ON HIGH 1 2
WNG/TAIL	2	ALL OFF <4>
ENG A/ICE	2	ALL OFF <4>

TURNROUND CHECKS 2

NOTICES	2	AUTO
NAV LAMPS	2	AS REQD
EMRG LTS	2	ARMED
DISPLAY	2	S3 A/ICE
CALL	2	**CHECKS COMPLETE**

START DRILLS 1

BEACON	2	ON
FLT RECORD	1	ON
DOOR WRNS	1	OUT
SEAT/HRNSS	#	ADJUST 1 2
DISPLAYS	2	S1 HYD S2 FUEL
FUEL	1	SET METERED
BOOST PMPS	1	ALL ON <8>

START DRILLS 2

THROTTLES	1	ALL SHUT
ALL ENGS	1	OPEN LP FUEL COCKS
	1	HP AIR COCKS
	1	HYD COCKS
DISPLAYS	2	S1 REQD ENG S2 ALL ENG
	2	S3 ELEC

START DRILLS 3

START MSTR	1	START
ENG 3	1	START
ENG 4	1	START
ENG 2	1	START
ENG 1	1	START
START MSTR	1	OFF
ENGS	2	CHK N2 EGT
ELEC	2	CHK AC+DC+BATT

START DRILLS 4

GRND SRVCS	2	REMOVE
TEST PANEL	2	OFF
MWS	2	RECALL
A/PILOT	#	ENGAGE/DISC 1 2
TEMP SEL	2	AUTO NORM <2>

START DRILLS 5

DISPLAY	2	S1 CNTRLS
YAW DAMPRS	1	ON 1 2
TRIMS	1	SET AIL+RUD+T/P
FLAP SLAT	2	SET FLAP T/O SLAT OUT
FLT CNTRLS	1	CHK
CALL	2	**DRILLS COMPLETE**

TAXI CHECKS 1

BRKS	1	CHK PRESS
V1 VR V2	#	CHK
ENG A/ICE	2	AS REQD
RELIGHT	2	AS REQD
MWS	2	CHK CLEAR

TAXI CHECKS 2

REVERSERS	1	CHK AT IDLE POWER
N2 BUG	2	SET
ROOF PANEL	2	ALL LTS OUT
COMPASS	#	CHK ALIGNED
CALL	2	**CHECKS COMPLETE**

AFTER T/O DRILLS

GEAR	2	UP LTS OUT
A/ICE	2	AS REQD
ALTIMETERS	#	SET QNH OR 1013
FLAP SLAT	2	UP AT 200KTS CHECK IN
DISPLAYS	2	S1 STATUS S3 STANDBY
RELIGHT	2	AS REQD
CALL	2	**DRILLS COMPLETE**

DESCENT CHECKS

FUEL	2	CHK
PRESSN	2	SET
ALTIMETERS	#	SET
SEAT/HRNSS	#	ADJUST 1 2
CALL	2	**CHECKS COMPLETE**

INITIAL APPROACH CHECKS

DISPLAYS	2	STATUS AND STANDBY
FLAP SLAT	2	SELECT T/O
ALTIMETERS	4	SET
ENG A/ICE	2	AS REQD
RELIGHT	2	AS REQD

FINAL APPROACH CHECKS

A/THRT ILS	1	ENGAGE
FLAP	2	SELECT APPROACH
CALL	2	**CHECKS COMPLETE**

LANDING CHECKS

GEAR	2	DOWN 3 GREENS
BRK PRESS	1	CHK ZERO
SPD BRK	1	IN
FLAP	2	SELECT LAND
THRESH SPD	1	SET BUG
A/F A/ICE	2	OFF
XFEEDS	1	NOT OPEN
CALL	2	**CHECKS COMPLETE**

AFTER LAND CHECKS

REVERSERS	2	CHK CANCELLED 1 4
BRK PRESS	1	CHK
RELIGHT	2	ALL OFF <4>
FLAP/SLAT	2	UP CHK IN
SPD BRK	1	CHK IN
TEMP SEL	2	MAN OFF <2>
CALL	2	**CHECKS COMPLETE**

SHUTDOWN CHECKS 1

PARK BRK	1	ON
SHUT HANDL	1	PULL ONLY 1 2 3
GRND PWR	1	CHK AVAIL SELECT
SHUT HANDL	1	PULL 4
BOOST PMPS	1	ALL OFF <8>
LAND LTS	1	RETRACT AND OFF
EMERG LTS	2	OFF

SHUTDOWN CHECKS 2

BEACON	2	OFF
NAV LTS	2	AS REQD
SEAT BELTS	2	OFF
ENG A/ICE	2	ALL OFF <4>
W/SCRN HTR	2	OFF <2>
PITOT HTRS	2	ALL OFF <4>
FLT RECORD	1	OFF
CALL	2	**CHECKS COMPLETE**

ENGINE FIRE

CALL	1	**FIRE ACTION**
SHUT HANDL	2	PULL
BOOST PMPS	1	OFF
XFEED VLVS	1	NOT OPEN
EXTING	2	1ST SHOT
		<WAIT 30SEC>
	2	2ND SHOT IF REQD

EMERGENCY SHUTDOWN CONTD

HYD CNTRL	*	OFF
GEN CNTRL	*	OFF
FLOW CNTRL	*	OFF
DISPLAY	*	SELECT FUEL
FUEL COCKS	*	CHK SHUT
		MAINTAIN FUEL BALANCE
		WITHIN 1000KGS

ENGINE OVERHEAT

CALL	1	**FIRE ACTION**
SHUT HANDL	2	PULL
BOOST PMPS	1	OFF
XFEED VLVS	1	NOT OPEN

ENGINE OIL LOW PRESSURE

CALL	1	**FIRE ACTION**
SHUT HANDL	2	PULL
BOOST PMPS	1	OFF
XFEED VLVS	1	NOT OPEN

DC ESSENTIAL BUS FAIL

STBY TRU	2	SELECT TO FAILED BUS
DISPLAY	2	CHK STBY TRU CONNECTED
DC SUPPLY	2	26 V 80 AMP BATT ON

CABIN ALT

DISCH VLV	2	SHUT
R COOL VLV	2	NOT OPEN
SPILL	2	NOT SPILL
FLOW CNTRL	2	NOT OFF

EMERGENCY DESCENT

THROTTLES	1	IDLE
SPDBRAKES	2	FULL
SPEED	1	M *84/360KT
NOTICES	2	ON
TRANSPNDER	2	A 7700

CHAPTER 18

NAVIGATION AND AIR TRAFFIC CONTROL

18.1. Navigation

The navigation facilities remained substantially the same as for the Familiarization Programme (see Chapter 11) except that the facility to fly from Paris to London was added (see Figures 48 to 50).

Some minor changes were made to the flight profiles for the London to Paris flights as a result of lessons learned in the Familiarization Programme, but these did not have any direct relevance to the human factors evaluation (see Figures 51 to 53).

18.2. Air Traffic Control

During the Familiarization Programme the ATC had been performed by the Flight Controller (see Chapter 11), but this had proved not to be cost-effective. It was decided, therefore, to allocate the ATC duties to the Resident Pilot.

The flight profile was defined in terms of speed and altitude (see Para. 18.1.) so it was possible to pre-programme the ATC providing the Assessment Pilots' transmissions were not significantly delayed by the other tasks given.

The operation of the R/T switches on the control columns illuminated a lamp on the aft pedestal so that the Observer and the Resident Pilot could monitor when the Assessment Pilot was speaking.

Tapes of background ATC were made for both directions of flight and were switched on by the Resident Pilot at a predetermined part of the flight after take-off. The tapes ran continuously through the flights except when transmissions were made from the Flight Deck their volume was reduced to zero. Different voices, accents and French, as well as English, were used in the compilation of the tapes.

Ground-to-air tapes were made for both directions of flight, but these could not be run continuously as the replies from the Ground had to follow the Assessment Pilots' transmissions which varied in time. Extinguishing of the transmit lamp provided the cue for the Resident Pilot to switch on the taped replies. On nearly all occasions this was realistic. Again different voices and accents were used to simulate different controllers on different frequencies.

ATIS broadcasts were taped to provide weather and the usual terminal area information. Different data were provided for departure from, and arrival at, both London (Heathrow) and Paris (Charles de Gaulle) airports.

The system adopted suffered from a lack of flexibility and did receive comments that by the end of a two-day period the messages could be predicted.

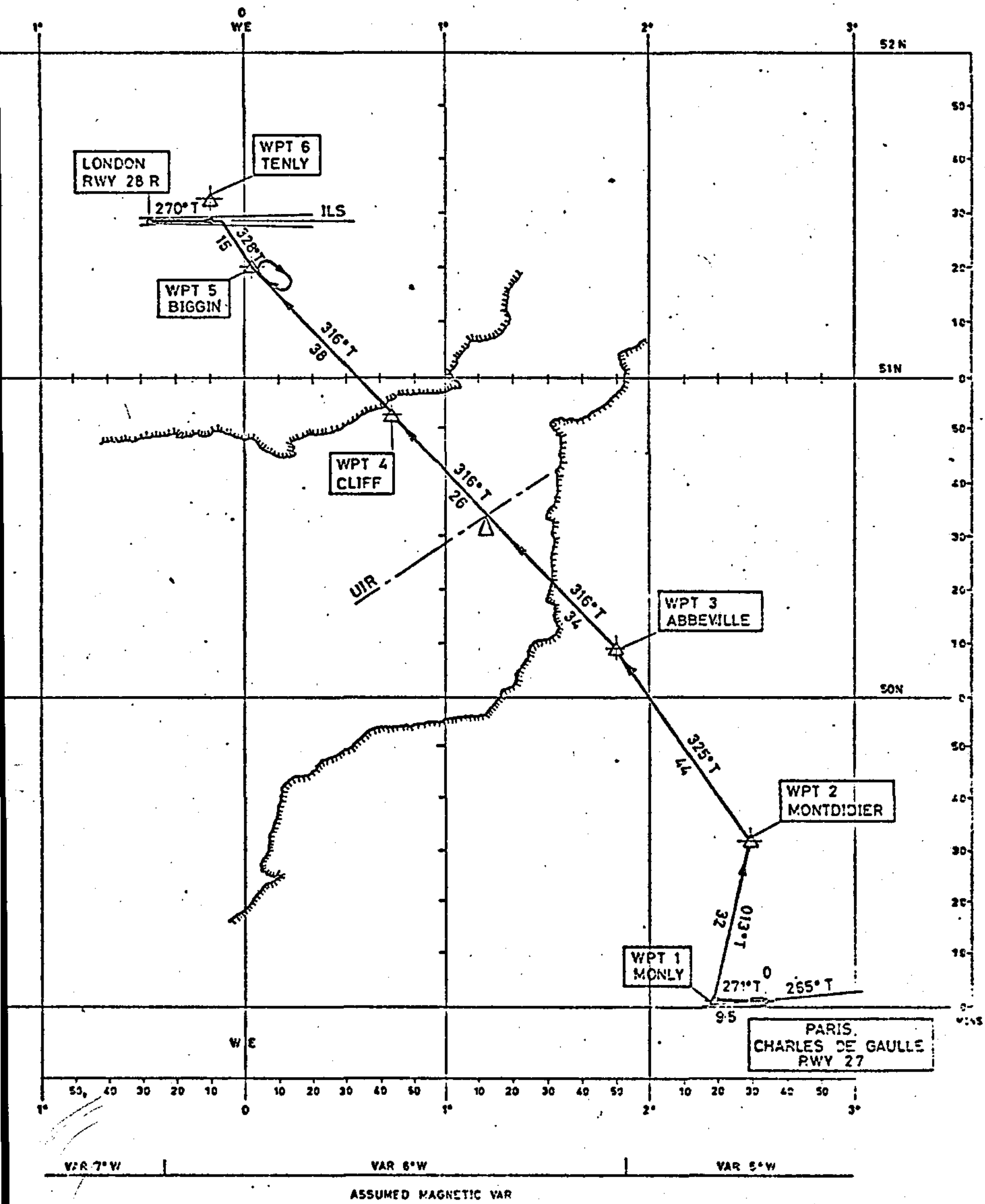

Figure 48

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Figure 49

ENROUTE REF.	ALTITUDE (FT) OR FLIGHT LEVEL	AIRSPEED (CAS) Kts	RECOMMENDED FLIGHT PROCEDURE	N2%
PARIS CHARLES DE GAULLE	DEPARTURE	-	Take-off - V_R 130 Kts and increase speed to 170 Kts at 1500 ft.	
-	1500	170	Maintain climb increasing speed to 200 Kts at 2000 ft. and level out.	
-	2000	200	Raise flaps etc. and then continue climb increasing speed to 220 Kts at 3000 ft. and level out.	
WAYPOINT 1 (MONLY)	3000	220	Maintain 3000 ft. and increase speed to 250 Kts.	
-	3000	250	Climb at 250 Kts to FL 70 and level. VS 1500 ft/min.	
-	FL 70	250	Maintain FL 70 at 250 Kts in App. area until cleared by Paris Ctl. Then increase speed to 300 Kts and climb as cleared.	
WAYPOINT 2 (MONTDIDIER)		300	Continue climb to FL 200 (3500 ft/min) and increase speed to Vmo (340 Kts).	

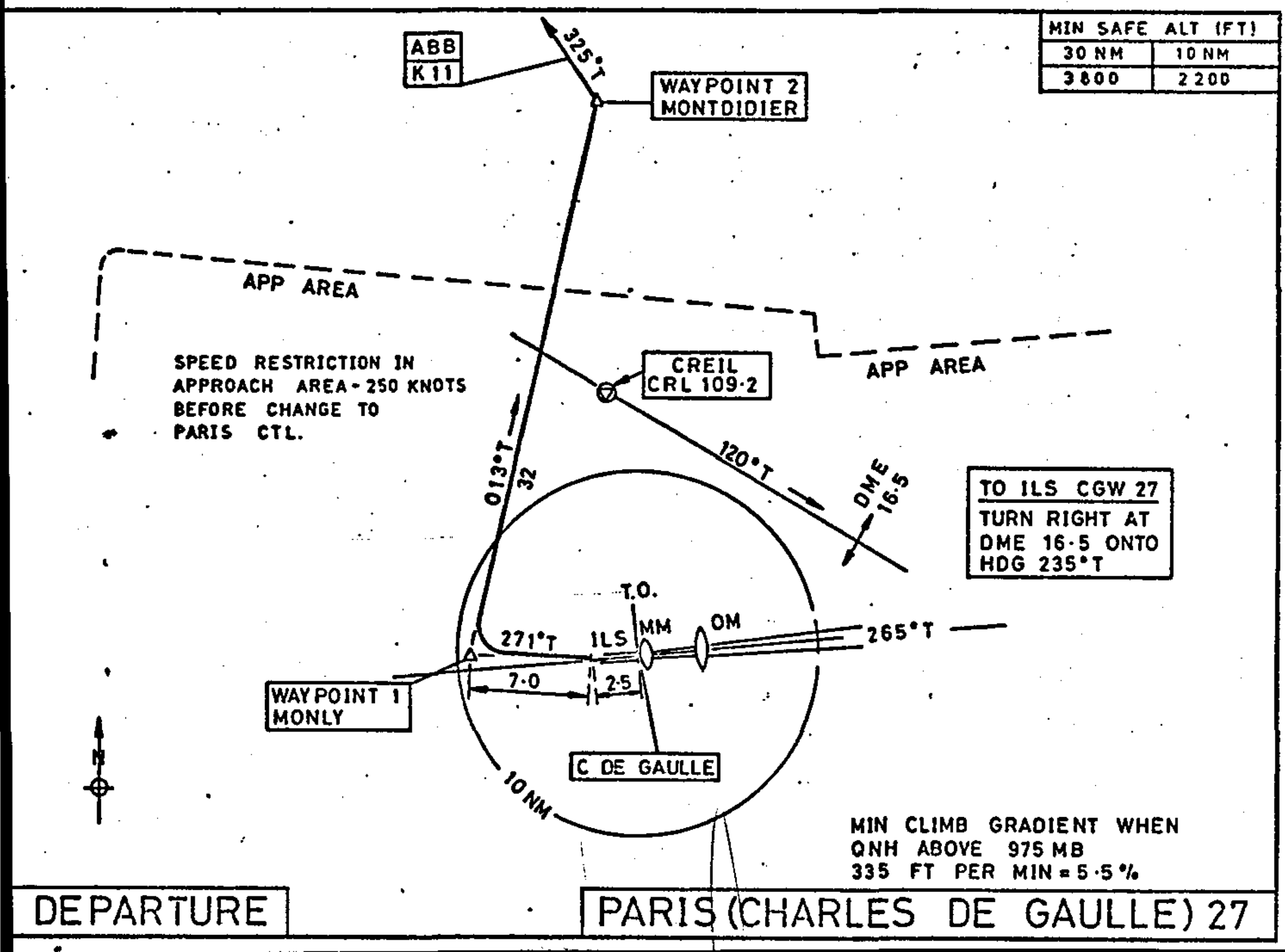
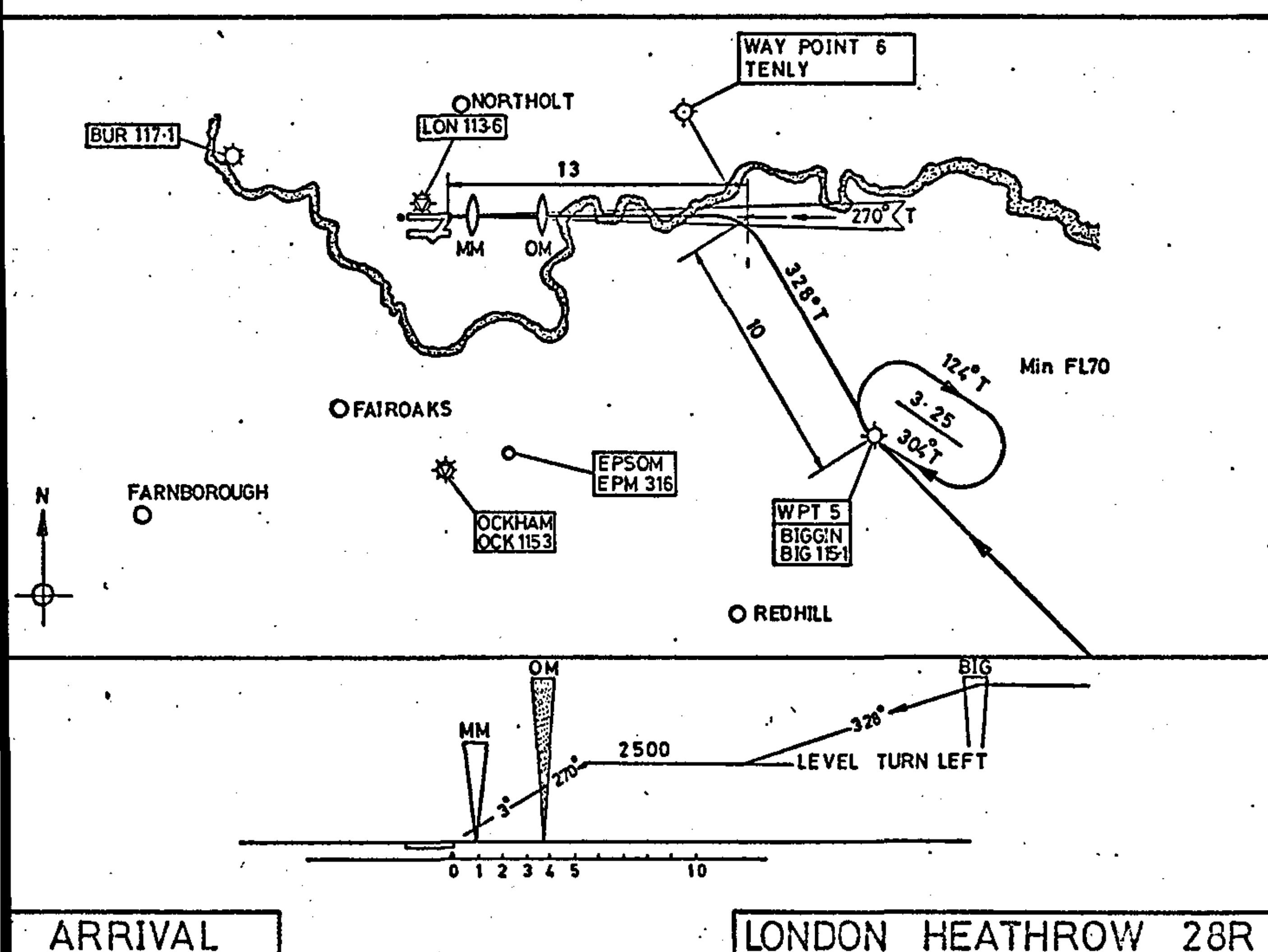


Figure 50

ENROUTE REF.	ALTITUDE (FT) OR FLIGHT LEVEL	AIRSPEED (CAS) Kts	RECOMMENDED FLIGHT PROCEDURE	NOTE
WAYPOINT 3 (ABBEVILLE)	FL 200	340	Maintain Altitude and Speed	
WAYPOINT 4 (CLIFF)	FL 200	340	Maintain 340 Kts and descend to FL 130	
	FL 130	340	Reduce speed to 300 Kts and continue descent to FL 90	
WAYPOINT 5 (BIGGIN)	FL 90	300	Reduce speed to 200 Kts and continue descent to 2500 ft.	
ILS CAPTURE DTG 5 TO WPT 6	2500	200	Reduce speed to 150 Kts. Select landing gear down and continue to glideslope interception	
	2500	150	Descend on the glideslope and reduce speed to 130 Kts by Threshold	
LONDON (HEATHROW)	ARRIVAL		Land and taxy to stand	



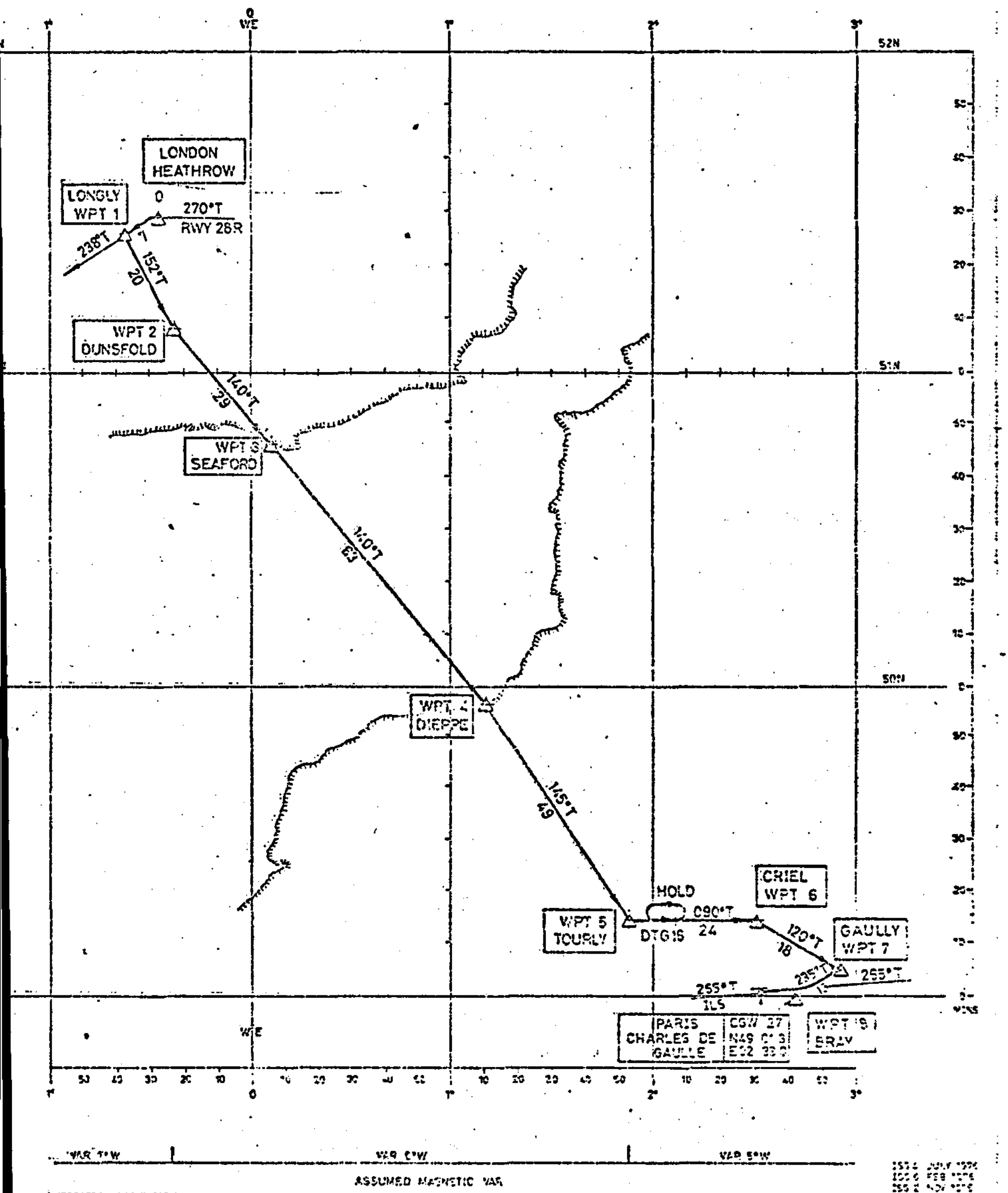
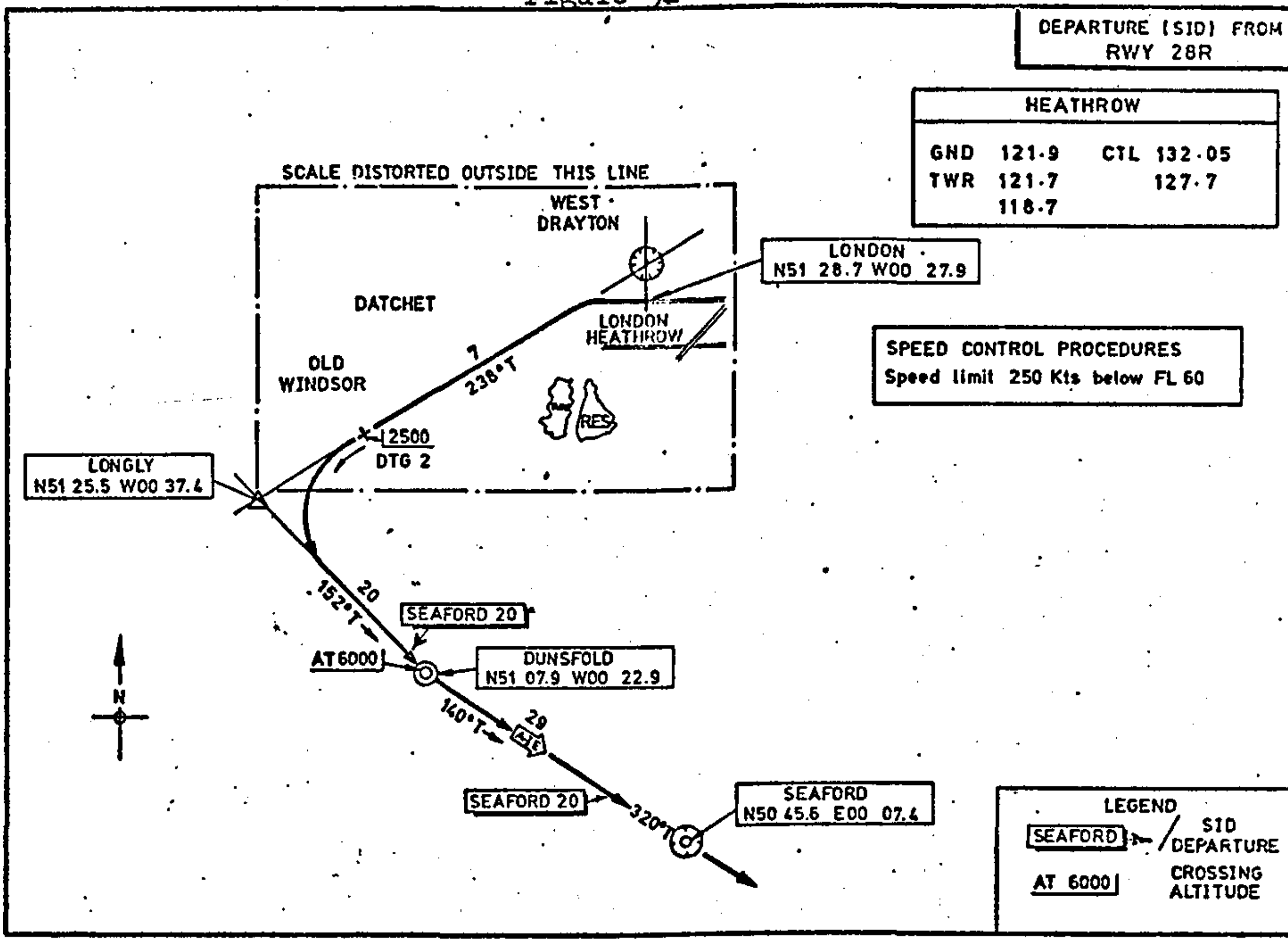
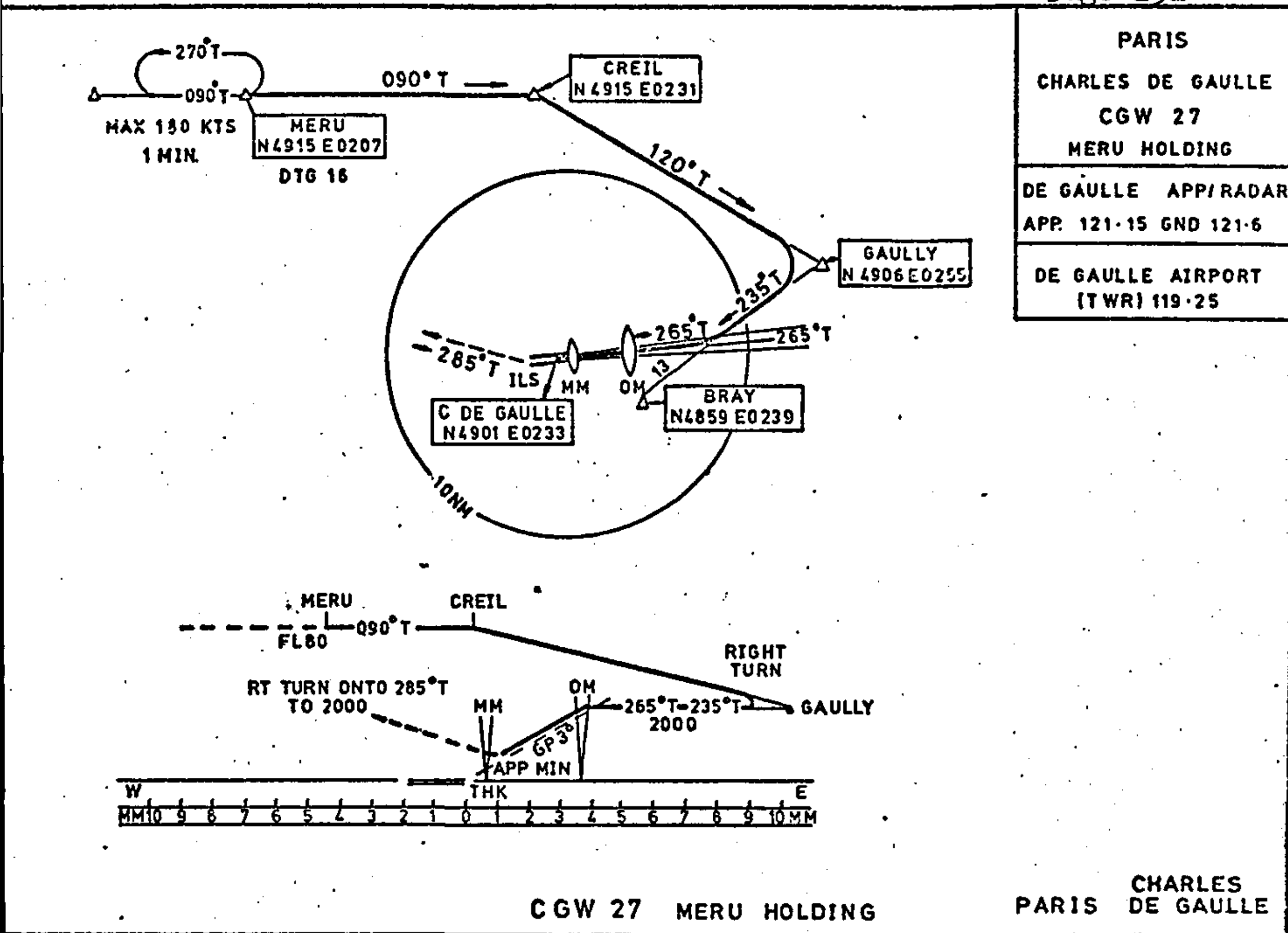

LONDON
HEATHROW
LONGLY
WPT 1
270°T
RWY 28R
238°T
152°T
20
WPT 2
DUNSFOLD
140°T
29
WPT 3
SEAFORD
140°T
63
WPT 4
DIEPPE
145°T
49
WPT 5
TOURLY
HOLD
090°T
24
DTG15
CRIEL
WPT 6
120°T
18
GAULLY
WPT 7
255°T
ILS
PARIS
CHARLES DE
GAULLE
52N
51N
50N
ASSUMED MAGNETIC VAR
MERCATOR PROJECTION

Figure 51



ENROUTE REF	ALTITUDE (FT) or FLIGHT LEVEL	AIRSPEED (CAS) Kts	RECOMMENDED FLIGHT PROCEDURE	NOTE
LONDON HEATHROW	DEPARTURE	130	Take-off - VR 130 Kts and increase speed to 170 Kts at 1500 ft.	
-	1500	170	Maintain climb increasing speed to 200 Kts at 2000 ft and level out.	
-	2000	200	Raise flaps etc. and then continue climb increasing speed to 220 Kts at 3000 ft and level out.	
WAYPOINT 1 (LONGLY)	3000	220	Maintain 3000 ft and increase speed to 250 Kts.	
-	3000	250	Climb at 250 Kts to be at FL 60 by WPT 2. (700 ft/min).	
WAYPOINT 2 (DUNSFOLD)	FL 060	250	Increase speed to 300 Kts and continue climb to be at FL 210 by WPT 3 and level out (3500 ft/min).	
WAYPOINT 3 (SEAFORD)	FL 210	300	Increase speed to 340 Kts (Vmo) and maintain to WPT 4.	
WAYPOINT 4 (DIEPPE)	FL 210	340	Maintain 340 Kts and descend to FL 11 at 11 NM to WPT 5. (2000 ft/min).	
DTG 11 to WPT 5	FL 011	340	Reduce speed to 250 Kts and continue descent to be FL 80 by WPT 5 and level out.	



ENROUTE REF.	ALTITUDE (FT) or FLIGHT LEVEL	AIRSPEED (CAS) Kts	RECOMMENDED FLIGHT PROCEDURE	[illegible]
WAYPOINT 5 (TOURLY)	FL 080	250	Maintain FL 80 at 250 Kts.	
WAYPOINT 6 (CREIL)	FL 080	250	Descend at 250 Kts to be at 2000 ft by WPT 7 and level out	
WAYPOINT 7 (GAULLY)	2000	250	Maintain 2000 ft and reduce speed to 150 Kts.	
ILS CAPTURE	2000	150	Capture ILS, select landing gear down and continue to glideslope interception	
-	2000	150	Descend on the glideslope and reduce speed to 130 Kts by Threshold	
PARIS (CHARLES DE GAULLE)	ARRIVAL	130	Land and taxy to Stand Yankee 8	

Figure 53

CHAPTER 19

QUESTIONNAIRES

19.1. Introduction

The questionnaires used in the Familiarization Programme (see Chapter 12) were aimed at gaining the pilots' general impressions of the Flight Deck and its systems. For the Evaluation Programme more detailed comments and information were required, and the questionnaires reflected this. The questionnaires were presented in a manner which was simple for the pilots to understand, and simple to analyse.

19.2. Programme

The programme for the Evaluation, as shown in Chapter 16, was divided into two pairs of consecutive days. This resulted in the production of four questionnaires, one for each day. As the third and fourth days did not immediately follow the first and second days a number of questions contained in Questionnaires 1 and 2 were repeated in Questionnaires 3 and 4. This repetition of questions enabled the author to ascertain if the pilots had changed their opinions about any aspects of the Flight Deck in the light of their further experience.

19.3. Content of Questionnaires

The Day 1 questionnaire contained questions about each of the formats presented on the systems displays, the warning symbols shown on these formats during the Day 1 exercises, the failures indicated during these exercises and the Engine Start

Panel. Each pilot was also asked, on the front page, to provide the following details:

Name

Organisation

Aircraft Flown (most recent first)

Total Hours,

Type of Glasses (if worn)

The Day 2 questionnaire contained questions about further warning symbols presented on the formats, the failures introduced in the Day 2 exercises, the Systems Displays Control Panels, the methods of presenting the checks and drills, the Systems control panels used in Days 1 and 2, the visibility and reach of items on the Roof Panel and general questions about the ATC and the exercises.

The Day 3 questionnaire covered the failures introduced in Day 3 and the control panels used to remedy these failures.

The Day 4 questionnaire again included the warning symbols on the formats, the failures and the controls associated with the Day 4 exercises. Some of the questions from the Day 1 and Day 2 questionnaires, where aspects of their associated exercises had been repeated in Days 3 and 4, were also included. The general questions were also repeated.

19.4. Layout of Questions

Each question was presented on a separate page and most incorporated an illustration, either a format, a control panel or a labelled part of the Flight Deck to help the pilots visualize the situation that they were commenting on. These illustrations not only served as reminders to the pilots, but also prompted them to provide detailed information which they may otherwise have omitted. (Illustrations of some of the pages are shown in Figures 54 to 60).

At the top of each page, and immediately under the question, one or more rating scales were provided. These scales were adapted from the work done by Duncanson (see reference in Para 3.2.). The questions relating to failures had two scales (one each for warnings and remedial drills) and the questions about the control panels had three scales (one each for layout, position and operation). All the rating scales were identical to avoid confusing the pilots.

In addition to the rating scales each pilot was expected to place a "cross" in each of a series of boxes down the right-hand side of the page. These boxes were divided into: BAD, POOR, FAIR and GOOD and were labelled and linked by an arrow to the relevant part of the illustrations. These boxes were partcularly important for the questions about formats and the control panels, where a large amount of information was required. This method not only enabled the pilots to comment on aspects which they might otherwise have missed, but also reduced the number of written comments they may have wished to make. Analysis was also simpler.

A space was provided on each page for the pilots to make comments as necessary, and a further space was provided for the person conducting the debriefing to add his comments.

19.5. Completion of Questionnaires

Each pilot was encouraged to complete his questionnaire on the Flight Deck where he could operate the displays and controls to refresh his memory.

19.6. Debriefing

Following the completion of the questionnaires debriefings were held to ensure that all topics were covered. The interviews were tape-recorded for future analysis.

19.7. List of Questions

All rating scales were identical. The words shown in parentheses are the labels applied to the scales, where appropriate. More than one label signifies that more than one scale was used for the question.

Day 1.

Q 1.1. How would you rate the presentation of the multi-engines format for normal operation?

Q 1.2. How would you rate the presentation of the Single Engine formats for normal operation? (START, ENGINES RUNNING)

Q 1.3. How would you rate the presentation of the Status format for normal operation? (See Figure 54)

Do you consider that the use of the Status format offers significant workload reduction? (See Figure 54)

How often did you use the Status format? (See Figure 54)

Q 1.4. How would you rate the presentation of the Flying Controls format for normal operation?

Q 1.5. How would you rate the presentation of the Pressurisation format for normal operation?

Q 1.6. How would you rate the presentation of the Anti-ice system format for normal operation?

Q 1.7. How would you rate the presentation of the Air Conditioning format for normal operation?

Q 1.8. How would you rate the presentation of the Electrics format for normal operation?

Q 1.9. How would you rate the presentation of the Hydraulics format for normal operation?

Q 1.10. How would you rate the presentation of the Fuel system format for normal operation? (See Figure 55)

Q 1.11. How would you rate the Multi-engines format with respect to the efficiency and presentation of the warnings? (See Figure 56)

Q 1.12. How would you rate the Single Engine formats with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 1.13. How would you rate the Flying Controls format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 1.14. How would you rate the efficiency of the Ice Detection Warning and the consequent drills? (WARNINGS, DRILLS)

Q 1.15. How would you rate the efficiency of the Windscreen Heater Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 1.16. How would you rate the efficiency of the Engine Reverser Unlocked warnings and the consequent drills? (WARNINGS, DRILLS)

Q 1.17. How would you rate the layout, position and operation of the Engine Start Panel? (LAYOUT, POSITION, OPERATION)

Q 1.18. How would you rate the efficiency of the Engine Oil Low Pressure warnings and the consequent drills? (WARNINGS, DRILLS)

Day 2

Q 2.1. How would you rate the Electrics format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 2.2. How would you rate the Hydraulics format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 2.3. How would you rate the Air Conditioning format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 2.4. How would you rate the Fuel system format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 2.5. How would you rate the Anti-ice system format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 2.6. How would you rate the efficiency of the CSD Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 2.7. How would you rate the efficiency of the Fuel Low Pressure warning and the consequent drills? (WARNINGS, DRILLS)

Q 2.8. How would you rate the efficiency of the Windscreen Heater Overheat warnings and the consequent drills? (WARNINGS, DRILLS)

Q 2.9. How would you rate the efficiency of the Anti-ice Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 2.10. How would you rate the efficiency of the Radio Fan Fail warning and the consequent drill? (WARNING, DRILL)

Q 2.11. How would you rate the efficiency of the Engine Vibration warnings and the consequent drills? (WARNINGS, DRILLS)

Q 2.12. How would you rate the layout, operation and position of the Systems Displays Control Panels? (LAYOUT, OPERATION, POSITION)

Q 2.13. How would you rate the position and operation of the throttles? (POSITION, OPERATION)

Q 2.14. How would you rate the philosophy and effectiveness of the Master Warning System?

Q 2.15. How would you rate the two methods of presenting Preflight Checks? In addition rate in order of preference. (PAPER, CRT)

Q 2.16. How would you rate the layout, position and operation of the Engine Shutdown Panels? (LAYOUT, POSITION, OPERATION)

Q 2.17. How would you rate the layout, position and operation of the Fuel System control panel? (LAYOUT, POSITION, OPERATION)

Q 2.18. How would you rate the layout, position and operation of the Anti-ice system control panel? (LAYOUT, POSITION, OPERATION)

Q 2.19. How would you rate the layout, position and operation of the Air Systems and Air Conditioning control panel? (LAYOUT, POSITION, OPERATION)

Q 2.20. How would you rate the layout, position and operation of the Electrics control panel? (LAYOUT, POSITION, OPERATION)

Q 2.21. How would you rate the layout, position and operation of the Test panel? (LAYOUT, POSITION, OPERATION)

Q 2.22. How would you rate the visibility and reach of controls and indicators generally on the Roof Panel? (VISIBILITY, REACH)

Q 2.23. How would you rate the presentation of the ATC?

Q 2.24. How would you rate the conduct of the exercises?

<u>Day 3</u>

Q 3.1. How would you rate the hydraulics format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 3.2. How would you rate the efficiency of the Feel Motor Fail warning and the consequent drill? (WARNING, DRILL)

Q 3.3. How would you rate the efficiency of the Hydraulics Overheat warning and the consequent drill? (WARNING, DRILL)

Q 3.4. How would you rate the efficiency of the Hydraulics Low Pressure warning and the consequent drill? (WARNING, DRILL)

Q 3.5. How would you rate the efficiency of the Ice Detection warning and the consequent drills? (WARNINGS, DRILLS)

Q 3.6. How would you rate the efficiency of the Anti-ice Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 3.7. How would you rate the efficiency of the Radio Fan Fail warning and the consequent drill? (WARNING, DRILL)

Q 3.8. How would you rate the efficiency of the Engine Overheat warnings and the consequent drills? (WARNINGS, DRILLS)

Q 3.9. How would you rate the layout, position and operation of the Engine Start panel? (LAYOUT, POSITION, OPERATION)

Q 3.10. How would you rate the layout, position and operation of the Anti-ice system control panel? (LAYOUT, POSITION, OPERATION)

Q 3.11. How would you rate the layout, position and operation of the Air Systems and Air Conditioning control panel? (See Figure 57)

Day 4

Q 4.1. How would you rate the Flying Controls format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 4.2. How would you rate the Electrics format with respect to the efficiency and presentation of the warnings? (WARNINGS)

Q 4.3. How would you rate the efficiency of the CSD Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 4.4. How would you rate the efficiency of the PCU Fail warnings and the consequent drills? (WARNINGS, DRILLS)

Q 4.5. How would you rate the efficiency of the Engine Fire warnings and the consequent drills? (See Figure 58)

Q 4.6. How would you rate the efficiency of the Air System Duct Overheat warning and consequent drill? (WARNING, DRILL)

Q 4.7. How would you rate the efficiency of the Engine Reverser Unlocked warning and consequent drill? (WARNING DRILL)

Q 4.8. How would you rate the layout, position and operation of the Systems Displays Control Panels? (See Figure 59)

Q 4.9. How would you rate the philosophy and effectiveness of the Master Warning System?

Q 4.10. How would you rate the general philosophy of the Hierarchy of Warnings as presented for the systems failures?

Q 4.11. How would you rate the two methods of presenting Preflight Checks? In addition rate in order of preference. (see Fig.60)

Q 4.12. How would you rate the acceptability of handling systems failures and malfunctions with one, two and three systems displays failed? (1 FAILED, 2 FAILED, 3 FAILED)

Q 4.13. How would you rate the use of the Standby Engine Instruments in the event of systems displays failure?

How would you rate the design and use of the Rotary Switch for the control of the Standby Engine Instruments?

Q 4.14. How would you rate the layout, position and operation of the Engine Shutdown panel? (LAYOUT, POSITION, OPERATION)

Q 4.15. How would you rate the layout, position and operation of the Fuel system control panel? (LAYOUT, POSITION, OPERATION)

Q 4.16. How would you rate the layout, position and operation of the Power Control Units control panel? (LAYOUT, POSITION, OPERATION)

Q 4.17. How would you rate the layout, position and operation of the Hydraulics system control panel? (LAYOUT, POSITION, OPERATION)

Q 4.18. How would you rate the layout, position and operation of the Electrics control panel? (LAYOUT, POSITION, OPERATION)

Q 4.19. How would you rate the layout, position and operation of the Test panel? (LAYOUT, POSITION, OPERATION)

Q 4.20. How would you rate the visibility and reach of controls and indicators generally on the Roof Panel? (VISIBILITY, REACH)

Q 4.21. How would you rate the presentation of the ATC?

Q 4.22. How would you rate the conduct of the exercises?

PILOT No:	
QUESTION	1.3

HOW WOULD YOU RATE THE PRESENTATION OF THE STATUS FORMAT, FOR NORMAL OPERATION?

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT.

STATUS

A/BRK OUT	FLAPS T/O	SLATS OUT
A/ICE.	ENGINE	WING TAIL
TOTAL FUEL	37790	
HYD PRESS	A 2900	B 2850
ELECT LOAD	AC 1+3 24	AC 2+4 25
	DC TR1 70	DC TR2 71
CABIN	TEMP 23	ALT 7500

CONTROL SURFACES	BAD / POOR / FAIR / GOOD
ANTI-ICE	BAD / POOR / FAIR / GOOD
FUEL CONTENTS	BAD / POOR / FAIR / GOOD
HYDRAULIC PRESSURES	BAD / POOR / FAIR / GOOD
ELECTRICAL LOAD - AC	BAD / POOR / FAIR / GOOD
ELECTRICAL LOAD - DC	BAD / POOR / FAIR / GOOD
CABIN TEMP. & ALTITUDE	BAD / POOR / FAIR / GOOD
LAYOUT	BAD / POOR / FAIR / GOOD

DO YOU CONSIDER THAT THE USE OF THE STATUS FORMAT OFFERS SIGNIFICANT WORKLOAD REDUCTION? YES ☐ NO. ☐

HOW OFTEN DID YOU USE THE STATUS FORMAT?

NEVER ☐ OCCASIONALLY ☐ OFTEN ☐

COMMENTS

CONTINUE OVERLEAF

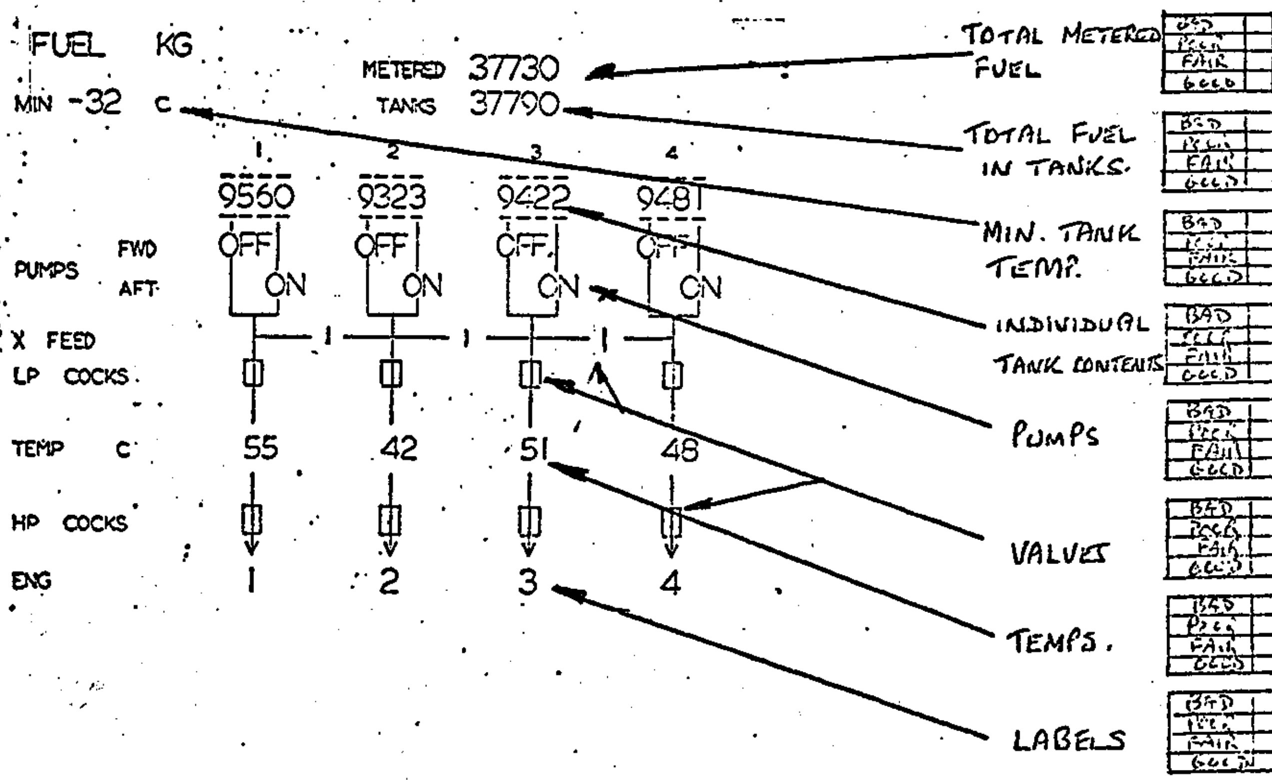
DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 54

PILOT No:	
QUESTION	1.10

HOW WOULD YOU RATE THE PRESENTATION OF THE FUEL SYSTEM FORMAT FOR NORMAL OPERATION?

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT



COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

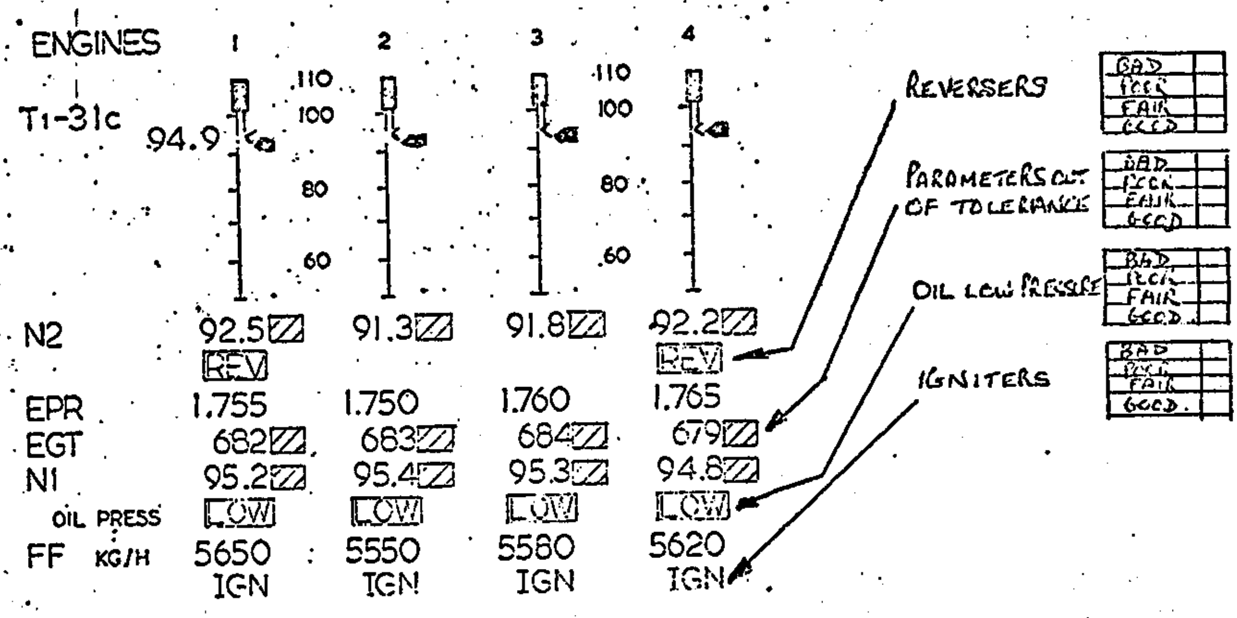
Figure 55

PILOT NO:	
QUESTION	1.11

HOW WOULD YOU RATE THE MULTI-ENGINES FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?

WARNINGS

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT



COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 56

PILOT NO:

QUESTION 3.11

HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE AIR SYSTEMS AND AIR CONDITIONING CONTROL PANEL?

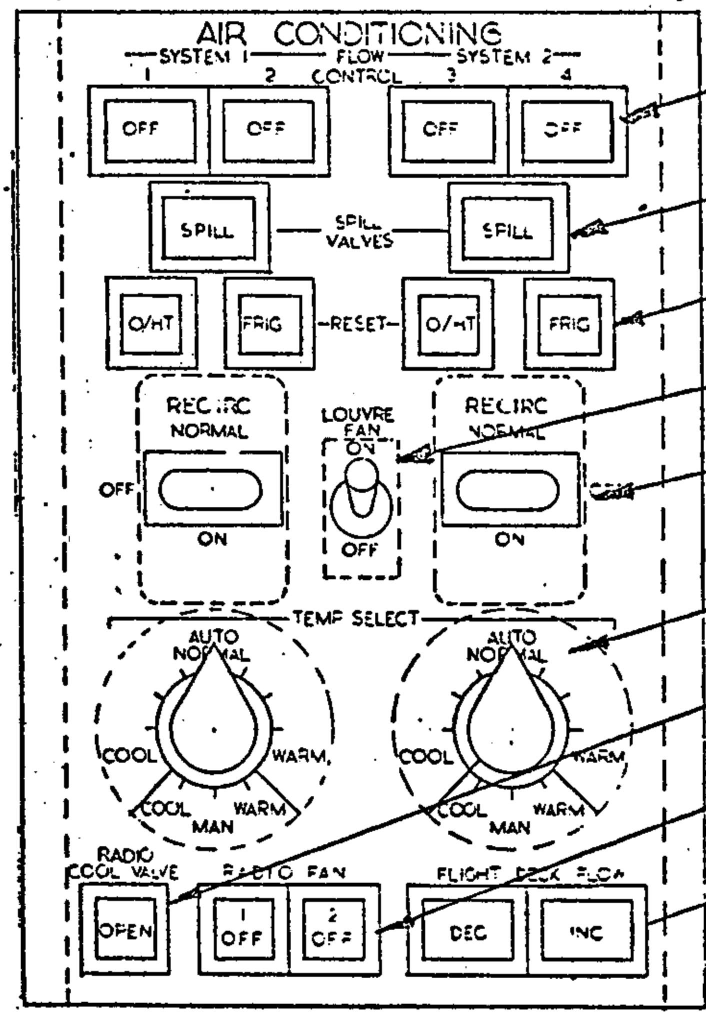
LAYOUT

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT

POSITION

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT

OPERATION



FLOW CONTROLS	BAD / POOR / FAIR / GOOD
SPILL VALVES	BAD / POOR / FAIR / GOOD
RESET	BAD / POOR / FAIR / GOOD
LOUVRE FANS	BAD / POOR / FAIR / GOOD
RECIRC. SWS.	BAD / POOR / FAIR / GOOD
TEMPERATURE CONTROLS	BAD / POOR / FAIR / GOOD
RADIO COOL VALVE	BAD / POOR / FAIR / GOOD
RADIO FANS CONTROLS	BAD / POOR / FAIR / GOOD
FLIGHT DECK FLOW CONTROL	BAD / POOR / FAIR / GOOD

COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 57

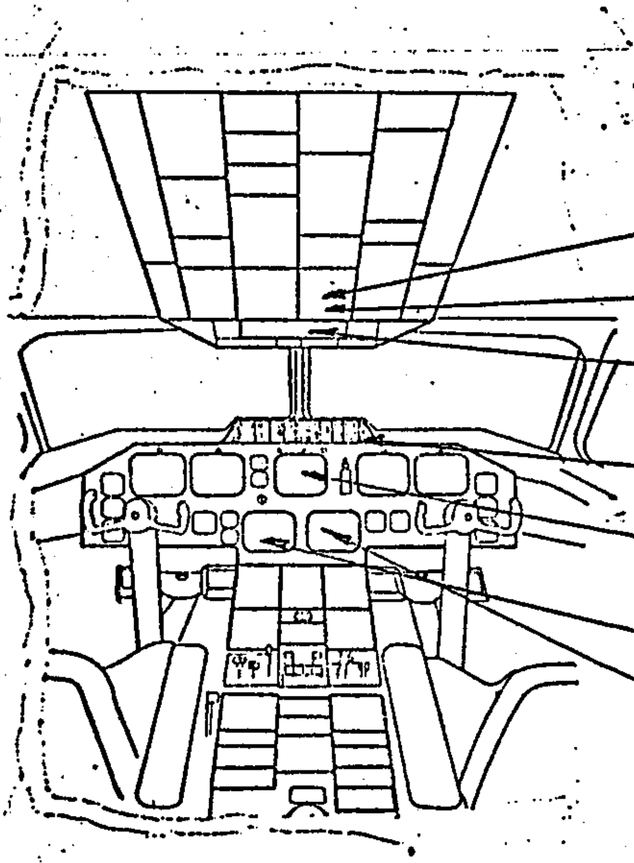
PILOT No:
QUESTION 4.5

HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE FIRE WARNINGS AND THE CONSEQUENT DRILLS?

WARNINGS

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

DRILLS



BELL	BAD / POOR / FAIR / GOOD
FIRE HANDLE	BAD / POOR / FAIR / GOOD
EXTINGUISHER	BAD / POOR / FAIR / GOOD
MWS	BAD / POOR / FAIR / GOOD
'FIRE' LIGHT	BAD / POOR / FAIR / GOOD
S2 WARNINGS	BAD / POOR / FAIR / GOOD
S1 WARNINGS	BAD / POOR / FAIR / GOOD
USE OF FUEL DISPLAY	BAD / POOR / FAIR / GOOD
SECONDARY ACTIONS	BAD / POOR / FAIR / GOOD

COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 58

PILOT NO:
QUESTION 4.8

HOW WOULD YOU RATE THE LAYOUT, OPERATION AND POSITION OF THE SYSTEMS DISPLAYS CONTROL PANELS?

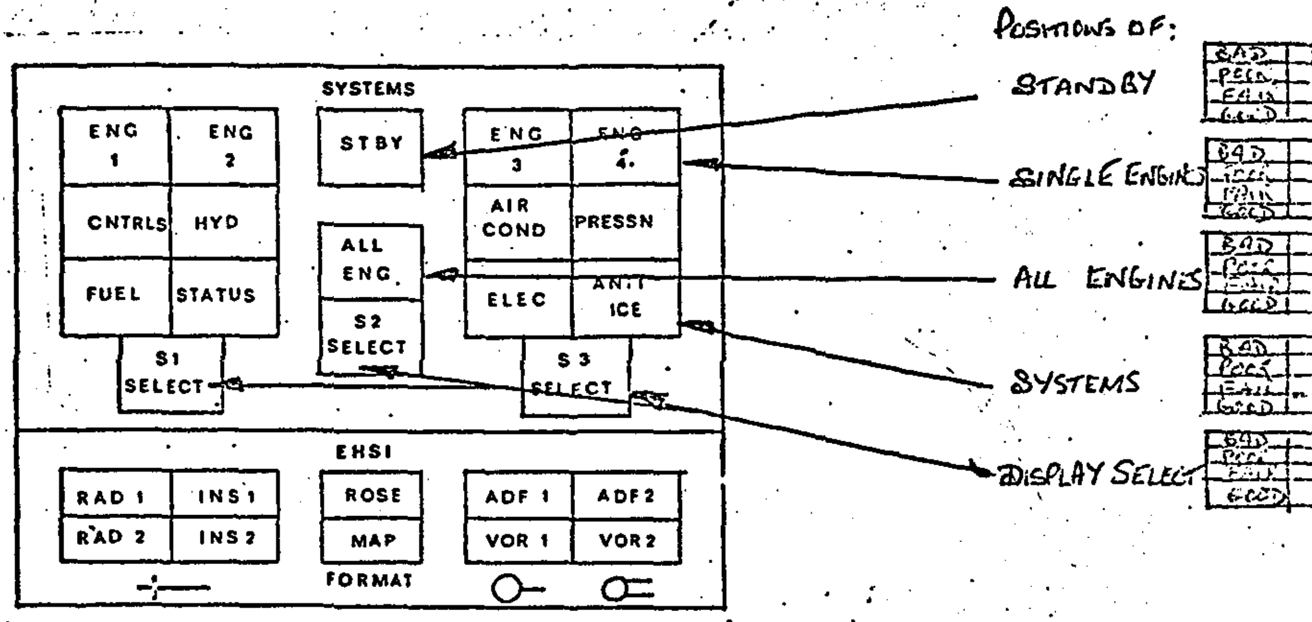
LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

OPERATION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

POSITION (INCLUDING TILT)



COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 59

QUESTION: 4.11

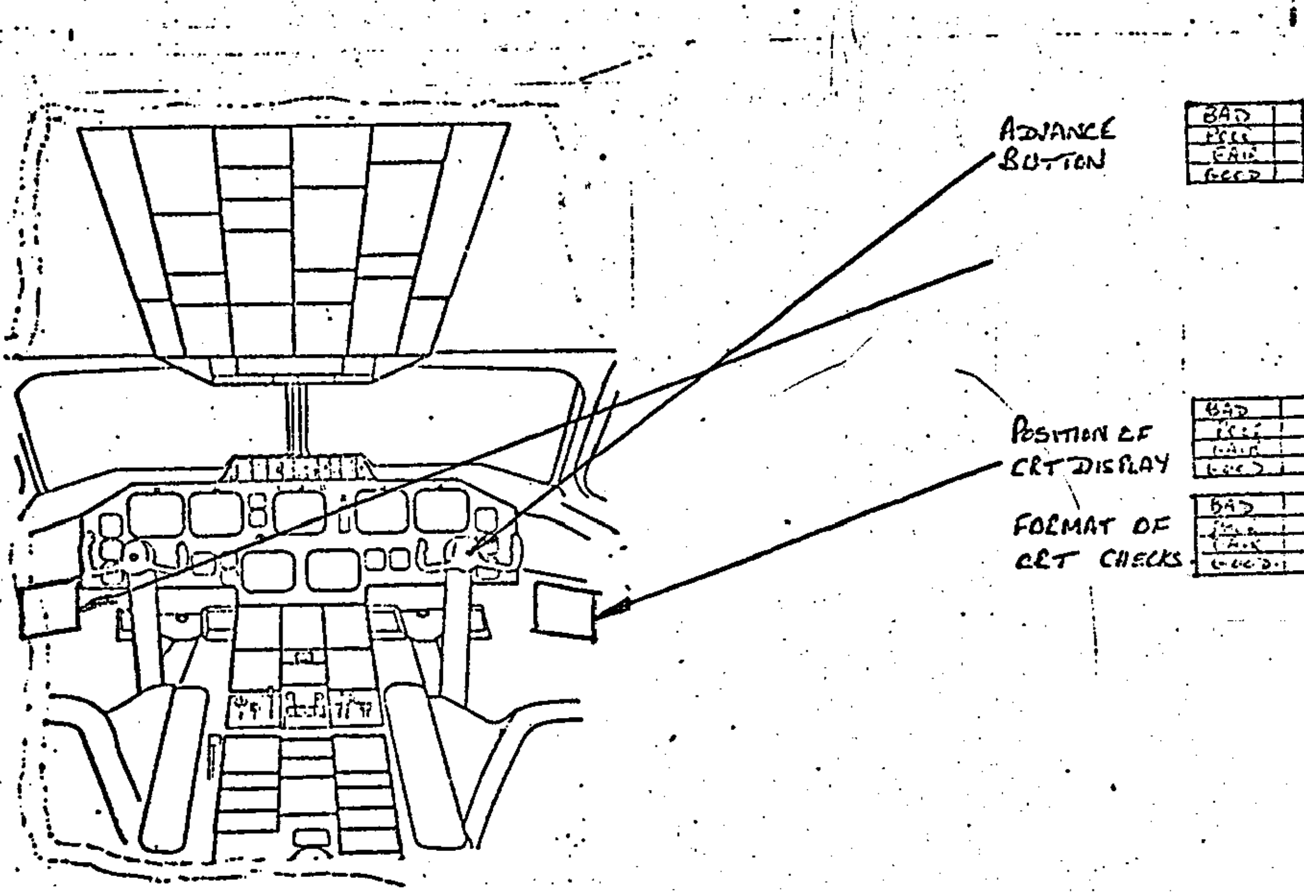
HOW WOULD YOU RATE THE TWO METHODS OF PRESENTING PRE-FLIGHT CHECKS? IN ADDITION RATE IN ORDER OF PREFERENCE?

PREFERENCE

☐ PAPER

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

☐ CRT



COMMENTS

CONTINUE OVERLEAF

DE-BRIEFING NOTES (NOT FOR PILOT USE)

Figure 60

CHAPTER 20

RESULTS, DISCUSSION AND CONCLUSIONS

20.1. Results

Nine pilots undertook Exercises 1 to 7, but because of a major computer failure the programme had to be terminated prematurely with the consequence that only five of the pilots completed exercises 8 to 14.

The pilots' flying experiences ranged from fighters to large transport aircraft, both civil and military. Several pilots had previously used CRTs. The differences in these backgrounds may have influenced the assessments.

All the pilots' responses to each question have been combined for presentation. (see Appendix 1). Where appropriate the Observer's notes have been added.

Answers to questionnaires are identified by day and question number, e.g. 4.13 denotes the questionnaire for Day 4, question number 13.

The compared pilots' ratings associated with a specific element are indicated next to their respective boxes. Where "half" values occur the pilots "ticked" the junction of two categories. In some cases some pilots did not provide a rating.

Response times to failures and times to read various displayed parameters are presented as histograms.

Format selection was timed from the request for data to the appropriate format selection. Reading Time was timed from availability of the appropriate format to the reading of the parameter. Errors in reading, or when the pilots were assisted, are excluded from the results.

The response to a failure was timed from the cancellation of the respective "attention-getter" to completion of the drill. The time from fault injection to cancellation of the "attention-getter" is not presented because there was no requirement for an immediate response to amber warnings. The times from fault injection to cancellation of red warnings are presented since these should have resulted in immediate responses and have provided an indication of the effectiveness of the "attention-getting" system.

The complete results are tabulated in Appendix 1 and the references in parentheses refer to this appendix.

20.2. Discussion

20.2.1. Design

20.2.1.1. Systems Displays

The redesigned formats for the ALL ENGINES, SINGLE ENGINES, FLYING CONTROLS and FUEL SYSTEM received high ratings, thus showing that the changes made since the Familiarization Programme were an improvement. (pages 3,7,12 and 29)

The introduction of a STATUS format also appears to have been a significant improvement. (page 10)

20.2.1.2. Systems Displays Control Panels

The manual display selections appeared to have been reduced to a level which could be controlled by the non-handling pilot at all stages of flight. This was achieved by the introduction of the STATUS format and, for failures, by the automatic priority system described in Para. 7.2.6.

The layout of the panels appeared satisfactory. (pages 33 & 34)

20.2.1.3. Pedestal

Trimming still remained a problem, but the changes to the throttle quadrants were an improvement (see Para. 14.6.).

20.2.1.4. Roof Panel

The repositioning of the Engine Start Panel and the redesign of the Test Panel were rated as improvements. However the method of operation of the Test Panel was still found to be tiring due to the need to maintain pressure on the test pushbuttons for long periods. (pages 35 & 50)

20.2.1.5. Check Lists

The presentation of check lists and drills on a CRT received very favourable ratings. Unfortunately the comparison with the back-projected display was not possible due to non-availability of suitable film. This was deferred to Phase 2 of the study (see Chapter 27), the assessment of the

Electronic Flight Instruments. (pages 92 & 93)

The ability to display the check list information at the EHSI positions (F2 and F3) was considered to be an important facility.

20.2.2. Operation

20.2.2.1. General

The Assessment Pilot was allocated the following tasks:-

i) Reading and performing the checks and drills from Preflight to Shutdown.

ii) Normal operation and selection of all systems.

iii) Abnormal operation and drills for all systems.

iv) ATC

v) Compilation of a flight log.

vi) Thrust management as required (the delegation of this task was related to the Assessment Pilots' operational experience.

vii) Reading specific values from the formats.

The sharing of the crew duties that would normally occur for two-crew operation was modified to allow the pilots to assess all the displays and controls for normal and abnormal operation. This additional workload could be judged as a partial substitute for the navigation control and monitoring task which was not simulated.

20.3. Conclusions

20.3.1. Displays & Formats

i) One pilot gave a "poorer" rating to each format which is because he felt colour was essential.

ii) All Engines - Good, no reading errors. (p.3-6)

iii) Single Engines - Improvements needed in the presentation of the digital data. (p.7-9)

iv) Status - gave a significant workload reduction by minimising format selection. Some improvement in data presentation was necessary. The reading times were slower than for some other formats. (p.10 & 11)

v) Flying Controls - Aircraft symbol too bold. Trim scales, particularly Pitch, needed improving. (p.12-14)

vi) Pressurization - Better differentiation between SET and CABIN required. (p.15 & 16)

vii) Anti-Ice - Some improvements wanted, Reading Times were poor. (p.17-19)

viii) Air Conditioning - Some difficulty was experienced in using this format mainly because it reflected the complicated nature of the system design. (p.20-22)

ix) Electrics - Introduction of additions to the flow diagram (e.g. ELRAT, Standby TRU) resulted in clutter. The format needed improving. (p.23-25)

x) Hydraulics - Satisfactory, subject to several minor improvements. (p.26-28)

xi) Fuel - Very satisfactory, best format of all. (p.32)

20.3.2. Control Panels

i) Displays Control Panel - Location good. (p.33 & 34)

ii) Engine Start Panel - Minor criticisms only. Tendency for pilots to rest their hands on the Shutdown

Handles when starting engines. (p.35 & 36)

iii) Engine Shutdown - Individual toggle switches were difficult to identify and operate. Many of the errors occurred when the pilots did not adhere to the Check Lists. The position and philosophy of the Shutdown Handles were liked. (p.37 & 38)

iv) Power Control Units - Liked. (p.39)

v) Anti-ice - (Individual criticisms were made). Philosophy of pushbutton operation needed improvement. (p.40 & 41)

vi) Air Conditioning - Labelling needed improving. There was a lack of familiarity with the controls which may have influenced some of the opinions made. (p.42 & 43)

vii) Electrics - Satisfactory, subject to some small changes. (p.44 & 45)

viii) Hydraulics - Satisfactory, but the pushbutton layout was prone to mis-selection. (p.46)

ix) Fuel - A few mis-selections were made, but otherwise a satisfactory panel. (p.47-49)

x) Test - Layout, position and philosophy good, but tiring to operate. (p.50)

xi) Visibility and Reach - Controls at edges of Roof Panel were difficult to operate. (p.51-52)

20.3.3. <u>Systems Failures</u>

i) Engine Reverser Unlocked - No significant problems. (p.53 & 54)

ii) Engine Oil Low Pressure - Warnings could be improved. (p.55 & 56)

iii) Engine Vibration - Drills needed improving. (p.57)

iv) Engine Overheat - Difficulty was experienced in identifying the correct engine. (p.58 & 59)

v) Engine Fire - No significant problems. (p.60 & 61)

vi) Power Control Units - No significant problems.(p.62-63)

vii) Feel Motor Fail - No significant problems.(p.64)

viii) Ice Warning - Warning philosophy needed improving and the selection of the Anti-ice format should have been automatic. (p.65-68)

ix) Anti-ice Fail - Warnings and drills needed improving. (p.69 & 70)

x) Windscreen Heater Fail - Warnings and drills needed improving. (p.71)

xi) Windscreen Heater Overheat - Warnings and drills needed improving. (p.72)

xii) Air Duct Overheat - No significant problems.(p.73 & 74)

xiii) Radio Fan Fail - No significant problems.(p.75 & 76)

xiv) CSD Fail - No significant problems.(p.77 & 78)

xv) TR Fail - There was some confusion with Generator Fail. (p.79)

xvi) Hydraulics Overheat - No major problems, one pilot diagnosed the wrong fault.(p.80 & 81)

xvii) Hydraulics Low Pressure - No significant problems. (p.82 & 83)

xviii) Fuel Low Pressure - Several pilots were confused by the warnings and the drills. (p.84 & 85)

20.3.4. <u>General</u>

i) The checks and drills were considered satisfactory in terms of length and complexity for the flights simulated. (p.92)

ii) The CRT presentation of normal checks and drills was considered an important innovation and was seen to have great potential. Many pilots did not use the "window" as intended which led to some errors being made. (p.92 & 93)

iii) Most of the systems failure drills were easily learned and followed.

iv) Certain pushbuttons and switches on the Roof Panel led to some errors in system selection which were not always readily apparent on the related system displays.

v) The use of split-caption illuminated pushbuttons on the Roof Panel to indicate both a fault and the subsequent action was an improvement.

vi) The workload associated with the operation and monitoring of the systems was within acceptable limits. (p.97)

vii) Some improvements were needed in the MWS. (p.87 & 88)

viii) The Hierarchy of Warnings was satisfactory subject to further experience with display failures. (p.89)

ix) The Standby Engine Instruments used were not the best available and were difficult to read. (p.91)

x) Some improvements were needed to the throttles. (p.94)

xi) The handling of the simulator needed improving. (p.97)

xii) The ATC simulation was helpful, but became too repetitive towards the end of each two-day programme. (p.95)

xiii) The conduct of the exercises was satisfactory. (p.96)

xiv) The questionnaires were well designed and easy to complete, but rather lengthy. In some instances they highlighted areas where the pilots had gaps in their knowledge of the systems operation. (p.96)

xv) The debriefing sessions were useful discussion periods.

xvi) No eyestrain or fatigue greater than would have been normal for an intensive two-day programme on a conventional simulator were experienced by the pilots. (p.97 & 98)

PART C

ELECTRONIC FLIGHT INSTRUMENTS EVALUATION

CHAPTER 21

CHANGES TO SIMULATOR

21.1. Introduction

For the assessment of the EFIs a number of changes to the simulator were made. Some of these changes were improvements suggested by the pilots in Phase 1 of the study.

21.2. Flight Deck Layout

The colour of the interior of the Flight Deck was changed to a "biscuit" colour, but the Roof Panel and the individual control units remained a "dark admiralty grey". The floor was covered with a matching carpet.

The colour change was as a result of a recommendation from the RAE to minimise the "swimming effect" of CRTs for night flying. The RAE had found that CRTs had an apparent movement in space when viewed in the dark on a dark coloured panel.

21.3. Glareshield

A full width Glareshield was introduced incorporating a redesigned AFCS. Panels were introduced at each end of the Glareshield on which were positioned for each pilot a clock and contrast controls for the EFIs. Lighting was changed to fluorescent, but without dimmers. These changes were made for a later assessment which is not included in this thesis.

21.4. Main Displays Panels

A new display unit with a modified filter was introduced but was not part of the assessment.

A functional RMI replaced the previous representation.

The marker lights were deleted as they were now represented on the EHSI.

21.5. Pedestal

The length of the Pedestal was reduced to improve access to the seat immediately aft of it. The roof flood light on the aft of the Pedestal (see Para. 4.10.) was removed. The Distance-to-go Indicator was replaced by a representation of a navigation controller, but with an operating Waypoint Number indicator.

A contrast control for the systems displays was located forward of the throttles.

21.6. Control Columns

Inching switches for the Documentation Display Check List windows were fitted (see Chapters 17 and 27).

21.7. Documnentation Displays

A back-projected Ferranti display was fitted at the forward end of the left side console (see Chapter 27).

21.8. Pilots' Seats

IPECO seats on curved rails were installed for each pilot.

An indicator was provided for establishing each pilot's eye reference position.

CHAPTER 22

DESCRIPTION OF FORMATS AND CONTROLS

22.1. Background

The formats for the EADI and the EHSI were designed after consultation with a number of the pilots who had taken part in the evaluation of the EFI formats that were used in the Systems Evaluation (see Parts A and B). This previous evaluation was at BAC Filton in 1973 (see Reference by B.J.Bleach in Para.3.2.)

The consultation took the form of a questionnaire, the content and analysis of which was not the responsibility of the author and is not included herein.

The formats and controls described in this Chapter include a few changes that were made during the initial part of the programme where some confusions were obvious. These changes were:

EADI: Flight Path Angle circles moved out from the centre area
Potential Flight Path Angle separated from Flight Path Angle
3° approach reference marks added

EHSI: Course and Bearing pointers suppressed when overlapping
Mode annunciation box accentuated

22.2. Description of EADI (see Figures 61 to 64)

1. Airspeed (Analogue)

Scale marks at 10° spacing. Pointer rotation 360°/100 knots. 100 knot digit changes 180° from pointer with $\pm$ 5 kt.

2. Speed Caption (SPD)

Flashed for V higher than Vmo, M higher than Mmo and

α higher than 20° (nominal) (α = incidence)

3. Airspeed (digital)

Digital readout 0 - 450 knots.

Dashes for:- ADC validity flag for ADC 1/ADC 2 comparator.

Analogue pointer removed.

4. Mach Readout

Mach No. displayed when M>0.50.

5. Selected Speed (SEL)

Digital readout of selected value and datum for autothrottle speed control.

Control E.1. Slew to change digits.

6. V Data

Automatic or manually inserted values.(auto only for this programme)

a) V1, VR, V2 until V2 exceeded, V1 and VR digits removed as V speed exceeded.

b) V2, V3, V4, VFTO after V2 exceeded, removed when M> 0.50

c) VNE - V equivalent to VMO or MMO limit, displayed when M>0.5.

d) VAT, V3, V4 - with APPR selected - Control D.1.

7. Speed Error

Displayed only with APPR selected (Control D.1.)

a) Speed Error Index - diamond against scale gives error between SPD SEL value and actual speed.

b) Speed Error Scale - Marks ± 10 ± 20 kt.

8. Lateral Deviation

Scale - dots = ±75 μA ± 150 μA.

Moving index with caption as follows:

a) VOR tuned (control K) and RAD 1/2 selected Control J.1. gives 'VOR'

b) INS 1 or 2 selected. (Control J.2 gives 'NAV')

In INS mode 1 dot = 3.75 NM.

c) ILS tuned (Control K) RAD 1/2 selected (control J.1) gives 'LOC'
Scale marks expanded scale ± 75 μA

9. Vertical Speed

Analogue scale marks.

Minor marks: 0-1000 ft/min, 200 ft/min intervals

Major marks: 0-6000 ft/min, 1000 ft/min intervals

Numerals at 0, 1, 2, 4 and 6 (1000s ft/min)

Pointer removed for ADC validity flag.

10. Vertical Error

a) V-Nav selected - Control D.2

Marks ± 100 ft and ± 200 ft.

Moving index. Caption 'N'

b) Altitude Hold selected - Control H.2

Marks ± 100 ft and ± 200 ft.

Moving index. Caption 'A'

c) ILS Tuned - Control K

Marks ± 75 μA ± 150 μA.

Moving index. Caption 'G'

At other times scale and index removed.

11. Selected Altitude (SEL)

Digital readout of selected value.

Datum for altitude aquire and altitude alert.

Control H.1 Rotate knob to change digits.

Push for altitude acquire.

12. Radio Altitude

Digital readout of radio altitude (Caption R)

Range 0-2500 ft. in 10 ft. steps.

Not displayed above 2500 ft.

Dashes for radio altitude validity/failure flag.

13. Altitude (digital)

Digital readout: 1000 to 50,000 ft. in 20 ft. steps.

Dashes for ADC validity or comparator flags, pointer removed.

14. Altitude Caption (ALT)

Flashed for Altitude Alert to standard ALT Alert logic. Datum set by control H.1 (see Item 11)

15. Altitude (analogue)

Scale marks at 100 ft. spacing.

Pointer rotation 360^o/1000 ft.

16. Pressure Setting

850 to 1050 mbs. in $\frac{1}{2}$ mb steps except at 1013.2 (precise No.)

Control A.1. Rotate knob to change digits.

a) 1013.2 selected - Control A.2

Digital and analogue values increase/decrease by the difference between value previously set and 1013.2

b) QFE/QNH selected - Control A.2

QFE and QNH values stored in the computer. When selected QNH indicated video inverted.

17. Compass 2 (Pl's display) or Track Angle Error (TKE)

a) MAG Heading from Compass 2 displayed except b).

b) With APPR selected, Control D.1

Track Angle Error (TKE) is displayed in place of MAG heading.

TKE = difference between selected course (magnetic) plus drift and existing heading.

18. Rate of Turn

Scale with moving index.

a) Scale marks L or R Rate 1 (3^o/sec)

Rate 2 (6^o/sec)

b) Scale marks L or R 5^o and 10^o track error. In conjunction with Item 17 b).

EADI Centre Circle (Figure 64)

19. Fixed Marks

Fixed marks at 0 and ± 90^{o} on the periphery.

The 0 mark provides a fixed index for the roll scale.

20. Bank Angle

Scale moving about a fixed mark. (Item 19)

Scale marks: 0^{o} special mark with reciprocal symbol

±30^{o} Large marks

±60^{o} Medium marks

±10^{o}, 20^{o}, 45^{o}, 180^{o} Small marks.

21. Attitude

Major Pitch Scale marks every 10^{o} between ± 80^{o}. Only two of the major marks are numbered at any one time, the numbers appearing progressively as the scale moves up or down.

2^{o} marks are displayed with a range of 20^{o} and transferred about the centre square into the appropriate 10^{o} segment (± 2^{o} hysteresis) as the scale moves up or down.

This transfer does not operate below V2.

2^{o} marks deleted when Flight Director on.

22. Flight Path Angle

Two open 2^{o} diameter circles, reference point at centre of circle. Indicates flight path angle when measured against the pitch scale.

Illustration A shows pitch angle (θ) 17^{o} and flight path angle (γ) 15^{o} therefore incidence (α) is 2^{o}.

23. Potential Flight Path Angle

Two solid circles when coincident with Flight Path Angle circles indicates zero longitudinal acceleration (i.e. steady IAS) (as shown in Illustration B).

Symbol removed with AT SPD engaged below VR.

(24.) Aircraft Symbol and Centre Reference Marks

Fixed aircraft wings with a centre reference square, size equal to 2° on the pitch scale. Reference datum is the centre of the square.

(25.) Flight Director (1 or 2)

Control B	when off	- no symbols, bar moves laterally only, on datum.
	Roll on	- Roll command only
	On	- Roll and Pitch Command

FD selection indicated on EHSI (see item 32)

(26.) Decision Height

Control (A.1)

By pulling the baroset knob against a spring the Radio Altitude indication (item 12) is replaced by DH and values between 0-999 can be inserted by rotation of the knob. (Fixed at 200 ft. for EFI evaluation)
When Radio Altitude decreases below the set DH the DH symbol as shown is displayed video inverted.

At 100 ft. above DH, plain video inverted window flashes.

(27.) Urgent Window

Video inverted window reserved for urgent information.

e.g. Caption G.SLOPE flashing indicates 2 dots low when below 500 ft.

22.3 Description of EHSI (see Figures 61, 62, 65, 66 and 67)

(28.) Heading (digital), Compass 1 (P1) or Compass 2 (P2)

a) Radio Mode: Magnetic heading (MAG) indicated by the compass rose is displayed digitally.

b) INS Mode: True heading (TRU) indicated by the compass rose is displayed digitally.

29. Selected Course/Desired Track

a) Radio Mode: Selected Course (CRS SEL) set by control C is displayed.

b) INS mode: Desired Track (DSR TRK) set by INS computer is displayed.

30. Selected Heading/Cross Track Distance

a) Radio Mode: Selected Heading (HDG SEL) set by control F is displayed. Used in conjunction with the bug (item 58) on the compass rose.

b) INS Mode: Cross Track Distance (XTK) Left (L) or Right (R) is displayed automatically in nautical miles.

31. Autopilot Engagement 1/2

AP 1/2 is displayed when selection is made on control G.1 Caption AP 1 (AP 2) is flashed for disconnect and can be cancelled by selecting Control G.1 to 'OFF'. If no AP engaged, audio warning and flashes until cancelled by AP disconnect.

For deliberate disconnect audio and flashes for 1.5 sec. When no AP engaged, no captions are displayed.

32. Flight Director Engagement 1/2

Caption FD 1(or FD 2)is displayed when selection is made on control B. (see item 25)

Indicates Flight Director engagement and guidance computer in use. When FD off, symbols are removed. FD may be engaged in any mode. With AP engaged and CWS (item 37) disengaged, AP control through previously selected FD mode. If FD not selected AP will operate in any selected mode.

33. Armed Lateral Mode

Caption indicates the lateral mode armed.

34. Active Lateral Mode

Caption (video inverted) indicates lateral mode active.

35. Armed Vertical Mode

Caption indicates the vertical mode armed.

36. Active Vertical Mode

Caption (video inverted) indicates vertical mode active.

37. Control Wheel Steering Engagement

Caption 'CWS' indicates Control Wheel Steering selected on control G.2 and gives CWS with AP in pitch and roll mode.

Note: This is the only way to obtain basic attitude mode.

38. Autothrottle Engagement

AT 1/2 is displayed when selection is made on control E.2.

39. Autothrottle Modes (video inverted)

a) Caption 'ARM' - indicates ARM 1/ARM 2 selected - control E.2. A/T speed engaged automatically at ALT capture.

b) Caption 'SPD' (video inv'td.) - SPD ACQ selected - control E.1. Acquires and holds SPD SEL value displayed on EADI (item 5)

c) Caption 'EPR' (video inv'td.) - EPR selected - control E.3. Controls to EPR limit selected.

When AT off, AT symbols removed.

40. Tuned Radio Frequency

Indicates frequency tuned on control K radio 1/2 or Auto-tune by Nav. computer.

For the EFI programme radio 1 was tuned manually and radio 2 by Auto-tune. Frequencies include VOR/DME or ILS.

41. Radio Designator

Indicates which radio is tuned (1 or 2) for the frequencies indicated in item 40.

A box enclosing 1 or 2 indicates the selected radio on control J.1.

42. Station Designator

Three alphas stored in the nav computer memory. Designates the station of the tuned frequency item 40 VOR or ILS.

Station designation replaced by crosses indicates VOR/ILS invalid/fail.

43. DME 1/2

Caption DME associated with tuned frequency, item 40 and numbers indicate distance to DME station (0.1 mile intervales below 99.9). Replaced by dashes when out of range.

44. ADF 1/2

Indicates ADF bearing (degrees) associated with pointer 1 (item 56) or pointer 2 (item 57) selected on controls J.4 and J.5.

Alphanumerics and pointer removed when ADF selected off, (i.e. button operation ADF-VOR-OFF).

Pointer removed when 'ANT' selected.

For the EFI programme the ADF stations were automatically designated and stored in the Nav. computer. No 'ANT' selection was available.

45. Time to Go

ETE is time to go to next WPT in tenth minute intervals.

46. Distance to Go

DIS is distance to go to next WPT in nautical miles (tenths below 99.9nm).

47. Ground Speed

GND SPD is existing ground speed in knots.

48. True Airspeed

TAS is true airspeed in knots.

Items 45 to 48 are displayed while NAV system (RAD or INS) is operating.

49. Compass Reference Marks

Reference for reading ROSE or MAP, MAG, or TRU analogue scales.

50. Compass Rose

Scale Marks - Large Marks every whole 10°

- Smaller marks every whole 5°

Numbered Marks - Every 30° (0 - 330°)

51. Lateral Deviation Scale

Scale - dots = ± 75 µA ± 150 µA.

Deviation indicated by beam bar on item 55.

With INS 1 or 2 selected (control J.2) Scale 1 dot = 3.75nm.

52. Aircraft Symbol

Origin of scale deviation reference marks.

53. Vertical Deviation

Scale - dots = ± 75 ± 150 ± 225 uA.

Moving index with caption as follows:-

a) Height Error (Alt. Acquire selected on control H.1)

Caption 'A' Scale 1 dot = 100 ft.

b) ILS tuned - control K. This overrides selection a).

Caption 'G' - Glideslope.

54. INS Selection

Selection of INS 1 or 2 - Control J.2 - indicated.

55. Index Pointer and Beam Bar

Operated by setting knob control C.

Bearing 'TO' - circle on point bar

Bearing 'FROM' - circle on reciprocal bar.

a) VOR tuned - control K.

RAD 1 or RAD 2 selected control J.1

Analogue of digital selected course. Number 1/2 in circle for VOR 1/2.

b) ILS tuned - control K.

RAD 1 or RAD 2 selected control J.1

Bearing to Localiser

'L' in circle for Localiser.

c) INS 1 or INS 2 selected - control J.2

Analogue of digital desired track. 'N' in circle for L.NAV waypoint.

Beam bar indicates deviation against scale item 51.

56. Bearing Pointer 1

a) VOR tuned - control K. VOR 1 selected control J.4

Pointer with 'V' in circle indicates VOR bearing obtained from RAD 1 system.

b) ADF tuned - Auto-tune only available.

ADF 1 selected - control J.4

Pointer with 'A' in circle indicates ADF bearing from ADF 1 system.

c) Waypoint: WPT selected - control J.4

Pointer with 'W' in circle indicates bearing to next WPT.

d) ILS 1 tuned. VOR 1 selected - control J.4

57. Bearing Pointer 2

a) VOR autotune only. VOR 2 selected - control J.5

Pointer with 'V' in circle indicates VOR bearing obtained from RAD 2 system.

b) ADF tuned - auto-tune only available.

ADF 2 selected - control J.5

Pointer with 'A' in circle indicates ADF bearing obtained from ADF 2 system.

The pointer may be removed by selecting 'OFF'.

58. Selected Heading Bug

Analogue of digital heading. Bug can be set on the compass rose by rotating the knob on control F. A digital reading is provided by item 30 in 'RAD' mode only. The bug is displayed in both 'RAD' and 'INS' modes and is visible on the Map format when within 25° of existing heading.

59. Drift Index

Indicates drift measured on heading scale. Range ± 15°.

60. Drift Marks

a) 'ROSE' selected - control J.3 - marks ± 10°

b) 'MAP' selected - control J.3 - marks ± 5°

61. Waypoint Alert

Next WPT number displayed up to 1 min. to go.

At 1 min. to go number changes to arrow L or R indicating direction of impending leg change flashing until change initiated.

62. Markers

Marker indications: a) A - Airways, b) O - Outer Marker,
c) M - Middle Marker

Flashed to standard frequency requirements.

63. Aircraft Symbol (Map)

Origin of reference marks and range rings.

64. Angular Marks

Fixed marks ± 30° ± 60° from aircraft position.

65. Range Rings

Five rings indicate range from present aircraft position, their value depending on the scale selected as follows:-

Without Weather Radar (not available):

The ring values are automatically selected according to altitude, the second ring being identified (Item 66)

i.e. Alt. above 15,200 ft.	- Range 40 nm.
Alt. 15,200 ft. to 10,200 ft.	- Range 20 nm.
Alt. 10,200 ft. to 5,200 ft.	- Range 10 nm.
Alt. below 5,200 ft.	- Range 5 nm.

66. Range Ring Scale

Indicates the scale selected. See item 65.

67. Compass Scale

Same indications as compass rose but scale expanded and limited to a range of ± 25° of existing indication. Numbered marks every 30°, Long marks every 10°, Short marks every 5°.

68. Map

Planned route is shown by lines between waypoints (indicated by stars) which move relative to the aircraft symbol according to aircraft position. A comprehensive set of symbols was planned but was not available for the EFI assessment. (Beacon - circle with designator alphas, VOR/DME Station - wheel with designator alphas, WPT - star with WPT No.).

22.4. EHSI Display Controls (Control J - Figure 62)

1. RAD 1/RAD 2

Operating 'RAD 1' or 'RAD 2' selects the source of the navigation data displayed by the Index Pointer and Beam Bar (Item 55).

With RAD selected Index Pointer indicates Selected Course and all headings, bearings, and courses given in degrees magnetic.

2. INS 1/INS 2

Operating 'INS 1' or 'INS 2' selects the source of the navigation data displayed by the Index Pointer and Beam Bar (item 55). With INS selected Index Pointer indicates Track and Beam Bar indicates Lateral Deviation off Track (nm.). All headings, bearings, and tracks are given in degrees true.

This control incorporates an 'OFF' position after the sequence of INS 1, INS 2, which removes pointer, beam bar, and deviation scale.

3. ROSE/MAP

Selects ROSE/MAP format in centre square.

4. ADF 1/VOR 1 (and WPT)

Operating 'ADF 1' or 'VOR 1' selects the data from radio 1 to bearing pointer 1 (item 56) on either the ROSE or MAP formats.

This control incorporates a 'WPT' selection after the sequence ADF 1, VOR 1, and bearing pointer 1 will indicate bearing to next waypoint. If this has not been programmed, the pointer is removed.

5. ADF 2/VOR 2

Operating 'ADF 2' or 'VOR 2' selects data from radio 2 to bearing pointer 2 (item 57) on either the ROSE or MAP formats.

This control incorporates an 'OFF' position after the sequence ADF 2, VOR 2, which removes the pointer.

For Controls 4 and 5 if either pointer is selected to 'VOR' when an ILS frequency is tuned, the pointer is removed.

22.5. Glareshield Controls (see Figure 62)

A. Altimeter

1. Pull to set DH, slew to set Baro. (not operative)
2. Baroset 1013.2/QNH/QFE - Operates digital indication (Item 16).

B. Flight Director

1. Display Selector Switch: Selects Command bars on EADI (Item 25).

   'ON' - both pitch and roll command bars displayed

   'ROLL ON' - roll command bars only displayed

   With F/D or Roll 'ON', caption displayed on EHSI (Item 32)

'OFF' - No Flight Director symbol displayed.

2. Synchronisation ('SYNC') - Synchronises pitch Flight Director with pitch hold modes.

C. Course Selection

1. Course Selector: Rotary slewing selector operates Index Pointer on EHSI (Item 55)
2. Turbulence Mode Selectors (Caption AP) (not operative): Push to engage turbulence mode.

D. Navigation Mode Selector

Six mode buttons:

1. APPR - Approach
2. V.Nav - Vertical Navigation (not operative)
3. L.Nav - Lateral navigation (e.g. area nav.)
4. Time Navigation (not operative)
5. V/L - VOR/Localiser
6. LAND - Automatic landing (not operative)

E. Autothrottle Selector

1. Speed Selector: Rotary slewing selector operates digital selected speed indication (Item 5). Pushing in the selector signals the selected speed to be acquired.
2. Autothrottle Selectors: ARM - sub-system available for use. Captions displayed on EHSI (Item 38)
3. EPR Selector - (Not operative)

F. Heading Selector

1. Heading Selector: Rotary slewing selector operates HDG bug on EHSI (Item 58). Pushing the selector signals the selected heading to be acquired.
2. Heading Mode Selector: Pushing in the selector selects Heading Hold.

G. Autopilot Selectors

1. Autopilot 1 OFF/ENGAGE Switches (AP 2 not operative).

When engaged, captions displayed on EHSI (Item 31).

2. Control Wheel Steering Selector: Switch in 'CAPT/FO' position, selects CWS, providing that AP is engaged. Caption displayed on EHSI (Item 37)

H. Pitch Mode Selector

1. Altitude Selector: Rotary slewing selector operates digital selected Altitude (Item 11). Pushing in the selector signals the selected Altitude to be acquired.

Pitch Mode Selectors:

2. ALT - Altitude Hold
3. IAS - Airspeed Hold
4. MACH - Mach No. Hold.
5. V/S - Vertical Speed Hold
6. FPA - Flight Path Angle Hold (not operative)

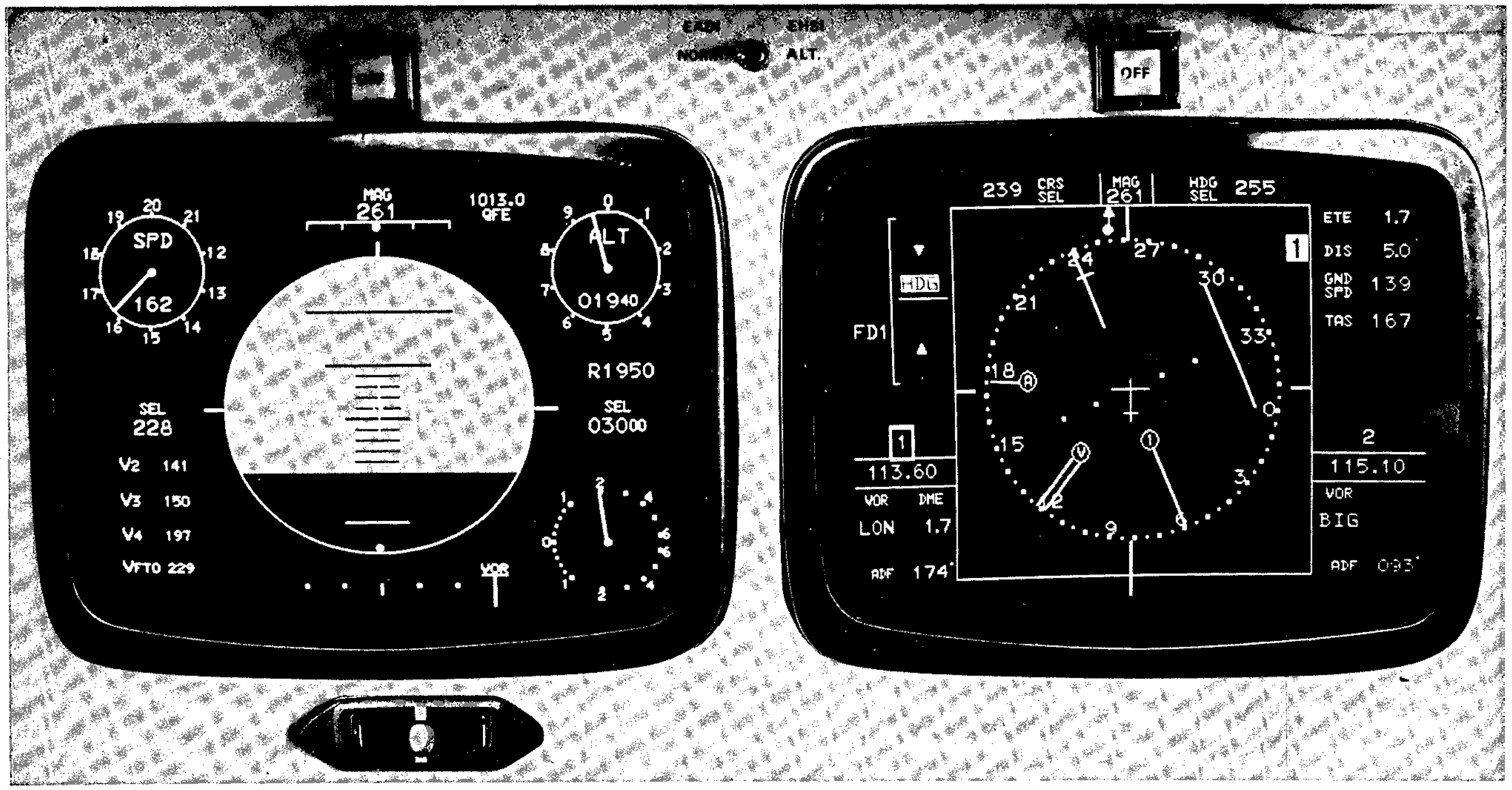
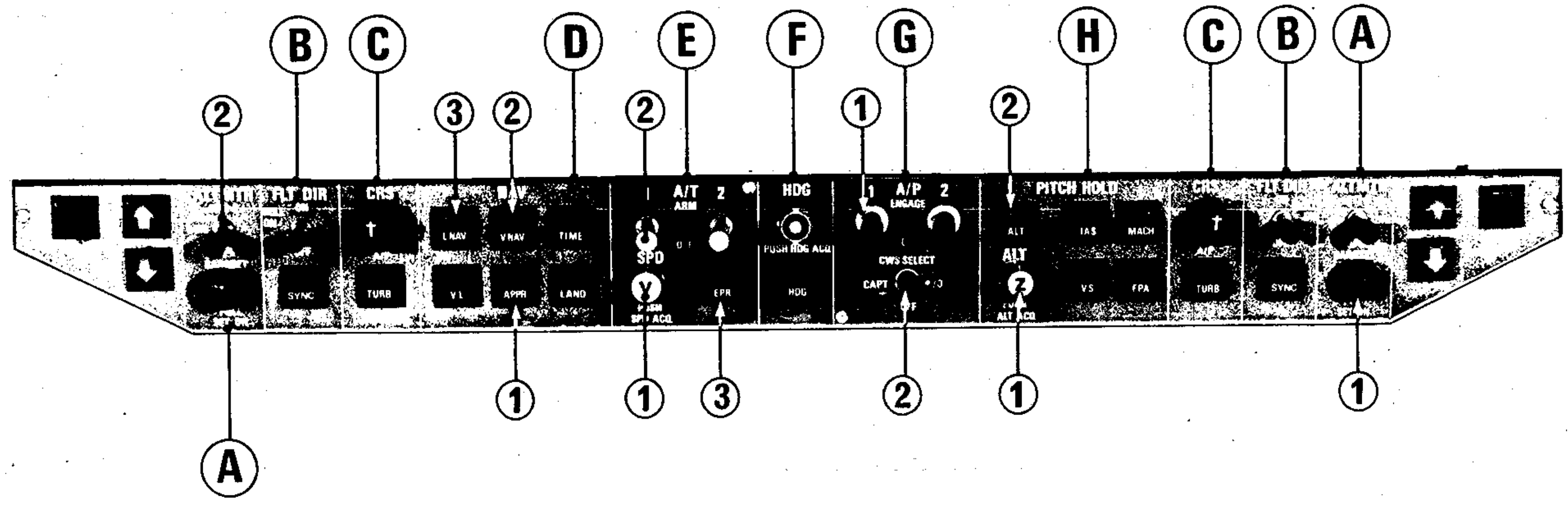


Figure 61

EADI

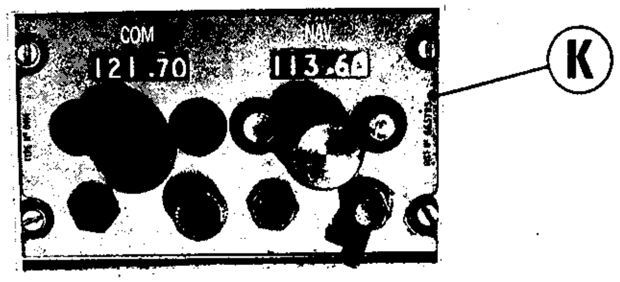
EHSI

CAPTAINS PANEL

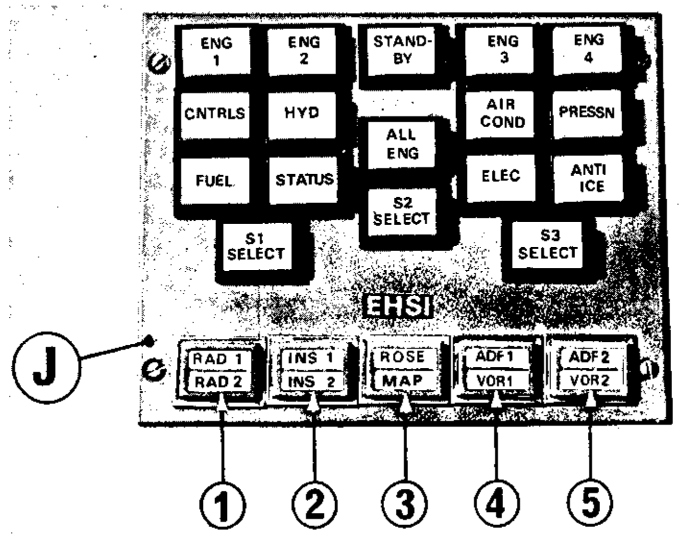


GLARE SHIELD CONTROLS

Figure 62



NAV/COMM FREQUENCY SELECTOR



DISPLAY CONTROLS

ASSOCIATED CONTROLS

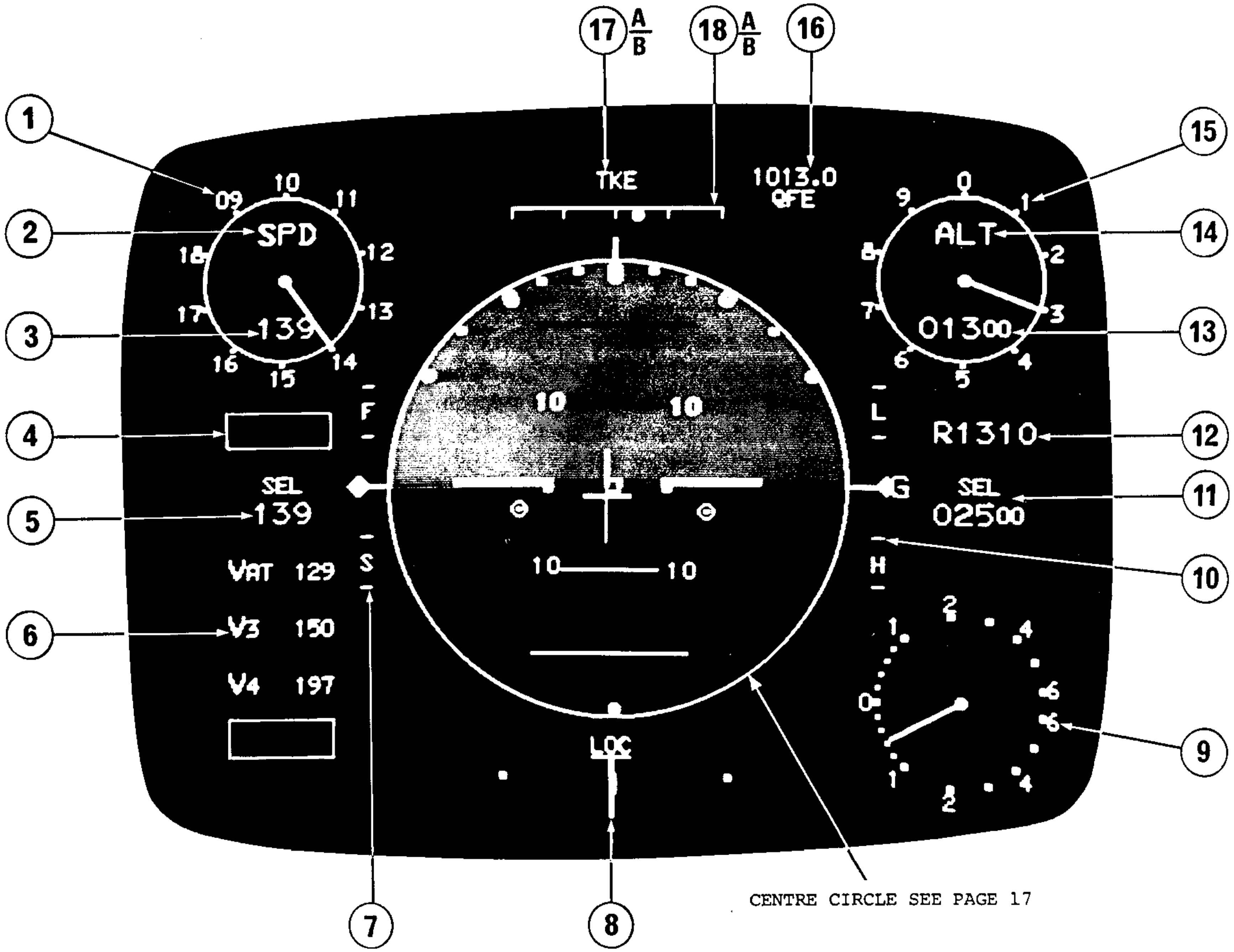
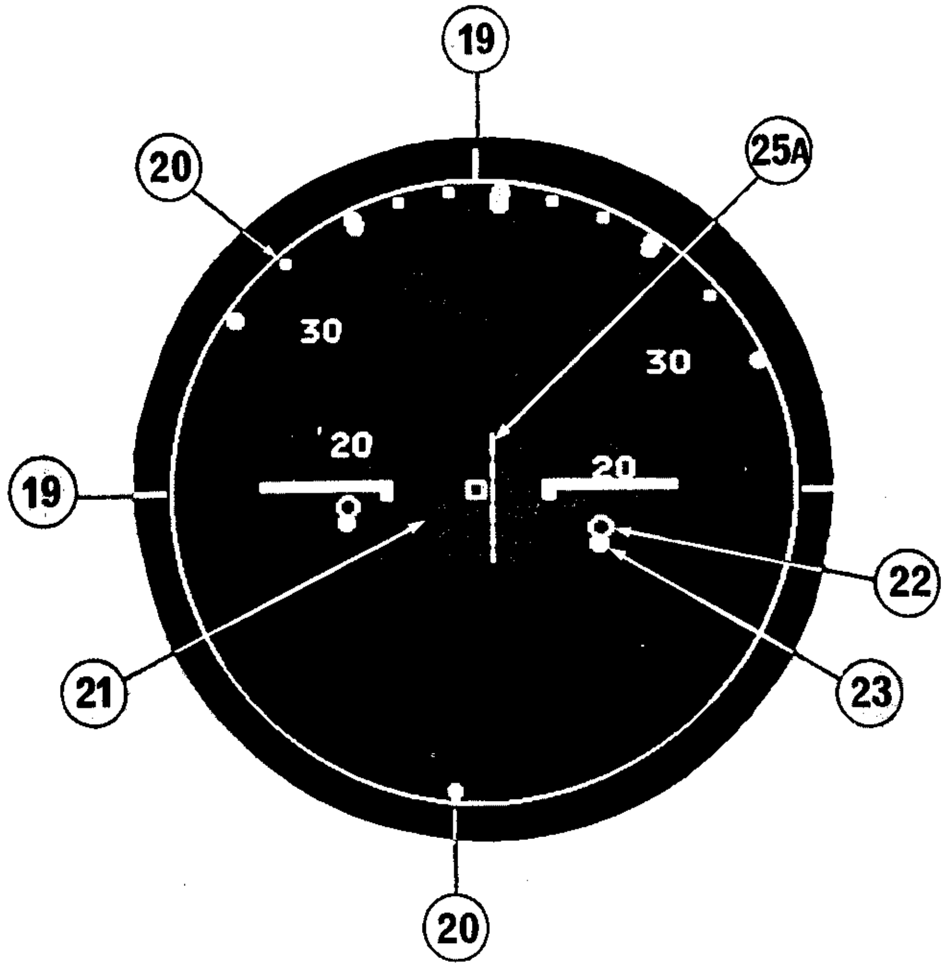


Figure 63

EADI



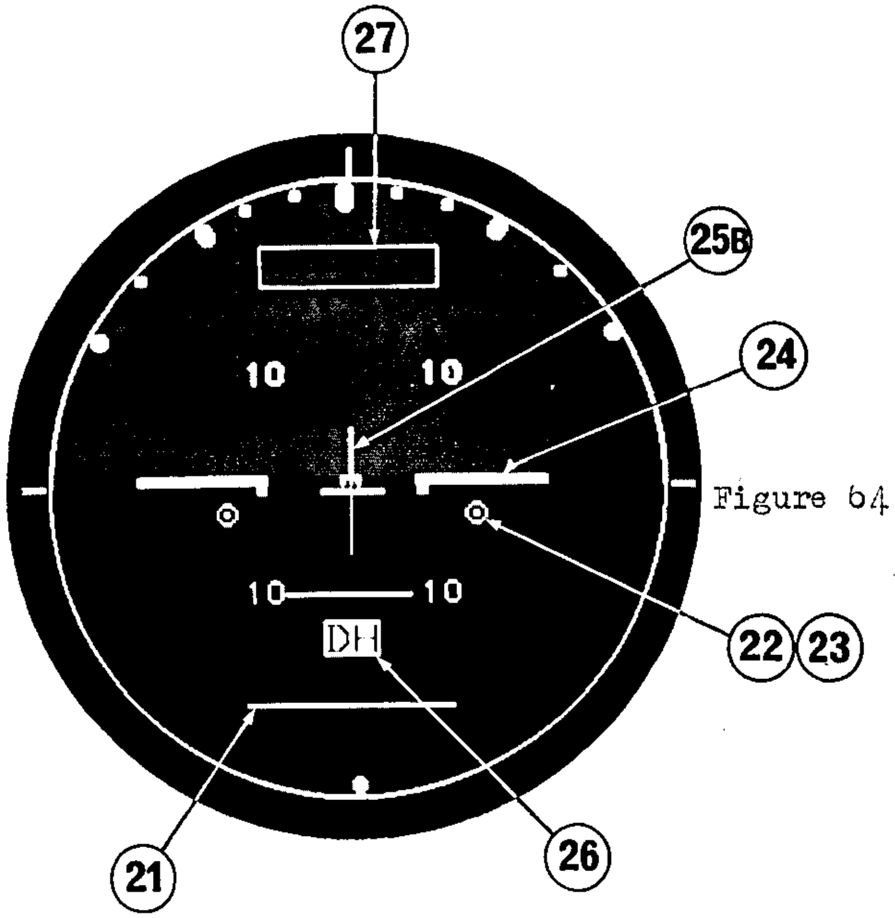


Figure 64

EADI CENTRE CIRCLE

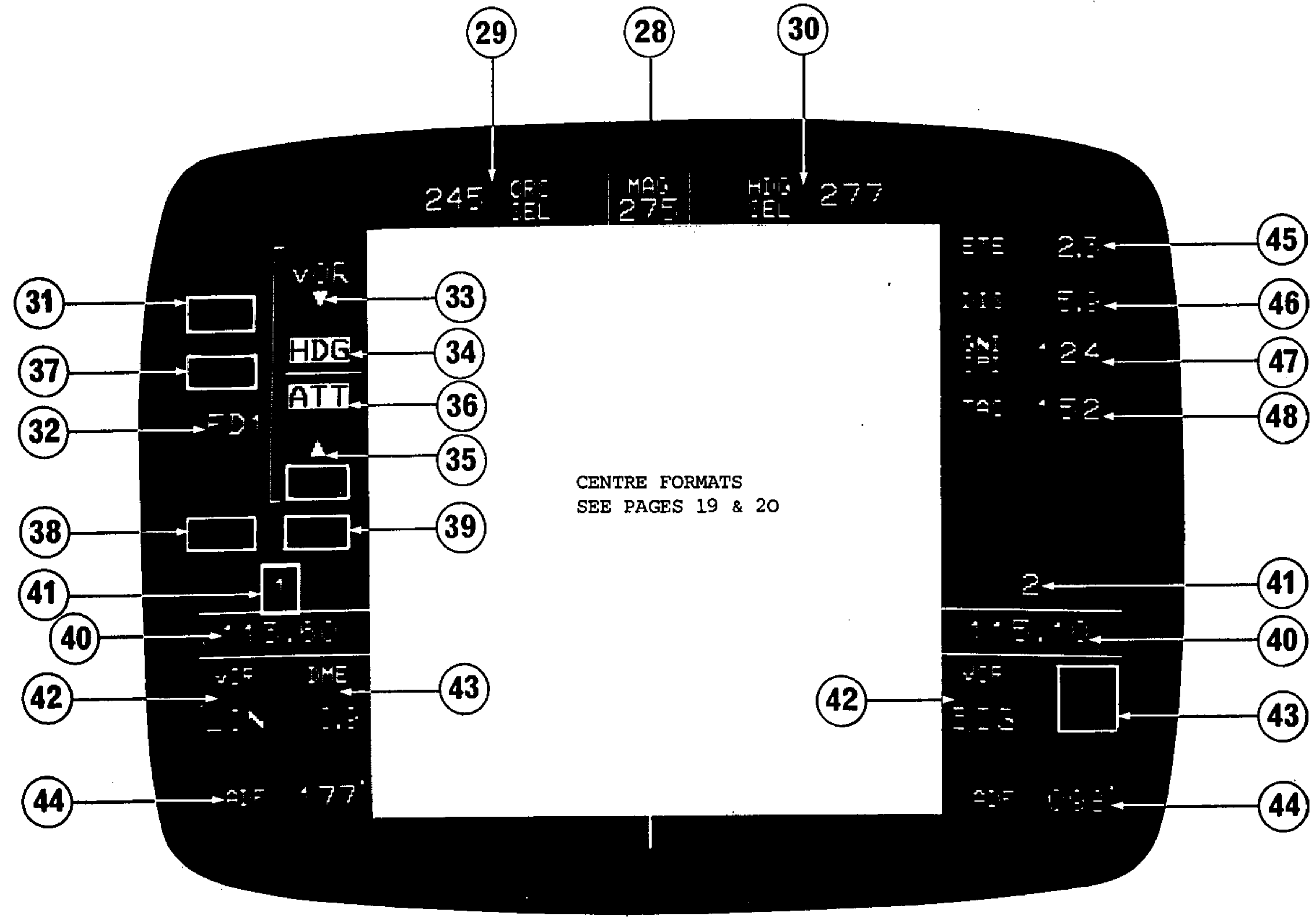


Figure 65

EHSI FIXED FORMAT

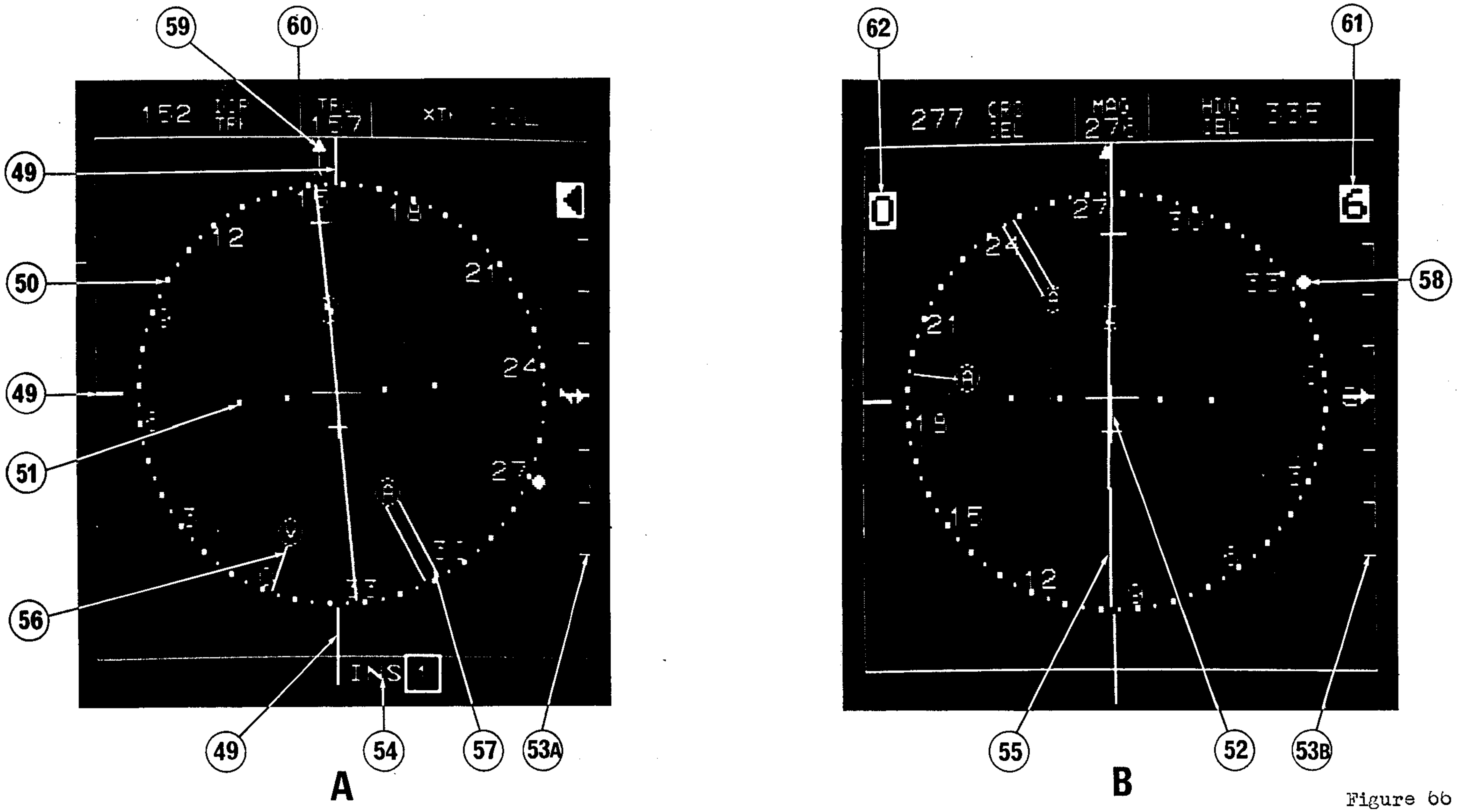


Figure 66

EHSI CENTRE FORMAT - COMPASS ROSE

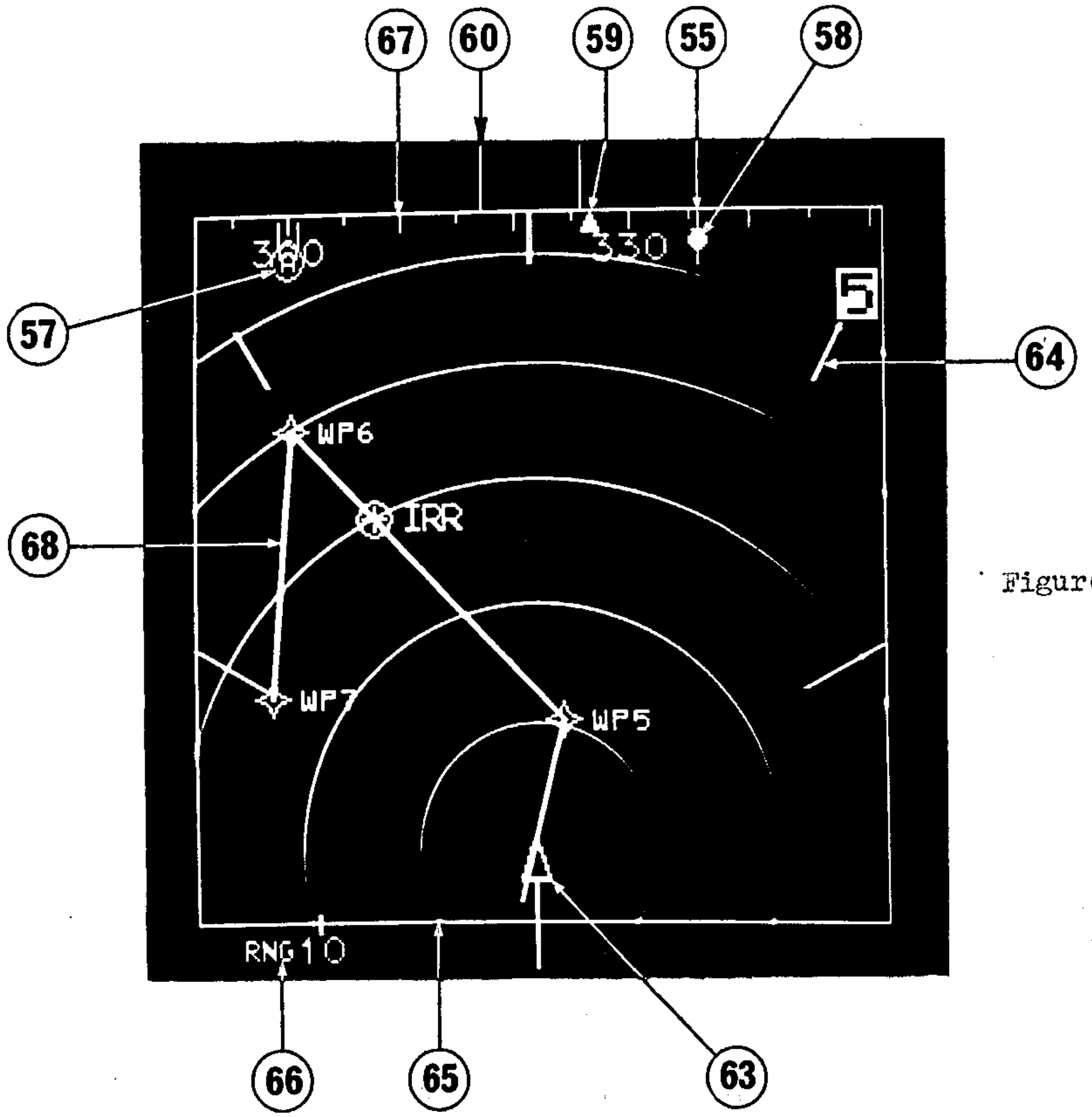


Figure 67

EHSI CENTRE FORMAT - MAP

CHAPTER 23

MONITORING AND RECORDING

23.1. Introduction

The monitoring and recording facilities used for the EFI Assessment were similar to those used for the Systems Evaluation (See Chapter 15).

23.2. Monitoring Team

23.2.1. General

The monitoring team consisted of two persons, the Resident Pilot and the Observer.

23.2.2. Resident Pilot

The Resident Pilot had the following tasks:

i) Briefing the Assessment Pilot on the Flight Deck.

ii) Handling of the throttles and secondary flying controls.

iii) Selection of Navigation and ATC frequencies.

iv) Operation of AFCS as appropriate.

23.2.3. Observer

The Observer had the following tasks:

i) Briefing, but not on the Flight Deck.

ii) Assisting with the briefing on the Flight Deck.

iii) Controlling the start and progress of the exercises.

iv) Keeping records of each flight.

v) Noting pilot actions and timing responses to requests for readings.

vi) Conducting the debriefings.

23.3. Monitoring Facilities

23.3.1. General

The Logs kept by the Observer and by the Computer were similar to those for the Systems Evaluation.

23.3.2. Timing

The Observer's watch was used to synchronise the two Flight Deck clocks and was used as the master time for the conduct of the exercises. Computer timing was started by the Observer operating an Ident button at "Brakes Off" for each exercise.

The pilots' responses were timed by a stop-watch.

23.3.3. Observer's Log

The log was kept in written form and supplemented by the use of a tape-recorder. Sample pages of the written log are shown in Figures 68 and 69. The tape-recorder was used as described in Para. 15.3.3.). The Observer's Log contained the following information:-

a) Date, Pilot's Name and Exercise Number

b) Simulator Deficiencies

c) Navigation details

d) Reading and Response Times

e) Pilots' and Observer's comments and tape ident.

f) Programme times

g) Other instructions.

The log sheets were used in conjunction with the computer printouts.

23.3.4. <u>Computer Printouts</u>

23.3.4.1. <u>PDP 11-45</u> (Flight Log)

This computer was programmed to print out out data automatically during flight and at additional points selected by the Observer from the Flight Deck. The recording points included Take-off, Waypoints, Localiser and Glideslope Acquisition, and Landing.

23.3.4.2. <u>PDP 11E10</u> (Exercise Log)

This computer was used to print out the following infomation in the form of display readings (see also sample page in Figure 70)

a) Item Number

b) Ident Number

c) Time in minutes and seconds from the first Ident (No. 000)

d) Computed Airspeed

e) Speed Error

f) Vertical Speed

g) Barometric Altitude

h) Radio Altitude

i) Pitch Angle

j) Bank Angle

k) Magnetic Heading

l) True Heading

m) Drift Angle

n) Localiser Deviation

o) Glideslope Deviation

p) Lateral Error

q) ADF 1 Bearing

r) ADF 2 Bearing

s) DME 1 Distance

t) Station 1 Identification Code

u) DME 2 Distance

v) Distance to Go to next Waypoint

w) Next Waypoint Number

x) Potential Flight Path Angle

y) Flight Path Angle

z) GPCU 1, GPCU 2, GPCU 3, GPCU 4, GPCU L, GPCU R. This was coded information giving the status of information on each format being shown to each pilot (e.g. Autopilot engaged, Map or Rose selected, etc.) For an explanation of the codes see Figures 71 (a), (b) and (c).

23.4. Questionnaires

A preprinted questionnaire was given to each pilot at the end of each day's flying, while he has still on the Flight Deck. The simulator was kept running while the pilots completed the questionnaires so that they could use the displays to assist them in answering the detailed questions. The questionnaire is described in Chapter 25.

23.5. Debriefing

Each pilot was given a short debriefing after he had completed his questionnaire. This debriefing was tape-recorded, but was only aimed at answering particular problems. A more comprehensive debriefing was given to each pilot at their place of work at a later date when more general questions were asked.

L.H.	PILOT	ADVANCED FLIGHT DECK - OBSERVER'S LOG	DATE 31-8-77
R.H.		EXERCISE 2d	SHEET 2
RIG DEFICIENCIES			CHECK LIST IN USE:

TIME	DIST TO GO SCHED	DIST TO GO ACTUAL	OBSERVER'S ACTION	IDENT	RDG CONFD	TIMES REQD	TIMES	TIMES	TIME	REMARKS
			"ARE YOU READY FOR Ex2d?"							
			"WHEN NAVIGATION IS RESET YOU WILL BE ON							
			COURSE 323° AT WPT 3							
			AT 8000' "AT 200 KTS(?)							
			"Ex 2d BEGINS NOW- STANDBY FOR RESET"							
			"BRAKES OFF"							
			753R RESET NAV (Ex2d)							
1158	25"		SIMULATOR FLYING	000	✓					A/P MODES: SEL HDG & ALT
	2/4		SPD:	032	✓					F/D PITCH: ✓ ROLL: ✓ A/T: ✓
	(WPT 4)								02¾	A/P out
			LEADING 8000'	034	✓					
			6000'	035	✓					
			2500'	036	✓					
			TAPE ON.		?					
	3/5		ASK FLT PATH ANGLE	037	1° UP	✓✓	1.7			Pilot "½°✓ up."
	(WPT 5)									
			ESTAB ON LOCALISER-HT:	041						

Figure 68

L.H.	PILOT	ADVANCED FLIGHT DECK - OBSERVER'S LOG	DATE 31-8-77
R.H.		EXERCISE 2d	SHEET 3
RIG DEFICIENCIES			CHECK LIST IN USE:

TIME	DIST TO GO SCHED	DIST TO GO ACTUAL	OBSERVER'S ACTION	IDENT	RDG CONFD	TIMES REQD	TIMES		TIME	REMARKS
	16/6		ASK PITCH ATTITUDE.	042	2° ✓ DN	✓✓	1.4			
			G/S INTERCEPT	043						
	12.5/6		ASK (FROM ATT DIR) LOCALISER DEVN	044	1/4 Dot L.	✓✓	1.1			Pilot "1/2 fly right." (Scaling error but right sense)
	10.5/6		ASK RADIO ALT	045	1890 ✓	✓✓	1.1			
			OUTER MARKER	046	✓					
	8/6		(= 10 PAST 5) ASK G/S DEVN FROM ATT. DIR. TAPE OFF	047	1/4 Dot HI	✓✓	2.9			
1215¼			TOUCH DOWN	050	✓					
1215	45"		BRAKES ON/ZERO GND SPD.	051	✓					
			"CARRY OUT AFTER LAND & SHUT DN CHECKS"							Briefing on Ferranti
18½			AFTER LAND CHECKS COMPLETE.	052						
			770 R GROUND POWER							
19¼			SHUT DOWN COMPLETE "END OF EX"	053						Looking at Ferranti.
1222			PILOT OFF DECK.							

Figure 69

Figure 70 Exercise Log

ITEM	IDENT	TIME	CAS	SPDERR	VS	ALT	RADALT	PITCH	BANK	MAG	TRUE	DRIFT	LOC	G/S	LAT
ADF1	ADF2	DME1	CODE1	DME2	DTG	WPNT	POTFPA	FPA	GPCU1	GPCU2	GPCU3	GPCU4	GPCUL	GPCUR	
00000	000000	000:00	0007	-0143	00000	00000	00000	-0000.9	00000	00275	00267	00014	-0002.9	-0002.9	0002.9
00173	00091	0001.5	LON	-0100.0	0007.2	000001	00054	-00140	000500	000100	000200	005001	040400	040400	
00001	000000	000:00	0014	-0136	00000	00000	00000	-0000.9	00000	00277	00269	00000	-0002.9	-0002.9	0002.9
00172	00091	0001.4	LON	-0100.0	0007.1	000001	00054	00000	000400	000000	000000	000001	044700	044700	
00002	000001	000:21	0104	-0047	00000	00000	00000	-0000.1	00000	00278	00270	00000	-0002.9	-0002.9	0002.9
00172	00091	0001.2	LON	-0100.0	0006.9	000001	00054	00000	000400	000000	000000	000001	044700	044700	
00003	000002	000:31	0140	-0010	00000	00000	00000	0000.1	00000	00278	00270	00000	-0002.9	-0002.9	0002.9
00171	00091	0001.1	LON	-0100.0	0006.7	000001	00014	00000	000400	000000	000000	000001	044700	044700	
00004	000003	000:33	0147	-0004	00010	00000	00000	0003.6	00000	00278	00270	00000	-0002.9	-0002.9	0002.9
00171	00091	0001.0	LON	-0100.0	0006.6	000001	00012	00000	000400	000000	000000	000001	044700	044700	
00004	000003	000:35	0149	-0001	00140	00010	00010	0013.6	-00001	00278	00270	00000	-0002.9	-0002.9	0002.9
00171	00091	0001.0	LON	-0100.0	0006.6	000001	00007	00002	000400	000000	000000	000001	044700	044700	
00005	000004	001:04	0144	-0006	04860	01520	01520	0019.0	-00001	00273	00265	-00001	-0002.9	-0002.9	0002.9
00169	00090	0000.9	LON	-0100.0	0005.9	000001	00017	00018	000400	000000	000000	000001	045700	045700	
00006	000005	001:42	0158	0007	03370	02740	02750	0014.9	00011	00283	00275	00001	-0002.9	-0002.9	0002.9
00166	00089	0001.6	LON	-0100.0	0004.9	000001	00009	00013	000400	000000	000000	000001	045700	045700	
00007	000006	002:09	0191	0040	00210	02940	02940	0004.4	00007	00287	00279	00003	-0002.9	-0002.9	0002.9
00164	00090	0002.3	LON	-0100.0	0004.4	000001	00005	00002	000400	000000	000000	000001	045700	045700	
00008	000007	003:59	0241	0090	03300	05010	03000	0008.2	00002	00273	00265	00000	-0002.9	-0002.9	0000.1
00153	00093	0006.9	LON	-0100.0	0004.1	000001	00005	00007	000400	000000	000000	000000	045700	045700	
00009	000010	004:49	0242	0091	02270	06530	03000	0007.0	00002	00280	00272	00000	-0002.9	-0002.9	0000.2
00148	00092	0009.4	LON	-0100.0	0005.5	000001	00005	00005	000400	000000	000000	000000	045700	045700	
00010	000012	005:50	0238	0087	01430	08510	03000	0004.5	00000	00275	00267	00000	-0002.9	-0002.9	0000.1
00142	00092	0012.4	LON	-0100.0	0008.0	000001	00005	00002	000400	000000	000000	000000	045700	045700	
00011	000014	006:41	0247	0096	02700	09800	03000	0006.5	00000	00278	00270	00000	-0002.9	-0002.9	0000.1
00138	00091	0015.1	LON	-0100.0	0010.5	000001	00005	00005	000400	000000	000000	000000	045700	045700	
00012	000015	006:49	0248	0097	01930	10010	03000	0001.3	-00001	00278	00270	00000	-0002.9	-0002.9	0000.1
00137	00091	0015.6	LON	-0100.0	0010.9	000001	00005	00001	000400	000000	000000	000000	045700	045700	
00012	000015	007:56	0315	0164	00290	09940	03000	0000.0	00001	00280	00272	00000	-0002.9	-0002.9	0000.0
00132	00091	0019.9	LON	-0100.0	0036.9	000002	00003	00000	000400	000000	000000	000000	045700	045700	
00013	000016	008:35	0340	0189	00290	10020	03000	-0000.1	-00004	00278	00270	00000	-0002.9	-0002.9	0000.0
00128	00091	0022.9	LON	-0100.0	0039.1	000002	00002	00000	000400	000000	000000	000000	045700	045700	
00014	000017	009:02	0329	0178	00540	10030	03000	0000.2	-00002	00275	00267	00000	-0002.9	-0002.9	0000.0
00126	00091	0025.0	LON	-0100.0	0040.7	000002	-00004	00001	000400	000000	000000	000000	045700	045700	
00014	000017	009:31	0309	0158	-02390	09620	03000	-0005.5	00000	00277	00269	00000	-0002.9	-0002.9	0000.0
00124	00091	0026.9	LON	-0100.0	0042.1	000001	-00007	-00005	000400	000000	000000	000000	045700	045700	
00014	000017	009:33	0008	-0142	-02170	00010	00010	0001.8	00000	00284	00276	00000	-0002.9	-0002.9	0002.9
00173	00091	0001.5	LON	-0100.0	0007.2	000001	00054	-00008	000400	000000	000000	000001	044700	044700	
00014	000017	009:37	0018	-0132	-01110	00000	00000	-0000.1	00000	00285	00277	00000	-0002.9	-0002.9	0002.9
00173	00091	0001.5	LON	-0100.0	0007.2	000001	00054	00006	000400	000000	000000	000001	044700	044700	

122833

CONTROL WORDS (CONWRD.TXT)

WORD	BIT	OCTAL	0	1
GPCU1				
	0	1		
	1	2		SHOW 'CMD'
	2	4		SHOW 'CWS'
	3	10		SHOW AUTO PILOT LEGEND
	4	20		SHOW 'AP1' & '2'
	5	40	SHOW 'AP1'	SHOW 'AP2'
	6	100		SHOW FLIGHT DIRECTOR LEGEND
	7	200	SHOW 'FD1'	SHOW 'FD2'
	8	400		SHOW AUTO THROTTLE LEGEND
	9	1000	SHOW 'AT1'	SHOW 'AT2'
	10	2000		SHOW 'SPD'
	11	4000		SHOW 'EPR'
	12	10000		SHOW DECISION HEIGHT DIGITS
	13	20000		SHOW V1,VR,V2 DIGITS
	14	40000		SHOW V3,V4,V5 DIGITS
	15	100000		SHOW VNE,VAT,V3 DIGITS
GPCU2 (PITCH HOLD MODES)				
	0	1		SHOW ' GS ' ACTIVE MODE
	1	2		SHOW 'ALT ' " "
	2	4		SHOW 'IAS ' " "
	3	10		SHOW 'MACH' " "
	4	20		SHOW ' VS ' " "
	5	40		SHOW 'FPA ' " "
	6	100		SHOW 'ATT '
	7	200		SHOW ' GS ' ARMED MODE
	8	400		SHOW 'ALT ' " "
	9	1000		SHOW 'IAS ' " "
	10	2000		SHOW 'MACH' " "
	11	4000		SHOW ' VS ' " "
	12	10000		SHOW 'FPA ' " "
	13	20000		SHOW 'ATT '
	14	40000		SHOW 'SYNC' PITCH MODE
	15	100000		SHOW 'SYNC' NAV. MODE

Figure 71 (a)

Explanation of Codes

GPCU3 (NAV. HOLD MODES)

0	1	SHOW 'VNAV' ACTIVE MODE
1	2	SHOW 'LNAV' " "
2	4	SHOW 'VOR ' " "
3	10	SHOW 'LOC ' " "
4	20	SHOW 'HDGS' " "
5	40	SHOW 'APPR' " "
6	100	SHOW 'LAND' " "
7	200	SHOW 'HDG ' " "
8	400	SHOW 'VNAV' ARMED MODE
9	1000	SHOW 'LNAV' " "
10	2000	SHOW 'VOR ' " "
11	4000	SHOW 'LOC ' " "
12	10000	SHOW 'HGDS' " "
13	20000	SHOW 'APPR' " "
14	40000	SHOW 'LAND' " "
15	100000	SHOW 'HDG ' " "

GPCU4

0	1		T/O MODE
1	2		APPR/LAND MODE
2	4	ADF1 RECEIVER ON	ADF1 RECEIVER OFF
3	10	ADF2 RECEIVER ON	ADF2 RECEIVER OFF
4	20	VOR1 SELECTED ON	ILS1 SELECTED ON
5	40	VOR2 SELECTED ON	ILS2 SELECTED ON
6	100		VOR1/DME1 FAIL
7	200		VOR2/DME2 FAIL
8	400	SHOW 'QFE'	SHOW 'QNH'
9	1000		PRESSURE = 1013.2
10	2000		ALT. WARNING
11	4000		REMOVE 2 DEG PITCH BARS
12	10000		
13	20000		
14	40000		WEATHER MODE 'ON'
15	100000	WEATHER MODE OFF	WEATHER MODE 'SBY'

Figure 71 (b)

Explanation of Codes

WORD	BIT	OCTAL	0	1
GPCUL/GPCUR				
	0	1	ROSE	MAP
	1	2		RAD & INS ALL SEL. OFF
	2	4	1	2
	3	10	RAD	INS
	4	20		WAYPOINT 'W'
	5	40		ADF1 & VOR1 SEL. OFF
	6	100	ADF1 SELECTED 'A'	VOR1 SELECTED 'V'
	7	200		ADF2 & VOR2 SELECTED OFF
	8	400	ADF2 SELECTED 'A'	VOR2 SELECTED 'V'
	9	1000	VOR POINTER INBOUND	VOR POINTER OUTBOUND
	10	2000		GLIDE SLOPE VERTICAL DEV. TUNED
	11	4000		ALTITUDE VERTICAL DEV. TUNED
	12	10000		VNAV. VERTICAL DEV. TUNED
	13	20000		LNAV. LATERAL DEV. TUNED
	14	40000		~~VOR LATERAL DEV. TUNED~~
	15	100000		LOCALISER LATERAL DEV. TUNED

Figure 71 (c)

Explanation of Codes

CHAPTER 24

PROGRAMME AND EXERCISES

24.1. Introduction

This part of the study was to evaluate the formats for the EADI and EHSI produced as a result of the consultations referred to in Para. 22.1.

The systems displays were used, but only to give the pilots enough information for the flying tasks. The displays were not evaluated apart from general comments on the presentations in association with the EFI's.

24.2. Programme

A single day's programme was arranged for each pilot which consisted of exercises to allow practice in flight handling using the EADI, simple navigation using the EFIs and measurement of the pilots' performance in achieving datum conditions.

The first flights were flown manually, but the autopilot and flight director were introduced at an early stage.

24.3. Timetable

The timetable that was aimed at for each pilot was as follows:

0915 Briefing on Programme (in Conference Room)

0930 Briefing on Formats and Controls (on Flight Deck)

1000 Exercise 1 - London Departure

1045 (Coffee)

1055 Exercise 2 - London Arrival

1145 Briefing on Navigation for Exercise 3

1155 Exercise 3 - London Circular

1300 (Lunch)

1400 Exercise 4 - Paris Departure

1420 Exercise 5 - Paris Arrival

1435 Briefing on Navigation for Exercise 6

1445 Exercise 6 - Paris Circular

1540 Discussion

1550 Exercise 7 (Optional)

1615 Questionnaire

1645 Debriefing

24.4. Navigation and Flight Planning

The navigation controls and indications are described in Chapter 22, but because of the limitations to the simulation a complete assessment was not possible.

A dual Nav/Comm comtroller was fitted on the left side of the Pedestal, aft of the throttles. Only the NAV selections were linked to the simulated navigation programme. The COMM frequencies could be selected, but were only used to give a representative workload, they were not linked to the simulation. With only one NAV selector the radio aids had to be arranged so that they could be tuned as a preflight action by the computer leaving only limited tuning required to be done by the pilots.

All ADF tuning was by the computers as ADF controllers were not fitted.

All the exercises were based on circular flights out of London (Heathrow) or Paris (Charles de Gaulle) airports and the navigation selections on these flights were identical to those used in the Departure and Arrival exercises where they were appropriate. INS navigation was used for the initial exercises, but the radio navigation was used for the circular flights and parts of the other exercises.

The INS programme for the flights was stored in the computer and selected from the Flight Deck by the Observer. No setting-up action was required to be done by the pilots.

24.5. Briefing

Briefing started immediately after the arrival of each Assessment Pilot and was in two parts:-

24.5.1. General Briefing

This was given by the Observer before the pilots went onto the Flight Deck. The pilots' knowledge of previously supplied data was ascertained and then a standard procedure adopted for the briefing. Few pilots had studied the supplied information beforehand making the relevance of such information questionable - this was taken into account in the briefings.

The objectives of the study and the exercises were explained whilst referring to the charts and navigational notes. A brief reference was made to the systems controls, dynamics of the simulator and the use of pre-recorded ATC.

The briefing concluded with a brief explanation of the methods of rating used in the Questionnaires (see Chapter 25).

24.5.2. Flight Deck Briefing

The briefing on the Flight Deck was given by the

Resident Pilot and was aimed at ensuring that the Assessment Pilots had an adequate working knowledge of the displays and controls to carry out the programme of exercises.

24.6. Exercises

Before starting the exercises, the Assessment Pilots were asked to ensure that their eyes were in the correct eye reference position (see Figure 72 and Table 6). Some pilots failed to maintain this position throughout the exercises. Each exercise is described in the following paragraphs, but should be read in conjunction with the figures at the end of this Chapter (Figures 73 to 83)

24.6.1. Exercise 1 - London Departure flights

This exercise was in three parts:-

24.6.1.1. Exercise 1b - Familiarization without Navigation. (see Fig. 73)

This exercise allowed the pilots to become familiar with the handling of the aircraft. It consisted of a take-off and climb straight ahead to 10,000 ft. The only requirement was that this was to be achieved in about 6 minutes. Some readings were requested in this flight:-

at 2500 ft - Vertical Speed
6500 ft - Airspeed
8000 ft - Pitch Angle
9500 ft - Heading

24.6.1.2. Exercise 1c - Departure using INS Navigation (see Fig. 74)

This exercise was part of the London

Circular flight plan with specified altitudes and rates of climb. It introduced a short period of navigation. To simplify the navigation task, the INS was programmed before take-off to automatically display the required indications. No selections were required by the pilots.

The following readings were also introduced:

4/1 Vertical Speed
19/2 Airspeed
17/2 Pitch Angle
13/2 Heading

24.6.1.3. <u>Exercise 1d</u> - Departure using Radio Navigation (see Fig. 75)

The route for this exercise was identical to Exercise 1c, but the pilots were required to use their own navigation with specified radio aids. Emphasis was placed on the indications displayed on the EHSI.

The readings requested were identical to those in Exercise 1c.

24.6.2. <u>Exercise 2</u> - London Arrival Exercises

This exercise was a descent from 8,000 ft to a landing and was divided into three parts:-

24.6.2.1. <u>Exercise 2b</u> - Familiarization without Navigation (see Fig. 76)

This exercise allowed time for the pilots to become familiar with the approach and landing of the aircraft. It consisted of a straight-in approach, intercepting the glideslope at 2,500 ft. and landing.

The following readings were requested:

3/5 Flight Path Angle

16/6 Pitch Angle

12.5/6 Localiser Deviation

10.5/6 Radio Altitude

8/6 Glideslope Deviation

24.6.2.2. Exercise 2c - Arrival using INS Navigation (see Fig. 77)

This exercise was part of the London Circular flight plan with specified altitudes and rates of descent. The INS programme was commenced at 8,000 ft. at an appropriate point on the route and the indications were automatically displayed until the ILS was selected. The flight finished with a landing.

The readings requested were identical to those in Exercise 2b.

24.6.2.3. Exercise 2d - Arrival using Radio Navigation (see Fig. 78)

The route for this exercise was identical to that for Exercise 2c except that the navigation was by using specified radio aids.

The readings requested were identical to those in Exercises 2b and 2c.

24.6.3. Exercise 3 - London Circular Flight (see Fig. 79)

The flight combined the take-offs and landings of Exercises 1d and 2d into a single circular flight of about 30 minutes duration. Radio navigation only was used. The use of the Autopilot and the Flight Director was decided by the Assessment Pilots. Checks and Drills where required were also done to give the pilots the opportunity of assessing the back-projected optical documentation display (see Chapter 27). ATC was used to add realism to the flight.

The following readings were requested.

4/1 Vertical Speed
19/2 Airspeed
17/2 Pitch Angle
13/2 Heading
8/2 QDM to Detling
3/2 Altitude
WPT2 Bank Angle and Rate of Turn
17/3 Lateral Nav. Error
14/3 True Heading
10.5/3 Range to Biggin
7/3 DME to Detling
3/5 Flight Path Angle
16/6 Pitch Angle
12.5/6 Localiser Deviation
10.5/6 Radio Altitude
8/6 Glideslope Deviation

24.6.4. Exercise 4 - Paris Departure using Radio Navigation (see Figure 80)

This exercise was part of the Paris Circular flight plan. The flight consisted of take-off and climb to 2,000 ft. and then level to Pontoise. After turning right from Pontoise the flight continued with a climb to 8,000 ft and the exercise terminated at Meru.

The following readings were requested:-

15/1 Radio Altitude
12.5/1 Drift Angle
10/1 Heading
7/1 Vertical Speed
4.5/1 Altitude

24.6.5. Exercise 5 - Paris Arrival using Radio Navigation (see Fig.81)

This exercise was the approach and landing part of the Paris Circular flight plan.. The flight started at 7,000 ft. outbound from Creil descending to a right turn to intercept the ILS and then a landing.

The following readings were requested:-

9/4 Lateral Nav. Error
6/4 DME to CDG
WPT4 Bank Angle and Rate of Turn
2/5 DME to RSY
15/6 Speed Error
13/6 Localiser Deviation
12/6 Glideslope Deviation
10/6 Flight Path Angle

24.6.6. <u>Exercise 6</u> - Paris Circular Flight using Radio Navigation (see Fig. 82)

Exercises 4 and 5 were combined into a single circular flight with a period of level flight at 8,000 ft. between. The flight used radio navigation, but the use of the Autopilot and the Flight Director was decided by the Assessment Pilots.

A demonstration of an Engine Fire situation was given before the flight to demonstrate the auto-recall of the required emergency drill on the Documentation displays (see Chapter 27). A systems failure was incorporated in Exercise 6, this was a DC Emergency Bus-bar Failure.

As in Exercise 3, checks, drills and ATC were included. The following readings were also requested:-

15/1 Radio Altitude
12.5/1 Drift Angle
10/1 Heading
7/1 Vertical Speed
4.5/1 Altitude
3/2 Altitude
WPT 2 Bank Angle
7/3 Flight Path Angle
3.5/3 True Heading
16/6 Potential Flight Path Angle
12/4 Pitch Angle
9/4 Lateral Nav. Error
6/4 DME to CDG
WPT 4 Bank Angle and Rate of Turn
2/5 QDM to RSY

15/6 Speed Error

13/6 Localiser Deviation

12/6 Glideslope Deviation

10/6 Flight Path Angle

24.6.7. Exercise 7 - Free Flying Period (see Fig. 83)

This was a period of about 20 minutes set aside fo the Assessment Pilots to repeat any parts of the programmed exercises for further examination of the indications on the displays. This was an optional exercise which was done either before or after answering the questionnaires. Eight pilots availed themselves of this exercise.

24.7. Questionnaires

These are fully described in Chapter 25.

24.8. Debriefings

Two debriefings were given to each pilot, one on the day of the exercises and another some time later.

24.8.1. Debriefing 1

This was a short debriefing held at the end of the day that the exercises were done. The Assessment Pilots were taken through their completed questionnaires by the Observer, with his notes, and photographs of the formats. The pilots were asked to comment on specific features including:-

a) Lateral versus Vertical scan

b) Readouts remote from selections

c) Display flicker

d) Pilots' eye fatigue

e) Pilots' general fatigue

f) Tunnelling effect of the displays

g) Cross-cockpit monitoring

The debriefing was tape-recorded for future reference in the analyses.

24.8.2. Debriefing 2

This debriefing was held at a later date and took the form of an interview, based on 43 specific questions. These questions are listed in Chapter 25. For reasons of non-availability of some pilots within a reasonable time of them doing the exercises only 13 pilots were given the second debriefing.

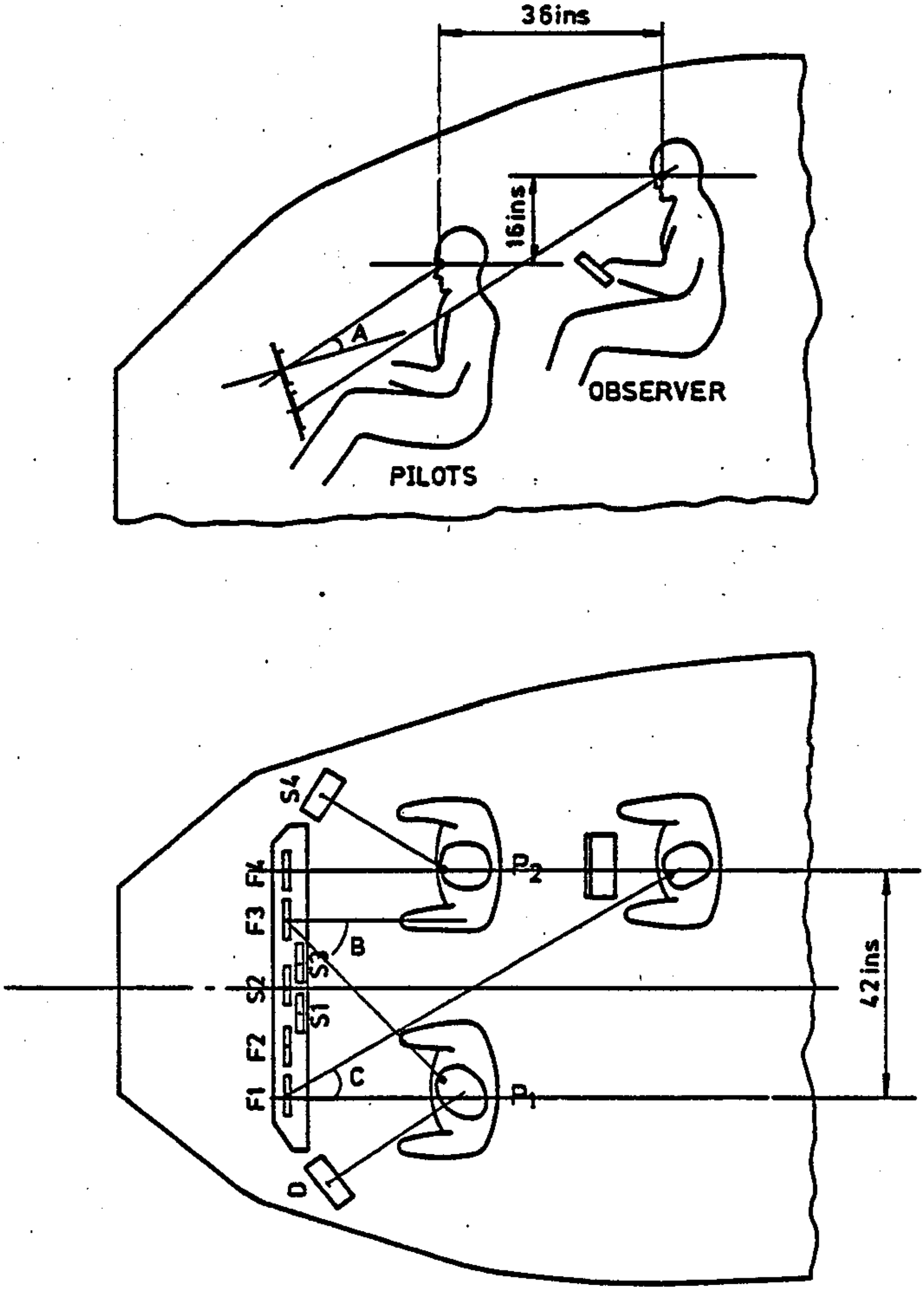


Figure 72

VISON ANGLES AND DISTANCES

Table 6

Vision Angles and Distances from Pilots

(P1) Position

Display	Distance ins	Angle A deg	Angle B deg
F1 EADI (P1)	31	15	0
F2 EHSI (P1)	32	14	18
F3 EHSI (P2)	45	11	51
F4 EADI (P2)	52	10	57
S1 Systems	38	26	33
S2 All Engines	37	12	38
S3 Systems	43	23	46
D1 Documentation (P1)	33	10	0 (head turned directly to display)

In the Observer's normal sitting position his eye was approx. 84 ins. fom the furthest display (F1) at approx. 30^{o} to the normal through the display (Angle C in the horizontal plane).

LIGHT PROCEDURE NOTES		EX 1B	FAMILIARISATION NO F/DIR OR AP		LONDON DEPARTURE	SHT 1

ITIAL SELECTIONS

		EADI SELECT	EHSI - SELECT
GEAR - DN	F/DIR - OFF	ALT - 3000	ROSE - HDG 277°
FLAPS - TO	AP - OFF	SPD - V2 + 10 (151)	RAD 1 - CRS 277°
TRIM - T/P	N2CMD - 93%	BARO - 1013.2	- PTR 1 VOR
			PTR 2 OFF

NAV. FREQ. TUNING - NOT REQUIRED

INITIAL LOCATION - LINED UP READY FOR TAKE OFF - BRAKES ON

RAKES OFF	EX. STARTS. CALL BRAKES OFF - STOPWATCH.
AKE OFF AND ITIAL CLIMB	TAKE OFF AND CLIMB - HDG 277°. N2 97% FOR 90 SECS THEN 93% AT V2 + 10 (151) LEVEL AT 3000 FT AND ACCELERATE WITH N2 93%. $\boxed{\text{V4 (197) RETRACT FLAPS AND SLATS}}$ $\boxed{\text{SPD SEL 250}}$ ACCELERATE CLEAN TO 250 KTS.
LIMB TO ,000 FT	CONTINUE CLIMB AT 250 KTS WITH N2 90% TO 10,000 FT. $\boxed{\text{ALT SEL 10,000}}$
,000 FT	LEVEL AT 10,000 FT AND INCREASE SPD TO VNE + 10 (350 KTS). EXERCISE COMPLETED WHEN VNE + 10 IS REACHED.

Figure 73

EX No. 1C Notes on SHT No. 2

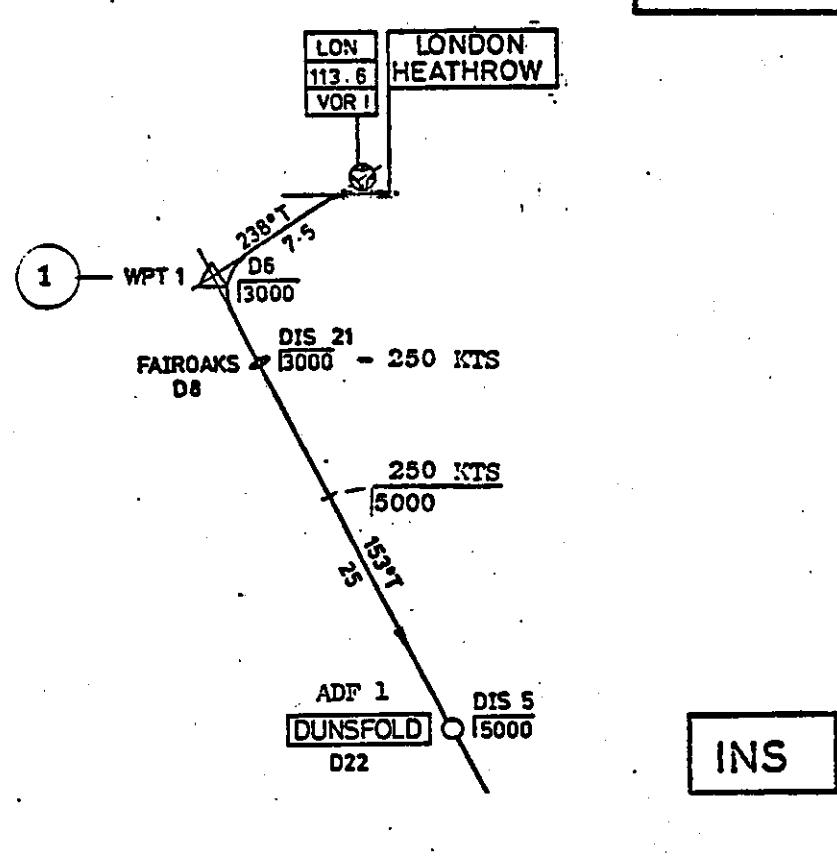


Figure 74 (a)

LIGHT PROCEDURE NOTES		EX 1C INS NAVIGATION F/DIR NO AP		LONDON DEPARTURE	SHT 2

ITIAL SELECTIONS | EADI SELECT | EHSI - SELECT

GEAR - DN
FLAPS - TO
TRIM - T/P

F/DIR - FD 1 (ROLL)
MODE - L.NAV.
N2CMD - 93%

ALT - 3000
SPD - V2 + 10 (151)
BARO - 1013.2

ROSE
INS 1/2
PTR 1 - ADF
PTR 2 - OFF

NAV. FREQ. AUTO TUNE ADF 1 401 DUN

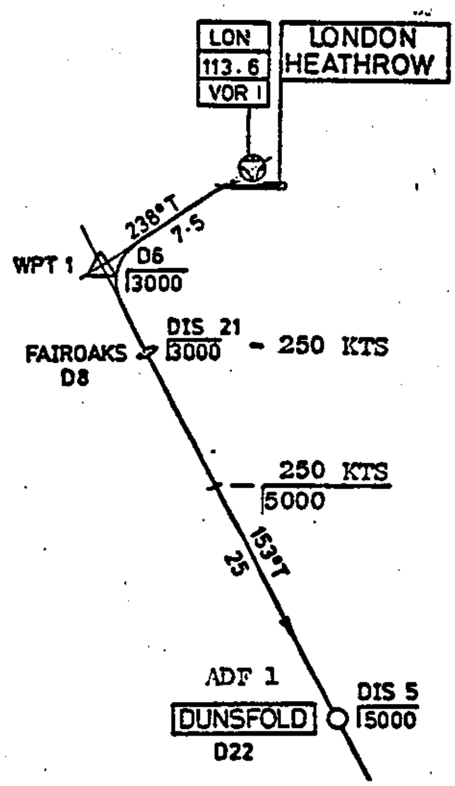
INITIAL LOCATION - LINED UP READY FOR TAKE OFF - BRAKES ON.

RAKES OFF	EX. STARTS. CALL BRAKES OFF - STOPWATCH.
AKE OFF AND ITIAL CLIMB	TAKE OFF AND CLIMB TO INTERCEPT TRK 238°T USING F/DIR.
	N2 97% FOR 90 SECS THEN 93% AT V2 + 10 (151)
	V4 (197) RETRACT FLAPS AND SLATS — SPD SEL 250
000 FT	INCREASE SPEED TO 250 KTS - LEVEL AT 3000 FT
PT 1	TURN LEFT MAINTAINING 3000 FT AND 250 KTS. N2 CLEAN AIRCRAFT 80%

(Contd. on SHT 3)

Figure 74 (b)

EX No. 1C Notes on SHT No. 3



INS

Figure 74 (c)

LIGHT PROCEDURE NOTES		EX 1C INS NAVIGATION (Cont.)		LONDON DEPARTURE	SHT 3

AIROAKS — CROSS FAIROAKS AT 3000 FT THEN CLIMB TO LEVEL AT 5000 FT. ALT. SEL. 5000

000 FT — MAINTAIN 5000 FT AT 250 KTS. N2 80% ON TRACK FOR WPT 2.

UNSFOLD DF 1 — END OF EXERCISE.

Figure 74 (d)

EX No. 1D Notes on SHT No. 4

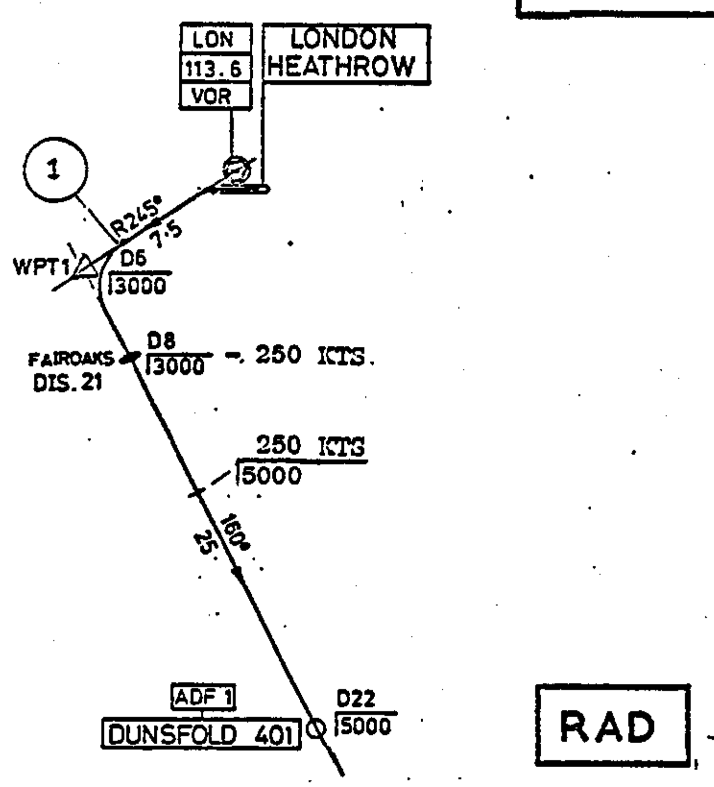


Figure 75 (a)

LIGHT PROCEDURE NOTES		EX 1D RADIO NAVIGATION AP		LONDON DEPARTURE	SHT 4

ITIAL SELECTIONS

		EADI SELECT	EHSI - SELECT
GEAR - DN	F/DIR - FD 1 (ROLL)	ALT - 3000	ROSE HDG 277°
FLAPS - TO	MODE - HDG/VL ARM	SPD - V2 + 10 (151)	RAD 1 CRS 245°
TRIM - T/P	N2 CLD - 93%	BARO - 1013.2	ADF 1 PTR 1 ADF
			PTR 2 OFF

NAV. FREQ. MAN. TUNE NAV 1 113.6 LON
AUTO TUNE ADF 1 401 DUN

INITIAL LOCATION - LINED UP READY FOR TAKE OFF - BRAKES ON

RAKES OFF	EX. STARTS. CALL BRAKES OFF - STOPWATCH.
AKE OFF AND NITIAL CLIMB	TAKE OFF AND INTERCEPT LON. R245 UNTIL LON. DME 6.
	N2 97% FOR 90 SECS THEN 93% AT V2 + 10 (151) INCREASE SPEED TO V4.
	V4 (197) RETRACT FLAPS AND SLATS / SPD SEL 250
000 FT	WHEN CLEAN INCREASE SPEED TO 250 KTS - LEVEL AT 3000 FT. TO FAIROAKS
ON DME 6 (1)	LEFT ONTO 160° (QDM DUNSFOLD) CLEAN AIRCRAFT N2 80%.

(Cont. on Sht 5)

Figure 75 (b)

EX No. 1D Notes on SHT No. 5

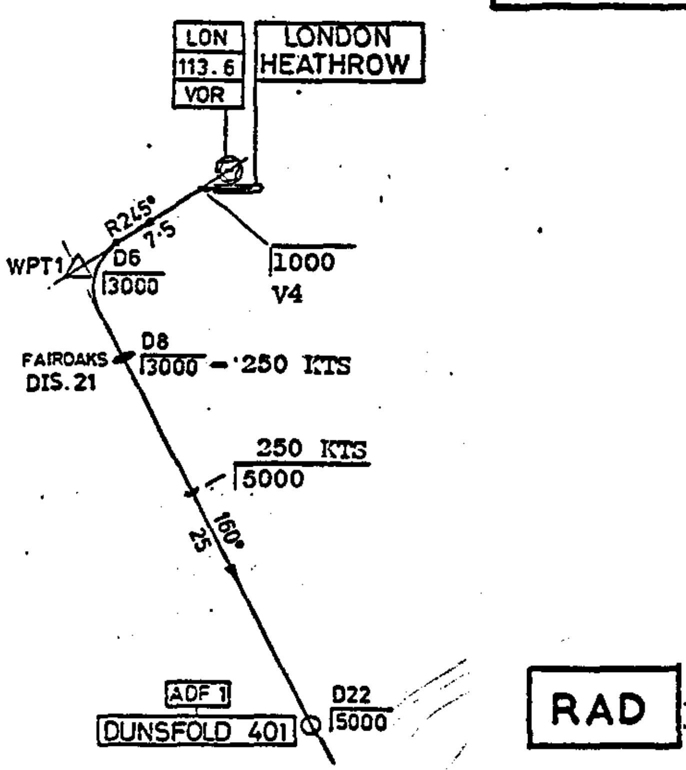


Figure 75 (c)

LIGHT PROCEDURE NOTES		EX 1D RADIO NAVIGATION (Cont,)		LONDON DEPARTURE	SHT 5

000 FT	CROSS FAIROAKS LON DME 8/R217 SPD 250 KTS.
LIMB	AFTER FAIROAKS CLIMB (N2 90%) TO LEVEL AT 5000 FT ALT. SEL 5000
000 FT	MAINTAIN 5000 FT AT 250 KTS. N2 80% QDM 160°
UNSFOLD ADF 1	END OF EXERCISE

Figure 75 (d)

EX No. 2B Notes on SHT No. 6

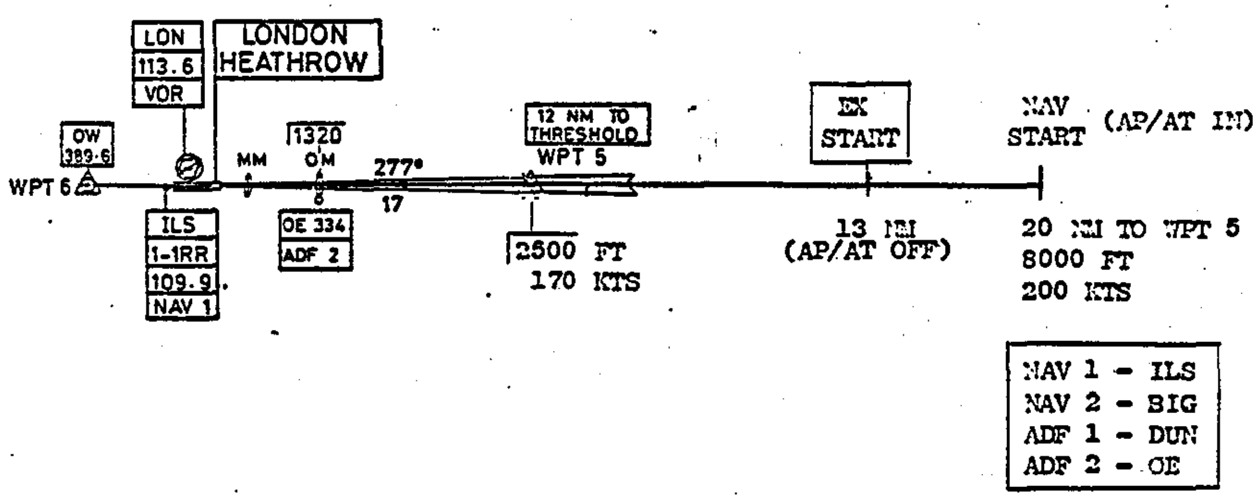


Figure 76 (a)

FLIGHT PROCEDURE NOTES		EX 2B FAMILIARISATION No. FD or AP		LONDON ARRIVAL	SH 6

INITIAL SELECTIONS

GEAR - UP
BRAKES - OFF
FLAPS - TO
TRIM - T/P

F/DIR - FD 1 ON
AP/AT - ENGAGED
MODE - HDG/ALT
N2 - 87%

EADI SELECT

ALT - 8000
SPD - 200
BARO - 1013.2

EHSI - SELECT

ROSE HDG - 277°
RAD 1 CRS 1 - 277°
PTR 1 - VOR = OFF
PTR 2 - OFF

NAV. FREQ. MAN. TUNE NAV 1 109.9 1-1RR
AUTO TUNE NAV 2 115.1 BIGGIN ADF 1 DUNSFOLD 401 ADF 2 OSCAR ECHO 334

INITIAL LOCATION 20 NM TO WPT 5 AT 8000 FT - IN LINE WITH ILS RWY 28R

NAV START	DISENGAGE AP/AT AND MAINTAIN 8000 FT AT 200 KTS HDG 277° N2 87%
EX. START	13 NM TO WPT 5 [SEL V/L] [ALT. SEL. 2500]
DESCENT	DESCEND ON LOCALISER AT 200 KTS (FLT. IDLE) THEN REDUCE SPEED TO 170 KTS AT 2500 FT - [APPR FLAP] [SEL. APPR MODE]
GLIDESLOPE	MAINTAIN 2500 FT AND REDUCE SPEED TO VAT + 10 [SPD SEL] BY GLIDESLOPE INTERCEPTION - [GEAR]
	DESCEND ON THE GLIDE. [LAND FLAP] LAND.
EX. END	CONTINUE STRAIGHT AHEAD TO A STOP - [BRAKES ON]

Figure 76 (b)

EX 2C Notes on page 7

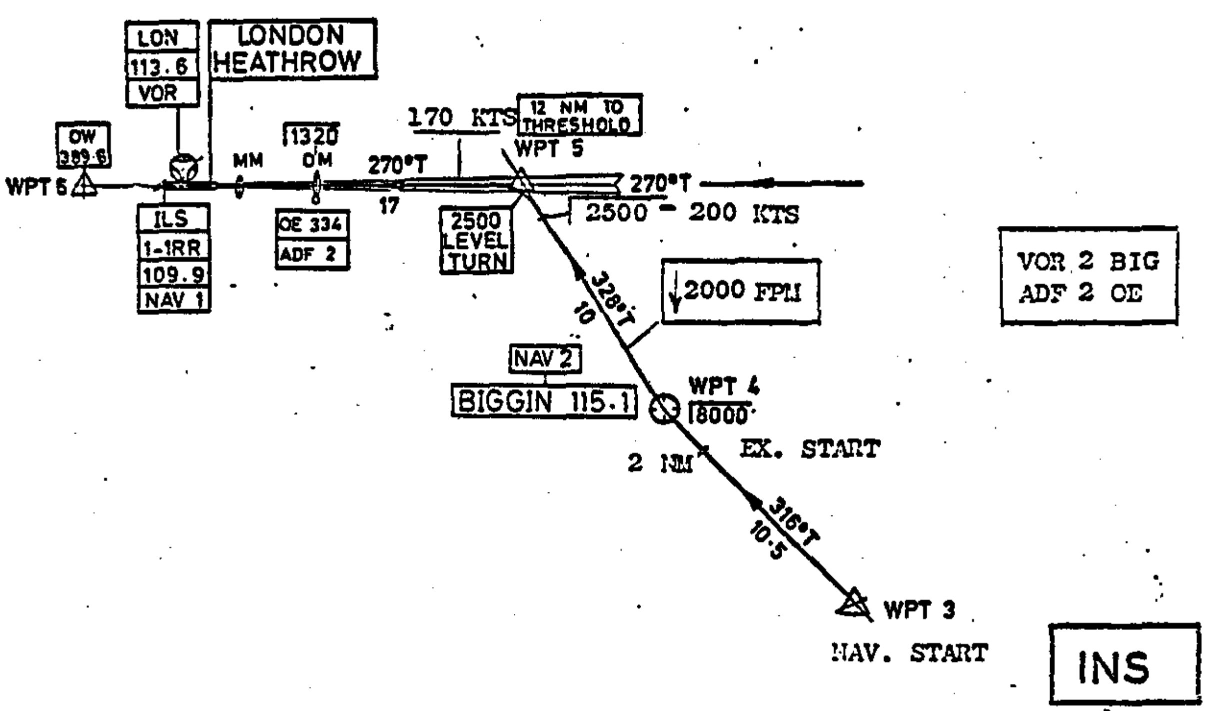


Figure 77 (a)

FLIGHT PROCEDURE NOTES		EX 2C INS NAVIGATION FD		LONDON ARRIVAL	SHT 7

INITIAL SELECTIONS

				EADI SELECT	EHSI - SELECT
GEAR	- UP	F/DIR	- FD 1 ON	ALT - 8000	ROSE
BRAKES	- OFF	AP/AT	- ENGAGED	SPD - 200	INS 1/2
FLAPS	- T.O.	MODE	- L.NAV/ALT	BARO - 1013.2	PTR 1 - WPT
TRIM	- T/P	N2	- 87%		PTR 2 - VOR

NAV. FREQ. MAN. TUNE NAV 1 109.9 1-1RR
AUTO TUNE NAV 2 115.1 BIGGIN ADF 1 401 DUNSFOLD ADF 2 334 OSCAR ECHO

INITIAL LOCATION AT WPT 3 ON TRK 316°T AT 8000 FT AT 200 KTS

NAV. START	DISENGAGE AP/AT AND MAINTAIN 8000 FT AT 200 KTS.
EX. START	2 NM TO BIGGIN (WPT 4) TRK 316°T - MAINTAIN 8000 FT/200 KTS.
BIGGIN	CROSS BIGGIN AT 8000 FT AND 200 KTS INTERCEPT TRK 328°T TO WPT 5 DESCEND AT FLT. IDLE TO 2500 FT [SEL ALT 2500] [SEL IAS + V/L] [SEL RAD 1] CRS 277°
2500 FT	TURN LEFT (CRS 277°) TO INTERCEPT LOCALISER MAINTAIN 2500 FT AND REDUCE SPD TO 170 KTS [SEL APPR] [APPR FLAP]
GLIDESLOPE	REDUCE SPD TO VAT + 10 (139) AT G.S. [GEAR] DESCEND ON THE GLIDE. [LAND FLAP] LAND.
EX. END	CONTINUE STRAIGHT AHEAD TO A STOP - [BRAKES ON]

Figure 77 (b)

Ex 2D Notes on SHT 8

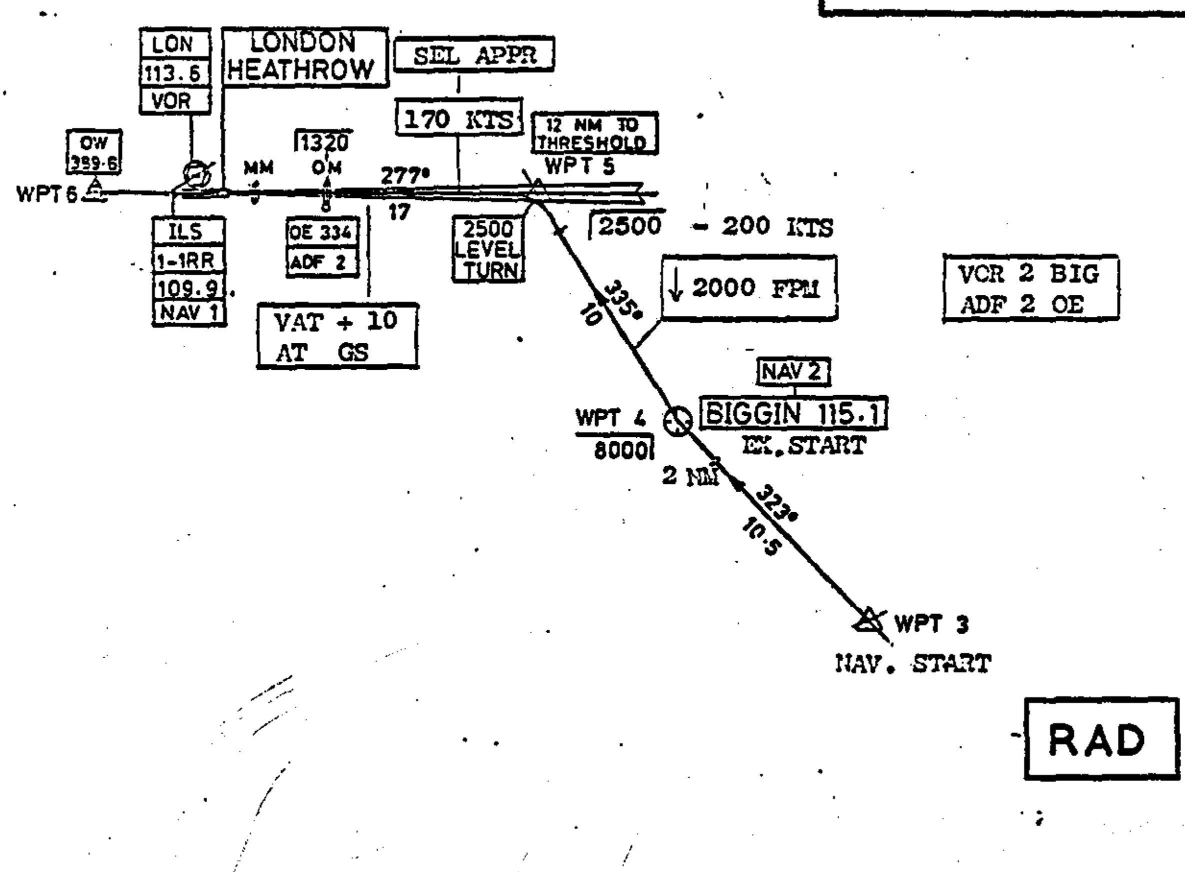


Figure 78 (a)

FLIGHT PROCEDURE NOTES		EX 2D RADIO NAVIGATION AP & FD		LONDON ARRIVAL	SHT 8

INITIAL SELECTIONS

				EADI SELECT	EHSI - SELECT
GEAR - UP	F/DIR - FD 1 ON	ALT - 8000	ROSE HDG - 323°
BRAKES - OFF	AP/AT - ENGAGED	SPD - 200	RAD 2 CRS 1 - 277°
FLAPS - T.O.	MODE - V/L + ALT	BARO - 1013.2	CRS 2 - 323°
TRIM - T/P	N2 - 87%		PTR 1 - WPT
			PTR 2 - VOR

NAV. FREQ. MAN. TUNE NAV 1 109.9 1-IRR
AUTO TUNE NAV 2 115.1 BIGGIN ADF 1 401 DUNSFOLD ADF 2 334 OSCAR ECHO.

INITIAL LOCATION AT WPT 3 ON CRS 323°M AT 8000 FT/200 KTS

NAV. START	DISENGAGE AP/AT AND MAINTAIN FL 80 AT 200 KTS.
EX. START	2 NM TO BIGGIN (WPT 4) CRS 323° - MAINTAIN FL 80/200 KTS.
BIGGIN	CROSS BIGGIN AT FL 80 AND 200 KTS INTERCEPT 335° OUTBOUND [SEL ALT 2500] [SEL IAS + V/L] DESCEND AT FLT. IDLE TO 2500 FT [SEL RAD 1]
2500 FT	TURN LEFT CRS 277° TO INTERCEPT LOCALISER. MAINTAIN 2500 FT AND REDUCE SPEED TO 170 KTS [SEL APPR] [SEL APPR FLAP]
GLIDESLOPE	REDUCE SPEED TO VAT + 10 (139) AT G.S. [GEAR] DESCEND ON THE GLIDESLOPE. [LAND FLAP] LAND.
EX. END	CONTINUE STRAIGHT AHEAD TO A STOP - [BRAKES ON] COMPLETE AFTER LAND AND SHUT DOWN CHECKS.

Figure 78 (b)

Ex 3 Note on SHT 9

LONDON CIRCULAR 1

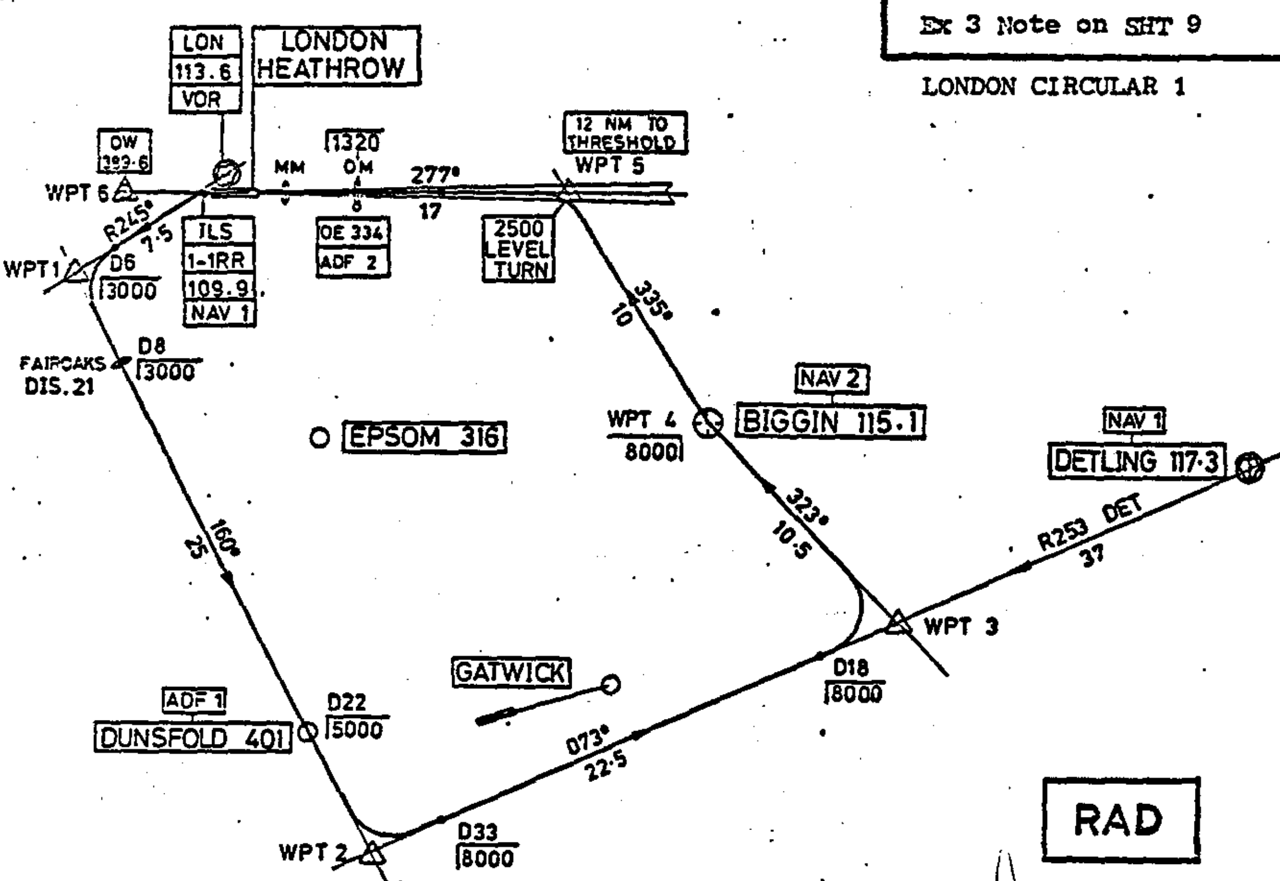


Figure 79 (a)

FLIGHT PROCEDURE NOTES		EX 3 RADIO NAVIGATION AP & FD		LONDON CIRCULAR 1.	SHT 9

INITIAL SELECTIONS

				EADI SELECT		**EHSI SELECT**	
GEAR	- DN	F/DIR	- FD 1 (ROLL)	ALT	- 3000	ROSE	HDG 277°
FLAPS	- TO	MODE	- HDG/VL ARM	SPD	- V2 + 10 (151)	RAD 1	CRS 1 245°
TRIM	- T/P	N2CMD	- 93%	BARO	- 1013.2		PTR 1 ADF
							PTR 2 OFF

NAV. FREQ. MAN. TUNE NAV 1 113.6 LON
AUTO TUNE ADF 1 401 DUN, NAV 2 115.1 BIG, ADF 2 334 OSCAR ECHO

ATIS QNH 1019. QFE 1016

INITIAL LOCATION PARKED ON STAND, ENGINES SHUT DOWN, BRAKES ON.

ENG. START PRE FLIGHT CHECKS
1 - 32

CALL LON. TWR. 121.7

176 - READY FOR LON. CIRC AS PLANNED

176 - Cross FAIROAKS at 3000 (1)
DUNSFOLD at 50
Onward clearance from
GAT. APP 119.6
Clear to start

176 - CLEARED NON-STANDARD DEPT.
ETC., ETC.

START DRILL
1 - 29

176 - Correct - Contact GND (2)
CTRL 121.9 for TAXI

176 - ROGER

Figure 79 (b)

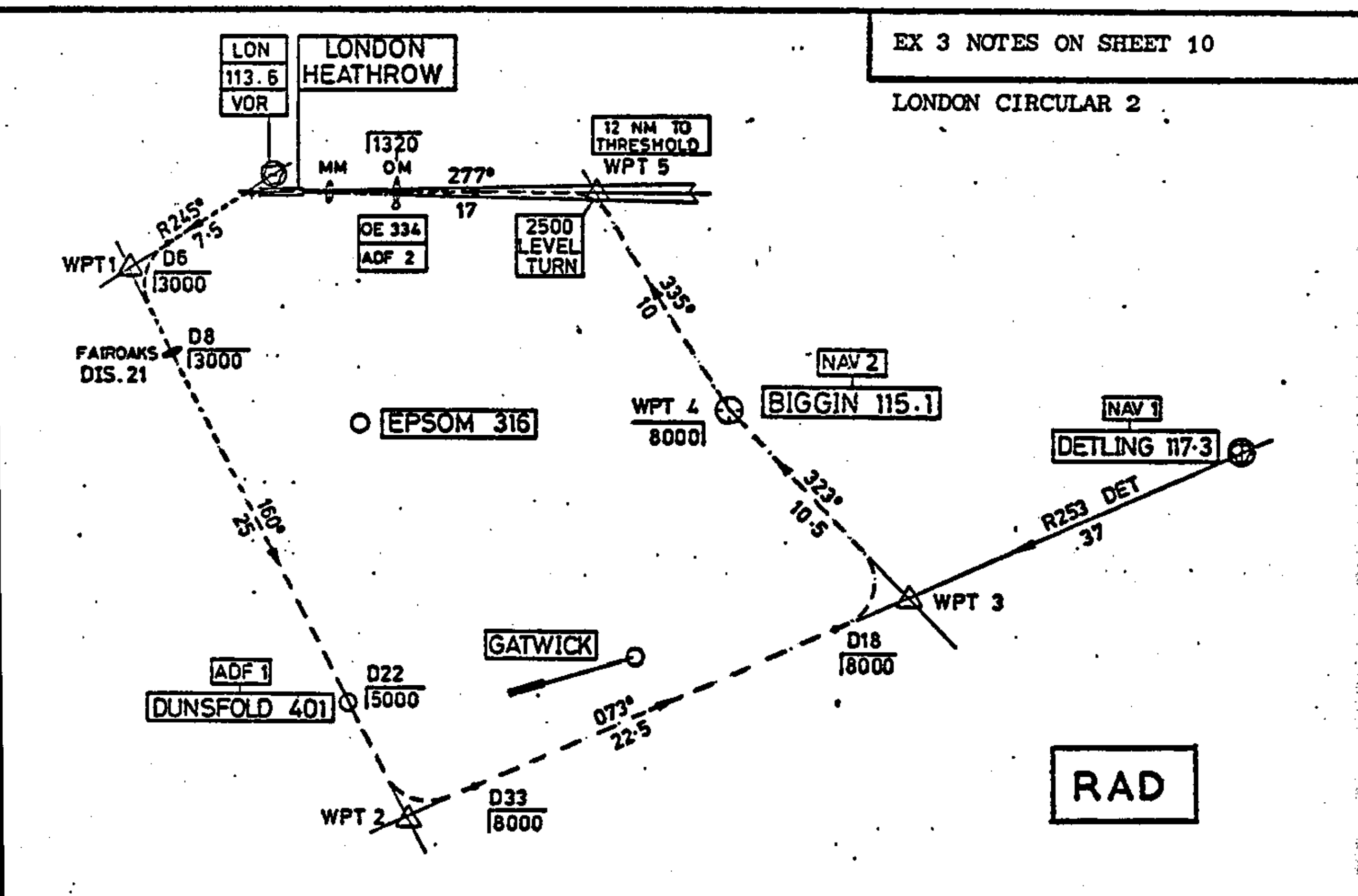


Figure 79 (c)

LIGHT PROCEDURE NOTES		EX 3 RADIO NAVIGATION (Cont)		LONDON CIRCULAR 2.	SHT 10

TAXI CHECKS
1 - 10

CALL GND 121.9

176 - READY TO TAXI
176 - Cleared BLK 18 RWY 28R (3)
176 - ROGER ETC.
176 - Correct - LON CTRL 132.05 (4)
176 - 132.05
176 - Call TWR 118.7 for take off (5)
118.7

CALL TWR 118.7

176 - BLK 18 READY FOR TAKE OFF
176 - Clear for take off WIND 270 8 KTS (6)
176

KE OFF EFING

AKES OFF — CALL BRAKES OFF - STOPWATCH.

KE OFF AND IMB TO 00 FT — TAKE OFF AND INTERCEPT LON R.245 UNTIL LON DME 6.
N2 97% FOR 90 SECS THEN 93% AT V2 + 10 (151).
INCREASE SPEED TO V4.

176 - Airborne - contact LON CTRL (7)

TER T.O. ILLS — V4 (197) RETRACT FLAPS & SLATS | SPD SEL 250

CALL LON 132.05

WHEN CLEAN, INCREASE SPEED TO 250 KTS LEVEL AT 3000 FT. TO FAIROAKS.

176 - OUTBOUND FOR RETURN TO HEATHROW
176 - Report passing 3000 (8)
176 - WILCO

Figure 79 (d)

EX 3 NOTES ON SHEET 11

LONDON CIRCULAR 3

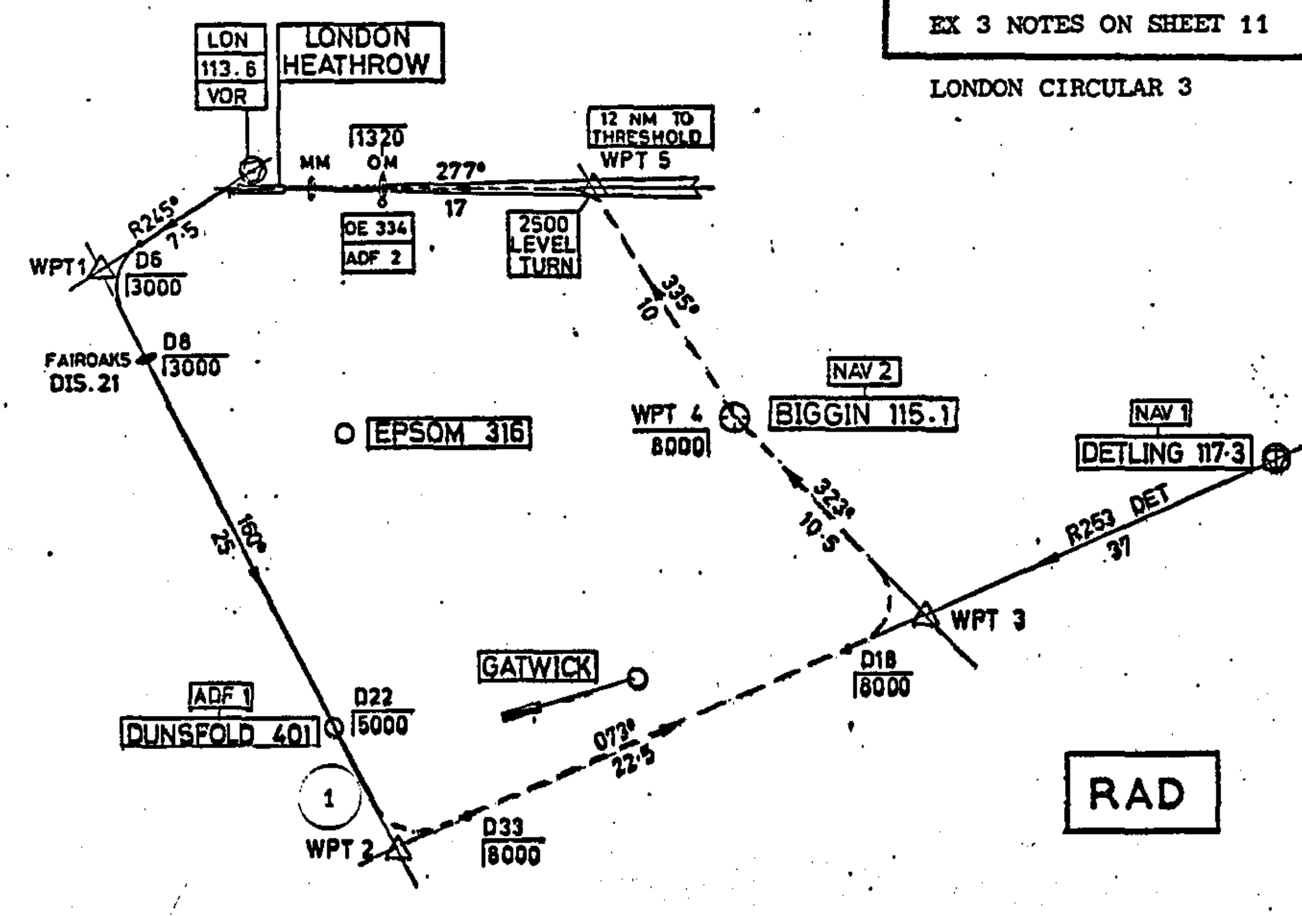


Figure 79 (e)

ON. DME 6	LEFT ONTO 160° (QDM DUNSFOLD) CLEAN AIRCRAFT N2 80%	CALL 132.05 LON
PT 1 PT 2	P2 OPTION RCSE OR MAP	176 – AT 3000 LON DME .... 176 – ROGER, FL 50 CHANGING TO 119.6
AIROAKS	CROSS FAIROAKS LON DME 8 SPD 250 KTS.	170 – After Fairoaks Cleared DUN at FL 50 Call GAT 119.6 (9)
LIMB	AFTER FAIROAKS CLIMB AT 250 KTS AND LEVEL AT 5000 FT ALT SEL 5000 N2 90%	CALL 119.6 GAT 176 – PASSING .... FOR 50 DUN AT .... 176 – After DUN continue as planned. Recleared BIG at FL 80. Report leaving 50. (10) 176 – WILL REPORT LEAVING 50.
000 FT	MAINTAIN 5000 FT AT 250 KTS N2 80% QDM 160°.	
UNSFOLD	CROSS DUNSFOLD AT 5000 FT THEN CLIMB TO 8000 FT AT 250 KTS. N2 93% ALT SEL 8000 MAN TUNE NAV 1 TO 117.3 DETLING FD 1 PITCH & ROLL SEL HDG HOLD SEL IAS HOLD SEL ALT. ACQ	CALL 119.6 GAT 176 – DUNSFOLD AT .... LEAVING 50 FOR 80 176 – Report reaching FL 80 (11)
1		

Figure 79 (f)

EX 3 NOTES ON SHEET 12

LONDON CIRCULAR 4

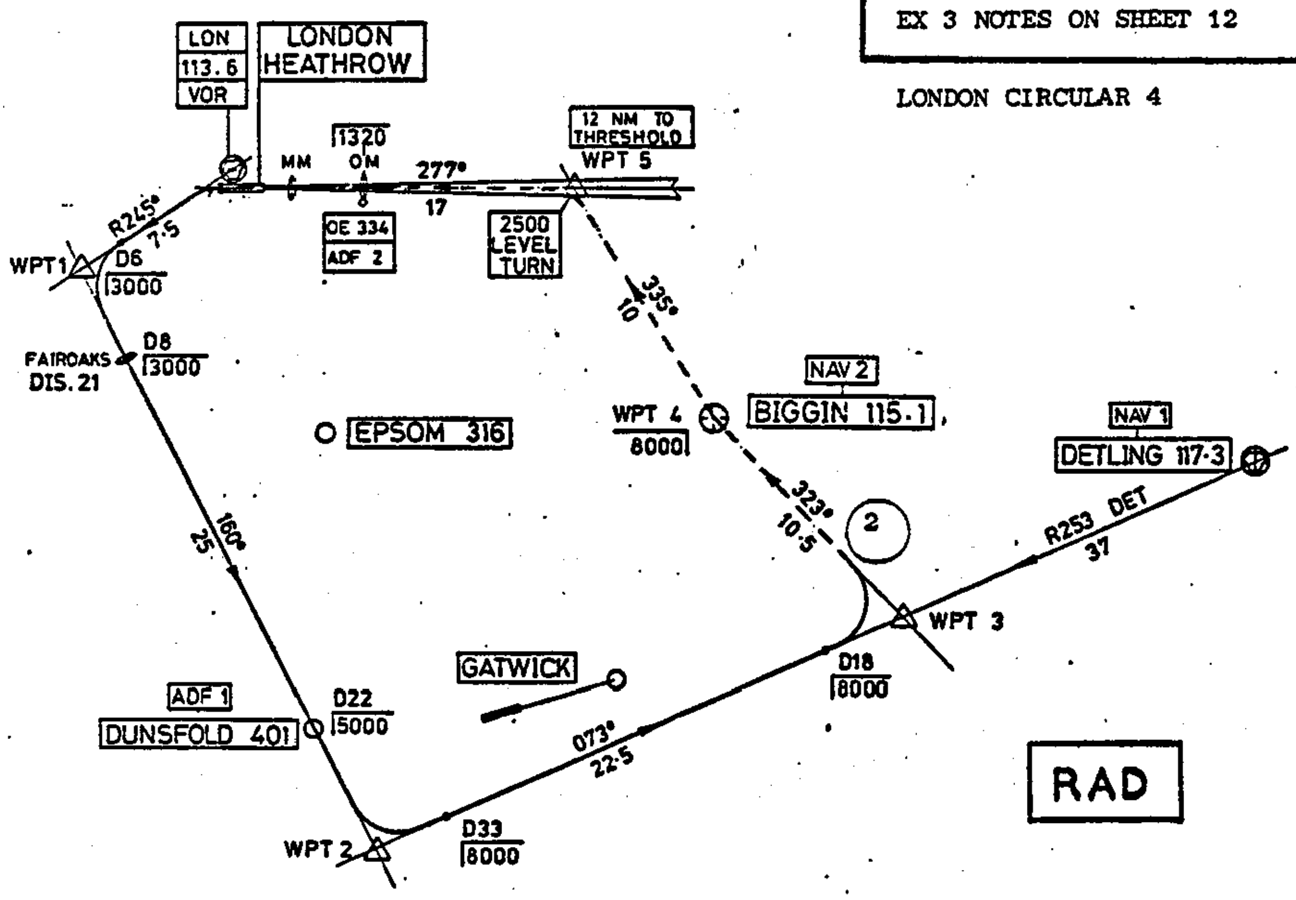


Figure 79 (g)

FLIGHT PROCEDURE NOTES		EX 3 RADIO NAVIGATION (Cont)		LONDON CIRCULAR 4.	SHT 12

PT 2 PT 3 ON DME 29	INTERCEPT CRS 073° REACH FL 80 BY DME 33 DET	
L 80	LEVEL AT 80 250 KTS N2 80% SEL MAP UNTIL ROSE INSTRUCTED	CALL 119.6 GAT 176 AT FL 80 176 - Maintain FL 80 Rep. Est. on TRK for BIG. (12) 176 WILL REPORT EST. INBOUND BIGGIN
ME 25 DET	MAINTAIN FL 80 AT 250 KTS. HDG SEL 073 SEL RAD 2 SEL CRS 2 323°	
ME 18 DET	INTERCEPT CRS 323° SEL ROSE	ATIS
IS 7 BIGGIN 2	REDUCE SPEED TO 200 KTS BY BIGGIN SPD SEL 200	CALL 119.6 GAT 176 - ESTB. INBOUND TO BIGGIN 176 - Cont. with LON. APP. 119.2 (13) 176 - 119.2

Figure 79 (h)

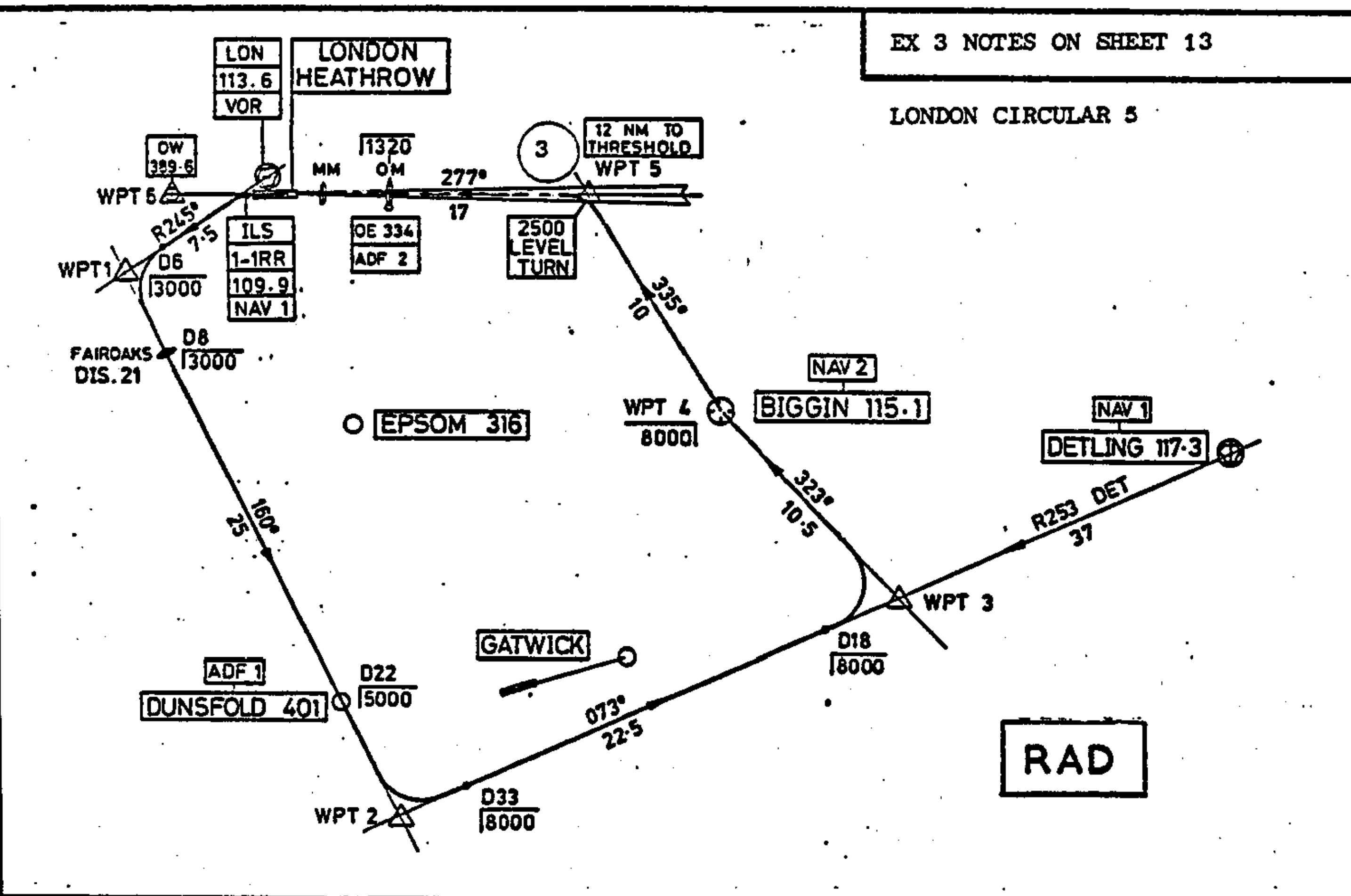


Figure 79 (i)

LIGHT PROCEDURE NOTES		EX 3 RADIO NAVIGATION (Cont)		LONDON CIRCULAR 5	SHT 13

		CALL 119.2 LON APPR 176 - FL 80 BIGGIN AT .... 176 - After BIG recleared 3000. Std. App. for 28R Report leaving 80 (14) 176 - RECLEARED 3000 AFTER BIGGIN, STD. APP. RWY 28R, WILL REPORT LEAVING 80
T 4 BIG T 5	CROSS BIGGIN AT FL 80 - 200 KTS. SEL HDG 323 / CRS 2 335 INTERCEPT 335° OUTBOUND	
SCENT	DESCEND AT FLIGHT IDLE TO 2500 FT SEL HDG 335 / SEL ALT 2500 SEL RAD 1 / IAS + V/L MAN. TUNE NAV 1 TO 1-RR - 109.9 SEL CRS 1 277° DESCENT CHECKS 1 to 5 APPROACH CHECKS 1 to 5	CALL 119.2 LON APPR 176 - LEAVING 80 FOR 3000 176 - Cont. with DIR 120.4 (15) 176 - 120.4 CALL 120.4 LON DIR 176 - PASSING .... FOR 3000 176 - Cont. descent to 2500 ft Report ESTB. (16) 176 - WILCO
0 FT 3	TURN LEFT CRS 277° TO INTERCEPT LOCALISER. SEL APPR / SEL. APPR FLAP MAINTAIN 2500 FT AND REDUCE SPEED TO 170 KTS.	CALL 120.4 LON DIR 176 - ESTABLISHED. 176 - Cont. descent on ILS Call TWR 118.7 at OM (17) 176 - ROGER CHANGING TO TWR

Figure 79 (j)

EX 3 NOTES ON SHEET 14

LONDON CIRCULAR 6

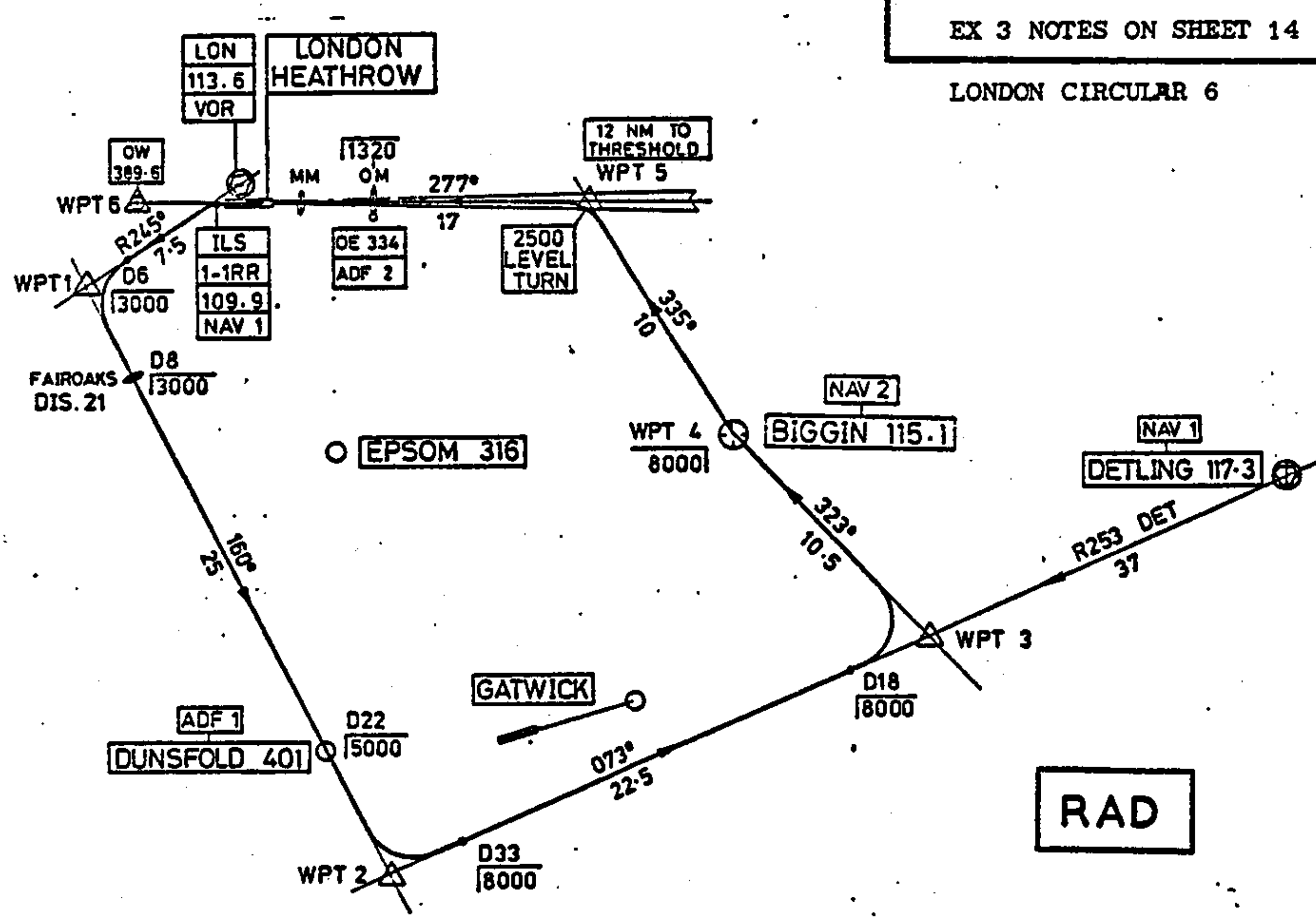


Figure 79 (k)

LIGHT PROCEDURE NOTES		EX RADIO NAVIGATION (Cont)		LONDON CIRCULAR 6	SHT 14

APPROACH DRILLS 6 - 3

LANDING CHECKS 1 - 8

LIDESLOPE — REDUCE SPEED TO VAT + 10 (139)
AT G.S. SPD SEL 139 GEAR
DESCEND ON THE GLIDESLOPE SEL. LAND FLAP

UTER MARKER

MM

CALL 118.7 TWR

176 - OUTER MARKER INBOUND
176 - Clear to land (18)
176 - CLEAR TO LAND

AND — LAND AND CONTINUE STRAIGHT AHEAD
TO A STOP. BRAKES ON

176 - Exit at BLK 113 (19)
176 IS CLEAR
176 - Contact LON. GND 121.9 (20)
176 CHANGING TO 121.9

AFTER LAND CHECKS 1 - 7

CALL 121.9 GND

176 ON TAXIWAY 13
176 - Taxi via the Outer for Stand ALFA 7 (21)
176 STAND ALFA 7

K. END — END OF CHECKS.
LEAVE ENGINES RUNNING

Figure 79 (1)

EX 4 NOTES ON SHEET 15

PARIS DEPARTURE 1

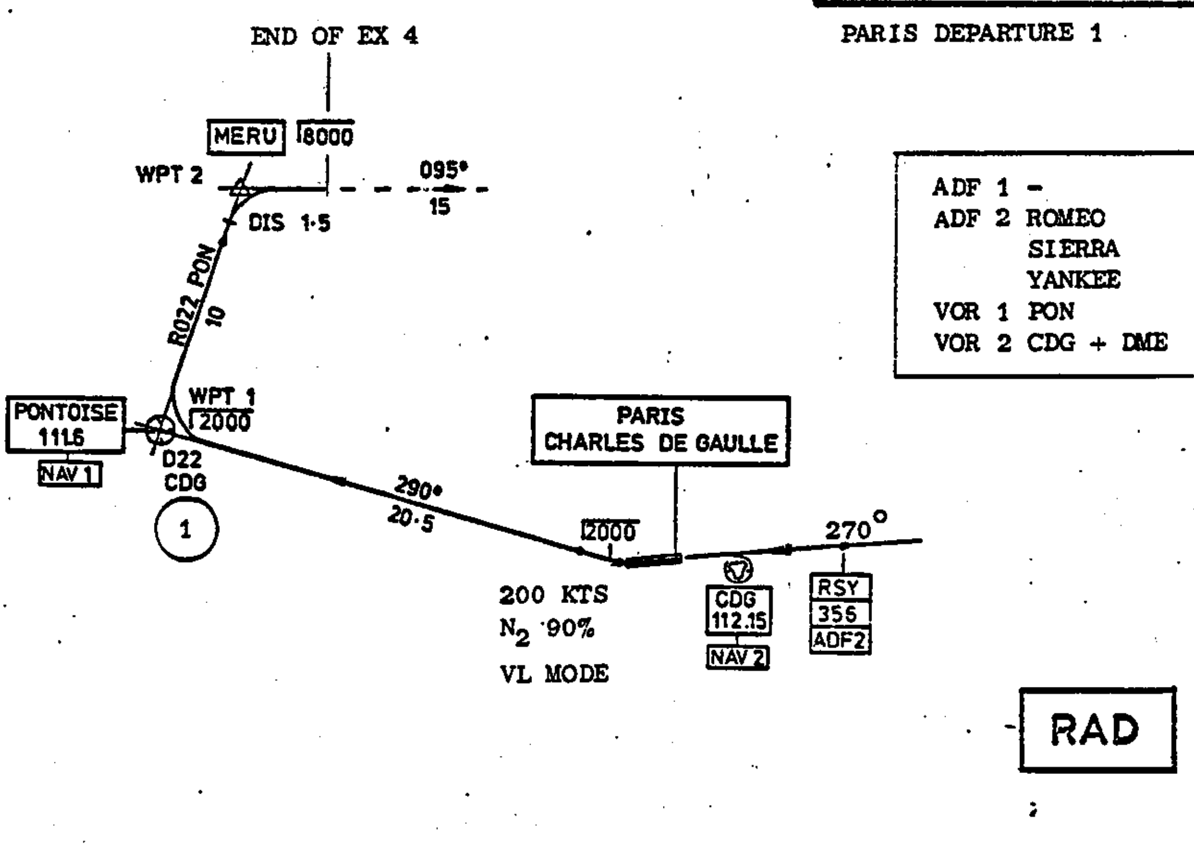


Figure 80 (a)

FLIGHT PROCEDURE NOTES		EX 4 RADIO NAVIGATION AP		PARIS DEPARTURE	SHT 15

NITIAL SELECTIONS — EADI SELECT — EHSI - SELECT

GEAR - DN	F/DIR - FD 1 (ROLL)	ALT - 2000	ROSE	HDG - 270°	
FLAPS - TO	MODE - HDG/VL ARM	SPD - V2 + 10 (151)	RAD 1	CRS - 290°	
TRIM - T/P	N2CMD - 93%	BARO - 1013.2		PTR 1 - VOR	
				PTR 2 - OFF	

NAV. FREQ. MAN. TUNE NAV 1 111.6/114.7 PON
AUTO TUNE NAV 2 112.15 CDG

INITIAL LOCATION - LINED UP READY FOR TAKE OFF - BRAKES ON

RAKES OFF — EX. STARTS. CALL BRAKES OFF - STOPWATCH

AKE OFF AND NITIAL CLIMB — TAKE OFF AND INTERCEPT PON R110.
N2 97% FOR 75 SECS THEN 93% AT V2 + 10 (151)
INCREASE SPD TO 200 KTS

SPD SEL 200

RIGHT ONTO CRS 290°. LEVEL AT 2000 FT. N2 90% - FLAP T.O.

APPROACHING WPT 1 — SEL HDG — CRS 1 022°

ME 22 CDG — SEL VL MODE — HDG SEL 000 — SPD SEL 250 — SEL ALT 8000

1

COMMENCE CLIMB TURNING RIGHT ONTO PON R022
INCREASE SPD TO 250 KTS — RETRACT FLAPS AND SLATS

Contd. on SHT

Figure 80 (b)

Ex 4 (Cont) Notes on SHT 16

PARIS DEPARTURE 2

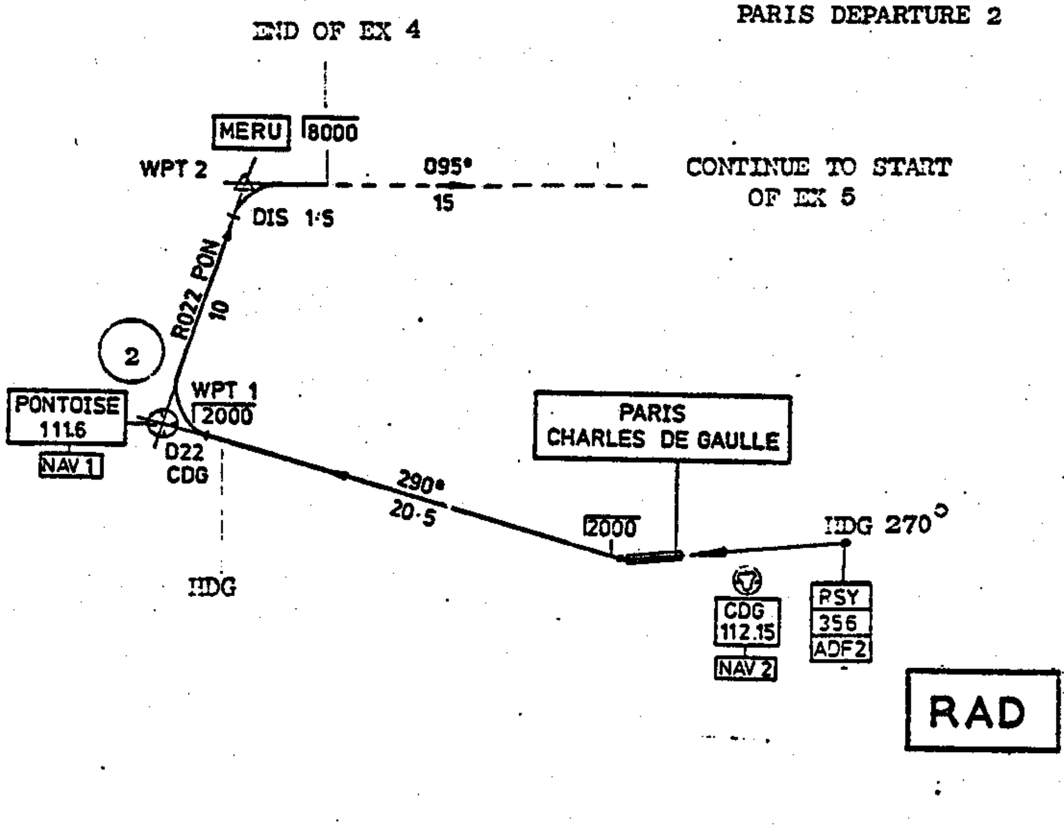


Figure 80 (c)

LIGHT PROCEDURE NOTES		EX 4 RADIO NAVIGATION (CONT)		PARIS DEPARTURE	SHT 16

IMB	2	CLIMB TO 8000 FT AT N2 93%
		MAN. TUNE NAV 1 TO 109.2 CREIL / SET CRS 1 095°
S 1.5 WPT 2 MENU		TURN RIGHT ONTO CRS 095° AND LEVEL AT 8000 FT/250 KTS. N2 80%
. END		ENGAGE AP/AT / SEL L/NAV/ALT
		FLIGHT CONTINUES TO CREIL. P2 TAKES OVER UNTIL START CONDITIONS FOR EX 5 ARE REACHED.

Figure 80 (d)

Ex 5 Notes on SHT 17

PARIS ARRIVAL 1

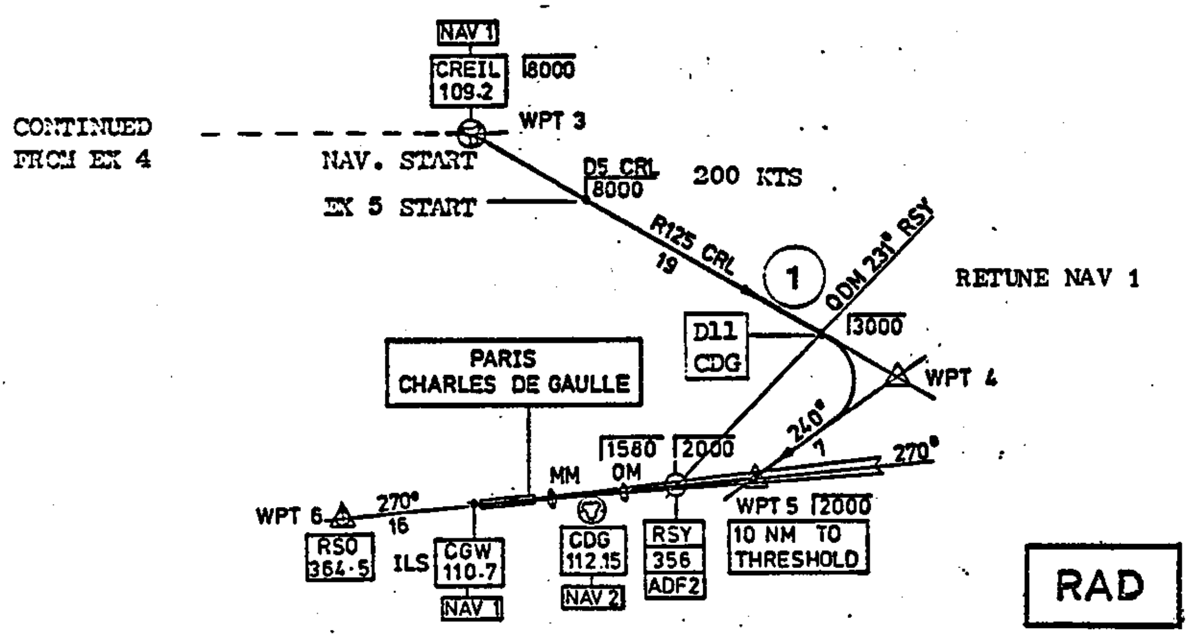


Figure 81 (a)

FLIGHT PROCEDURE NOTES		EX 5 RADIO NAVIGATION FD		PARIS ARRIVAL	SHT 17

CONTINUED FROM EX. 4

ITIAL CONDITIONS

CHECK

GEAR - UP
BRAKES - OFF
FLAPS - UP

F/DIR - FD 1 ON
AP/AT - ENGAGED
MODE - HDG/ALT
N2 - 87%

EADI SELECT

ALT - 8000
SPD - 250
BARO - 1013.2

EHSI - SELECT

ROSE HDG - - 125°
RAD 1 CRS 1 - 125°
PTR 1 - ADF 1
PTR 2 - OFF

CHECK NAV 1 TUNED TO 109.2 CREIL

AUTO TUNE ADF 2 TO 356 RSY
ADF 1 TO 364•5 RSO

V. START — P1 TAKES OVER AT WPT 3 [SEL - V/L & ALT]
MAINTAIN CRS 125° REDUCING SPD TO 200 KTS [SPD SEL 200]

. START — DME 5 CRL (DIS 14 TO WPT 4) [SEL - ALT 3000] [SEL V/L + IAS]
DESCEND AT FLT. IDLE TO LEVEL AT 3000 FT/200 KTS

00 FT — MAINTAIN 3000 FT AT 200 KTS
(1) [MANTUNE NAV 1 TO 110.7 CGW] [SEL - HDG/ALT]
[SEL CRS 1 270°] [SEL V/L]

Cont. on SHT

Figure 81 (b)

Ex 5 Notes on SHT 18

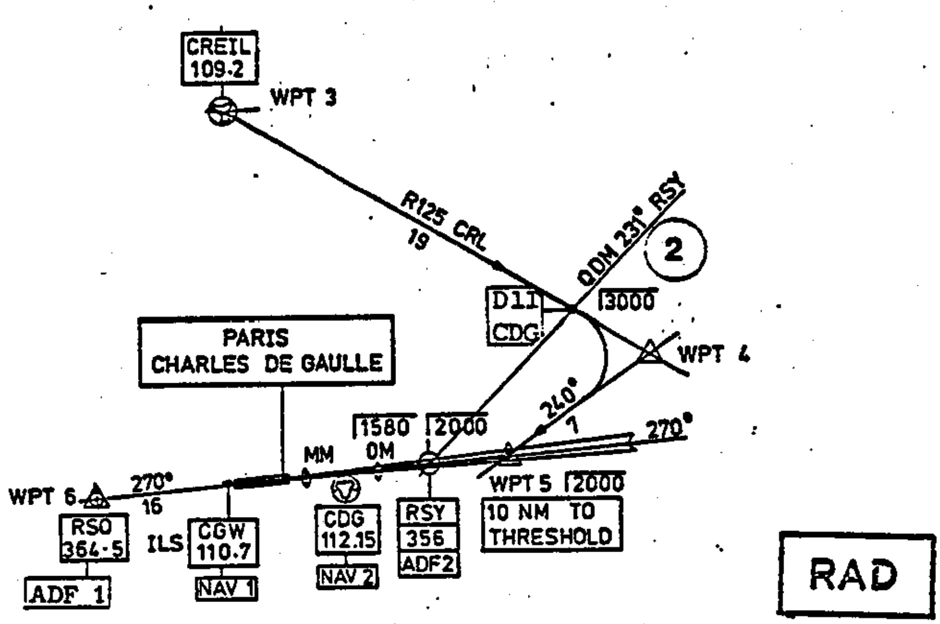


Figure 81 (c)

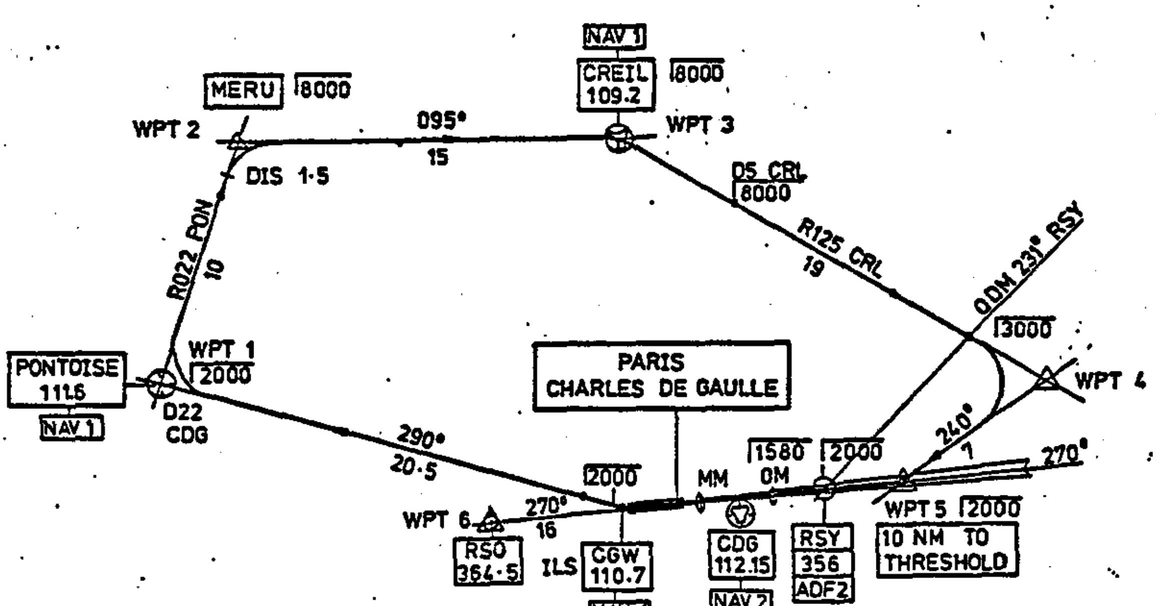
FLIGHT PROCEDURE NOTES		EX 5 RADIO NAVIGATION (Cont.)		PARIS ARRIVAL	SHT 18

QDM 231° RSY (2)	TURN RIGHT ONTO CRS 240° AND DESCEND TO REACH 2000 FT AT 200 KTS BY WPT 5.
WPT 5	INTERCEPT THE LOCALISER. MAINTAIN 2000 FT AND REDUCE SPEED TO 170 KTS [SEL ALT HOLD] [SEL APPR] [SEL APPR FLAP]
GLIDESLOPE	REDUCE SPD TO VAT + 10 (139) AT G.S. [GEAR] DESCEND ON THE GLIDE [SEL. LAND FLAP] LAND.
EX. END	CONTINUE STRAIGHT AHEAD TO A STOP - [BRAKES ON] COMPLETE AFTER LAND AND SHUT DOWN CHECKS.

Figure 81 (d)

Ex 6 Notes on SHT 19

PARIS CIRCULAR 1



RAD

Figure 82 (a)

FLIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION F/DIR AND AP		PARIS CIRCULAR 1	SHT 19

INITIAL SELECTIONS

		EADI SELECT	EHSI SELECT
GEAR - DN	F/DIR - FD 1 (ROLL)	ALT - 2000	ROSE HDG - 270°
GLAPS - TO	MODE - HDG/VL ARM	SPD - V2 + 10 (151)	RAD 1 CRS - 290°
TRIM - T/P	N2CMD - 93%	BARO - 1013.2	PTR 1 - VOR
			PTR 2 - OFF

NAV. FREQ. MAN. TUNE NAV 1 111.6/114.7 PON
AUTO TUNE NAV 2 112.15 CDG
ADF 2 356 RSY.

ATIS QNH 1014
QFE 1004

INITIAL LOCATION AIRCRAFT ON STAND, ENGINES SHUT DOWN, BRAKES ON

EX. START TURN ROUND CHECKS 1 to 11

CALL 126.65 TWR

276 - READY FOR PARIS CIRC AS PLANNED

276 - Cleared to cross Pontoise at 2000 ft, MERU at FL 80, Creil at F80 the ILS for RWY 27. Call De Gaulle GND 121.6 for start. (1)

276 - CLEARED NON-STD DEPARTURE TO CROSS PONTOISE AT 2000 FT CHANGING TO GROUND 121.6

START DRILL 1 to 29

CALL 121.6 GND

276 - READY TO START

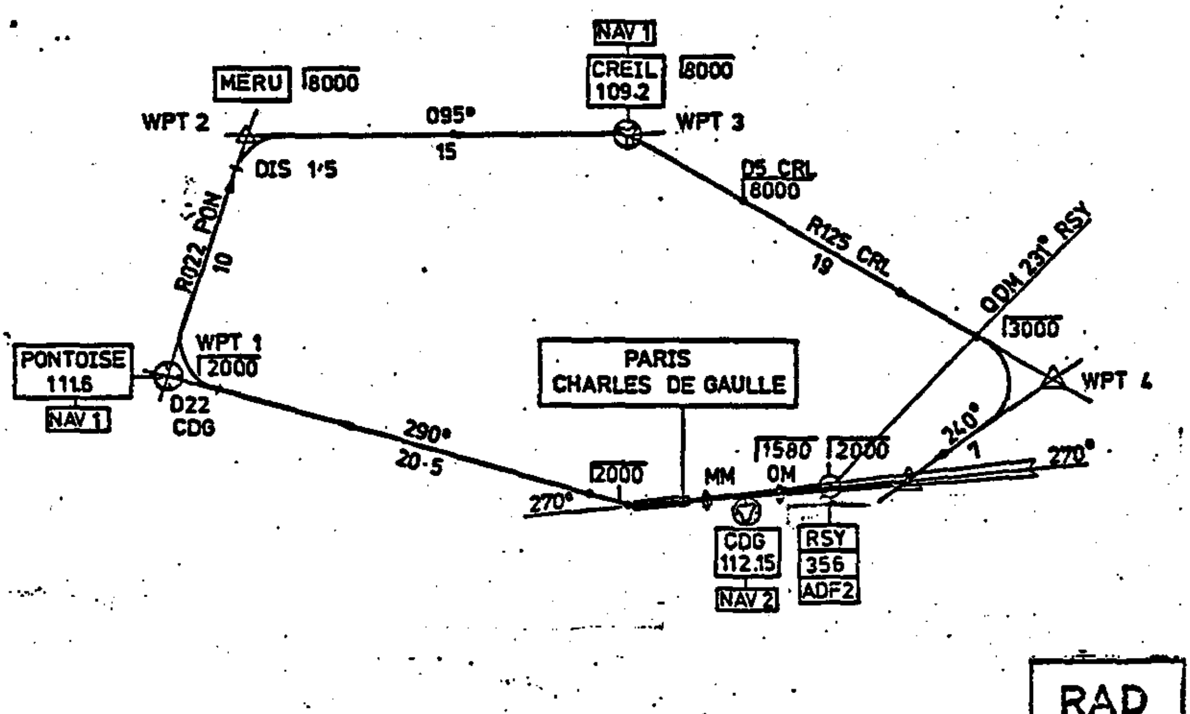
276 - Clear to start engines (2)

276 - CLEAR TO START

Figure 82 (b)

Ex. 6 Notes on SHT 20

PARIS CIRCULAR 2



RAD

Figure 82 (c)

FLIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION (Cont)		PARIS CIRCULAR 2.	SHT 20

TAXI CHECKS 1 to 10 $\boxed{\text{N2 CLD 93\%}}$

CALL 121.6 GND

276 - READY TO TAXI

276 - Cleared to Holding Point Taxiway 18 RWY 27 (3)

276 - TAXIWAY 18 RWY 27

276 - HOLDING TAXIWAY 18

276 - Line up and hold RWY 27 Call TWR 119.25 for T.O. (4)

276 - CHANGING TO TWR

TAKE OFF BRIEFING

CALL 119.25 TWR

276 - READY FOR TAKE OFF

276 - Clear to take off (5)

276 -

BRAKE OFF — CALL BRAKES OFF - STOPWATCH

TAKE OFF AND CLIMB TO 2000 FT — TAKE OFF AND INTERCEPT PON R110
N2 97% FOR 75 SECS.
THEN 93% AT V2 + 10 (151)
INCREASE SPEED TO 200 KTS

276 - Airborne Contact Paris CNTL 128.1 (6)

276 - CHANGING TO 128.1

CALL 128.1 PARIS

276 - OUTBOUND TO PONTOISE

276 - Clear 2000 ft own nav to Pontoise. (7)

276 - CLEARED 2000 FT
WILL BE OPERATING AT 200 KTS
TO PONTOISE.

276 - Roger - Report 1 min to PON. (8)

276 - WILCO

AFTER T.O. DRILLS 1 to 7

$\boxed{\text{SPD SEL 200}}$

Figure 82 (d)

Ex 6 Notes on SHT 21

PARIS CIRCULAR 3

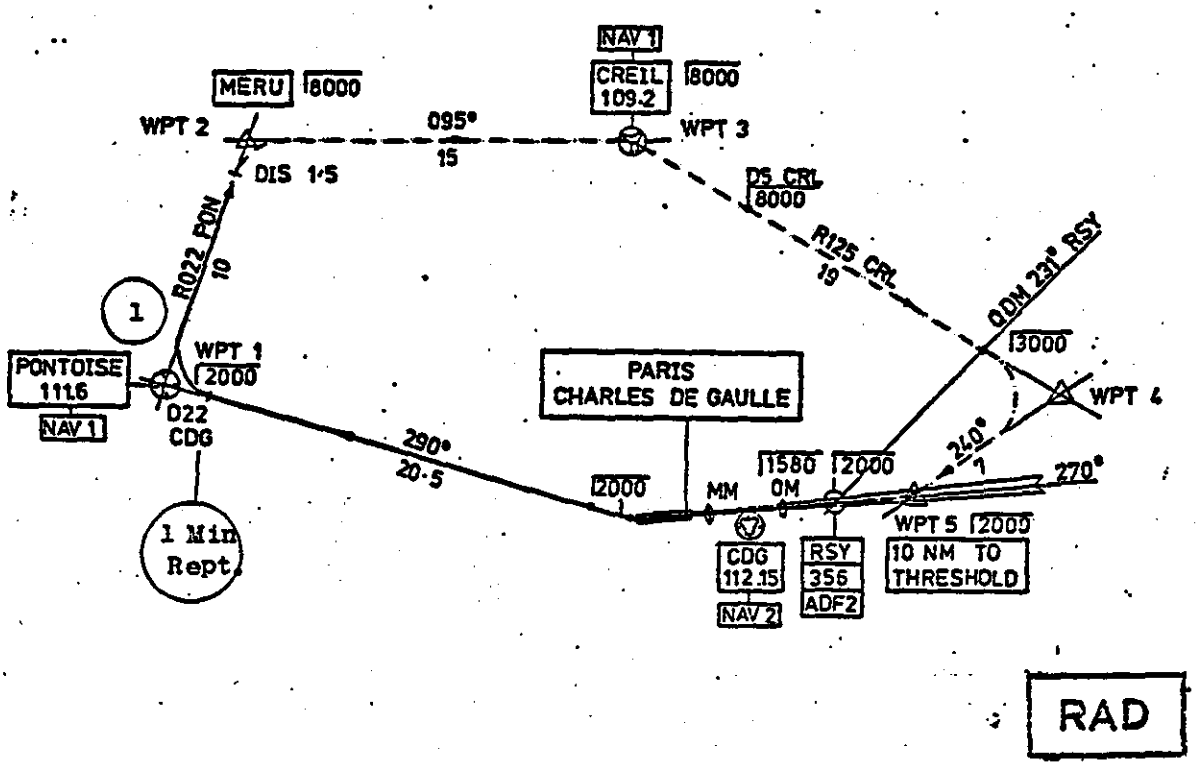


Figure 82 (e)

FLIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION (Cont)		PARIS CIRCULAR 3	SHT 21

	TURN RIGHT ONTO CRS 290° AND LEVEL AT 2000 FT	
2000 FT	MAINTAIN 2000 FT AT 200 KTS	
	P2 OPTION ROSE/MAP/CWS	
1 MIN PON		CALL 128.1 PARIS
		276 - AT 2000 FT. PON AT ....
		276 - MERU at FL 80 Reporting passing 60 (9)
	SEL HDG · SEL CRS 1 022°	276 - ROGER - WILL REPORT PASSING 60. SPD RESTRICTION 250 KTS
		276 - Understood. (10)
DME 22 CDG CLIMB	COMMENCE CLIMB TURNING RIGHT ONTO PON R022 INCREASE SPD TO 250 KTS. N2 93% RETRACT FLAPS & SLATS	
WPT 1 PON WPT 2 1	CLIMBING TO FL 80 · SEL ALT 8000 SEL V/L · HDG SEL 000 · SPD SEL 250 MAN TUNE NAV 1 TO 109.2 CREIL SEL CRS 1 095° · SEL V/L	

Figure 82 (f)

Ex 6 Notes on SHT 22

PARIS CIRCULAR 4

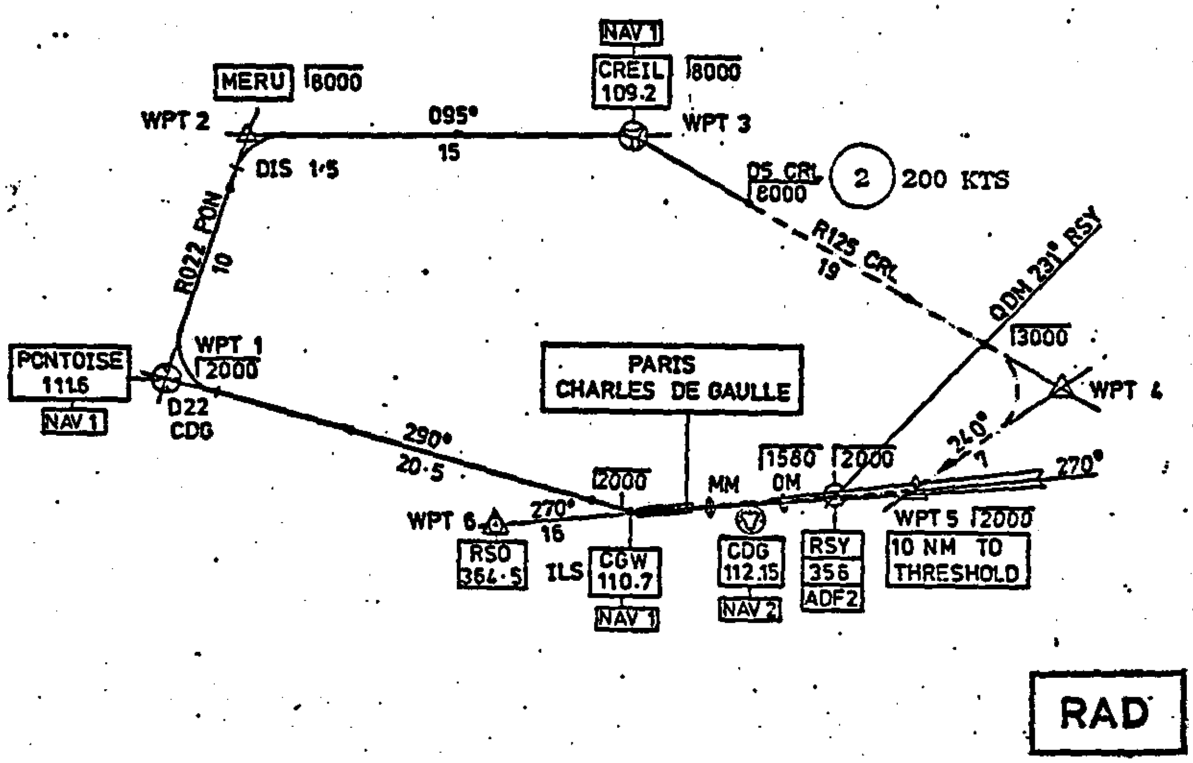


Figure 82 (g)

LIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION (Cont)		PARIS CIRCULAR 4	SHT 22

000 FT

CALL 128.1 PARIS

276 – THRO' 80

276 – After MERU report on TRK for Creil. Maintain 80. (11)

276 – WILCO.

IS 1.5 WPT 2 — TURN RIGHT ONTO CRS 095°
AND LEVEL AT 8000 FT. N2 80%

PT 2 MERU
WPT 3

CALL 128.1 PARIS

276 – EST. ON TRK FOR CREIL

276 – Maintain 80
Call DG APP 121.15 (12)

276 – CHANGING TO 121.15

000 FT — MAINTAIN 8000 FT AT 250 KTS N2 80%

SEL MAP UNTIL ROSE INSTRUCTED

CALL 121.15 APPR

CRS SEL 125° | SEL V/L

276 AT FL 80 CREIL AT ....

276 – Maintain 80 Report Creil (13)

276 – WILCO

PT 3 CREIL
WPT 4

TURN RIGHT ONTO R125 CRL. SEL ROSE
REDUCE SPEED TO 200 KTS BY
DME 5. CRL SPD SEL 200

2

SEL FD 1 PITCH & ROLL

CALL 121.15 APPR

APP – 276 at FL80
Crossed Creil at ....

276 – Cleared Std App for RWY 27. Recleared 3000 ft. Report leaving FL 80. (14)

276 – STD APP RWY 27
RECLEARED 3000 FT

Figure 82 (h)

Ex 6 Notes on SHT 23

PARIS CIRCULAR 5

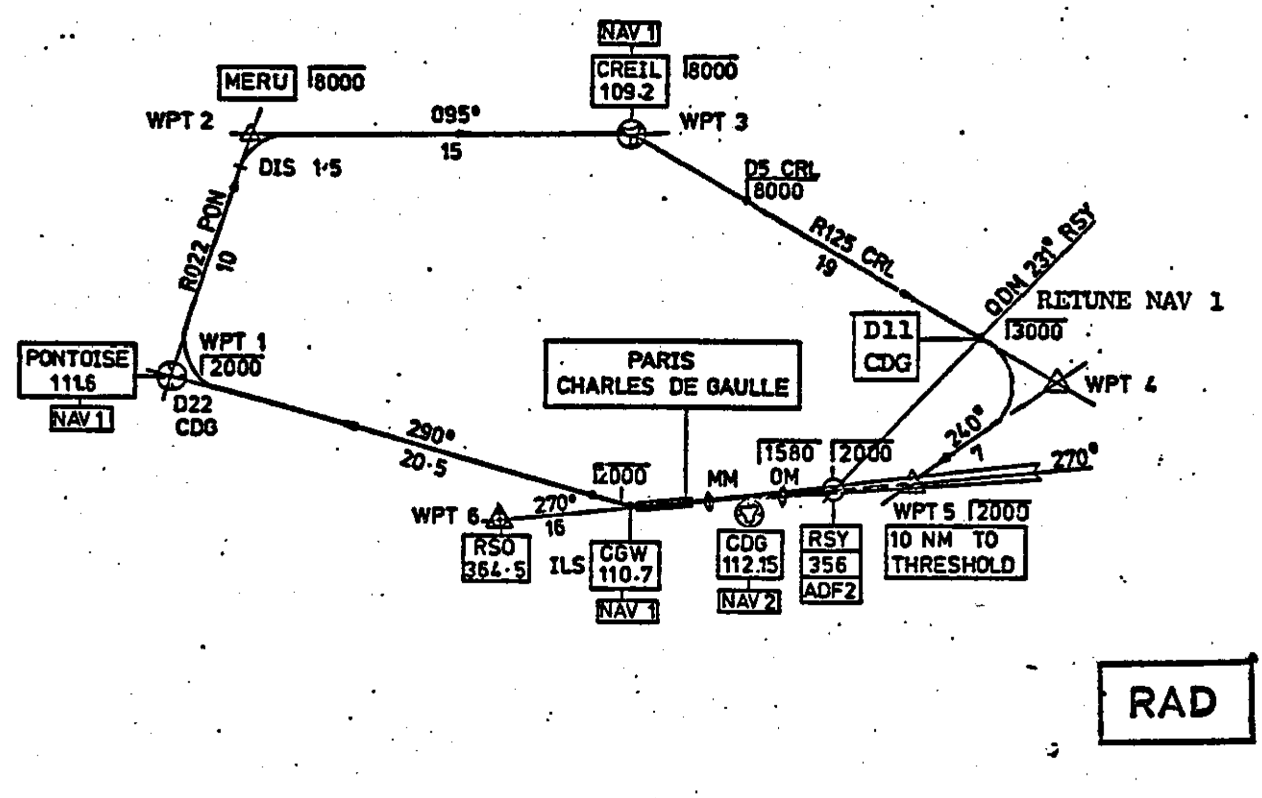


Figure 82 (i)

FLIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION (Cont)		PARIS CIRCULAR 5	SHT 23

LIE 5 CRL (DIS 14 WPT 4) DESCEND AT FLT. IDLE TO LEVEL AT 3000 FT/200 KTS

CALL 121.15 APPR

ALT SEL 3000

276 - LEAVING 80 FOR 3000
276 - Roger (15)

SEL ADF 2 | SEL V/L + IAS

DESCENT CHECKS 1 to 5

ATIS

APPROACH CHECKS 1 to 5

000 FT — HDG SEL 240° | SEL ALT

CALL 121.15 APPR

31 RSY — TURN RIGHT ONTO CRS 240°
DESCENDING TO 2000 FT | ALT SEL 2000

276 - LEVEL AT 3000
276 - Recleared 2000
Report out of 3000 (16)
276 - RECLEARED 2000
LEAVING 3000 FOR 2000
276 - Roger - report EST. (17)

PT 4 / PT 5 — MAN TUNE NAV 1 TO 110.7 CGW

SEL RAD 1 | SEL CRS 1 270° | SEL V/L

REDUCE SPD TO 170 KTS

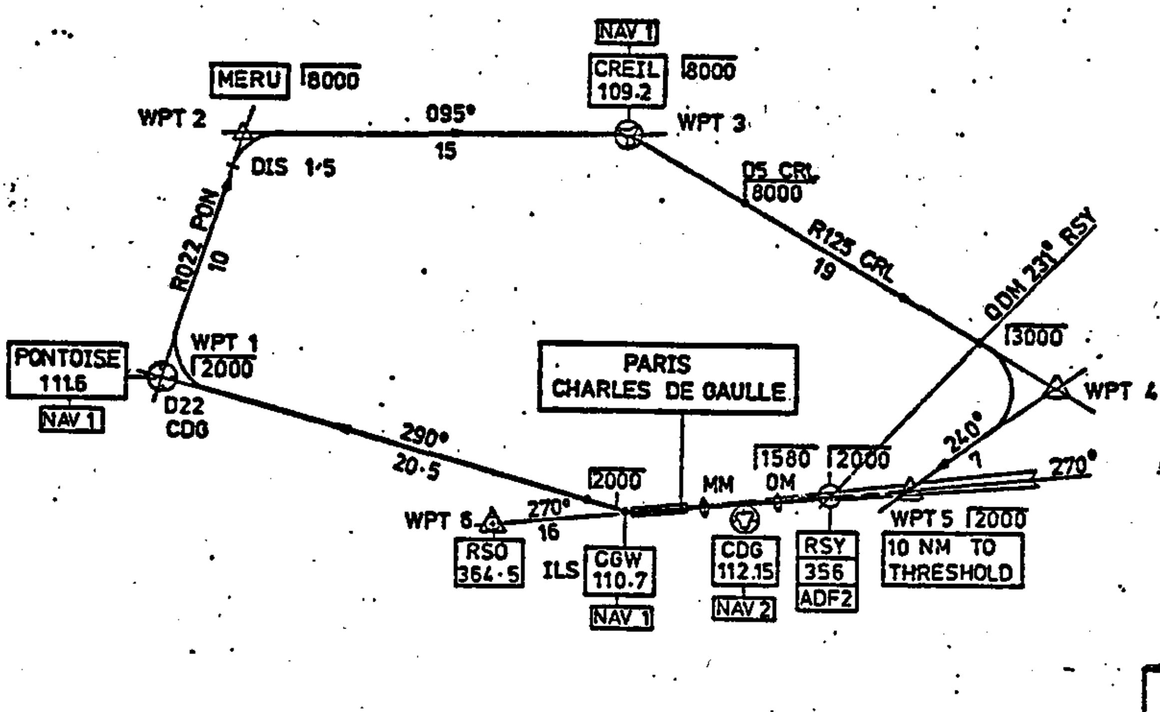
SPD SEL 170 | SEL APPR

APPROACH DRILLS 6 to 8
SEL APPR FLAP

Figure 82 (j)

EX 6 Notes on SHT 24

PARIS CIRCULAR 6



RAD

Figure 82 (k)

FLIGHT PROCEDURE NOTES		EX 6 RADIO NAVIGATION (Cont)		PARIS CIRCULAR 6	SHT 24

LOCALISER		CALL 121.15 APPR
WPT 5 WPT 6		276 - EST ON LOCALISER 276 - Continue descent on ILS Call DG TWR 119.25 at OM (18) 276 - TWR AT OUTER MARKER
2000 FT	LANDING CHECKS 1 to 8	
GLIDESLOPE	REDUCE SPEED TO VAT + 10 (139) AT G.S. SPD SEL 139 GEAR	
	DESCEND ON THE GLIDESLOPE SEL LAND FLAP	
OUTER MARKER		CALL 119.25 TWR
MM		276 - OUTER MARKER INBOUND 276 - Clear to Land (19) 276 -
LAND	LAND AND CONTINUE STRAIGHT AHEAD TO A STOP. (BRAKES ON	276 - Exit at Taxiway 14 . (20) 276 - TAXIWAY 14 276 - 18 CLEAR 276 - Contact DG GND 121.6 (21) 276 - 121.6
	AFTER LAND CHECKS 1 to 7	CALL 121.6 GND
EX. END	CHECKS COMPLETE LEAVE ENGINES RUNNING	276 - CLEAR 27 276 - Turn left Taxiway 14 for stand Zulu 3 (22) 276 - STAND ZULU 3

Figure 82 (1)

Ex 7

OPTIONAL FREE FLYING

THIS EXERCISE PROVIDES THE PILOT
WITH THE OPPORTUNITY TO RE-EXAMINE
POSSIBLE PROBLEM AREAS ON THE DISPLAYS

Figure 83

CHAPTER 25

QUESTIONNAIRES AND DEBRIEFING

25.1. Questionnaires

The completion of the questionnaires in the previous parts of the study had taken much longer than had been anticipated, by almost all the pilots. In view of this, and the fact that completion at the end of a concentrated day was not the optimum time, it was decided to continue with the philosophy of presenting the questions pictorially, and to require only ratings to be given. Separate sheets were included for the pilots to provide comments if they so wished. Comments were, however, mandatory for any ratings of "POOR" or worse.

It had been noticed in the previous questionnaires that some pilots had tended to give constant ratings for many questions and it was felt that the layout shown might have led these pilots to rate each question the same without really thinking about them to any great depth. Different rating scales were therefore used, and indeed on several occasions it was found that some pilots did rate some items in error and several corrections were made.

The questionnaires were only designed to obtain information about the EFIs. The more general subjects were covered by a separate tape-recorded interview (Debriefing 2) where a fixed list of questions was asked.

The questionnaire is shown on the following pages:-

SDW-63/A/48/413

HSA (H) Res/2147/JWW/413

ADVANCED FLIGHT DECK

EADI/EHSI ASSESSMENT 1977

QUESTIONNAIRE

Name: ______________________________

Rank: ______________________________

Company/Organisation: ______________________________

Glasses worn: YES/NO (delete as appropriate)

No. of Flying Hours: ______________________________

Types of aircraft flown ______________________________
(most recent at top)
____
____
____

Previous experience with electronic displays (excluding this simulator at Weybridge)
____
____
____

NOT FOR PILOT'S COMPLETION

Pilot No:
Date:
WEYBRIDGE/FILTON/RAE

NOTES

Questions A1 - A19 - To be completed by the pilots who took part in the Filton exercises in 1974 only.

Questions B1 - B7 - To be completed by all pilots

Questions C1 - C23 - To be completed by all pilots

Questions D1 - D46 - To be completed by all pilots

Please answer all questions by placing a cross on the rating scale thus ——X—— at a position reflecting your opinion. Please do not put more than one cross on the line.

If you wish to make any written comments please write these on the sheets provided, but please remember to fill in the question number.

A1. How would you rate the grouping of the indications on the EADI compared with a conventional arrangement of separate instruments?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A2. How would you rate the display of alternative centre formats on the EHSI compared with a conventional arrangement of separate instruments?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A3. How would you read the readability of the EADI compared with conventional instruments?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A4. How would you rate the task of monitoring the indications of the electronic displays compared with equivalent conventional instruments?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A5. How would you rate the task of cross-cockpit monitoring of the EADI/EHSI compared with a conventional instrument layout?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A6. How would you rate the acceptability of the EADI format when transferred to the adjacent display?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A7. To achieve the task objective how do the airspeed indications on the EADI compare with the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A8. To achieve the task objective how does the Mach No. indication on the EADI compare with the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A9. To achieve the task objective how do the altitude indications on the EADI compare with the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.10 To achieve the task objective how does the radio altitude indication on the EADI compare with the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.11 To achieve the task objective how does the vertical speed indication on the EADI compare with the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.12 To achieve the task objective how does the pitch indication on the EADI compare with the presentation on the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.13 To achieve the task objective how does the roll indication on the EADI compare with the presentation on the conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.14 How would you rate the Flight Director symbol on the EADI compared with the indication on a conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.15 How would you rate the localiser/glideslope indications on the EADI compared with the presentation on a conventional instrument?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.16 How would you rate the compass rose, course/track pointer and deviation presentation on the EHSI compared with the conventional HSI?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.17 How would you rate both bearing pointers on the EHSI compared with the conventional HSI?

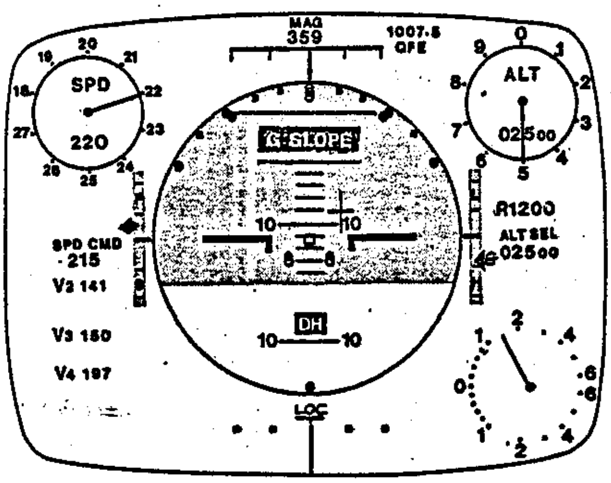
VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

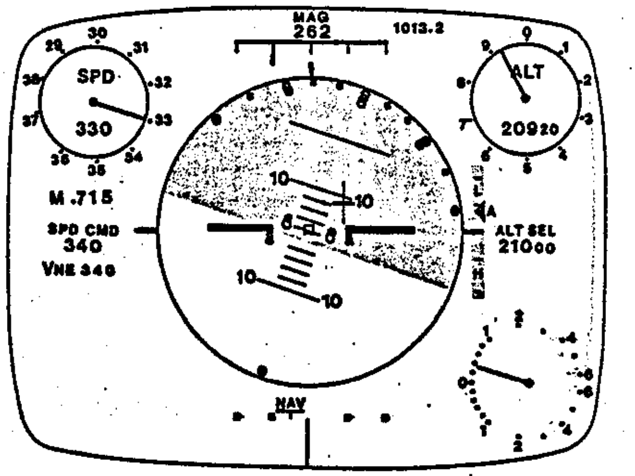
A.18 How would you rate the glideslope indication on the EHSI compared with the conventional HSI?

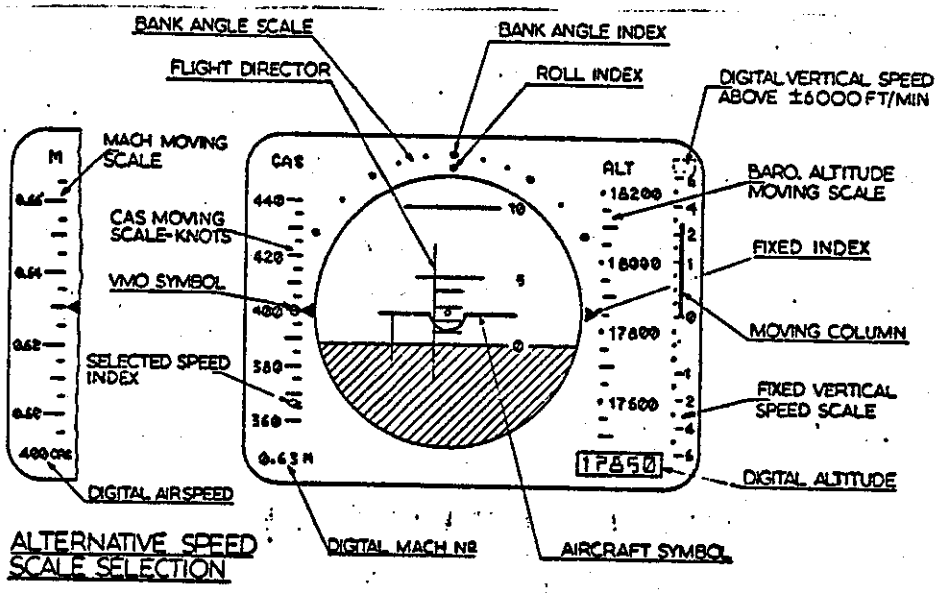
VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

A.19 How would you rate the acceptability of the exercises you have done for assessing the EADI and EHSI?

UNACCEPTABLE — BAD — POOR — FAIR — GOOD — EXCELLENT







3.1 How would you rate the digital airspeed presentation on the new format (top) compared with the previous format (lower)?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

3.2 How would you rate the analogue airspeed presentation on the new format compared with the previous format?

3.3 How would you rate the Mach. No. presentation on the new format compared with the previous format?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

3.4 How would you rate the digital altitude presentation on the new format compared with the previous format?

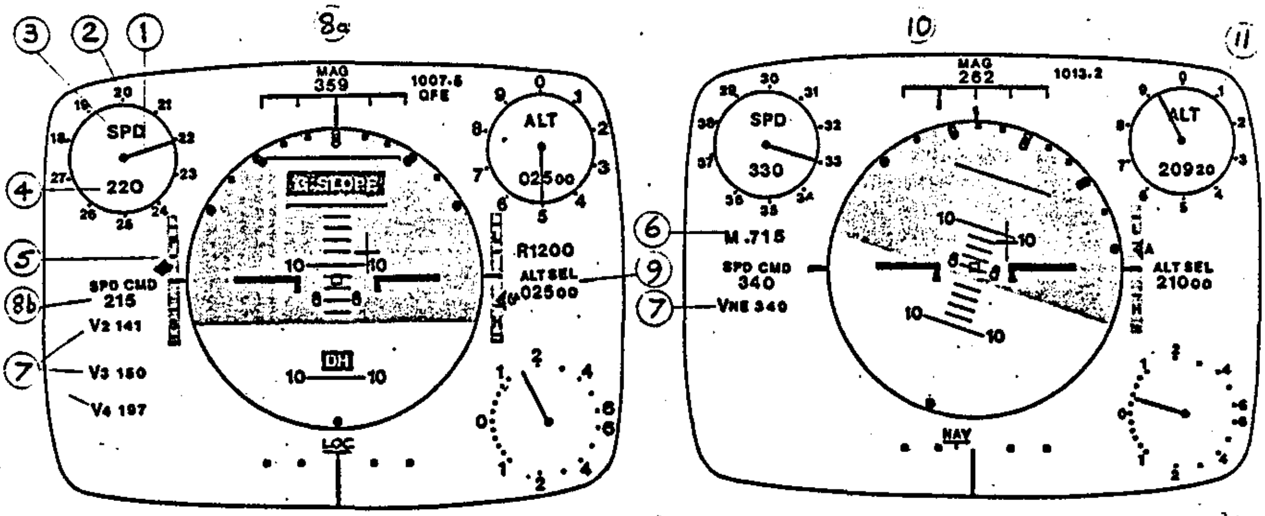
3.5 How would you rate the analogue altitude presentation on the new format compared with the previous format?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER

3.6 How would you rate the radio altitude presentation on the new format compared with the previous format?

3.7 How would you rate the vertical speed indication on the new format compared with the previous format?

VERY MUCH WORSE — COMPARABLE — VERY MUCH BETTER



C.1 AIRSPEED POINTER

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION & ROTATION

C.2 AIRSPEED ANALOGUE SCALE NUMBERS

PRESENTATION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PHILOSOPHY OF NUMBER CHANGE

C.3 SPEED LEGEND (SPD)

PRESENTATION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PHILOSOPHY OF OCCULTING

C.4 DIGITAL AIRSPEED

POSITION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION (SHAPE)

SIZE

TOO SMALL ABOUT RIGHT TOO LARGE

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C.5 FAST SLOW

C.6 MACH/VELOCITY

POSITION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PHILOSOPHY OF USE

C.7 VELOCITY TARGET DATA

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION

C.8a SPEED SELECT

POSITION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION

C.8b MAG. HEADING

POSITION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION

C.9 ALTITUDE SELECT

POSITION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION

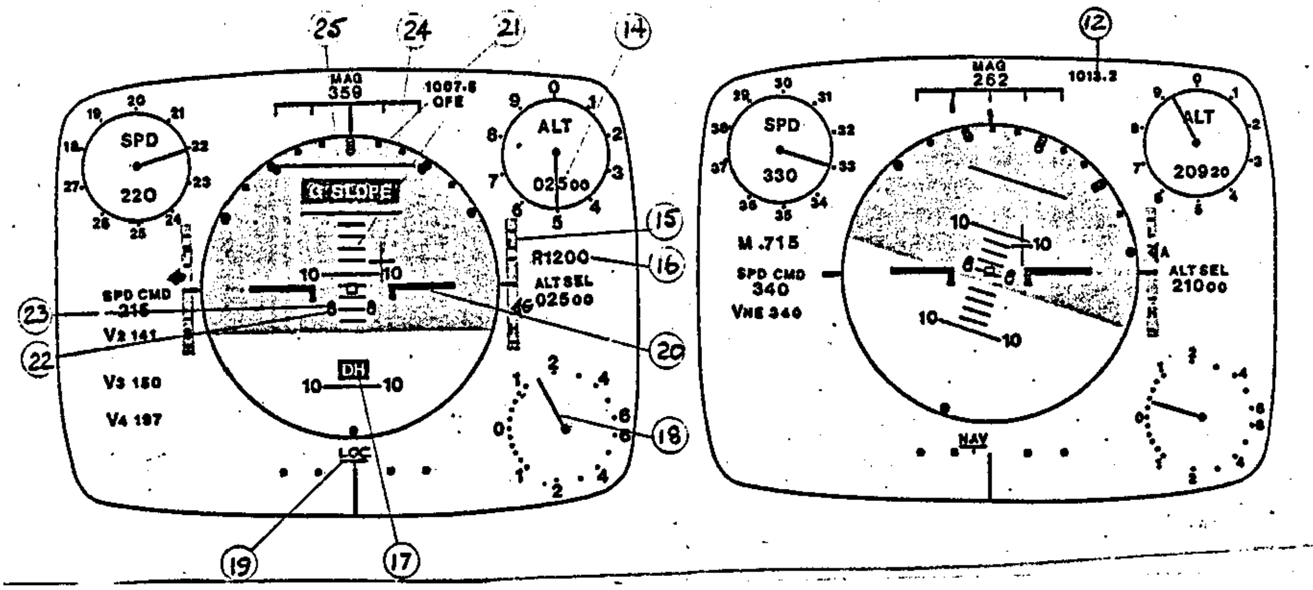
UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C.10 RATE OF TURN

C.11 ALTITUDE ANALOGUE

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

PRESENTATION



C.12 PRESSURE SETTING

PRESENTATION — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C.13 SLEW RATES

ALTITUDE — VERY FINE FINE COARSE VERY COARSE

SPEED

C.14 DIGITAL ALTITUDE

POSITION — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

ALERT PHILOSOPHY — TOO SMALL ABOUT RIGHT TOO LARGE

DIGITS SIZE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C.15 HIGH/LOW

C.16 RADIO ALTITUDE — TOO SMALL ABOUT RIGHT TOO LARGE

DIGITS SIZE

POSITION — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C.17 DECISION HEIGHT WARNING

C.18 VERTICAL SPEED — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SCALE & POINTER

C. 19 LATERAL PATH ERROR

SCALE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SYMBOL

C.20 FIXED ATTITUDE MARKS — TOO SMALL ABOUT RIGHT TOO LARGE

SIZE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SHAPE

C. 21 MOVING ATTITUDE MARKS

PITCH — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

ROLL

C. 22 FLIGHT PATH ANGLE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

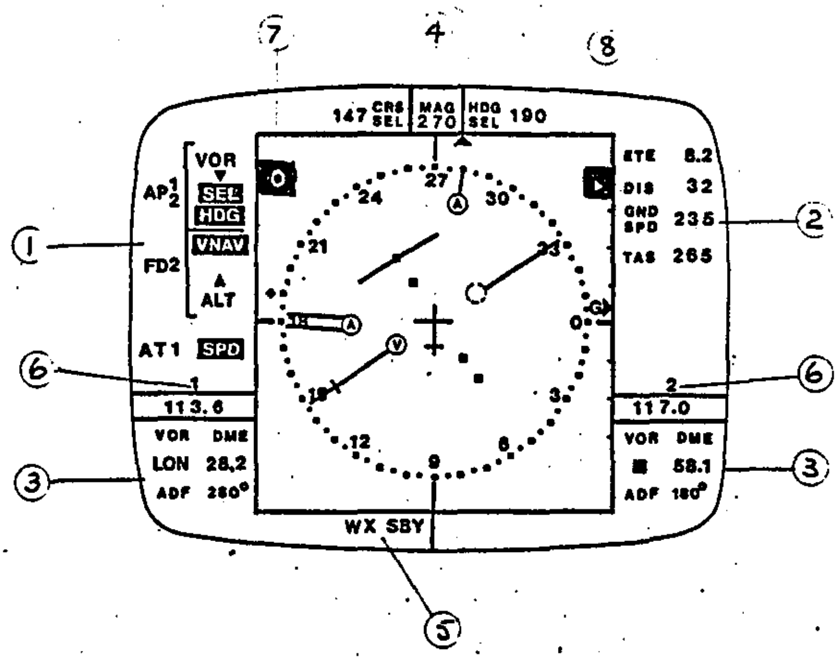
C. 23 POTENTIAL FLIGHT PATH ANGLE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

C. 24 FLIGHT DIRECTOR

C. 25 URGENT MESSAGES

SIZE — UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

ATTENTION GETTING



D.1 AP/CWS/FD/AT/PITCH HOLDS MODES/NAV MODES/SYNC. INDICATIONS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.2 ETE/DIS/GND SPD/TAS INDICATIONS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.3 DME/VOR/ADF INDICATIONS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.4 CRS SEL/DSR TRK/MAG-TRU/HDG SEL/XTK DIS INDICATIONS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.5 WEATHER RADARS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.6 NAV MODE INDICATIONS

LAYOUT

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

EFFECTIVENESS

D.7 MARKER INDICATIONS

LEGIBILITY

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

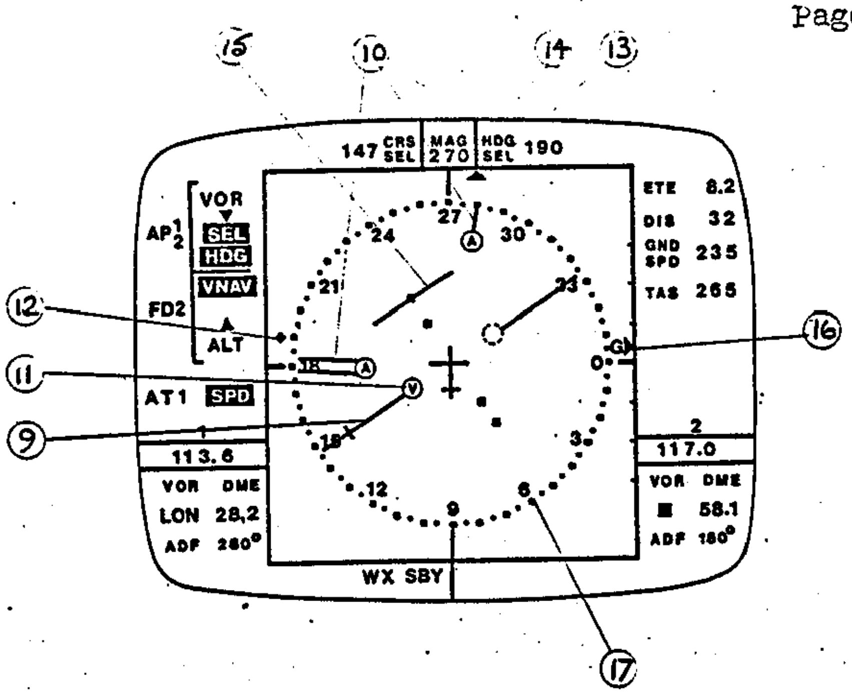
OCCULTING

D.8 TURN ARROW/NEXT WPT.NO.

LEGIBILITY

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

OCCULTING



D.9 COURSE/TRACK POINTER

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

D.10 BEARING POINTERS

D.11 TO (T) OR FROM (F) INDICATIONS

LEGIBILITY

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

D.12 HEADING BUG

D.13 DRIFT INDICATION

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

D.14 FIXED LUBBER MARK

D.15 LATERAL DEVIATION

LINE

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SCALE

D.16 VERTICAL DEVIATION

SYMBOL

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SCALE

D.17 COMPASS ROSE

SCALE NUMBERS

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

SCALE GRADUATIONS

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

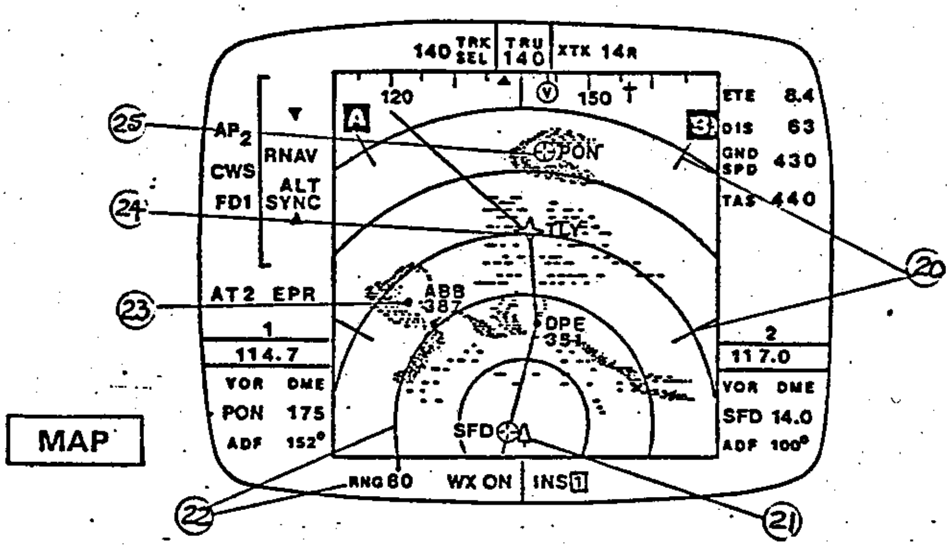
D.18 COMPASS REFERENCES

D.19 SLEW RATES

COURSE

VERY FINE FINE COARSE VERY COARSE

HEADING



.20 ANGULAR MARKS

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

.21 AIRCRAFT SYMBOL

.22 RANGE MARKS AND SCALES

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

.23 CIRCLE

.24 STAR

UNACCEPTABLE BAD POOR FAIR GOOD EXCELLENT

.25 WHEEL

COMMENTS

QUESTION NUMBER	

25.2. List of Questions asked in Debriefing 2

Q 1. What are your general impressions of the electronic flight instruments as shown?

Q 2. Do you think the lack of colour was a significant disadvantage? If so, what parameters were affected most?

Q 3. Do you think the lack of depth was a significant disadvantage? If so, what parameters were affected most?

Q 4. Did you find that the presentation of parameters, hitherto on separate instruments, (e.g. altitude, airspeed, vertical speed) on one display significantly reduced your scanning.

Q 5. Do you consider that the positioning of the dials on the EADI was adequate for altitude, airspeed and vertical speed? The "Basic Tee" philosophy had been adhered to as far as possible, do you think that was necessary?

Q 6. What are your comments on lateral scan as opposed to the conventional vertical scan?

Q 7. Did you notice any tunnelling effect?

Q 8. Would you like to comment on cross-cockpit monitoring using CRTs?

Q 9. Do you think the philosophy of reproducing the ADI and HSI in formats similar to their conventional presentations is the correct way to go?

Q 10. Which parameters did you find were easiest to misread?

Q 11. Which parameters do you think need only be displayed on selection?

Q 12. Are there any parameters which you think can be dispensed with?

Q 13. Are there any parameters which you found particularly difficult to understand or use?

Q 14. Would you like to comment on the shading?

Q 15. Would you like to have complete control of the contrast and brilliance settings of the displays in the air, or would you be prepared to have some form of automatic control?

Q 16. Apart from the "jitter" due to computer deficiencies, are there any movements which you found annoying or unnatural?

Q 17. What are your comments on the clarity of the pointers? (Each taken in turn)

Q 18. Are the pointers of benefit in the displays of altitude, airspeed and vertical speed? (i.e. are the analogue displays necessary?)

Q 19. What is your opinion or preference regarding the use of dial and pointer presentations as opposed to strip presentations for altitude, airspeed and vertical speed?

Q 20. Would you like to comment on the alphanumerics with respect to their shape and clarity?

Q 21. Did you find any of the scales, including the speed error type, confusing? If so, why?

Q 22. Would you like to comment as to whether or not you found any parts of the displays cluttered?

Q 23. Do you consider that the digital presentations of barometric and radio altitude and altitude select were clear enough to avoid confusion? You may indicate any improvements you think are necessary.

Q 24. Do you consider that the airspeed and mach number presentations were clear enough to avoid confusion? You may indicate any improvements you think are necessary.

Q 25. Would you like to comment on any aspect of the centre of the EADI, e.g. aircraft symbol?

Q 26. Would you like to comment on the use of the 'V' speeds and the possible use of "bugs" on the ASI?

Q 27. Do you think the presentations of the warning labels and messages were effective?

Q 28. How useful do you think the EHSI MAP format was, and how much use did you make of it?

Q 29. Are there any particular aspects of the EHSI and the EADI which are not covered in the questionnaire that you would like to mention?

Q 30. Would you like to comment on the remoteness of the controls from the displays?

Q 31. Which controls do you think were not within a satisfactory reach and where would you have located them?

Q 32. Which controls do you think were unacceptable and what suggestions would you make to improve them?

Q 33. Would you like to comment on the Displays and Radio Control Buttons, e.g. position, logic, philosophy?

Q 34. Would you like to comment on the AFCS Panel, e.g. position, logic, philosophy?

Q 35. Would you like to comment on any aspect of the simulator or programme that you found tiring or tedious?

Q 36. Did you at any stage suffer from eye or mental fatigue?

Q 37. Did you notice any display flicker or annoying distractions in your peripheral vision at any time?

Q 38. Did you find that the handling characteristics of the simulator influenced your ratings?

Q 39. Had you studied the documentation sent to you before the assessment?

Q 40. The briefing was kept short because of shortage of time. Did this affect your assessment of the displays?

Q 41. What aspects did you find lacking in the briefings?

Q 42. How would you have preferred to have been given the briefing to have been of most benefit?

Q 43. Would you like to comment further on any aspect of the programme or exercises?

CHAPTER 26

RESULTS, DISCUSSION AND CONCLUSIONS

26.1. Results

The standard to which the EADI format was initially evolved and subsequently modified was significantly affected by limitations to the waveform generator, in particular:-

a) Restricted character library

b) Only two sizes of character

c) Insufficient total number of lines

d) Inability to display different formats on the P1's and P2's EADIs.

A persistent fault resulted in the pitch lines and numerals "jerking", so giving an impression of the display moving towards and away from the pilot. A further distraction arose from the apparent lack of resolution which made the pitch lines change in thickness and brightness at small roll angles.

The EHSI was not limited by the waveform generator, but the full potential of the MAP format could not be assessed as this was not sufficiently programmed.

Twenty pilots took part in the assessment between 5th. July and 1st. September, 1977.

The simulated aircraft was generally found to be more difficult to control than a real aircraft. With poor flight director performance, poor handling and lack of motion cues, the pilots had a higher than intended flight control workload.

The extent of the simulation in terms of display development, switching logic, autopilot and flight director modes, and navigation facilities enabled the pilots to make realistic assessments in comparison with their experience. Some of the more complex features were not available throughout the programme and others were added or changed during the period that the first 10 pilots attended. This resulted in a slightly varying format standard and display logic for these items. The formats and logic, however, did remain constant for Pilots 11 to 20.

A full list of the comments made by the pilots and the completed rating scales are included in Appendix 2.

26.2. Discussion and Conclusions

26.2.1. Comparison of EADI with Phase 1 format

26.2.1.1. Airspeed

The rating patterns for digital and analogue indications are similar with the exceptions that one pilot did not give a rating and another thought that the Phase 1 format tape indication gave a better analogue indication. With these exceptions it would seem that the counter-pointer format was preferred.

26.2.1.2. Mach No.

The ratings give a mean showing that the format was comparable or marginally better than the Phase 1 format. Two pilots gave an inferior rating because of the lack of analogue information and that the digital information was not obvious against the background numeric information in the same area.

26.2.1.3. Barometric Altitude

The mean ratings for both the digital and analogue formats indicate an improvement over the Phase 1 formats. One pilot gave a rating slightly worse as he felt that a tape scale would be better for this parameter, but considered neither the Phase 1 format nor the format assessed to be satisfactory. There was more diversity of opinion on the digital indication than the analogue, with ratings of just comparable by four pilots and worse by two. One of these two latter pilots liked the Altitude digits appearing in line with the aircraft symbol as in the Phase 1 format, although these were part of the moving scale, the actual digital readout being lower down. It would seem therefore that this pilot was looking for digital altitide in a horizontal scan area rather than in a dial in a corner of the display. This conclusion is supported by the views that SPD in line with the horizontal datum was also liked by this pilot.

26.2.1.4. Radio Altitude

The mean rating is similar to that for Barometric Altitude and again indicates an improvement over the Phase 1 format. Four pilots did not give a rating and one pilot gave a worse rating, but no comments.

26.2.1.5. Vertical Speed

Although the mean rating is comparable to the ratings for the other parameters and indicates an improvement over the Phase 1 format it includes four ratings showing little or no improvement and one worse. While the majority of pilots considered the dial and pointer indication to be an improvement because of its similarity with a conventional instrument, some pilots considered that there were merits in a vertical strip scale.

26.2.2. Comparison of EFIs with Conventional Instruments

26.2.2.1. Monitoring of EADI/EHSI

26.2.2.1.1. Own Displays

Mean rating - comparable. Five pilots who did not complete this section commented favourable on this feature with only minor exceptions. The EFIs were considered to be easier to look at and to get all the information needed, compared with a number of single instruments. Views on the side-by-side arrangement of the displays were divided, but 75% of the pilots who criticised this arrangement rated it better than conventional.

26.2.2.1.2. Cross-cockpit

Mean rating - marginally better. Four of the pilots who did not complete this section commented on this feature, three had doubts about the readability of the far side of the P2's EHSI from the P1 position. However, two of these pilots regarded the lack of parallax and cut-offs an advantage over some conventional flight decks. One pilot gave a very bad rating because of the lack of colour differentiation of the various parameters. Excluding this pilot, the average opinion appears to be better than conventional. The main criticism was that some of the indications were too small and that a reliable comparator may be necessary.

26.2.2.2. <u>EADI Indications</u>

26.2.2.2.1. <u>Grouping of Indications</u>

Mean rating - better

Five pilots who did not complete Section A made comments, four regarded the access to information as being easy, two with some reservations. One pilot regarded the grouping as inferior as there was too much data in a small area. The main criticisms were:-

a) The indications on large conventional instruments have been condensed into an area which may be too small.

b) It was difficult to notice changes without colour differentiation.

c) There was the question of certifying a "handded" presentation on a single display.

26.2.2.2.2. <u>Readability of EADI</u>

Mean rating - comparable.

The main criticisms were:-

a) Larger conventional instruments were easier to read.

b) Size of analogues may be too small.

c) Spoiled by lack of a stable presentation.

26.2.2.2.3. <u>Transfer of EADI format</u>

Mean rating - Slightly worse. Four pilots who did not complete Section A had mixed opinions, one regarded transfer as acceptable as a reversionary situation and three said that it upset their lateral scan pattern, particularly for azimuth information. It should be noted that although this feature had been included here the question was related to acceptability and not a comparison. The main criticisms were:-

a) Higher Workload

b) Tendency to over concentrate on the central display (EHSI)

c) EADI should be central for Approach.

26.2.2.2.4. <u>Airspeed</u>

Mean rating - slightly worse. It would seem from the comments made that the main reasons for these poorer ratings are:

a) Small size of dial and pointer.

b) Larger digital reading required.

c) At least one "bug" on the analogue is required.

26.2.2.2.5. Mach No.

Mean rating - Slightly worse.

The main reasons for this mean rating seem to be:-

a) Not sufficiently noticeable

b) Not as good as a combined ASI/Mach No. instrument.

26.2.2.2.6. Barometric Altitude

Mean rating - Slightly worse

The main reasons for this mean rating are:-

a) Lack of ability to 'bug' Altitude

b) Pointer not prominent enough

c) Digits not large enough

d) Possibility of confusion between the actual digital Altitude and the Selected Altitude.

26.2.2.2.7. Radio Altitude

Mean rating - Worse

The main reasons for the poor ratings seem to be:-

a) Lack of an analogue presentation

b) The location was very poor.

26.2.2.2.8. Vertical Speed

Mean rating - Slightly better

The main criticisms were:-

a) Could be misread in the 600 to 800 ft. range because the scale was too small.

b) Pointer not dominant enough.

26.2.2.2.9. <u>Pitch</u>

Mean rating - Slightly worse

The main reasons for this mean rating seem to be:-

a) The 2^{o} pitch marks were not clear enough.

b) There were abrupt changes on the display as the scale moved.

c) Instability of indication during roll

d) Confusion with the Flight Director bar.

26.2.2.2.10. <u>Roll</u>

Mean Rating - Slightly Worse

The main reasons for the poorer ratings seem to be:-

a) Indication not precise enough for Wings Level

b) Instability of symbols during roll

c) Marks not prominent enough.

26.2.2.2.11. <u>Flight Director Symbol</u>

Mean Rating - Worse

The main reasons for this poor mean rating seem to be:-

a) Not large or dominant enough

b) A uniform "cross" was preferred

c) Confusion with pitch marks and the centre square.

26.2.2.2.12. Localiser/Glideslope

Mean Rating - Comparable

The main criticisms were:-

For the Localiser:-

a) Index had too many different functions

b) Need for an expanded scale when on the ILS.

c) The caption on the moving index was confusing.

For the Glideslope:-

a) Not dominant enough among the other indications

b) The sense of the scale was confusing.

26.2.2.3. EHSI Indications

26.2.2.3.1. Selectable Centre Formats

Mean Rating - Slightly better

The main criticisms were:-

a) Different presentations on the same format not liked.

b) Map not as clear as on a separate display.

26.2.2.3.2. Compass Rose, CRS Pointer and Deviation

Mean Rating - Slightly Worse

The main criticisms were:-

For the Compass Rose and Heading Bug:-

a) Dots instead of lines were poor compared with conventional displays.

b) Not enough contrast between the 0 and 5^{o} marks.

c) Movement of Rose not as smooth as desired.

d) Heading Bug not prominent enough.

For the CRS Pointer and Deviation:-

a) Pointer and deviation bar not dominant enough.

b) Designator letters on the pointer not dominant enough.

c) TO/FROM Designators would have been better as arrowheads.

For the MAP:-

a) Lack of full circle for the Rose.

b) CRS pointer too small

Generally too much information was presented on the Rose format causing some confusion.

26.2.2.3.3. <u>Bearing Pointers</u>

Mean Rating - Slightly Worse

The main reasons for the poorer ratings seemed to be:-

a) Lack of 'points' and 'tails' on the pointers.

b) Lengths of pointers badly matched

c) Designators 'V' and 'A' confusing

d) Lack of differentiation of pointers when overlapping.

e) Instability of movement of pointers. Generally not being able to select No.1 VOR and No.1 ADF was a problem. It was felt that coloured peripheral pointers on conventional instruments are much clearer.

26.2.2.3.4. Glideslope

Mean Rating - Comparable

No comments were made.

26.2.3. Pilots' Comments on the EADI and Reading Times

26.2.3.1. Reading Times

26.2.3.1.1. Airspeed

The airspeed error scale was not used and in almost all cases the airspeed was read from the analogue scale and subtracted from the selected airspeed to give the airspeed error.

26.2.3.1.2. Digital Readouts (Altitude, Radio Altitude, Magnetic Heading

Selected altitude was frequently confused with radio altitude otherwise the readouts were clearly read.

26.2.3.1.3. Speed Error Scale

Difficulties were experienced in interpreting this scale, hence the comments in Para. 26.2.3.1.1., above.

26.2.3.1.4. Vertical Speed

Errors in miscaling were made and these are explained under the comments made to question C.18 in Appendix 2.

26.2.3.1.5. Glideslope Deviation

The delays in reading this scale were due to interpretation.

26.2.3.1.6. Lateral Nav. Error & Localiser Deviation

Delays were experienced in reading due to the interpretation of the scale.

26.2.3.1.7. Pitch Attitude and Flight Path Angle

Similar reading times were recorded for each of these, but confusions did exist between them.

26.2.3.1.8. Bank Angle

Difficulties were experienced in interpreting this scale.

26.2.3.2. Comments

26.2.3.2.1. Airspeed Pointer

Satisfactory, no reason apparent for the single 'poor' rating.

26.2.3.2.2. Airspeed Scale Numbers

Satisfactory, although several 'poor' ratings were recorded for the presentation and the number change. Considerable use was made of this scale.

26.2.3.2.3. Speed Legend

Satisfactory, but the occulting was not obvious enough.

26.2.3.2.4. Digital Airspeed

Satisfactory. Several comments were made about the size of the digits and that there was a possibility of confusion with the selected altitude. No reading errors were recorded as the analogue scale was almost always used in preference to the digital reading.

26.2.3.2.5. Fast/Slow Scale

Only rated "Fair". Difficulties were experienced in interpreting values and the sense of this scale. It would appear from the comments and observations made that this scale was not necessary.

26.2.3.2.6. Mach No./ Velocity

Satisfactory, but from the ratings and comments the philosophy needs improving. The Mach No. was rarely used in the exercises given.

26.2.3.2.7. 'V' Speeds

Satisfactory from the rating scales, but the comments were mixed with suggestions for improvement being offered. The majority of the pilots were in favour of 'bugs' on the ASI.

26.2.3.2.8. Speed Select

There was a possibility of confusion with the actual spead readout.

26.2.3.2.9. Magnetic Heading

Satisfactory.

26.2.3.2.10. Altitude Select

There was a possibility of confusion with radio altitude. This did occur on three occasions.

26.2.3.2.11. Rate of Turn

The concensus of opinion was that this was not required.

26.2.3.2.12. Analogue Altitude

Satisfactory.

26.2.3.2.13. Altimeter Pressure Setting

Satisfactory although the digits were rather small for cross-cockpit monitoring.

26.2.3.2.14. Slew Rates

These were unacceptable.

26.2.3.2.15. Digital Altitude

The position was good, but some pilots were more critical of the alert philosophy. Generally the readout was satisfactory.

26.2.3.2.16. High/Low Scale

Most pilots though that this was a poor scale and no improvement was noticed after a minor change was made to stop the deletion of the pointer at the ends of the scale. The opinions expressed show that this scale was only of benefit as a Glideslope indication.

26.2.3.2.17. Radio Altitude

There was unanimity that the size of the digits was satisfactory. A large majority were in favour of the position even though six errors in reading were recorded. The comments also recorded the ease of misreading.

26.2.3.2.18. Decision Height

Very widespread ratings were made showing that this was not satisfactory. No significant change was shown after the 'flashing' was inhibited. The comments offered improvements, but generally stated that the symbol was not compulsive enough.

26.2.3.2.19. Vertical Speed

Less than satisfactory ratings were recorded by the first few pilots, but these improved when the 1,000 ft/min. scale marks were increased in size. There were ten instances of this scale being misread even though the response times were fast. The scale markings were frequently criticised and several pilots suggested a vertical strip scale for this parameter.

26.2.3.20. Lateral Path Error

Two pilots gave a 'Bad' rating having both been confused by the scale. The symbol was changed after the first few pilots and the ratings did show a significant improvement, but two pilots still misinterpreted the scale. The possibility of misinterpreting the scale was probably the reason for the longer reading times.

26.2.3.2.21. Fixed Attitude Marks

The sizes were satisfactory, but a wider variation in the ratings was recorded for the shapes. Some comments were made for improvements.

26.2.3.2.22. <u>Moving Attitude Marks</u>

<u>Pitch</u>

The pitch scale marks were initially rated 'Poor', but after several changes were made to reduce clutter in the centre of the ADI (see Chapter 22) a significant improvement was recorded. The readings were generally given quickly, but several errors were made, at least one of which was attributable to confusion with the Flight Path Angle. Most of the comments concerned the confusions and clutter and the improvements made reflected these comments. Persistent computer problems also affected the presentation of this parameter.

<u>Roll</u>

The ratings had a wide variation showing that this scale was not satisfactory. One pilot gave an unacceptable rating, but did not give a reading. The Reading Times were similar to those for Pitch, but no errors were recorded. Most of the comments concerned the poor zero datum which, after being enlarged, received satisfactory ratings.

26.2.3.2.23. <u>Flight Path Angle</u>

Considerable confusion occurred between the Flight Path Angle and

Pitch, and also with the Potential Flight Path Angle. Unfamiliarity with this type of parameter was the prime reason. The comments show that the idea was good and some suggestions were made for improvement.

26.2.3.2.24. Potential Flight Path Angle

Similar comments as for Flight Path Angle, above.

26.2.3.2.25. Flight Director

The Flight Director was not bold enough and tended to be hidden in the clutter. The accuracy of the Flight Director was very poor and did not always correlate with the raw data.

26.2.3.2.26. Urgent Messages

Only a limited use was made of this facility. Generally the ratings and comments show that the position was satisfactory, but the "attention-getting" needed improving, possibly with colour.

26.2.4. Pilots' Comments on the EHSI, and Reading Times

26.2.4.1. Reading Times

26.2.4.1.1. True Heading

The response time was longer than for many other parameters due to a selection being necessary. Many pilots were confused in not realising that a selection was required.

26.2.4.1.2. <u>Radials</u>

These readings were abandoned after Pilot No.5 because the pilots appeared to have a lack of understanding of the question. These readings were complicated because there were no 'tails' on the Bearing Pointers to give direct readings. A calculation was therefore necessary. The question had been designed to bring to the pilots' notice the lack of 'tails', but unduly prolonged reading times interfered with the rest of the programme.

26.2.4.1.3. <u>Q.D.M.'s</u>

These caused confusion because the pilots were not used to giving them.

26.2.4.1.4. <u>D.M.E.'s</u>

Readings were given both for 'DET' and 'CDG' beacons. The means indicate that about 2 seconds was the average Reading Time.

26.2.4.1.5. <u>Drift Angle</u>

The delays were mainly due to the difficulty in interpreting the scale.

26.2.4.2. Comments

26.2.4.2.1. AP/CWS etc. Modes

These were unsatisfactory mainly because the pilots were not fully conversant with the logic and philosophy of the AFCS. The comments generally concerned the logic and that the modes were not obvious enough. Colour may help.

26.2.4.2.2. ETE/DIS etc. Indications

Satisfactory, although there were several criticisms about the unfamiliar terminology used.

26.2.4.2.3. VOR/ADF/DME Indications

A satisfactory layout, but some reservations were expressed about the effectiveness of these indications. The readings for DME received satisfactory response times. The comments were similar to those for the AP/CWS etc. Modes, above. The ADF particularly needed improvement.

26.2.4.2.4. CRS SEL/DSR TRK etc. Indications

Generally satisfacory although several pilots were confused about the layout. The changes introduced during the programme to improve the layout (see Chapter 22) did not significantly affect the ratings.

26.2.4.2.5. Weather Radar

Not assessed although six ratings were given. (This facility was deleted from the programme after the Questionnaires had been written).

26.2.4.2.6. Nav. Mode Indications

Satisfactory, but several criticisms were made that the display lacked impact.

26.2.4.2.7. Marker Indications

Satisfactory.

26.2.4.2.8. Turn Arrow/Next WPT No.

Satisfactory. One pilot commented that when he was concentrating on his EADI the occulting of the Arrow/WPT No. was outside his peripheral vision.

26.2.4.2.9. Course/Track Pointer

Satisfactory, although there was room for improvement particularly with respect to the clutter with pointers in close proximity to each other. The pointer could also be thicker.

26.2.4.2.10. Bearing Pointers

Not satisfactory. Similar comments about clutter as for the Course/Cross-track pointer. (A), (V) and (N) were too small. The pointers lacked 'tails'. The clutter made the pointers difficult to find. Colour would be of help.

26.2.4.2.11. To/From Indications

Widespread ratings were recorded. The indications were not satisfactory. No comments were given.

26.2.4.2.12. Heading Bug

Unacceptable as it was. The comments show that it was too small and not clear. A "point" for accuracy was required in addition to the digital readout. The change to thicken the "blob" after Pilot No.8 made the ratings and the comments significantly worse.

26.2.4.2.13. Drift Angle

Not satisfactory. The comments show that it would be better nearer to the Rose. Occasionally it was lost in the clutter. It needed to be more distinctive.

26.2.4.2.14. Fixed Lubber Mark

Satisfactory. No comments except that one pilot wanted 45° marks to be considered.

26.2.4.2.15. Lateral Deviation

Satisfactory, but the cross-bar could be more distinctive.

26.2.4.2.16. Vertical Deviation

Satisfactory.

26.2.4.2.17. Compass Rose

Mixed opinions were recorded for this parameter. The Rose did not move smoothly because the numbers were not updated at the same time as the scale graduations. The ratings broadly correlate with the comments.

26.2.4.2.18. Compass References

Few pilots rated these, but of those that did the References appeared satisfactory.

26.2.4.2.19. Slew Rates

Unacceptable.

26.2.4.2.20. Map - Angular Marks

Varying ratings and comments were made so that a satisfactory conclusion cannot be made.

26.2.4.2.21. Map - Aircraft Symbol

Satisfactory.

26.2.4.2.22. Map - Range Marks and Scales

Generally satisfactory, although there was a possibility of confusion as to the actual range showing. Clearer labelling was needed, and possibly also manual selection of the scale.

26.2.4.2.23. Other Map Symbols

Satisfactory, although they may be difficult to distinguish when cross-cockpit monitoring.

26.2.5. Pilots' Comments made in the Debriefings

26.2.5.1. General Impressions

Comparable with conventional instruments, generally favourable. The system has potential and the flexibility would be an advantage.

26.2.5.2. Colour

Colour was definitely desired if only limited to a few paramters. Areas that would benefit most from the use of colour were stated as the centre of the ADI, the pointers on the EHSI and the mode annunciators.

26.2.5.3. Lack of Depth

Not a disadvantage. On the contrary, the elimination of parallax for cross-cockpit monitoring was an advantage.

26.2.5.4. Reduction of Scanning

Most pilots commented that scanning was reduced, several were not sure and several found no change from conventional instruments. A frequent comment was that it was almost possible to fly an approach using only the EADI.

26.2.5.5. Philosophy of EADI as a "Basic Tee"

The philosophy used was satisfactory and probably helped the pilots to readily adapt to the displays.

26.2.5.6. Lateral Scanning

Most pilots found the new scanning pattern relatively easy to adapt to. Four pilots did find the scanning difficult. The change in scanning pattern for the reversionary situation was not easy to adapt to. Several pilots commented that there was less need for the EHSI with the EADI as shown.

26.2.5.7. Tunnel Vision

None, or at least no more than with conventional instruments.

26.2.5.8. Cross-cockpit Monitoring

Relatively easy to do, especially as there were no parallax problems.

26.2.5.9. Philosophy of producing formats similar to conventional instruments

Satisfactory and helped reduce learning time.

26.2.5.10. Parameters that need only be displayed on selection

None.

26.2.5.11. Parameters that could be dispensed with

None, except those already referred to.

26.2.5.12. Parameters Difficult to Understand or Use

None.

26.2.5.13. Shading

Satisfactory except that several pilots felt that the brilliance of the shading on the ADI should have been controlled separately from the remainder of the display.

26.2.5.14. Control of Brilliance and Contrast

Three pilots wanted manual control, but the majority were in favour of an automatic control to a manually preset datum. A manual override would be necessary.

26.2.4.15. Annoying or Unnatural Movements

None, except for the computer problems already referred to.

26.2.5.16. Clarity of Pointers

Generally acceptable, except for the comments already referred to.

26.2.5.17. <u>Benefit of Pointers for Altitude, Speed and Vertical Speed</u>

Analogue scales essential.

26.2.5.18. <u>Dials versus Strip Displays</u>

Dials and pointers preferred. Some pilots had no objections to strips for vertical speed.

26.2.5.19. <u>Alphanumerics</u>

Clarity and shape satisfactory.

26.2.5.20. <u>Clutter</u>

Centre of EADI and EHSI as already referred to, otherwise satisfactory.

26.2.5.21. <u>Usefulness of MAP</u>

The majority of pilots found the Map very useful and worth retaining although there was a significant number who did not use the Map at all. Some pilots found the scale at the top of the Map confusing.

26.2.5.22. <u>Remoteness of Controls</u>

Satisfactory, but a few pilots would have liked some of the AFCS readouts on the Glareshield Controller.

26.2.5.23. <u>Reach of Controls</u>

Satisfactory, except possibly that the CRS select on the Glareshield Controller could be nearer to the centre. Several pilots felt that the pushbutton selectors on the Pedestal were too far forward.

26.2.5.24. Pushbutton selector for the EHSI

About 50% of the pilots found the logic unsatisfactory, particularly having more than two functions on one button.

26.2.5.25. AFCS

Criticisms principally concerned the logic mainly due to unfamiliarity. Several pilots felt that the buttons were too similar and that the Controller should have been divided into segments, possibly with the use of colour.

26.2.5.26. Programme

The poor handling increased the workload. More than one day was needed for the assessment.

26.2.5.27. Eye or Mental Fatigue

None.

26.2.5.28. Annoying Distractions or Flicker

None.

26.2.5.29. Influence of Handling Characteristics on the Ratings

Some pilots admitted that the poor handling and the poor Flight Director could have affected their ratings.

26.2.5.30. Documentation

Most pilots had studied the supplied data beforehand, although a few had not studied them in depth.

26.2.5.31. Briefing

Satisfactory, although more on the AFCS was needed. Some pilots felt that simple tasks should have been part of the briefing before the exercises were flown.

26.2.5.32. Exercises

Although the tasks were too numerous for a single day the exercises were generally satisfactory. More evaluation of the EHSI and a representative navigation workload were needed before workload measurements could be made.

CHAPTER 27

BACK-PROJECTED OPTICAL DOCUMENTATION DISPLAY ASSESSMENT

27.1. Description

A Ferranti Back-Projected Optical Documentation Display was located on the P1 side of the Flight Deck and outboard of the pilot (See Frontispiece). All controls associated with the display were situated immediately underneath it with the exception of the Line Advance Button which was in the centre of the control handwheel hub. (See the illustration in the Questionnaire at the end of this chapter for details).

The pilots were required to use the Documentation Display for their Checks and Drills in Exercises 3 and 6 of the EFIs Assessment. They were also expected to use the Display for the emergency failure, also in Exercise 6, see Para. 24.6.6. for details.

Examples of charts could also be displayed, but this facility was not an important part of the Assessment, although some questions were included in the Questionnaire.

Each pilot was given a Questionnaire at the end of the day's programme to take away and complete at his leisure. Ideally the Questionnaire should have been completed at the end of the day, but time did not permit this.

Only thirteen pilots returned the Questionnaire completed and of these eleven were given the second debriefing.

27.2. Discussion of Pilots' Comments

The full list of the pilots' comments is given in Appendix 3. Almost all the pilots accepted the Documentation Display in principle, but most commented that it was a large and expensive piece of equipment to dedicate to displaying Check Lists and Charts. Possibly the system could have been justified if all documentation, e.g. manuals, were included. Concern was expressed about reliability. It was thought that, in the event of a breakdown, paper documentation would still need to be carried and that the Documentation Display, as shown, would be superfluous. Two reasons were given: (1) The access time to paper documentation could be quicker or, at least, it would not be significantly slower, and (2) Paper has the flexibility of being able to be moved around the Flight Deck, whereas a fixed system has not. Although these reasons also applied to the CRT system the pilots felt that a CRT system could be justified for the Check Lists and possibly the Charts. The CRT system did not, as presented however, have the advantage of colour.

The capabilities of the system for displaying Checks and Drills were recognised, but the Charts as shown were unusable. The alphanumerics using standard 'Jeppeson' or 'Aerad' charts were too small when situated so far from the eyes and were therefore illegible. Conversely, the size of the print on the Check Lists was criticised by some pilots as being too large. All the pilots were able to easily read the Check Lists. The Emergency Check Lists, particularly the automatic presentation, received favourable comment. Colour was a significant advantage for emergency presentations and drew the pilots' attention to the Display. The large expanse of red (or amber) area displayed in an emergency had the effect of drawing the pilots' attention to the Documentation Display first, instead of to the Master Warning System. This obviously places the necessity for very high integrity and reliability on the Documentation Display system, which must be at least as high as the MWS.

The most commonly criticised aspect of the Documentation Display system was the pushbutton page selectors. On many occasions the pilots missed the numbers they required and were forced to wait for the required number to recycle as no backstep was provided. The Octal system of page coding was unnatural to most pilots and complicated the selection process. The fact that the index numbers did not change as the pages changed was also criticised, although other pilots felt that this was helpful as they could return to the page selected at a later time, for example after an emergency.

If the Documentation Display system as shown were adopted special charts would need to be produced and filmed and most pilots felt that these would not be cost-effective. A comprehensive updating system and status indication would also be needed to ensure that outdated charts were replaced as necessary.

27.3. Conclusions

The presentation of the Check Lists was good, but, with the exception of the lack of colour, could be done equally well on the CRT system which was more flexible.

The presentation, by photographic reproduction, of 'Jeppeson' and 'Aerad' charts would not be satisfactory because, to make the alphanumerics legible, only a small area of each chart could be displayed.

27.4. Questionnaire

An example of the Questionnaire used in the Documentation Display Assessment is shown on the remaining pages of this chapter.

ADVANCED FLIGHT DECK

PHASE II

DOCUMENTATION SYSTEM

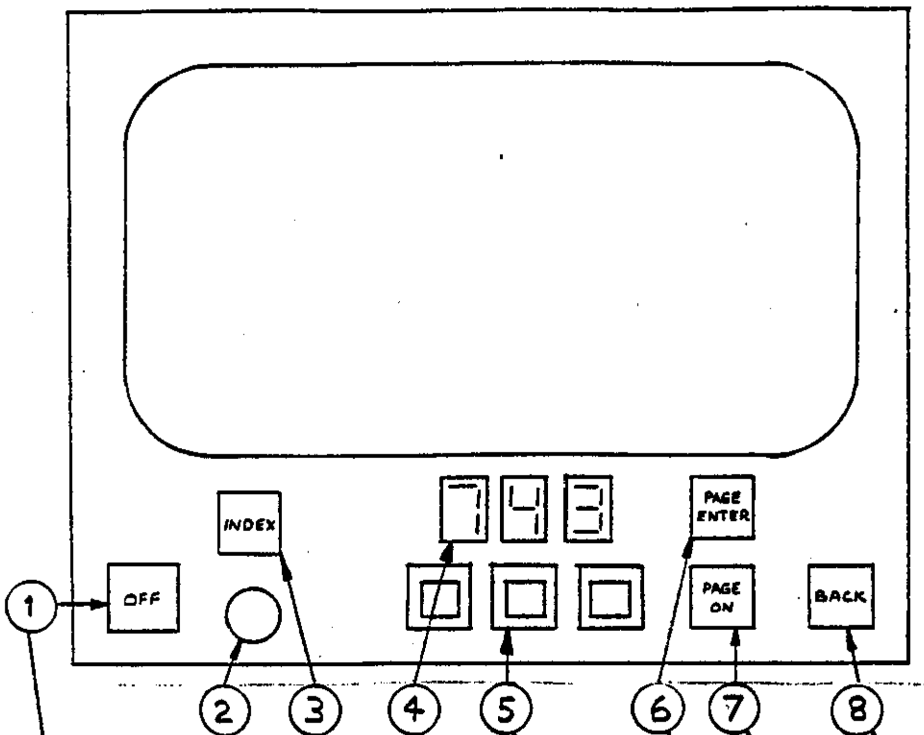
QUESTIONNAIRE

NAME ....

RANK ....

COMPANY/ORGANISATION ....

Glasses worn: YES/NO (Delete as appropriate)



	1 OFF BUTTON	2 BRIGHTNESS CONTROL	3 INDEX BUTTON	4 PAGE NO. INDICATORS	5 PAGE SELECTOR BUTTONS	6 PAGE ENTER BUTTON	7 PAGE ADVANCE BUTTON	8 BACK LINE BUTTON	9 LINE STEP BUTTON (ON CONTROL WHEEL)
Position	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD
Function	BAD / POOR / FAIR / GOOD		BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD
Hold-down Function				BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD			BAD / POOR / FAIR / GOOD	
Colour	BAD / POOR / FAIR / GOOD		BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	BAD / POOR / FAIR / GOOD	
Shape				BAD / POOR / FAIR / GOOD					

NOTE:

Please mark each box above thus: BAD / POOR / FAIR / GOOD X , as appropriate.

Use separate sheet for comments.

(10) How would you rate the character sizes on the check lists only?

Far Too Small — Small — Moderate — Could be Smaller

(11) How would you rate the contrast of the white characters on a black background?

Unacceptable — Bad — Poor — Fair — Good — Excellent

(12) How would you rate the acceptability of emergency check lists on a red background?

Unacceptable — Bad — Poor — Fair — Good — Excellent

13) How would you rate the acceptability of those emergency check lists on an amber background?

Unacceptable — Bad — Poor — Fair — Good — Excellent

14) How would you rate the charts as presented? (State which charts)

Unacceptable — Bad — Poor — Fair — Good — Excellent

5) What is your opinion of the screen size?

Far Too Small — Small — Moderate — Could be Smaller

6) What is your opinion of the screen brightness in the ambient conditions shown?

Too Dim — Dim — Bright — Too Bright

7) How would you rate the access time?

Unacceptable — Bad — Poor — Fair — Good — Excellent

8) How would you rate the fixed lines for locating each item?

Unacceptable — Bad — Poor — Fair — Good — Excellent

9) How would you rate the philosophy of indexing by numerical codes?

Unacceptable — Bad — Poor — Fair — Good — Excellent

(20) How would you rate the procedure for selecting a page?

Unacceptable Bad Poor Fair Good Excellent

(21) How would you rate the philosophy of an emergency drill overriding the current page?

Unacceptable Bad Poor Fair Good Excellent

(22) What is your opinion of the workload associated with this display?

Unacceptable High Moderate Low

(23) Do you consider that this type of documentation display has potential for aircraft operation?

YES ☐ NO ☐

(24) Please comment below on any further development that you think is necessary.

(25) Please comment on the information displayed (e.g. amount, type)

COMMENTS

QUESTION NUMBER	

SUMMARY AND CONCLUSIONS

CHAPTER 28

SUMMARY OF STUDY AND CONCLUSIONS

28.1. Introduction

This chapter contains the conclusions that can be drawn from the study. Although some of these conclusions have human factors implications the main human factors findings are included in Chapter 29.

28.2. Aircraft Systems

a) Two crew operation of an aircraft originally designed for three required the elimination of the Flight Engineer's station and the design and manufacture of simplified systems control panels for roof installataion within reach of either of the pilots.

b) The use of three electronic displays for systems information and located in the centre panel resulted in the dissociation of the displays from the controls and the inability to present all the systems formats at the same time.

c) Dissociation of controls from displays led to the design of display formats reflecting systems layouts in clear mimic form and control panels of similar outline.

d) Dissociation of controls from systems warnings led to the incorporation of fault identification within control pushbuttons.

e) Since simultaneous visual monitoring of all of the systems was not possible, automatic monitoring and presentation of a systems fault was provided when this was significant. Out-of-tolerance conditions were also detected. Video-inverted captions and flags were displayed to indicate these conditions using the logic available from the MWS.

f) The detection of simultaneous faults in several systems required the development of a priority system related to fault and systems importance.

g) The absence of display parallax significantly increased the ability for pilots to monitor displays across the Flight Deck.

28.3. Electronic Flight Instruments

a) The displays of flight information were limited for Phase 1 and it was recognised that the EADI was only suitable for simple manually controlled manoeuvres, or to monitor the performance of the AFCS. The EHSI was unsuitable for any navigation function other than to monitor a computer defined flight plan.

b) Video transfer of the EADI and EHSI formats for display failure or navigation monitoring was provided.

c) In the event of total EADI failure it was assumed that a safe flight path could be achieved using either of the standby attitude, altitude and airspeed indicators (shown for the exercises in representation form only).

d) In the event of total EHSI failure it was assumed that a safe flight could be achieved using the standby RMI and compass (shown in representation form only for the exercises).

28.4. Documentation Display - (Checks and Drills)

a) A limited assessment of the presentation of Checks and Drills was introduced during the latter part of the study, including a comparison between electronic display (CRT) and optical back-projection.

b) Automatic presentation of emergency and failure drills was easily mechanised using the logic available to provide automatic display of systems faults.

28.5. Simulator Handling

a) Since the Assessment Pilots were mainly concerned with aircraft systems management and the evaluation of displays, the overall workload was not significantly affected by anomalies in the stability and control characteristics ofthe simulator.

b) Large changes in feel forces with speed in cruise conditions (300 to 340 knots, 18,000 to 21,000 feet) were experienced during flight which were well outside the VC10 ranges. In order to reduce the workload for the handling pilots, extensive use was made of the autopilot which gave acceptable accurate control from climb to landing.

c) To provide a realistic handling workload during the assessment of the EFIs, development of the aerodynamic simulation and redesign of the artificial feel and trim systems was carried out. There were still some problems, however, with stability and these may have influenced some pilots assessments.

d) In the near steady conditions that existed for the chosen flight profiles the absence of simulator motion did not affect the handling tasks.

e) Since there was no requirement to assess the manual landing task the lack of external visual cues was unimportant.

28.6. Air Traffic Control

a) It was recognised that the assessments by non-handling pilots would be unrealistic without ATC and navigational duties. Initially an external station with controller was used which, although operationally satisfactory, was found to be expensive in manpower terms.

b) During the latter parts of the programme the ATC function was transferred to the Resident Pilot. The ATC service was developed using four commercial tape-players each with remote controls located on the Pedestal. The pre-recorded tapes provided:

i) Background ATC related to predicted positions on the London to Paris or Paris to London routes, assuming the required speeds were maintained.

ii) Ground-to-air instructions to the Flight Deck

iii) London ATIS

iv) Paris ATIS

c) The tape system proved to be inexpensive and satisfactory to operate.

28.7. Control of Exercises

a) The control of the exercises arranged for the Familiarization Programme was provided by an external operator. As with the ATC, this was found to be expensive in manpower so during the Systems and EFIs Evaluations this function was transferred to the Observer.

b) The Observer operated the fault injection equipment in addition to monitoring and recording the pilots' comments and reactions.

c) The monitoring of discrete events was supplied by continuous print-outs from a digital computer.

28.8. Utilisation

a) In the period March to May, 1976, 11 pilots took part in a two-day Familiarisation Programme during which 77 hours of 'flight' time were recorded.

b) In the period August to December, 1976, 9 of the 11 pilots returned for a two-day Systems Evaluation and 5 of these completed the full four-day programme. During this period 72 hours of 'flight' time were recorded.

c) In the period July to September, 1977, 20 pilots took part in a single day assessment of the EFIs during which 68 hours of 'flight' time were recorded.

28.9. Techniques

a) The pilots were asked to read parameters and repeat their values. On some occasions this involved format selection for the systems displays before the required parameter was displayed. The times to respond and the accuracy of responses were recorded.

b) The pilots' reaction times for recognition and control of injected faults were timed by the Observer. On most occasions fault injection was arranged so as not to conflict with another task.

c) The pilots considered that the content of the exercises produced a realistic workload and that the objectives of providing 'training' during the Familiarisation Programme and evaluation during the later periods was achieved.

d) The pilots accepted that the length and detailed nature of the Questionnaires was necessary.

28.10. General Conclusions

a) The Flight Deck was suitable for two-crew operation.

b) The fixed display brightness level was satisfactory for the ambient conditions on the simulator, but investigation is needed into bright high-contrast and shadowed conditions.

c) There was no greater eye fatigue than would have been experienced when doing similar tasks in a conventional simulator.

d) The electronic displays were generally acceptable.

e) The introduction of a Status Display gave a significant reduction in selection and monitoring workload.

f) The failure to recognise the amber "Attention-getters" for long periods requires the addition of an audio to the MWS.

g) There was a broad acceptance of the readouts being remote from their controls.

h) The use of limited colour, especially for the EFIs, would eliminate many of the criticisms.

28.11. Conclusions on Display Formats

28.11.1. Systems

a) A practical means of checking the warnings on the formats during Preflight Checks when more than 7 flags were displayed was needed.

b) The loss of one of the three systems displays caused no concern. The loss of two of the three systems displays was satisfactory when use was made of the standby engine instruments to enable the remaining display to be used for systems data.

c) Adequate display redundancy was normally available to consider the presentation of documentation on a systems display or, when on the ground, on a flight display.

d) The ability to select a systems display to 'Standby' reduced clutter and, in conjunction with automatic presentation after fault detection, increased the visual impact of the warning system.

e) The displays priority hierarchy did not deprive the pilots of the ability to select any system for presentation on any available display.

f) Significant mistakes were not made in reading data from the matrix of digits on the All Engines format, nor were the response times any longer than the average.

g) Out-of-tolerance flags should not be used to warn of EGT values in the 'amber' region when in the climb.

h) All engine warnings should be shown on the primary format

i) The fuel format was the best, with good warnings.

j) The hydraulics format was the next best, with good analogue presentations and a simple diagram, but too many flags.

k) The Air Conditioning and Electric formats were too cluttered.

l) The Anti-ice format was a confusing diagram.

m) The Pressurization format was the only all-alphanumeric systems format. Some pilots would have preferred analogue elements. It was found to be difficult to distinguish between 'Set' and 'Achieved' values.

n) On the Flying Controls format the aircraft symbol was too bold, and the trim scales were confusing.

o) On the Status format the lines of data in alphanumeric form had to be scanned. The Electrical Load presentation was also not clear.

p) For the Documentation Display there were seen to be potential advantages in the electronic display of normal checks and drills. Some difficulties were experienced in operating the back-projected system.

28.11.2. Flight Displays

28.11.2.1. EADI

a) The following items were considered acceptable:

i) Analogue speed and altitude; speed and altitude deviation warnings.

ii) Digital readout of existing speed and altitude, with some preference for an increase in character size.

iii) Digital readout of Mach No. and 'V' speeds.

iv) Baro setting and annunciation

v) Digital magnetic heading

vi) Lateral path and vertical path error

vii) Urgent message window and Decision Height window.

b) The following items were given varied or neutral ratings:

i) Flight Path Angle

ii) Potential Flight Path Angle

iii) Analogue Vertical Speed

iv) Pitch Scale (excluding 2^{o} marks)

v) Digital readout of Radio Altitude

c) The following items were considered poor (or not used - NU)

i) Position of digital readout of selected speed/altitude, with some preference for an increase in character size.

ii) 2^{o} pitch marks which were displayed within varying 10^{o} pitch marks depending on existing altitude

iii) Fast/Slow speed indication (NU)

iv) Rate of turn indication (NU)

v) Roll angle marks

vi) Altitude error indication (NU)

vii) Lack of analogue presentation of Radio Altitude.

d) The following items were considered unacceptable:

i) Slew controls for selecting digital speed and altitude

ii) Flight Director symbol and its sluggish performance

iii) Lack of analogue presentation of 'V' speeds on ASI.

28.11.2.2. <u>EHSI</u>

a) The following items were considered acceptable:

i) Course pointer and deviation bar

ii) Vertical deviation indication

iii) Digital readouts of radio frequencies and DME information

iv) Time, Distance, Ground Speed, True Airspeed readouts

v) Map display and associated symbols.

b) The following items were given varied or neutral ratings:

i) Digital Magnetic and True Headings

ii) Identification of active radio navigation system

iii) Compass scale on Rose Display

iv) Marker and waypoint indications

c) The following items were considered poor:

i) Course pointer To/From and Nav Annunciators

ii) Bearing pointers

iii) Map display compass scale

iv) Heading Bug

v) Drift Bug

vi) Mode indicator

d) The following items were considered unacceptable:

i) Slew controls

ii) Multi-function pushbuttons

28.12. Conclusions on Controls

28.12.1. Systems Controls

a) Because the Systems Displays Control Panels were frequently used any selections must be instinctive. Further improvement is needed in layout and operation.

b) Engine Shutdown Panel - with one exception the concept and position were liked. There was a possibility of misselecting the toggle switches and the switch identifications needed improving.

c) Fuel Panel - The pump and crossfeed switches were too similar.

d) Hydraulics Panel - switches too similar.

e) Air Conditioning Panel - the system operation was not easily learned, the systems response and stability not being realistic.

f) P.C.U. Panel - the use of split caption switches to annunciate failures and systems condition was well received. The philosophy could be extended to the other panels.

g) Test Panel - the centralised arrangement was good but the overhead position and the time involved in using the panel resulted in some physical discomfort.

28.12.2. Glareshield Controller

a) The slew controls for Course, Heading, Baro setting, Altitude and Speed were very poor. There was a general preference for rotary selectors unless a large reduction in the total slewing time could be achieved.

b) There were too many similar controls which were too close together.

c) The mode selection and logic needed simplification.

CHAPTER 29

SUMMARY OF THE HUMAN FACTORS' RESULTS OF THE PROGRAMME

29.1. Most of the detail conclusions relating to the design of the Electronic Displays System and the Controls are considered in Chapter 28. In this chapter the human factors implications only are listed. These are further discussed in Chapter 30. References to the results are given in parentheses where appropriate, but these are not exhaustive.

a) Character Sizes (para.13.21, App.2 pages 7,47-9)
These were quite readable, contrary to the published recommendations.

b) Pilots' Scan Patterns (App.2 pages 4-6)
All the pilots had to change their scan patterns from those used with conventional instrument panels, but their subjective opinion showed that the new patterns were easily learned.

c) Format Clutter (App.2 pages 5,6,10,24,25,35,52)
Some of the formats exhibited instances of clutter and these were particularly noticeable on the EADI and EHSI.

d) Symbology (App.2 pages 5-11,35-40,51-52)
The symbology used was limited by computer constraints, but was in general considered acceptable. Some of the symbols for valves required improvement on the Air, Fuel and Pressurization formats. On the EADI the Flight Director symbol was insufficiently obtrusive. Some of the pointers on the EHSI were poor.

e) Contrast on Formats (para. 13.2.2. and App.2 pages 6 & 50)
The aircraft representation on the Flying Controls format

and the shaded areas on the EADI were over-bright.

f) Flicker (para. 13.2.2. and App. 2 page 55)

Contrary to expectations, no peripheral flicker was admitted to by the pilots.

g) Tunnelling Effect (App.2 pages 6 & 49)

Although the pilots did not admit to any tunnelling effect they did tend to concentrate on the EADI with a consequent reduced evaluation of the EHSI.

h) Parallax (App.2 pages 4,5,57-50)

Parallax was eliminated and the ability to monitor across the flight deck was increased.

i) Pilots' Mental Workload (paras. 13.2.1., 13.2.2.,App.2 pages 6, 53-54)

The mental workload was higher because of the systems display switching involved. There is no evidence to suggest that this was offset by reduced scanning.

j) Remoteness of Control Panels (App.1 pages 1-32)

Eye and head movement was increased for systems operation because the controls were on the roof panel and the displays on the main instrument panels. The remoteness of the displays did not appear to contribute to the errors that were made.

k) Master Warning System (App.1 page 88 and App.2 page 26)

Many amber warnings went unnoticed for long periods of time.

CHAPTER 30

DISCUSSION OF THE HUMAN FACTORS PROGRAMME AND SUGGESTIONS FOR FUTURE STUDY

30.1. Introduction

This chapter is an appraisal of the programme and makes suggestions for further study.

30.2. Programme

30.2.1. No matter how well organized a programme may be there will always be problems. The programme for Part A was concentrated into two days. Although all the exercises were accurately timed beforehand it soon became obvious that it was going to be difficult to adhere to the times scheduled. The majority of pilots took longer than anticipated, but there were some who finished on time. One of the main causes of delay was the time taken to complete the questionnaires. The same problems persisted for Parts B and C even though care was taken to reduce the content of the programme and simplify the questionnaires.

30.2.2. The aim of the programme was to evaluate the proposed displays and controls system in as realistic a situation as possible. Whilst this environment enabled the pilots to make a positive assessment, it was, in retrospect, not ideal for evaluating some of the basic human factors aspects for direct comparison with conventional displays and controls. A full flight has too many variables for some of the basic data to be collected accurately. The programme has, however, demonstrated that the concept is feasible and useable. Smaller studies are needed before optimum formats can be produced and compared with conventional displays in controlled conditions.

30.2.3. The pilots used in the programme came from a wide variety of backgrounds and hence their assessments are not comparable with each other.

30.2.4. There was an insufficient number of pilots to provide statistical substantiation to the conclusions drawn. To have provided the required number for this programme would have been too expensive and have taken a much longer time. Nevertheless, the small sample has enabled reasonable assumptions and conclusions to be made.

30.2.5. The author has not been responsible for the designs of the formats and controls, although he did make suggestions, some of which were incorporated. He has, therefore, been impartial throughout the programme. When having been concerned with the design it is too easy to influence the Assessment Pilots, particularly when the experimenter is with them throughout the whole programme. Pilots who are not "strong-willed" may say what one wants them to say, particularly if an affable relationship exists. This may have occurred in a few instances, although every care was taken to ensure that it did not. It is not thought, however, that any influences have significantly affected the conclusions.

30.2.6. The problem with the type of programme used is that there are no data with which to compare the results. Data on conventional displays and controls have not been collected and are not available, mainly because of the reasons outlined in para. 30.1.2. Only the pilots' experience can be used as a basis for comparison.

30.2.7. Many people were involved with the design of the Flight Deck and the programme. Because of the length of time involved from the start of each part of the programme to when the final conclusions could be drawn, there were tendencies to make changes midway through, after some criticisms had been made. These were resisted as far as possible in Parts A and B, but for Part C some changes were made during the period that the first ten pilots made their assessments. These changes have, however, not significantly affected the conclusions drawn by the author.

30.3. <u>Techniques</u>

30.3.1. <u>Exercises</u>

30.3.1.1. Each pilot was required to sit with his eyes in a predetermined optimum position. Although this was explained to the pilots beforehand, they did not all maintain this position. One pilot leaned very far forward, but when questioned he claimed that he could clearly read the displays and reach the controls when seated with his eyes in the eye reference position.

30.3.1.2. The handling of the aircraft was very poor and required undue concentration. This was particularly noticeable in Parts A and B where the pilots' concentration was taken away from the Systems Displays to the EADI. This reduced the amount of effort the pilots were able to put into the systems assessment. However, the pilots said that this did not affect their assessments. One pilot was seen to be very erratic in his flying of the simulator, but when observed in an aircraft later the same day his flying was smooth, thus showing that the simulator had deficiencies.

30.3.1.3. The exercises were based on a "building-block" technique, i.e. the exercises became progressively more complicated, each forming the basis for the next. This method appears to have been satisfactory.

30.3.1.4. The exercises were compiled in order that the readings requested and the other tasks given occurred at the same time in each exercise for each pilot. This was an attempt to standardize the workload so that reliable comparisons could be made. In most instances the programme was closely followed, but there were a few occasions when ATC or abnormal response times by the pilots delayed the readings or caused them to be deleted.

30.3.1.5. All the pilots were instructed not to repeat the questions when giving their answers, but nevertheless some pilots persisted in doing so.

30.3.1.6. All the readings were requested in an identical fashion as outlined in para. 8.4. This method was satisfactory.

30.3.1.7. The tape recorder was switched to intercom in advance of a system malfunction being injected. Some pilots noticed a faint 'pop' when the intercom was switched on. This alerted them to the fact that a fault was imminent. Various methods were tried to inhibit these cues. For details see para. 15.3.3.

30.3.2. Questionnaires

30.3.2.1. The questionnaires used in the Familiarization Programme (see Chapter 12) took much longer to complete than had been allowed for. The answers to the questions, being in the pilots' own handwriting, were frequently difficult to read. It was noted in the debriefings that much more comment needed to be included.

30.3.2.2. As a result of the lessons learned in the Familiarization Programme, and the fact that considerably more data were required in the Evaluation Programme, it was decided to use the pictorial questionnaires as described in Chapter 19. The illustrations definitely helped the pilots to visualize the aspects of displays, controls, systems or the Flight Deck on which they were rating and commenting. A large amount of detail was required and time did not permit the more usual questionnaire to be used so the pictorial idea was invented and was very successful. Although the questionnaires still took a long time to be completed by some pilots they were definitely an improvement and easier to analyse. The use of the boxes was an improvement and helped the pilots to cover all the detail required and at the same time reduced the amount of written data. Without these 'prompts' the pilots would not have covered all the relevant aspects. Some pilots found the box completion laborious and occasionally some boxes were omitted, but most agreed that they were necessary.

30.3.2.3. When designing the EFI questionnaire, it was decided to continue the pictorial philosophy, but because many rating scales were to appear on each page it was decided to vary the type of rating scales used. It was noticed in the Evaluation Programme that some pilots tended to rate all the boxes and scales identically and possibly did not think about their answers in sufficient depth. As the rating scales appeared in the EFI questionnaire it was felt that there would be a tendency for identical unconsidered ratings to continue. To eliminate this problem different scales were inserted for some questions. Indeed, what was expected happened, and some pilots rated some questions wrongly and had to re-rate them.

30.3.2.4. Every care was taken to ensure that the questions were compatible with the standard of the Flight Deck. In all the questionnaires there were, however, several questions which were not compatible due either to a last minute change being made to the

Flight Deck or to the computing not being finished. Some pilots noticed these incompatibilities and commented on them or omitted the questions, but there were some pilots who answered the questions when they should have been unable to have done so. This obviously casts doubts as to how reliable their answers to the other questions were. For example, in Part C the Weather Radar (D5) was not demonstrated and yet six pilots gave a rating to this question. There were some pilots who were meticulous in their answers and provided short comments in the margin adjacent to their ratings.

30.3.2.5. In all cases the questionnaires, except for the Documentation Questionnaire, were completed at the end of a day's exercises. This time was not ideal as some of the pilots were anxious to leave, but it was thought to be the best time available as the information was fresh in their minds.

30.3.3. Briefings

The method of briefing (see Chapters 9, 16 and 24) was not ideal, particularly as so much information was required to be absorbed in such a short time. After discussion with, and observation of, the pilots it is concluded that the optimum method of briefing is to give it in the form of a demonstration with greater pilot participation. This type of briefing would require an additional day in the programme.

30.3.4. Debriefings

The methods of debriefing used were satisfactory.

The debriefings at the end of each day's exercises were conducted in Part A by the Exercise Controller and in Parts B and C by the Observer. The questions were phrased objectively in order that the pilots' replies were not influenced. However, other persons were present at the debriefings who were given opportunities to ask questions towards the end of each session. These questions often led to a discussion where the pilots' opinions may have been influenced. These opinions are not included in the results in Appendices 2 and 3. The debriefings were used to discuss the reasons for any unusually long resplonse times to readings or systems failures and to discuss any comments made during the exercises or in the questionnaires. The opportunity was also taken to discuss the pilots' general attitudes to the type of displays and controls system being evaluated. The additional debriefing used in Part C for more general topics was useful. This allowed the pilots time to consolidate their thoughts and to discuss the study with their colleagues. Occasionally changes of opinion, or at least of emphasis on their opinions, were detected.

30.4. Discussion of Human Factors' Results

The discussion of the topics below relates to the results in Chapter 29. The same item letters have been used in Chapter 29 and below to facilitate comparisons. Many of the topics below suggest future research is necessary and these are listed in para. 30.5.

a) Character Sizes

The two character sizes used (0.16" and 0.12") were satisfactory for viewing distances up to 50", in contradiction to the published recommendations. They were even legible when viewed from the Observer's position (see Fig. 72 and Table 6). Whilst these sizes were acceptable for static conditions further evaluation is needed in dynamic flight where environmental constraints are imposed (e.g. turbulence, high ambient lighting).

b) Pilots' Scan Patterns

Although the subjective opinions show that the new scan patterns were easily learned, eye movement recordings are necessary for verification. Particularly, some of the reading exercises should be repeated with an eye recorder in use. Problems may occur when any of the flight displays (F1 to F4) fail, because then new scan patterns would be needed to which the pilots would not be familiar. The display failures themselves would increase the pilots' stress levels and when an unfamiliar scan pattern is also necessary reading errors could occur.

c) Format Clutter

Attempts were made to reduce the clutter on the EHSI when course, heading and bearing pointers coincided (see para. 22.1., 22.3., 26.2.4.2.9. and 26.2.4.2.10), but these were not sufficient. The use of colour could possibly eliminate these problems. The other major incidence of clutter was in the centre of the EADI, particularly the poor definition of the Flight Director. Colour would probably be of help here.

d) Symbology

The limiting constraints imposed by the computers and the programme adopted did not allow significant changes to be made to the symbology during the different parts of the study. Most of the problems concerned symbol legibility when associated with the surrounding symbols and background. Improvements are necessary to some symbols of the EADI and EHSI (see Chapter 26) and the use of colour could offer significant improvements.

e) <u>Contrast on Formats</u>

The present method of controlling displays brightness and contrast does not allow for the control of individual areas of a display. The large expanses of green (the aircraft representation and the shading on the EADI referred to in Chapter 29), can,and did, cause distractions away from the other formats. It is also possible that these areas may also contribute to eye fatigue although no evidence has at present been collected to this effect. It would seem, therefore, that a method of controlling the brightness of small areas of a display is desirable. Alternatively, further development is needed to produce improved methods of shading.

f) <u>Flicker</u>

The author did see peripheral flicker when he "looked" for it. Although the pilots claimed that they did not notice any flicker it is possible that their workload and concentration necessary for the tasks given caused the flicker to go unnoticed.

g) <u>Tunnelling Effect</u>

The EADI was a very sophisticated format and it was possible to do a large part of each flight using this format and excluding the use of the EHSI. The poor Flight Director and handling characteristics may have contributed to this effect with the result that the EHSI did not receive a full evaluation.

h) <u>Parallax</u>

The elimination of parallax offers significant advantages for observing displays at large angles from the pilots' perpendicular vision to the displays.

i) <u>Pilots' Mental Workload</u>

The fact that the pilots had to select formats to make some of their readings must have created extra workload, both covert and overt. Scanning does not appear to have been reduced as the pilots had to look at the format controls to make their selections. Consideration should be given to the design of format selectors that can be operated only by tactile means.

j) Remoteness of Control Panels

Most of the reading errors were caused by misreading the parameters on the formats. The only errors noticed when the controls were the cause were when the pilots were operating the Engine Start controls. The apparently poor labelling of the toggle switches was a contributory factor, but it was noticed that most errors occurred when the pilots did not adhere to the Check List Order.

k) Master Warning System

A visual warning alone is not sufficient. It is suggested that all MWS warnings should be accompanied by an audio signal. The problem may be exacerbated in high ambient light conditions.

30.5. Suggestions for Future Studies

From studying the principal findings in para. 30.4. some areas for future study become apparent:-

a) The character sizes as shown were satisfactory for a static environment, but further studies are essential in either a moving-base simulator or in the air.

b) The scan patterns for P1 and P2 are different due to the "handed" displays. In the event of a display failure the patterns would again be different. Studies are necessary into the effects of varying scan patterns. An eye movement recorder would be a useful asset in these studies.

c) Colour can offer significant advantages and the next logical step would be to study these advantages.

d) Alternative methods of shading to reduce the contrast (glare) need investigation.

e) Studies are needed into the long-term viewing effects in both dark adapted and high ambient lighting conditions to see if there is any noticeable peripheral flicker and and physiological and psychological effects.

f) The viewing of head-down raster displays during varying levels of vibration and turbulence requires investigation.

g) Studies of pattern recognition for the preflight checking of warnings to speed-up the check procedure are needed in case automatic methods are not available.

h) Various format control designs requiring tactile operation only need developing in order that eye and head movement may be reduced.

If any study similar to that described in this thesis is repeated with new equipment and designs as suggested in this chapter, consideration should be given to analysis of data by computer. In any study of this nature there are so many variables that human analysis of the data collected takes a very long time and in some cases is impossible.

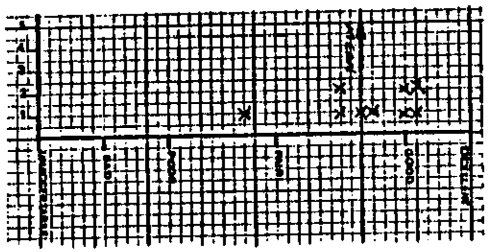
APPENDIX 1

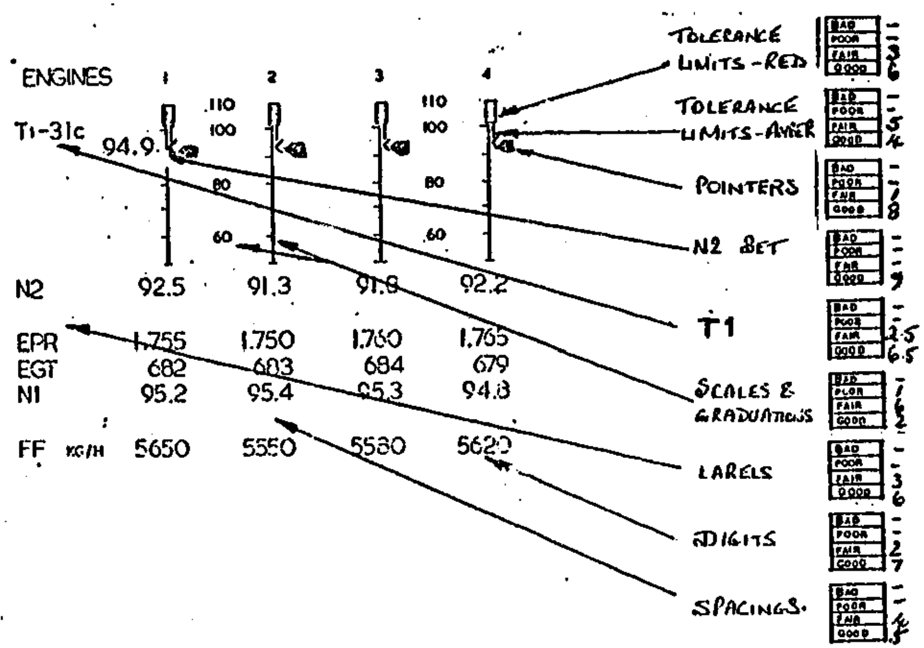
RESULTS OF SYSTEMS EVALUATION

(SEE CHAPTER 20)

INDEX TO RESULTS OF SYSTEMS EVALUATION

1.1 HOW WOULD YOU RATE THE PRESENTATION OF THE MULTI-ENGINE FORMAT?





Pilot's Comments

1. A good display and easy to use (2 pilots)

2. Amber boxes distracting on take-off (1 pilot)

3. EPR digits stand-out among other digits due to their being 4 figures in each (1 pilot)

4. Scale numbers rather small and difficult to relate to scales. Would be improved by moving scales closer together (1 pilot)

5. Improved pointers were excellent (1 pilot)

6. Reversed writing on warnings (see Q.1.11) could be clearer (1 pilot)

7. Would prefer two N_2 bugs one for take-off power and one for noise abatement power (1 pilot)

8. Colour needed (1 pilot)

9. Spacing would be improved with less information (1 pilot)

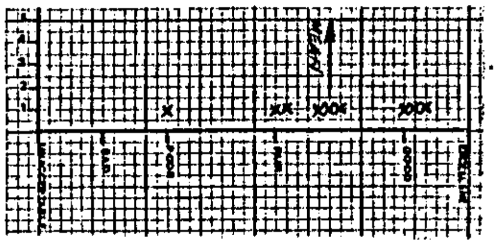
10. Not an enthusiast for strip displays and therefore prejudiced against them (1 pilot)

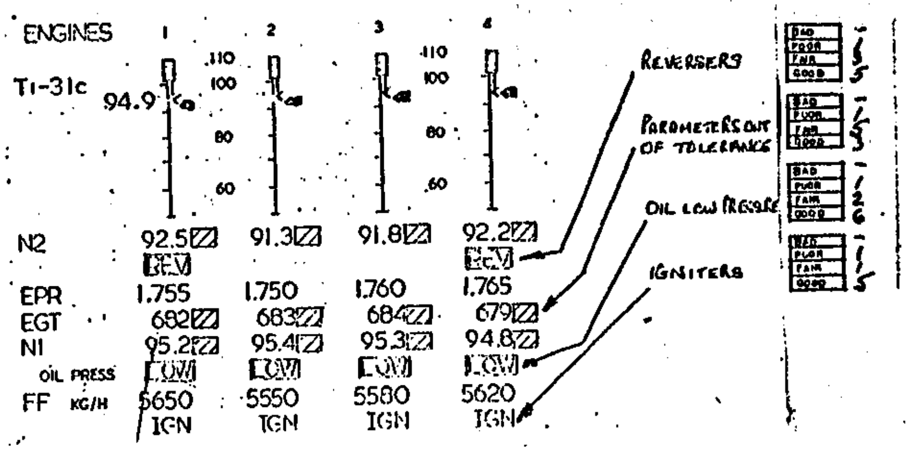
11. Reading of digits situated closely together requires more concentration (1 pilot)

12. Vibration readings wanted on this format (1 pilot)

Three pilots did not make any comment.

1.11 HOW WOULD YOU RATE THE MULTI-ENGINES FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





Pilot's Comments

1. Amber blocks distracting on take-off (1 pilot)

2. Information cluttered, but it is necessary. Perhaps more analogues could be used on a two-engine format (1 pilot).

3. All 'reversed' writing could be clearer (1 pilot)

4. Warnings clearly seen (1 pilot)

5. Warnings need to be in colour (1 pilot)

6. Igniters could tie up with 'Relight' (1 pilot)

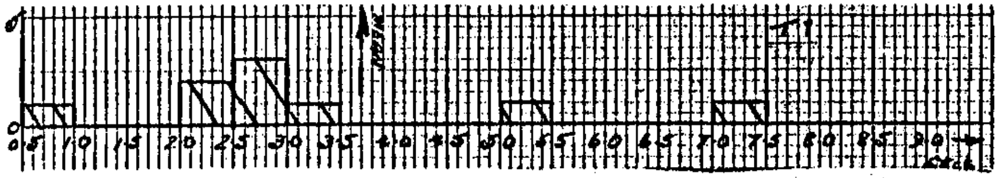
7. Prejudiced against strip displays (1 pilot)

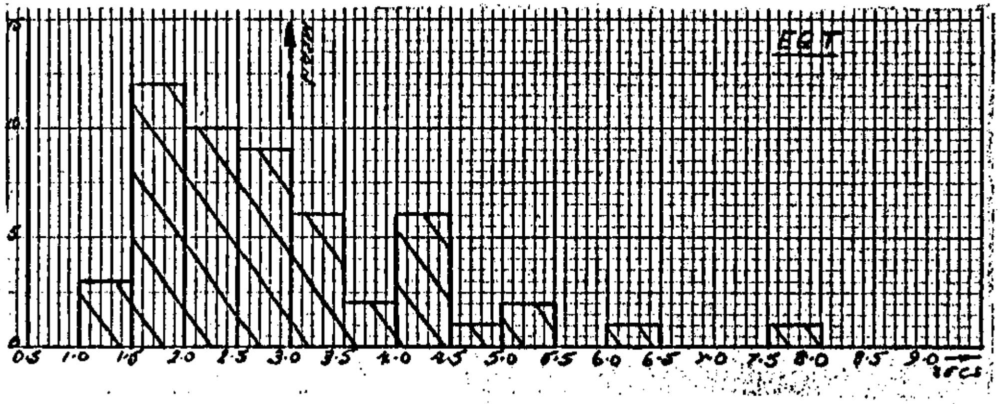
8. Out of amber tolerance not really required. Out of red tolerance should be latching (1 pilot)

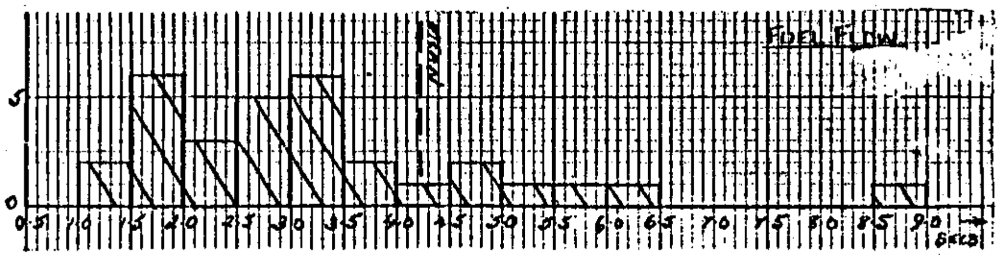
Three pilots did not make any comment

MULTI - ENGINES

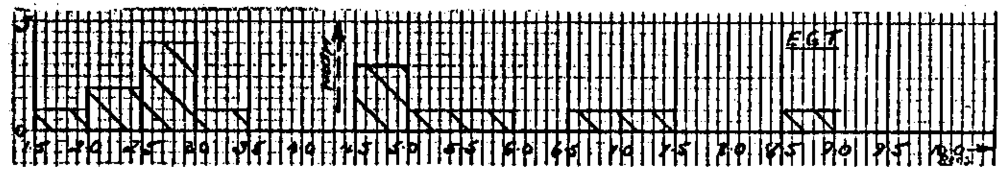
READING TIMES

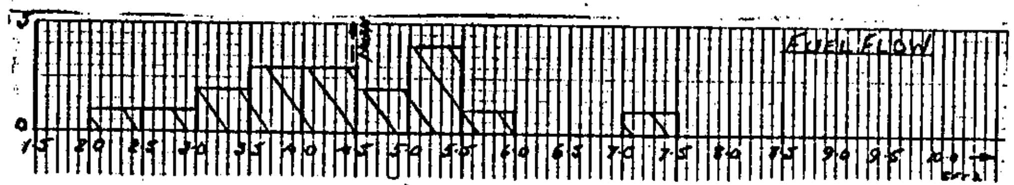






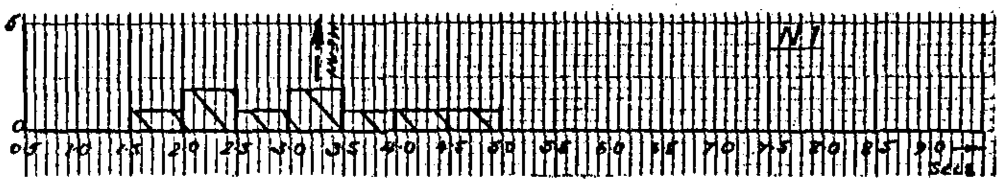
FORMAT SELECTION TIMES

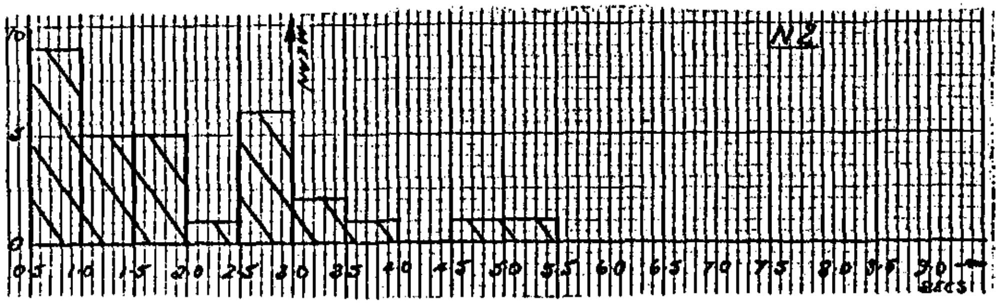




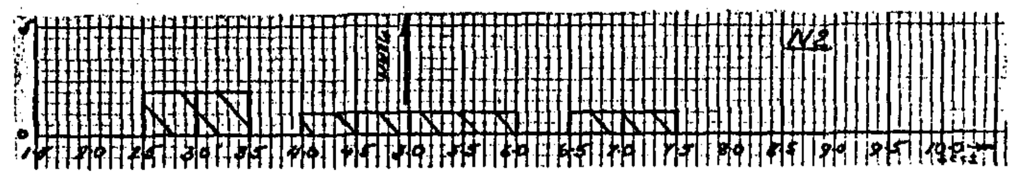
MULTI - ENGINES

READING TIMES

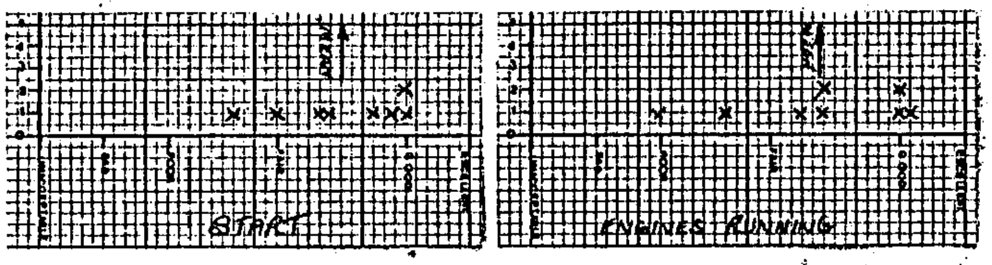


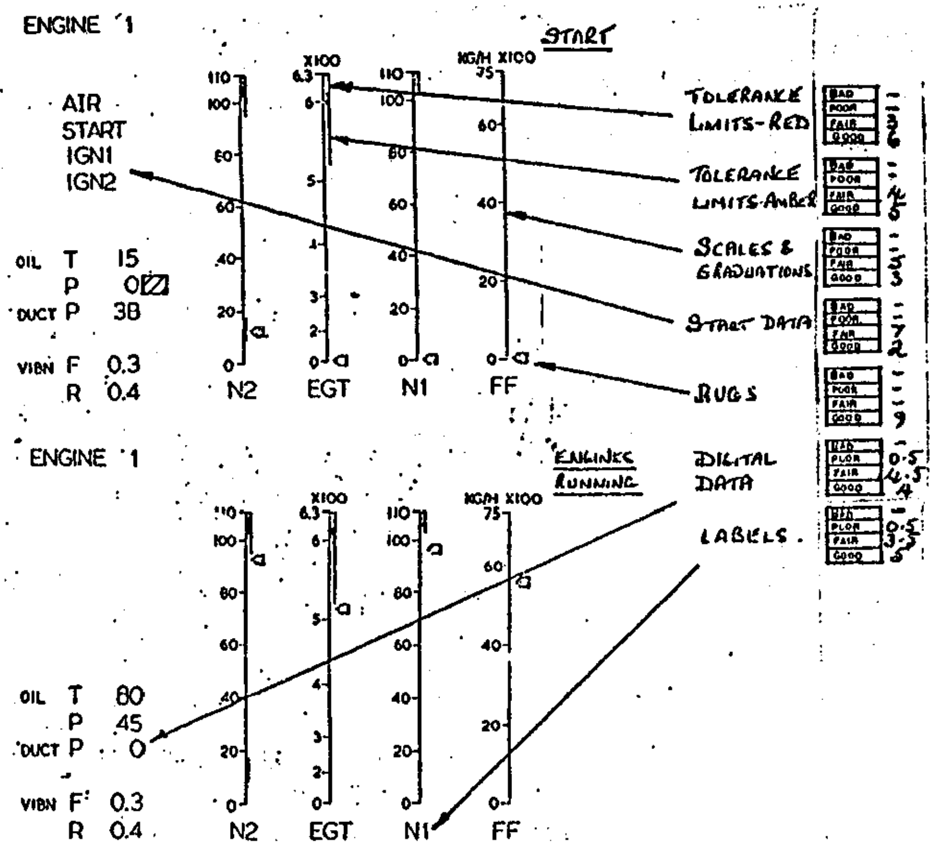


FORMAT SELECTION TIMES



1.2 HOW WOULD YOU RATE THE PRESENTATION OF THE SINGLE ENGINE FORMATS FOR NORMAL OPERATION?





Pilot's Comments

1. Words OIL, DUCT, VIBN should have larger letters (2 pilots)

2. Labels OIL, DUCT, VIBN F.R. etc. too brief (1 pilot)

3. Display not compelling enough (2 pilots)

4. Scales require further subdivision marks (1 pilot)

5. Good for starting and the digital information was not missed (2 pilots)

6. Start sequence not clear (1 pilot)

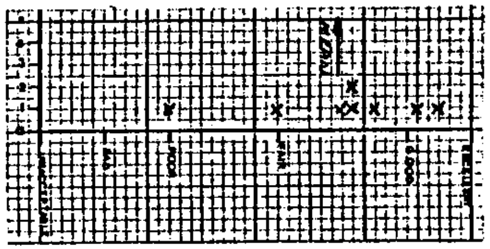
7. The x 100 is unnecessary (1 pilot)

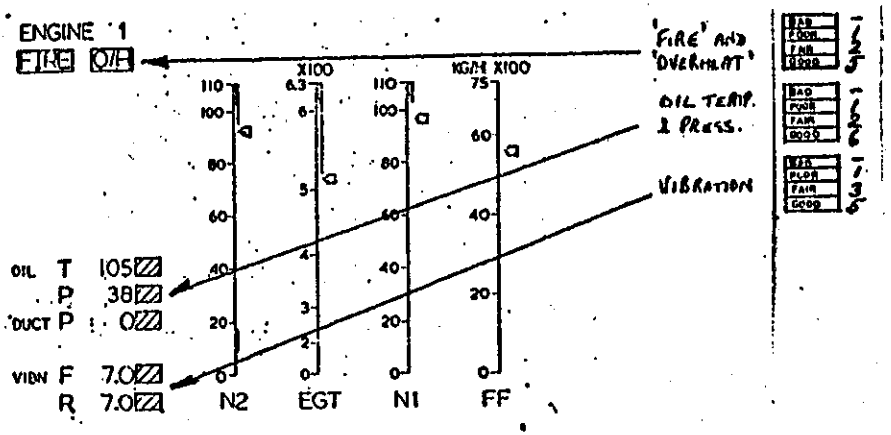
8. Would like to concentrate on one format for starting (1 pilot)

9. N2 scale should be same as multi-engine display (1 pilot)

One pilot did not make any comment.

1.12 HOW WOULD YOU RATE THE SINGLE ENGINE FORMATS WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





Pilot's Comments

1. Duct Pressure is too close to Oil Temperature and Pressure (1 pilot)

2. Fire and Overheat, although flashing, do not seem very clear. The inverted letters need to be heavier (1 pilot).

3. The square warning indications would probably be better to the left of the digital values. On the right they could almost be misidentified as bugs on this format (1 pilot).

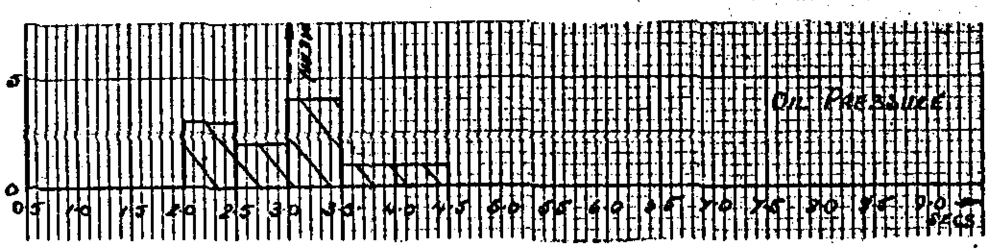
4. Vibration not dominant enough. In practice would fluctuate, suggest a scale is preferable to digits (1 pilot)

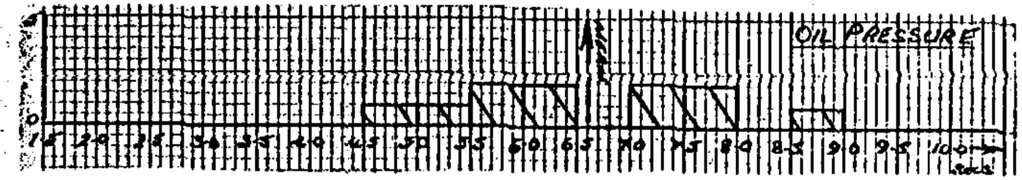
Six pilots did not make any comment

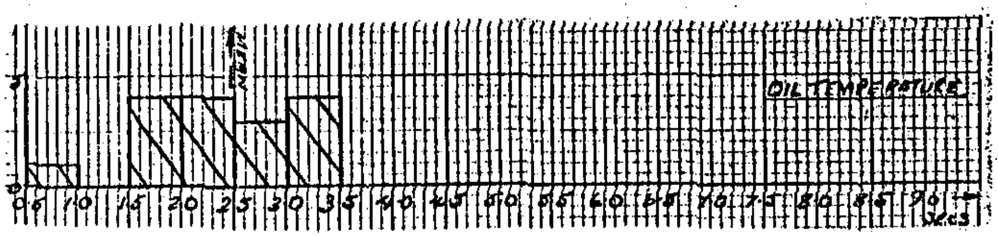
SINGLE ENGINE

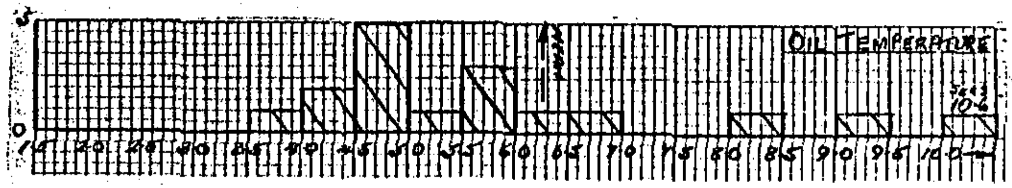
READING TIMES

FORMAT SELECTION TIMES

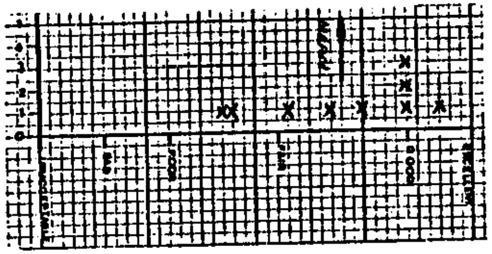


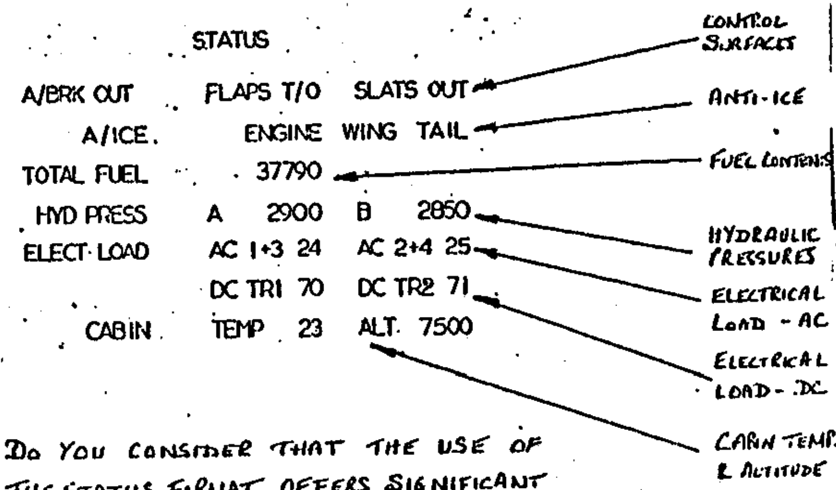






1.3 HOW WOULD YOU RATE THE PRESENTATION OF THE STATUS FORMAT FOR NORMAL OPERATION?





	BAD	POOR	FAIR	GOOD
CONTROL SURFACES	–	–	1	7
ANTI-ICE	–	–	–	7
FUEL CONTENTS	–	–	1	7
HYDRAULIC PRESSURES	–	–	1.5	6.5
ELECTRICAL LOAD - AC	–	1	4	2
ELECTRICAL LOAD - DC	–	1	4	2
CABIN TEMP. & ALTITUDE	–	–	2.5	5.5
LAYOUT	–	2	[illegible]	2

DO YOU CONSIDER THAT THE USE OF THE STATUS FORMAT OFFERS SIGNIFICANT WORKLOAD REDUCTION? YES $\boxed{9}$ NO $\boxed{0}$

HOW OFTEN DID YOU USE THE STATUS FORMAT?

NEVER $\boxed{0}$ OCCASIONALLY $\boxed{1.5}$ OFTEN $\boxed{7.5}$

Pilot's Comments

1. Display somewhat cluttered and it is difficult to extract the information needed at a glance. (3 pilots)

2. Electrical data difficult to read (4 pilots)

3. Airbrake indication did not stand out, but flaps, slats, anti-ice and hydraulics data was good (1 pilot).

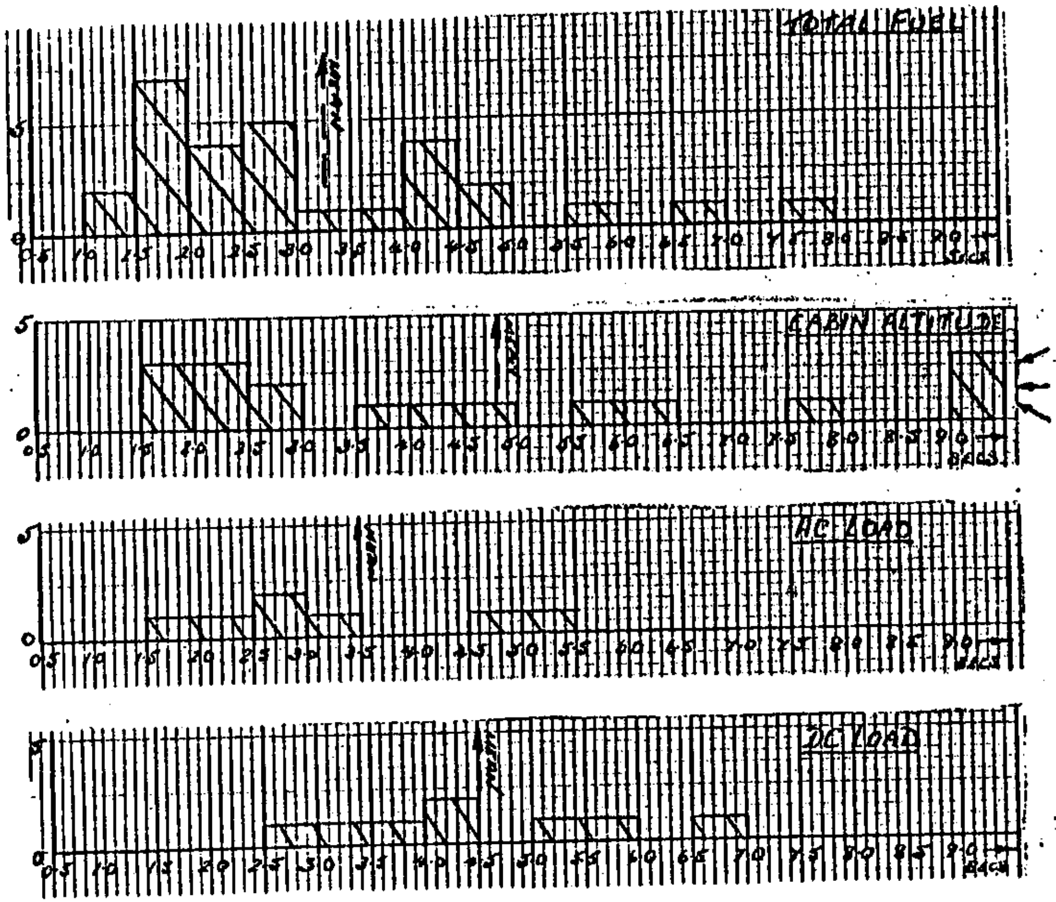
4. Does give a significant workload reduction.

5. Format should be available on S4 Documentation Display (1 pilot).

One pilot did not make any comment.

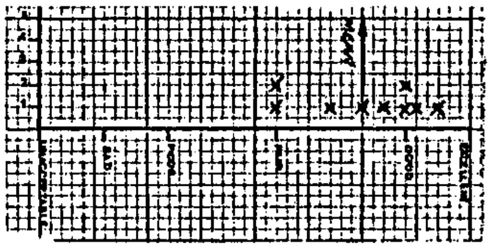
STATUS

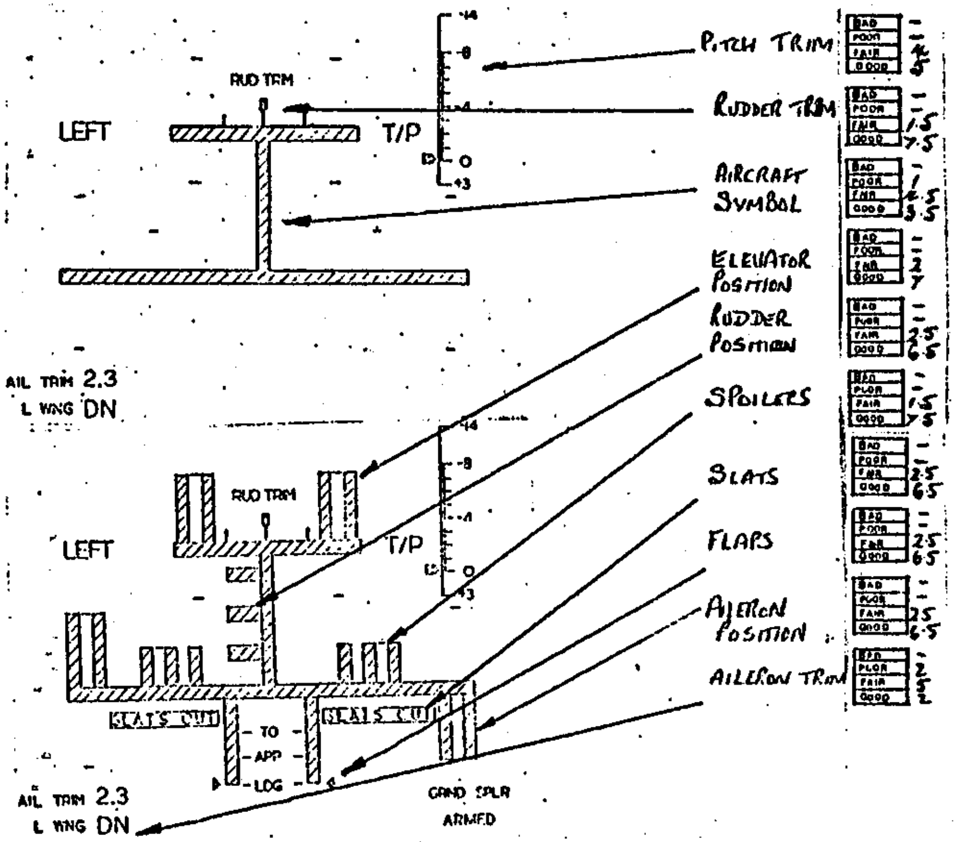
READING TIMES



1. 10.2
2. Selected Air Cond, but read from Status.
3. 10.5

1.4 HOW WOULD YOU RATE THE PRESENTATION OF THE FLYING CONTROLS FORMAT FOR NORMAL OPERATION?





Pilot's Comments

1. Aircraft symbol is too bold and bright (3 pilots)

2. Aircraft symbol good for VC10, but may not be for other conventional types (1 pilot)

3. Better than Stage 1 - Familiarisation format (1 pilot)

4. Aileron Trim needs improving (2 pilots)

5. Tailplane trim does not appear to work in correct sense (1 pilot).

6. Tailplane trim is a big improvement (1 pilot).

7. Would like an electronic slip ball, which would be useful for asymmetric flying.

8. Trim indications for rudder and aileron may be simpler if surface is displaced (1 pilot)

9. Pitch trim scale a bit cluttered (1 pilot)

10. Rudder trim indication not required (1 pilot)

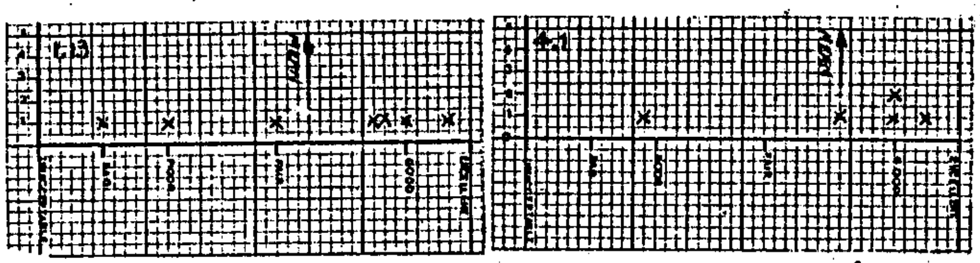
11. Double line of pitch trim scale is confusing (1 pilot)
One pilot did not make any comment.

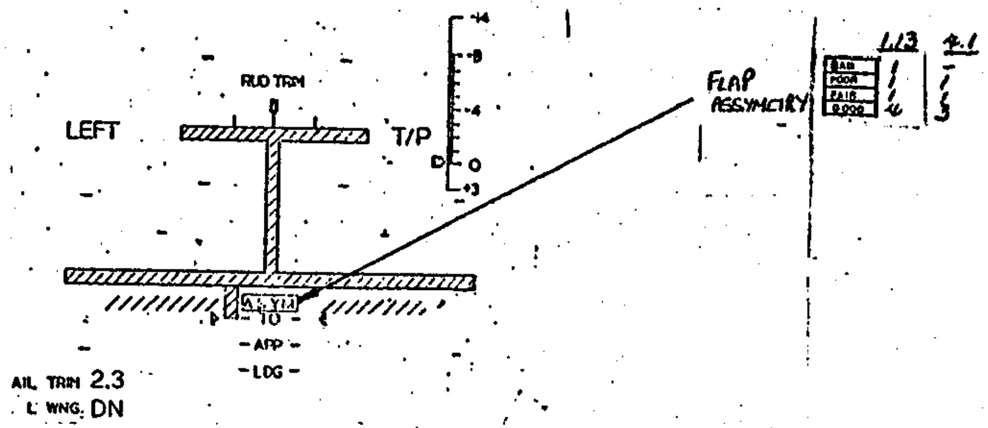
Observer's Notes

1. Aileron trim confused with pitch trim (1 pilot)

One pilot did not make any comment.

1.13 & 4.1 **HOW WOULD YOU RATE THE FLYING CONTROLS FORMAT WITH RESPECT TO THE EFFICIENCY ANDPRESENTATION OF THE WARNINGS?**





Pilot's Comments

(1.13)

1. Not used but looks clear (2 pilots)

2. Flashing would be better (2 pilots)

3. Would like a display similar to the concorde ICOVOL Display (1 pilot)

Five pilots did not make any comment

(4.1)

1. Not obvious when slats are out, suggest indication should flash (1 pilot)

2. Maximum Rudder deflection marks are required below the tailplane, but no problem was found in findingthe control surfaces zero position (1 pilot)

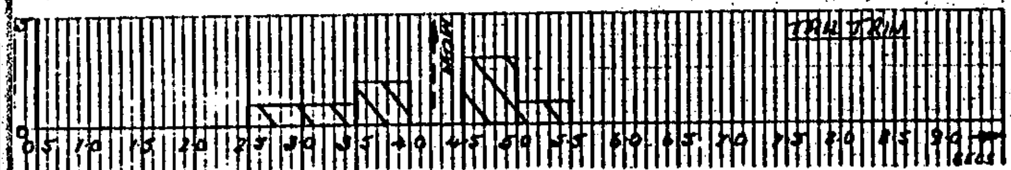
3. The 'ASYM' could be missed, perhaps it should flash (1 pilot)

4. Good format (1 pilot)

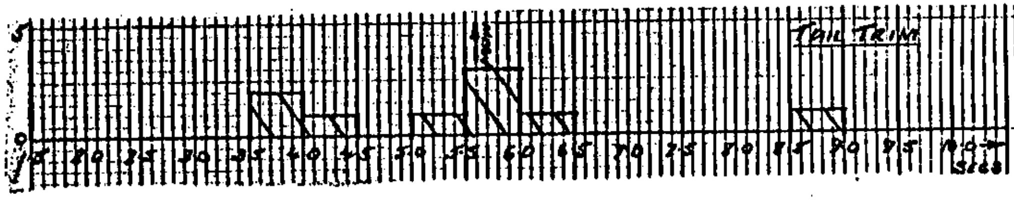
One pilot did not make any comment

FLYING CONTROLS

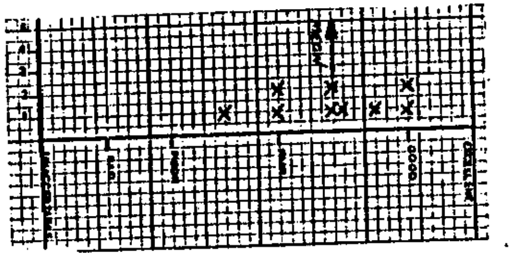
READING TIMES

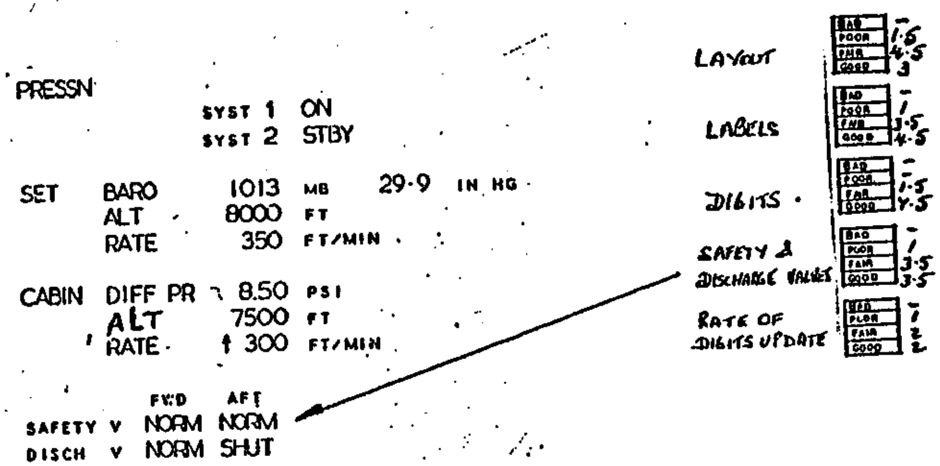


FORMAT SELECTION TIMES



1.5 **HOW WOULD YOU RATE THE PRESENTATION OF THE PRESSURISATION FORMAT FOR NORMAL OPERATION ?**





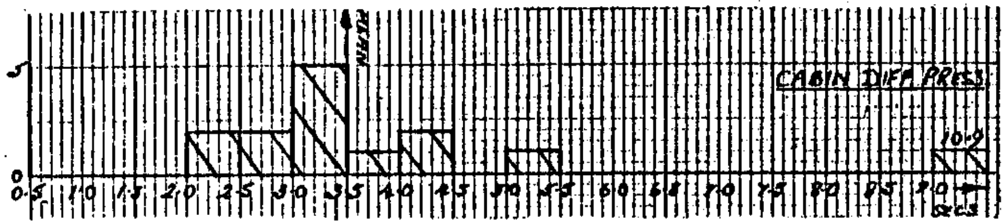
Pilot's Comments

1. Better layout needed to differentiate between 'SET' and 'CABIN' (4 pilots). (1 further pilot was also initially confused.
2. Gearing on baro set too high (1 pilot)
3. Would prefer an analogue for Safety and Discharge valves (1 pilot).
4. Gauge readings are more quickly interpreted, but the format is adequate (1 pilot).
5. Format has to be read, would prefer analogues (1 pilot)

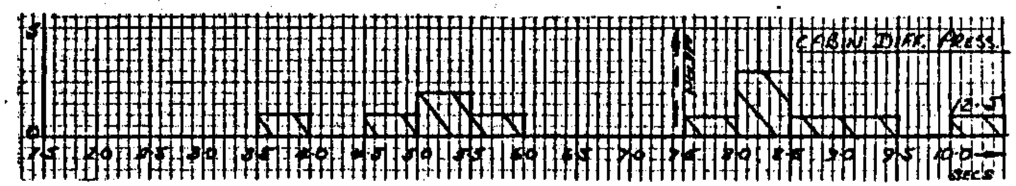
Two pilots did not make any comment

PRESSURISATION

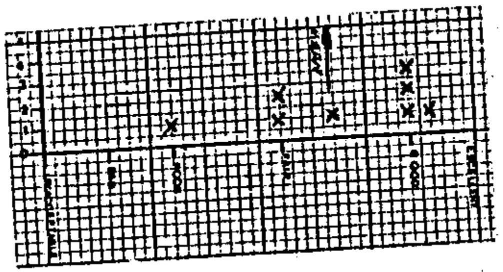
READING TIMES

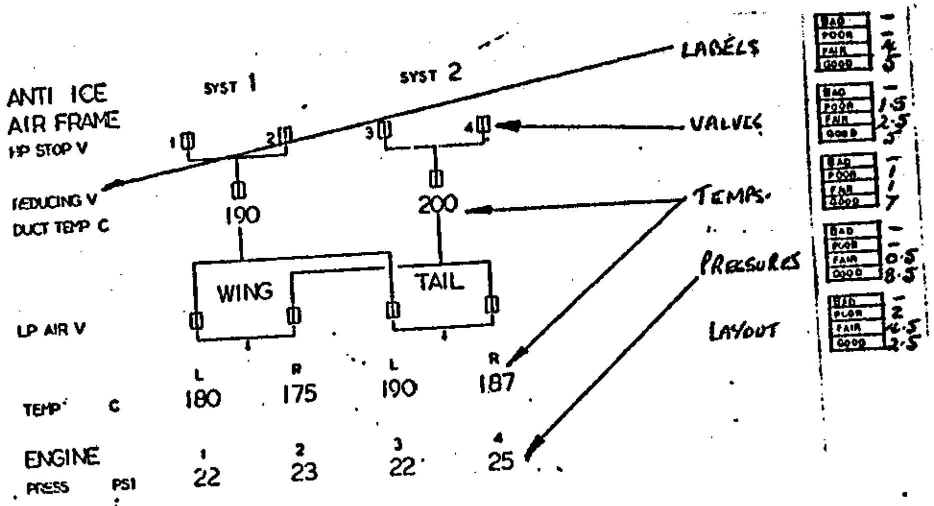


FORMAT SELECTION TIMES



1.6 <u>HOW WOULD YOU RATE THE PRESENTATION OF THE ANTI-ICE SYSTEM FORMAT FOR NORMAL OPERATION?</u>





<u>Pilot's Comments</u>

1. Word PRESS out of view (1 pilot)

2. Labelling of valves needs improving (1 pilot).

3. Information was better presented on STATUS format (1 pilot).

4. Wing and Tail layout needs improving (2 pilots)

5. A lot of little used information is continuously displayed on this format (1 pilot).

6. The format should be displayed before the anti-icing check list is actioned (1 pilot).

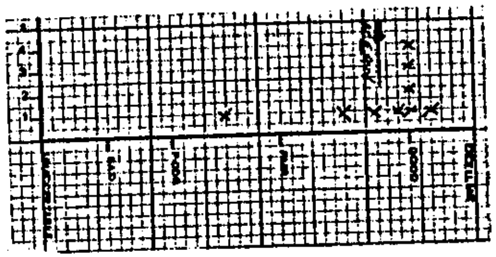
7. Engine anti-icing is lost at the bottom (1 pilot)

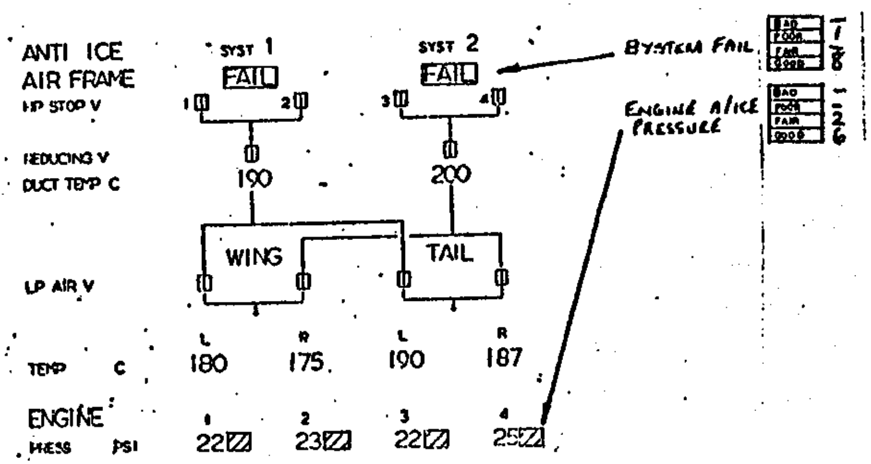
8. Perhaps a valve in motion should flash (1 pilot)

9. Duct temps should not break flow line (1 pilot)

Two pilots did not make any comment.

2.5 HOW WOULD YOU RATE THE ANTI-ICE SYSTEM FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





Pilot's Comments

1. HP Stop Valve should be HP Air (1 pilot)

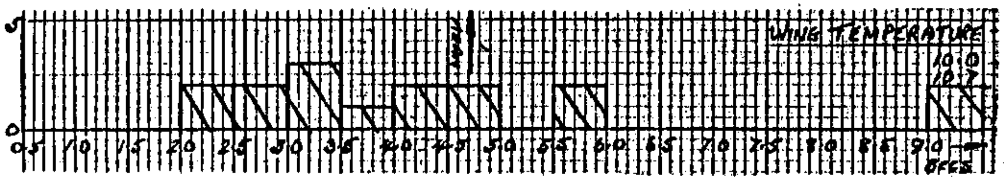
2. FAIL might be better against cocks line (1 pilot)

3. Good display (1 pilot)

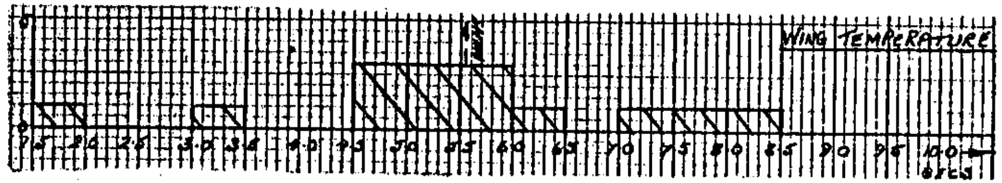
Seven pilots did not make any comment

ANTI-ICE SYSTEM

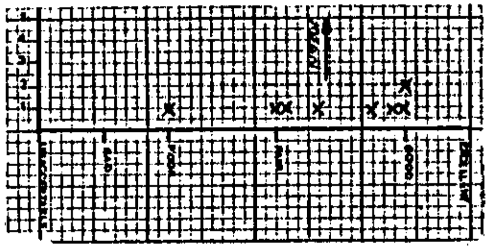
READING TIMES

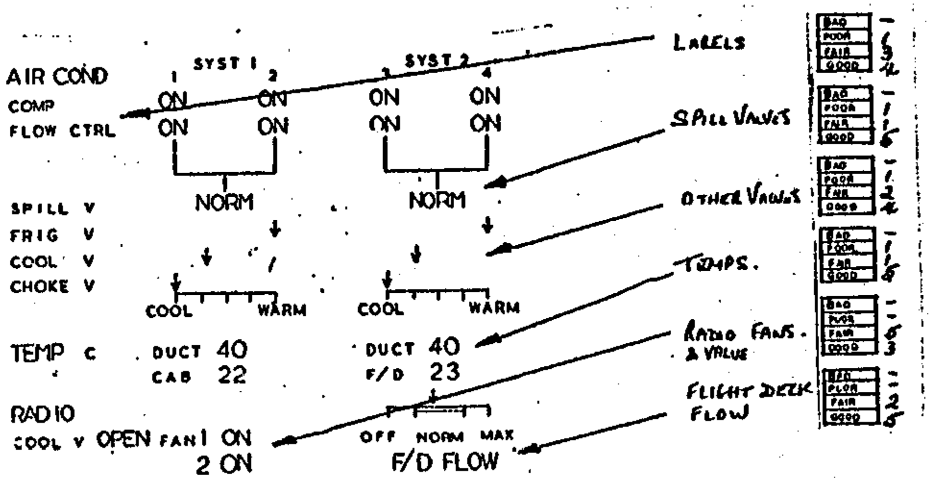


FORMAT SELECTION TIMES



1.7 <u>HOW WOULD YOU RATE THE PRESENTATION OF THE AIR CONDITIONING FORMAT FOR NORMAL OPERATION?</u>





<u>Pilot's Comments</u>

1. Symbols should be standardised to indicate 'flow' or 'no flow' :- either ON MVC OFF or (1 pilot)

2. Cabin and Flight Deck temperatures should be separated from duct temperatures to make them clearer (1 pilot)

3. Need time to understand system (3 pilots)

4. A good display and easy to use (1 pilot)

5. Warnings would be better in colour (see Q.2.3) (1 pilot)

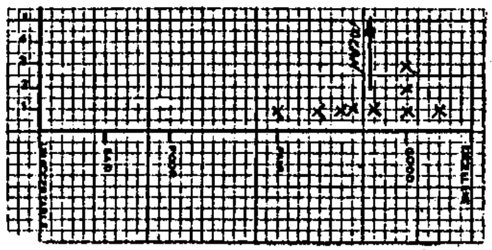
6. Spill Valves might possibly be improved by a larger analogue valve symbol. Analogue for ON and an inverted OFF may help (1 pilot)

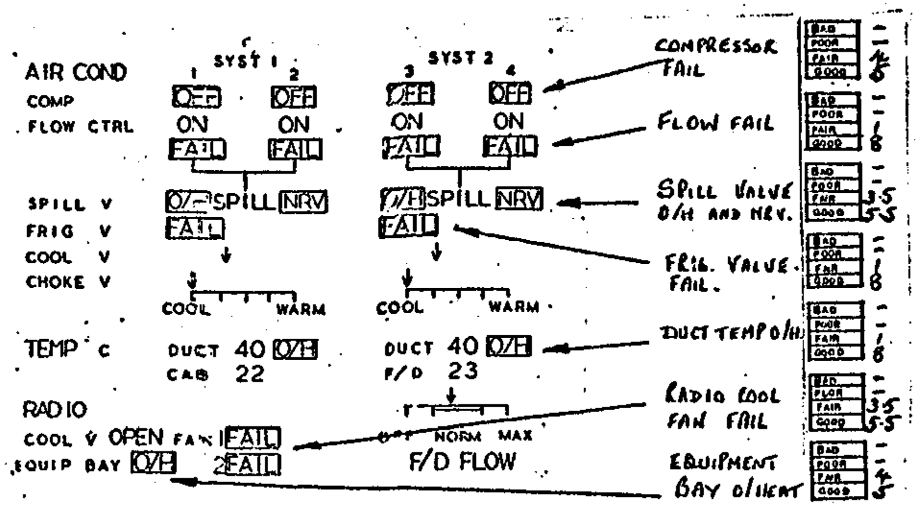
7. Radio cool valve and fan indication not necessary (1 pilot)

8. After a System failure it would be more logical to remove it from format (1 pilot)

Two pilots did not make any comment,

2.3 HOW WOULD YOU RATE THE AIR CONDITIONING FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





Pilot's Comments

1. Flight deck flow diagram could be in a better position, but there is no more space with present layout (1 pilot).

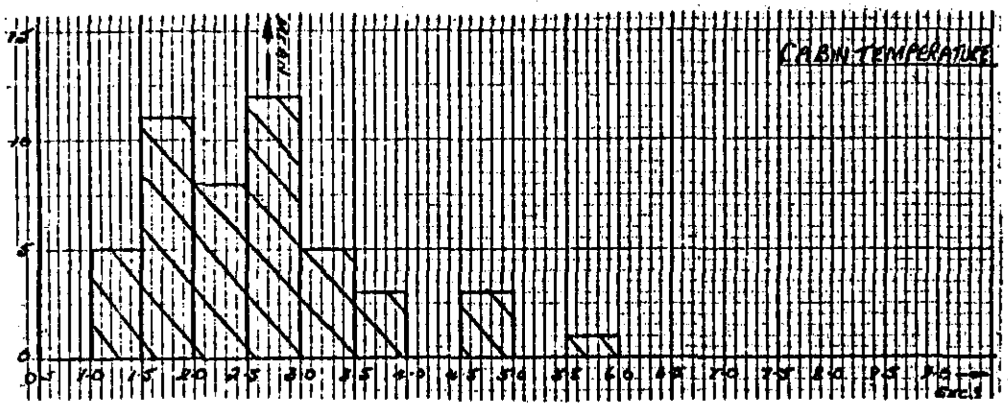
2. Format is acceptable, but the control of cabin and flight deck temperatures manually (i.e. after a Duct overheat) is very time consuming. (1 pilot)

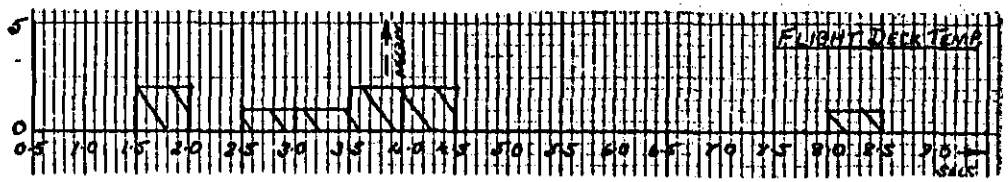
3. Fan block would be better separated from captions on left (2 pilots)

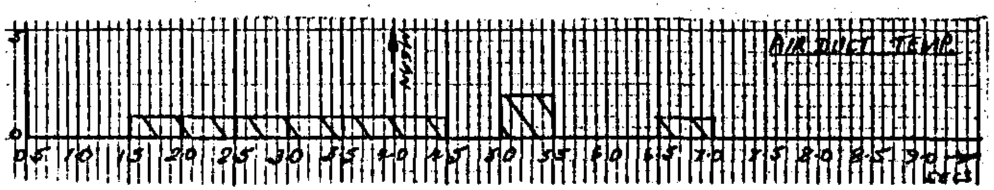
Five pilots did not make any comment

AIR CONDITIONING SYSTEM

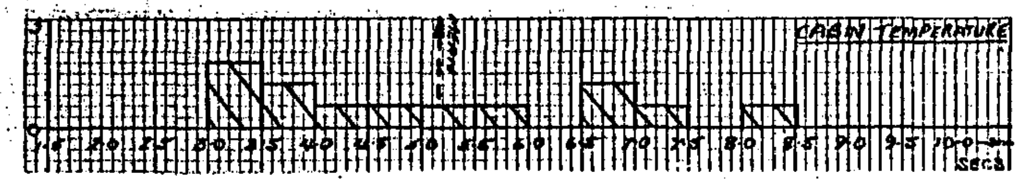
READING TIMES



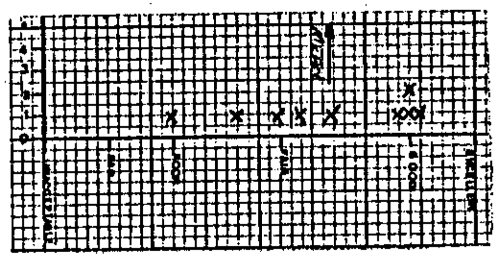


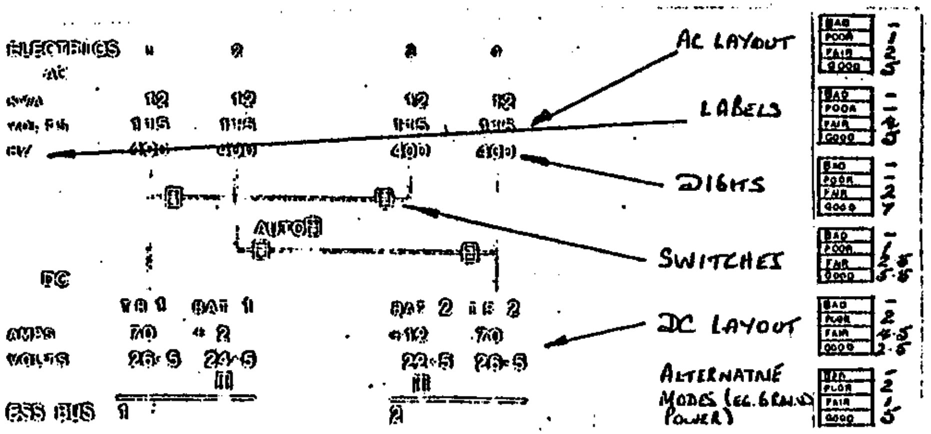


FORMAT SELECTION TIMES



1.8 HOW WOULD YOU RATE THE PRESENTATION OF THE ELECTRICS FORMAT FOR NORMAL OPERATION?





Pilot's Comments

1. The display is confusing and cluttered during non-standard conditions, i.e. with STANDBY TRU or ELRAT. (3 pilots)

2. Too much digital information (1 pilot)

3. AC layout not easy to read (1 pilot)

4. DC layout slightly cluttered or not easy to read (3 pilots)

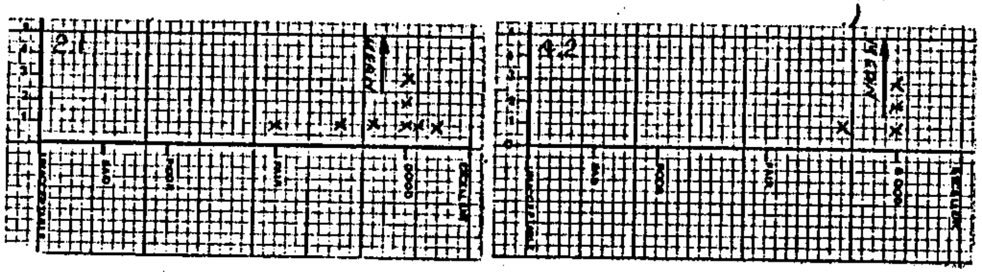
5. Liked format but preferred switched off indications to be shown (1 pilot)

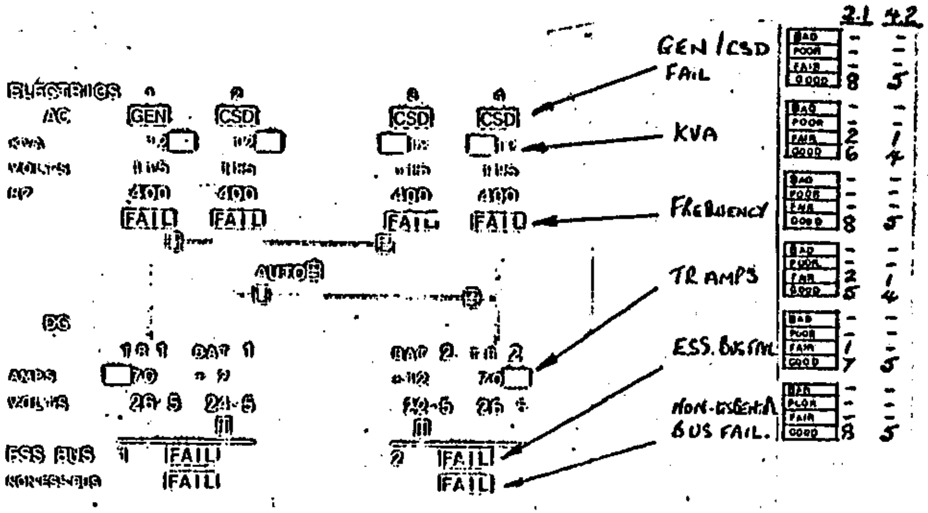
6. Unsuitable for two crew operation (1 pilot)

7. A generator switched off is not readily identifiable

3 pilots did not make any comment

2.1 & 4.2 HOW WOULD YOU RATE THE ELECTRICS FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





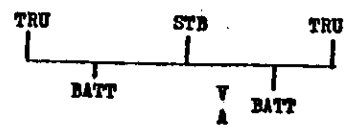
Pilot's Comments

(2.1)

1. Warnings are readily identifiable (1 pilot)

2. A Warning would be useful when a GEN control switch is off. (2 pilots) Would like something obvious like: x x x or X (1 pilot)

3. Battery Amps very poor suggest:-



4. Limit flags do not instinctively indicate their purpose (1 pilot)

Five pilots did not make any comment

(4.2)

1. May be worth deleting a 'failed' system from the format (1 pilot)

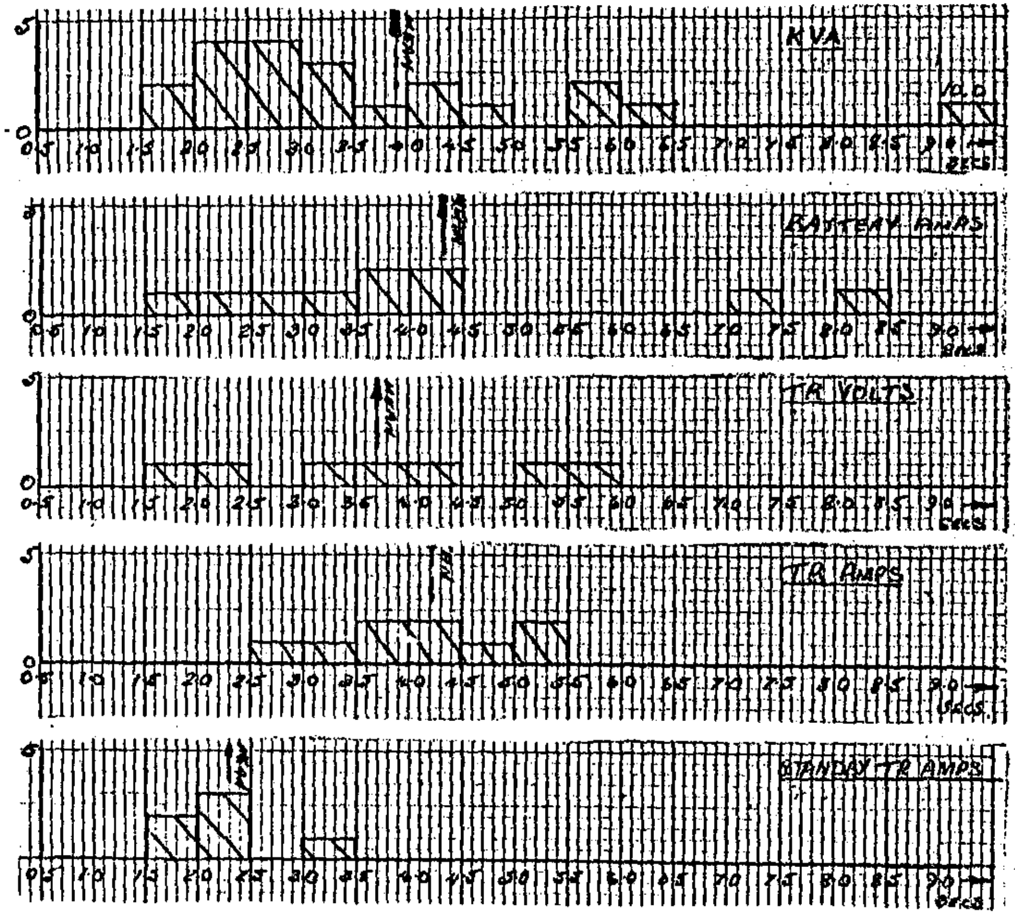
2. All the warnings appear easy to recognise (1 pilot)

3. Battery information could be below the busbars for greater clarity (1 pilot)

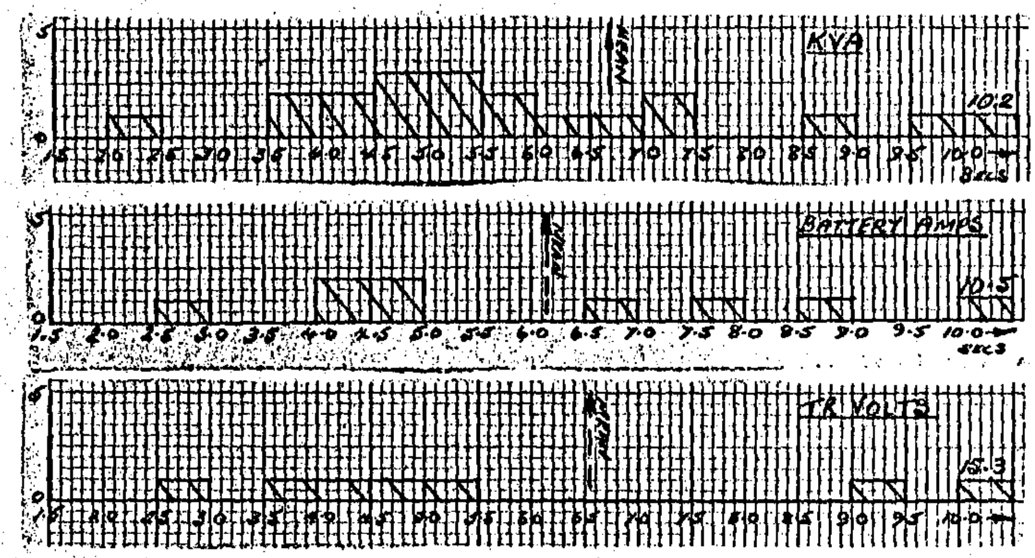
Two pilots did not make any comment

ELECTRICS

READING TIMES



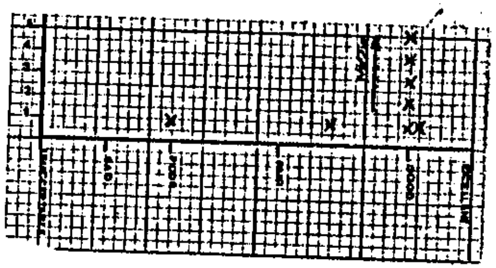
FORMAT SELECTION TIMES

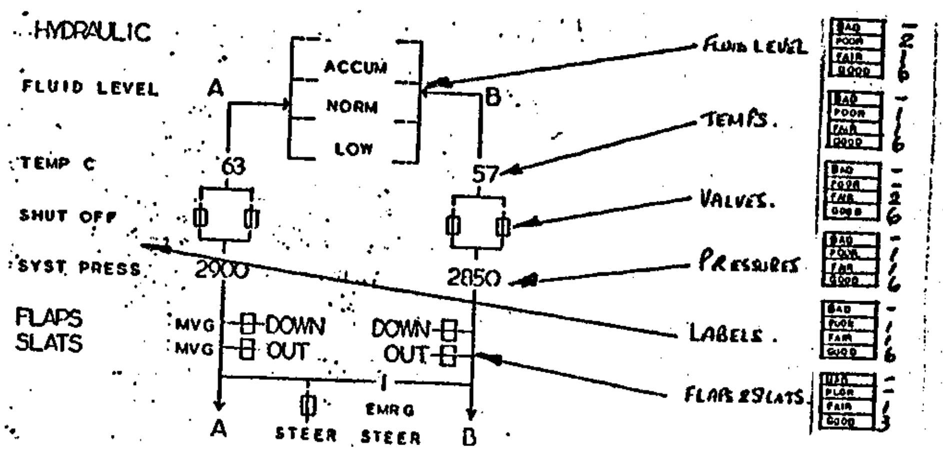


ERRORS IN READING

Battery Amps - 1 pilot was confused with battery volts.

1.9 HOW WOULD YOU RATE THE PRESENTATION OF THE HYDRAULICS FORMAT FOR NORMAL OPERATION?





Pilot's Comments

1. Fluid level lines could be more prominent (1 pilot)

2. Clear analogue layout (1 pilot)

3. Flaps and Slats not used with this display (but would be with a failure) (2 pilots)

4. Labelling very good as long as it agrees with panel engraving (1 pilot).

5. Temperature and Pressure spacing bad. Labels a long way from value. Slats and Flaps take a lot of room (1 pilot).

6. Warning flags (see Q.312) would be better in colour (1 pilot).

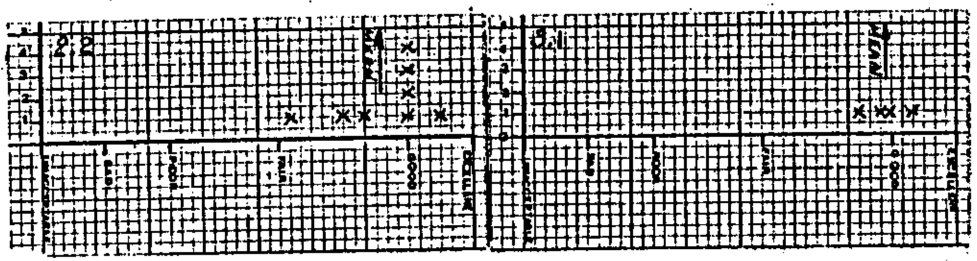
7. Good Display (1 pilot)

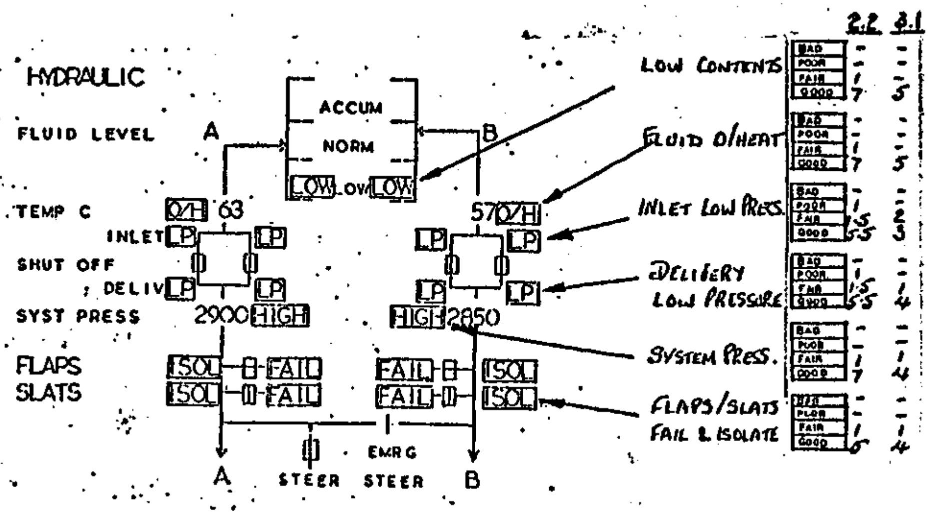
8. Fluid levels waste a lot of space, but format is fairly clear (1 pilot)

9. Difficult to identify hydraulics valves (1 pilot)

Three pilots did not make any comment.

& 3.1 <u>RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?</u>





(2.2)

1. The temperature and pressure indications are somewhat dominated by the circuit diagram (1 pilot)

2. Suggest the following convention for valves open: giving the flow direction (1 pilot)

3. Appeared to be too many warnings on format, particularly LP warnings (1 pilot).

4. A good logical presentation, but perhaps other services could be included (e.g. landing gear) (1 pilot)

Six pilots did not make any comment

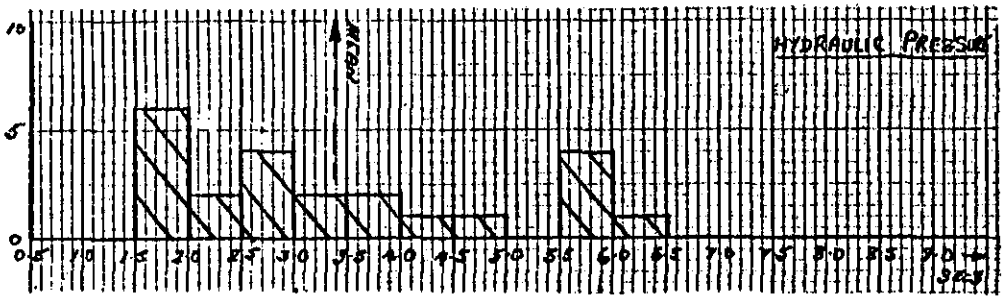
(3.1)

1. A symbol indicating the pump near the shut-off valve would be excellent (1 pilot)

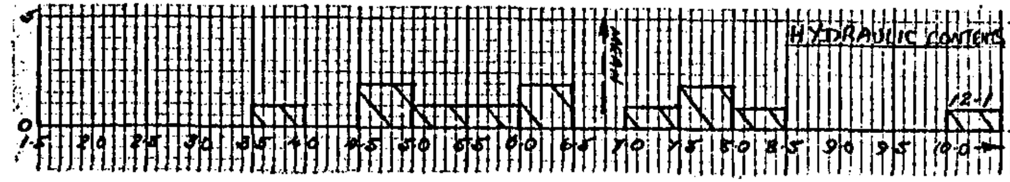
Two pilots made comments similar to those in 2.2 above and two pilots did not make any comment.

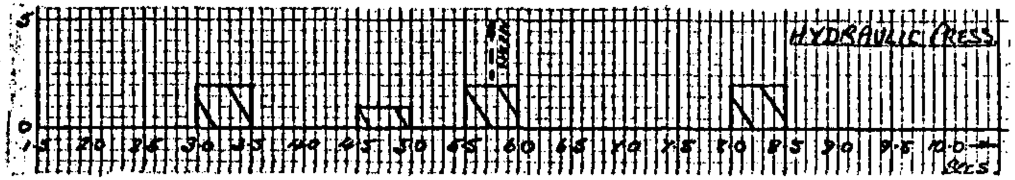
HYDRAULICS

READING TIMES

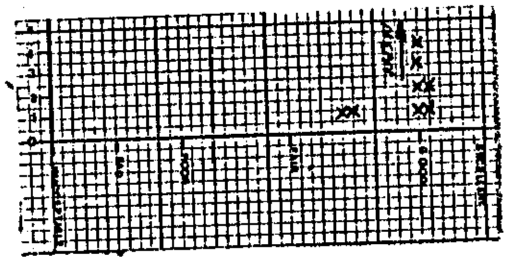


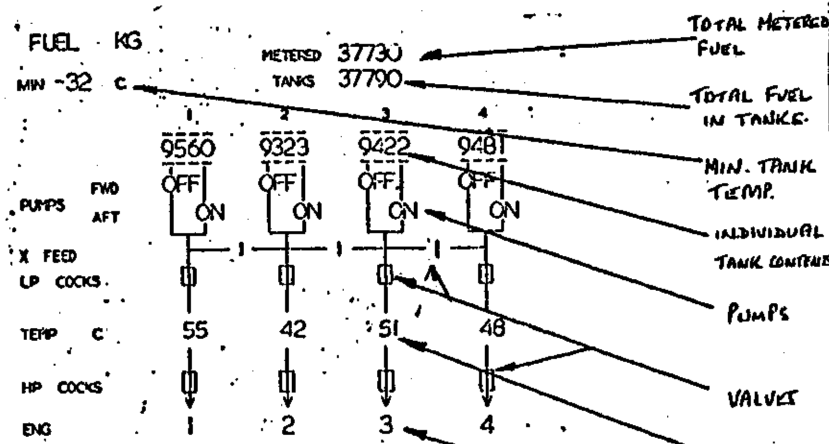
FORMAT SELECTION TIMES





1.10 HOW WOULD YOU RATE THE PRESENTATION OF THE FUEL SYSTEM FORMAT FOR NORMAL OPERATION?





	BAD	POOR	FAIR	GOOD
TOTAL METERED FUEL	-	-	0.5	8.5
TOTAL FUEL IN TANKS	-	-	0.5	8.5
MIN. TANK TEMP.	-	0.5	0.5	8
INDIVIDUAL TANK CONTENTS	-	-	1.5	7.5
PUMPS	-	-	2	7
VALVES	-	-	1.5	7.5
TEMPS.	-	-	0.5	8.5
LABELS	-	-	0.5	8.5

Pilot's Comments

1. METERED and TANKS too close (1 pilot)

2. PUMPS clear to see at a distance (1 pilot)

3. Valves better than before, but still only fair (1 pilot)

4. Easy format to use (2 pilots)

5. Analogue of tank contents might be useful as a quick indication of fuel on-board or asymmetry. (1 pilot)

6. Pump OFF would be better inverted (1 pilot)

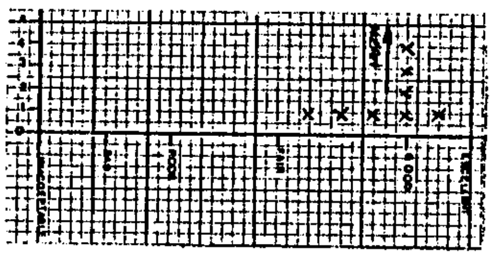
7. Tank Fuel and Tank Fuel Temperature could be shown related (1 pilot)

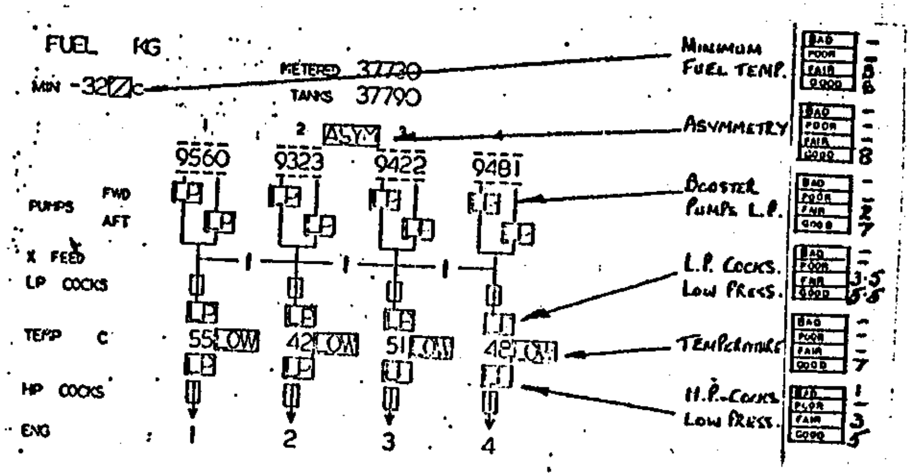
8. Warning flags (Q.2.4) would be better in colour (1 pilot)

9. Clear and unambiguous format (1 pilot)

Two pilots did not make any comment

2.4 HOW WOULD YOU RATE THE FUEL SYSTEM FORMAT WITH RESPECT TO THE EFFICIENCY AND PRESENTATION OF THE WARNINGS?





Pilot's Comments

1. Too many LP warnings (1 pilot)

2. Cocks are rather small (1 pilot)

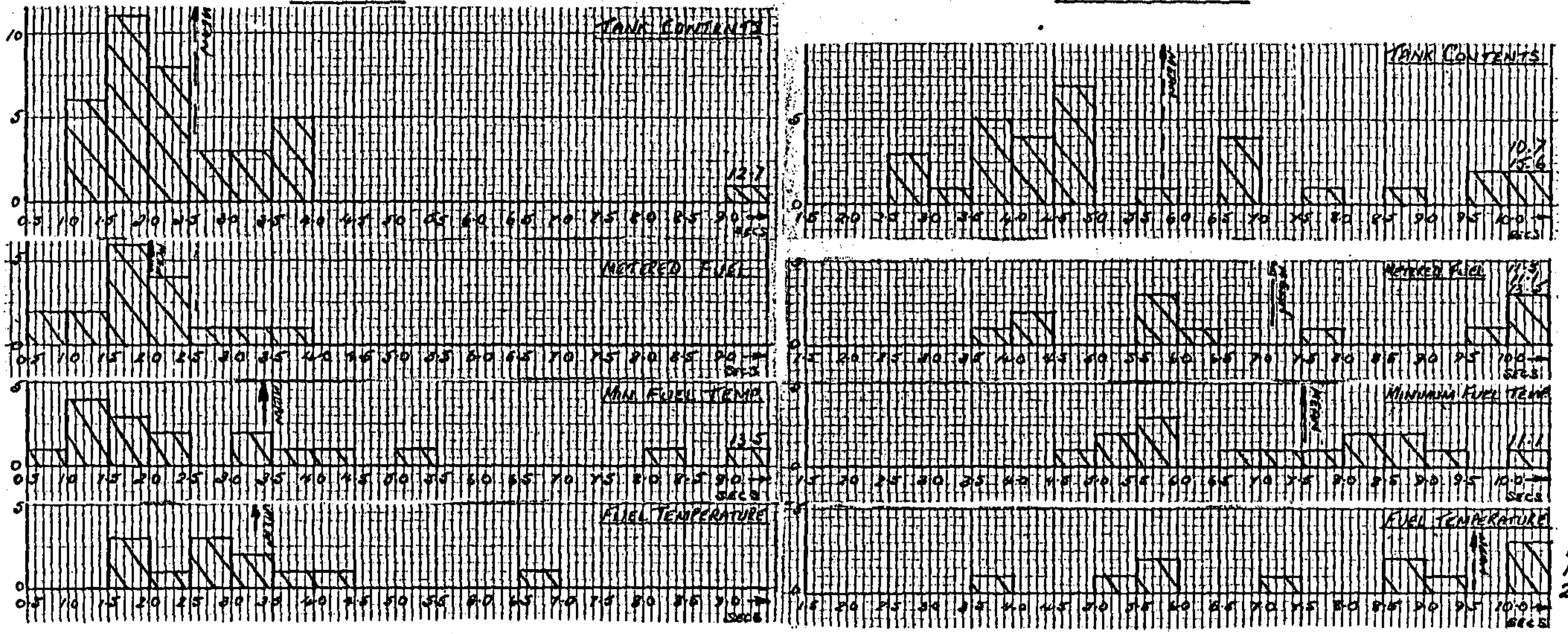
3. Best format (1 pilot)

Six pilots did not make any comment

FUEL

READING TIMES

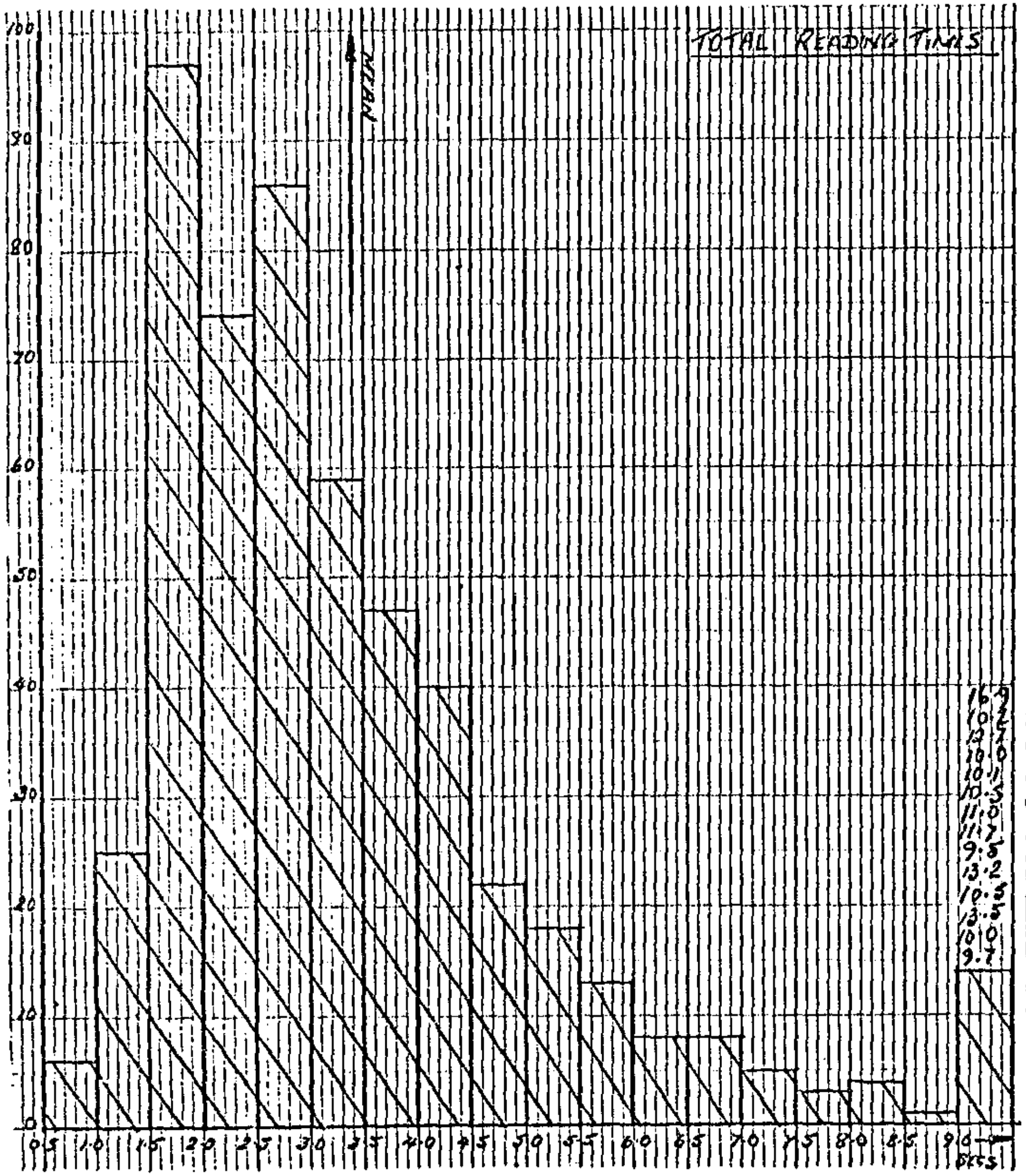
FORMAT SELECTION TIMES

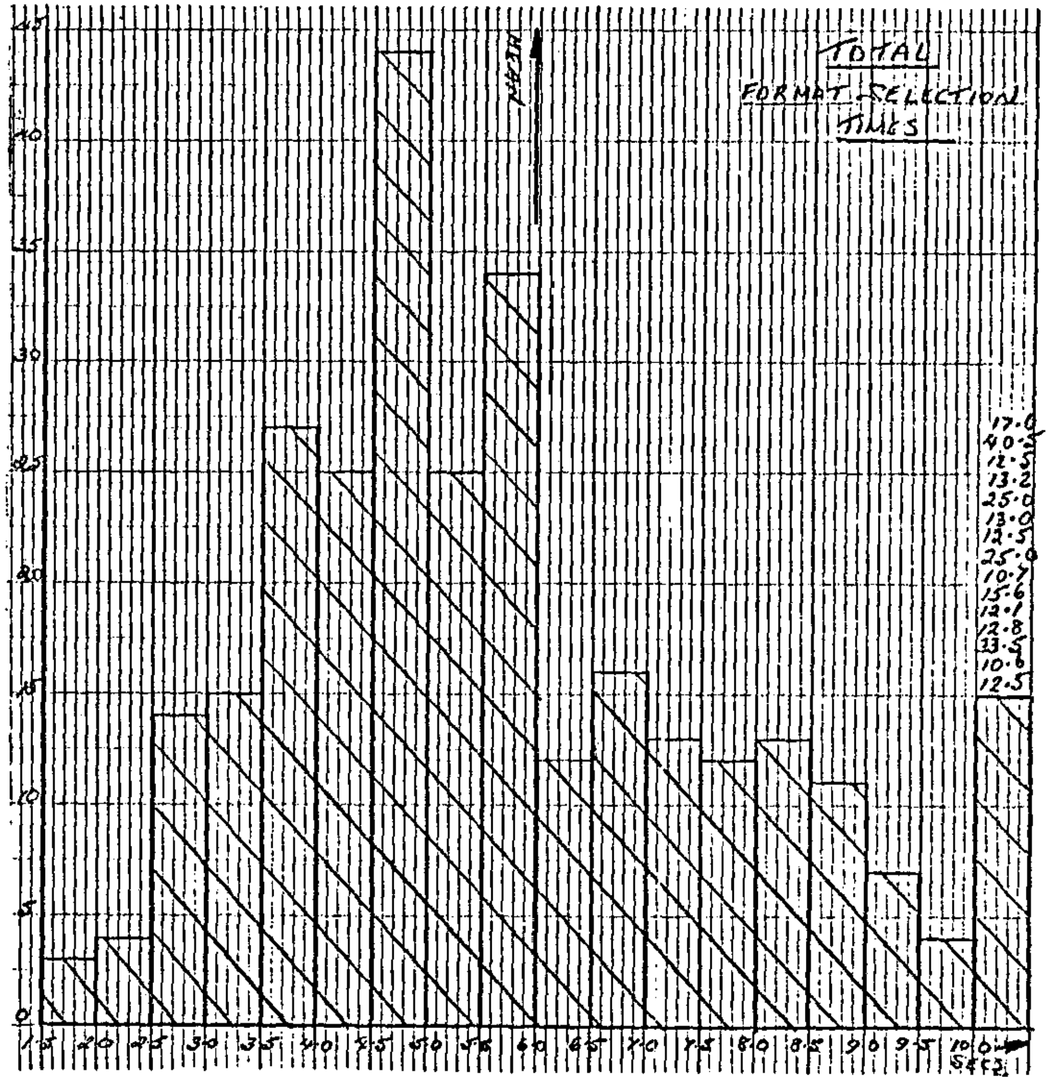


ERRORS IN READING

1. OAT instead of Min.Fuel Temp. (1 pilot)
2. Frequently engine fuel inlet temperatures were thought to be on the single engine displays which were selected in error. These mis-selections were due to both unfamiliarity and the manner the questions were phrased. Two pilots needed prompting for these parameters.
3. One pilot confused metered fuel and total contents
4. One pilot was confused with Min.Fuel Temp.

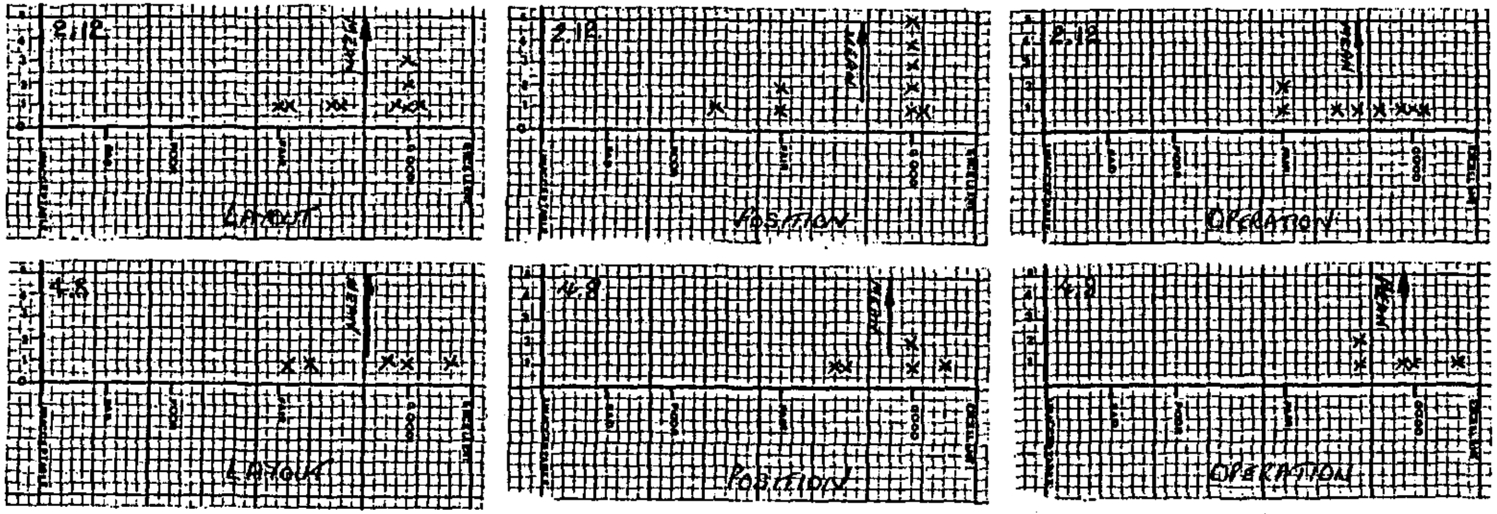
SUMMATED TIMES FOR ALL DISPLAYS AND FORMATS

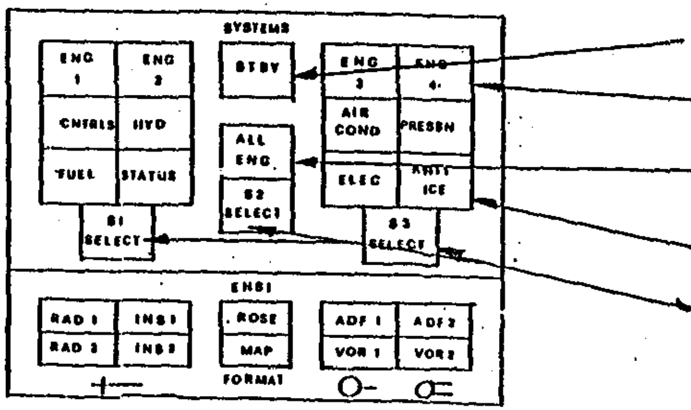




2.12 &
4.8

HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE SYSTEM DISPLAYS SELECT PANELS?





POSITIONS OF:		2.12	4.8
STANDBY	BAD	-	-
	POOR	1	1
	FAIR	2	1
	GOOD	5	2
SINGLE ENGIN	BAD	-	-
	POOR	-	-
	FAIR	2	1
	GOOD	6	4
ALL ENGINES	BAD	-	-
	POOR	-	1
	FAIR	1	1
	GOOD	7	3
SYSTEMS	BAD	-	-
	POOR	-	-
	FAIR	4	1
	GOOD	4	4
DISPLAY SELECT	BAD	-	-
	POOR	-	-
	FAIR	3	2
	GOOD	5	3

2.12 & 4.8 **<u>HOW WOULD YOU RATE THE LAYOUT, OPERATION AND POSITION OF THE SYSTEM DISPLAYS SELECT PANELS</u>**

Pilots' Comments
(2.12)

1. Position STANDBY below S2 (1 pilot)

2. Engines should be separated by small space from systems (1 pilot)

3. All Engines to go back to where Standby is (1 pilot)

4. Position 'Fuel' and 'Status' above S3 as these are mainly used (1 pilot)

5. Move 'select' buttons away from the 'operate' buttons (1 pilot)

6. Systems layout should show the order of preference, if possible (1 pilot)

7. Standby to be selected by pressing appropriate select button. If format not selected after short delay Standby to be promulgated. Next selection need require pushing only the appropriate format button (1 pilot)

8. Select buttons to be dropped slightly and perhaps coloured (green ?) to differentiate them (1 pilot)

9. Only two rows of buttons within comfortable reach, would prefer panel nearer (2 pilots)

10. Flush button preferred (1 pilot)

11. Hierarchy not obvious (2 pilots)

Three pilots did not make any comment.

(4.8)

1. Would interchange STBY and ALL ENG buttons (1 pilot)

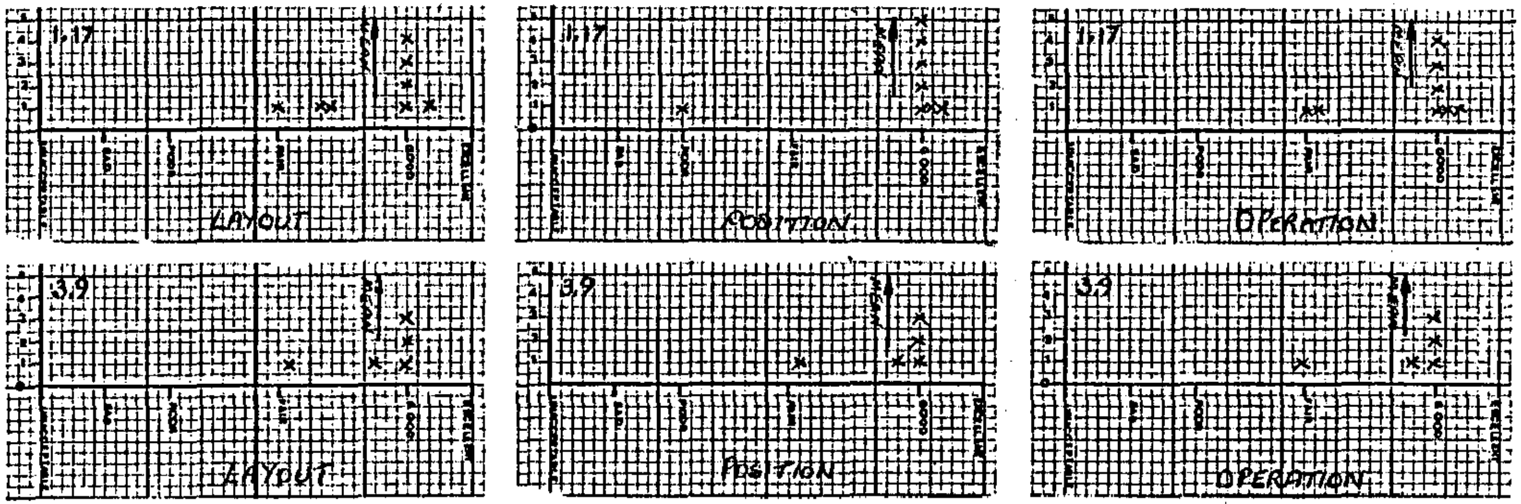
2. Panel is still a long way from P2 when he is navigating, but basically a good panel (1 pilot)

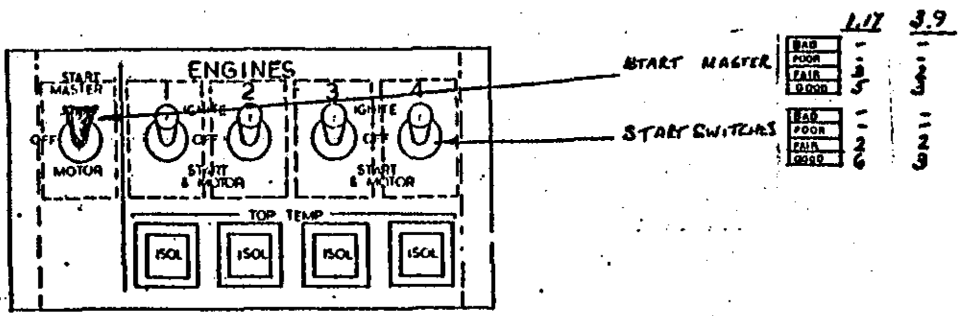
3. May be a problem in putting on APU. Perhaps a discrete display panel is necessary (1 pilot)

4. Small improvement could be made by moving S1, S2 and S3 buttons slightly aft (down) (1 pilot)

5. Have reservations about the concept of standby (1 pilot)

1.17 HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION
& OF THE ENGINE START PANEL
3.9





1.17 & 3.9 **HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE ENGINE START PANEL**

Pilots' Comments
(1.17)

1. Not sure whether four separate switches are better than a selector and one switch (1 pilot)

Eight pilots did not make any comment

(3.9)

1. Start master switch is too close and similar to ignition switches (1 pilot)

2. When operating this panel there is a tendency to reset hand on surrounding buttons. Could shut an engine down when selecting relight e.g. with a heavy hand or shirt cuff (1 pilot)

3. Simple to use for starting and relight but tendency to reset hand on shut-down handle when starting (1 pilot)

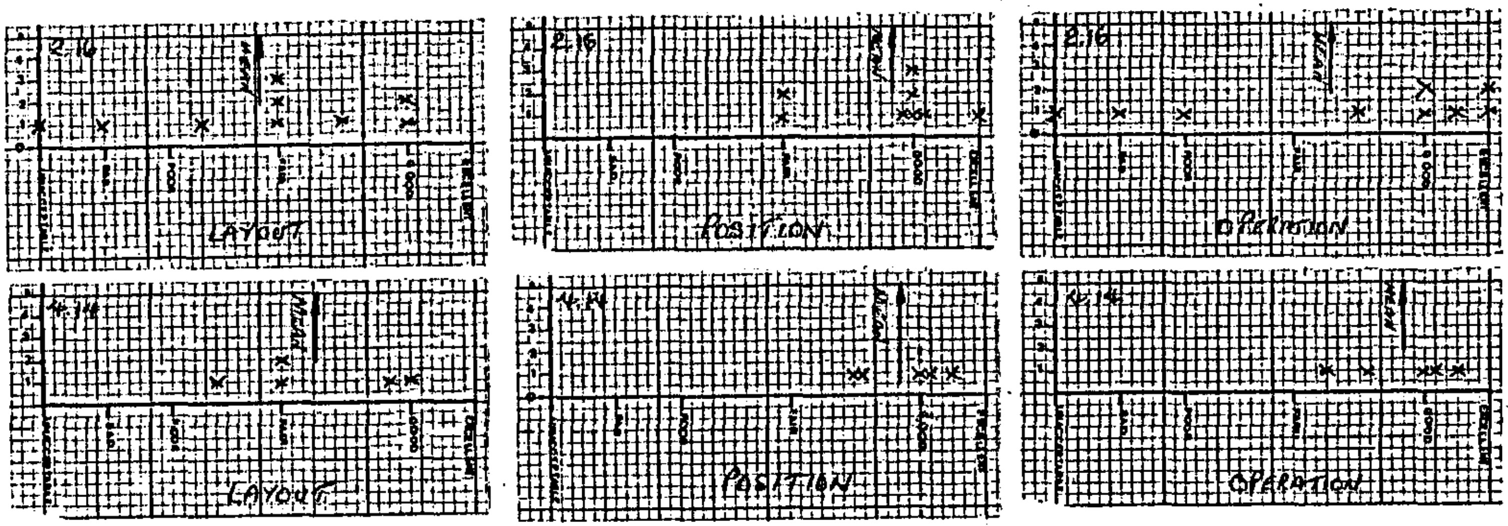
4. Start master switch should be designed to prevent inadvertant operation (1 pilot)

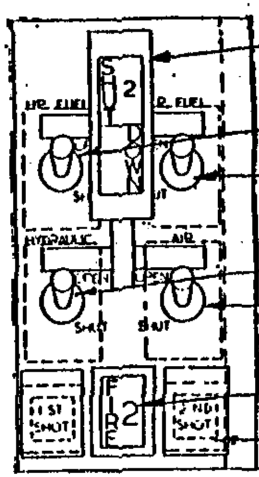
5. Should be a light associated with the relight switches (1 pilot)

6. Holding up arm on engine start is tiring (1 pilot)

Two pilots did not make any comment.

2.16 & 4.14 HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE ENGINE SHUT DOWN PANEL?





		2.16	4.14
SHUT-DOWN HANDLE	BAD	–	–
	POOR	–	–
	FAIR	1	1
	GOOD	8	4
HP. VALVE	BAD	–	–
	POOR	2.5	–
	FAIR	3.5	3
	GOOD	2	1
LP. VALVE	BAD	–	–
	POOR	1.5	–
	FAIR	3.5	3
	GOOD	3	1
HYDRAULICS VALVE	BAD	–	–
	POOR	1.5	–
	FAIR	3.5	2
	GOOD	3	2
AIR OXYGEN VALVE	BAD	–	–
	POOR	1.5	–
	FAIR	3.5	2
	GOOD	3	2
FIRE LIGHT	BAD	–	–
	POOR	–	–
	FAIR	0.5	–
	GOOD	7.5	5
EXTINGUISHER BUTTONS	BAD	–	–
	POOR	1	–
	FAIR	2	1
	GOOD	5	4

2.16 & 4.14 **HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE ENGINE SHUT DOWN PANEL?**

Pilots' Comments

(2.16)

1. When operated the fire handle should stay down to indicate it has been pulled (1 pilot).

2. Difficult to see individual switches for start and emergencies. Extreme care is needed in Precautionary Shut-down to ensure correct switches are operated. (5 pilots)

3. Suggest the switches are colour or shape coded (1 pilot)

4. Extinguisher buttons need separating between engines (3 pilots)

5. Possibility of mis-selection is high, vital switches need guarding (1 pilot)

6. Difficult to see LP fuel legends from P2 positions (1 pilot)

7. Suggest ganging switches for engine start (1 pilot)

Three pilots did not make any comment.

(4.14)

1. Switches are all similar and labelling is obscured (4 pilots)

2. Same lever for normal and emergency shut-down is liked providing lever is readily identifiable (3 pilots)

3. Would like switches parallel to start panel (1 pilot)

4. Why not start engines using shut-down in reverse order (1 pilot)

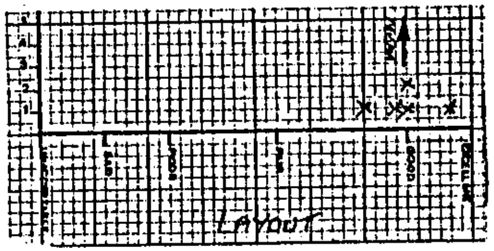
5. Do not see need for pilot operated switches on the shut-down panel, perhaps indications are sufficient (1 pilot)

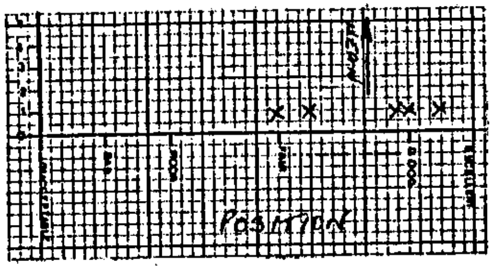
Observers' Notes

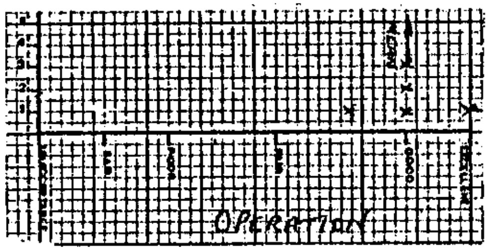
1. During engine start one pilot opened all engine HP fuel cocks instead of HP air (Ex.4)

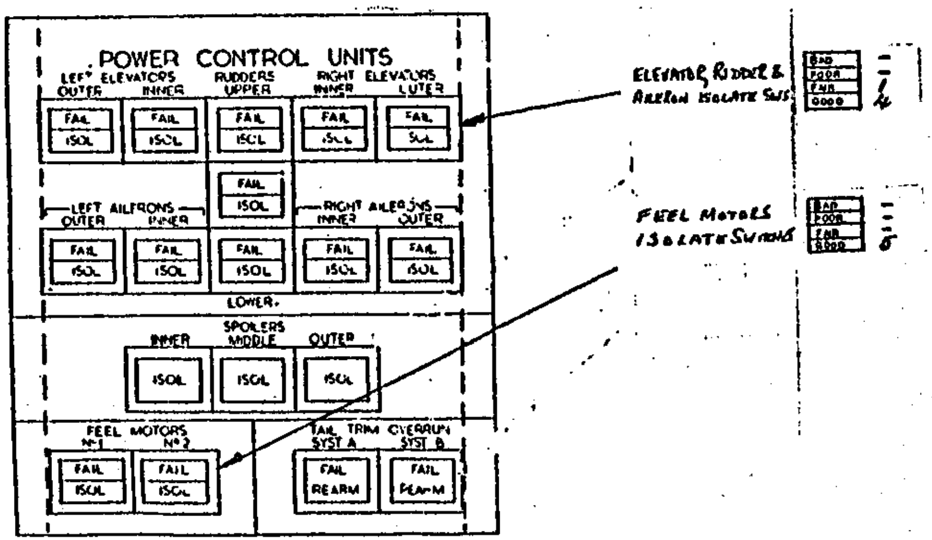
2. One pilot operated several wrong switches during start (Ex.10)

4.16 HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE POWER CONTROL UNITS CONTROL PANEL?









Pilots' Comments

1. Layout is good but the button could be recessed (1 pilot)

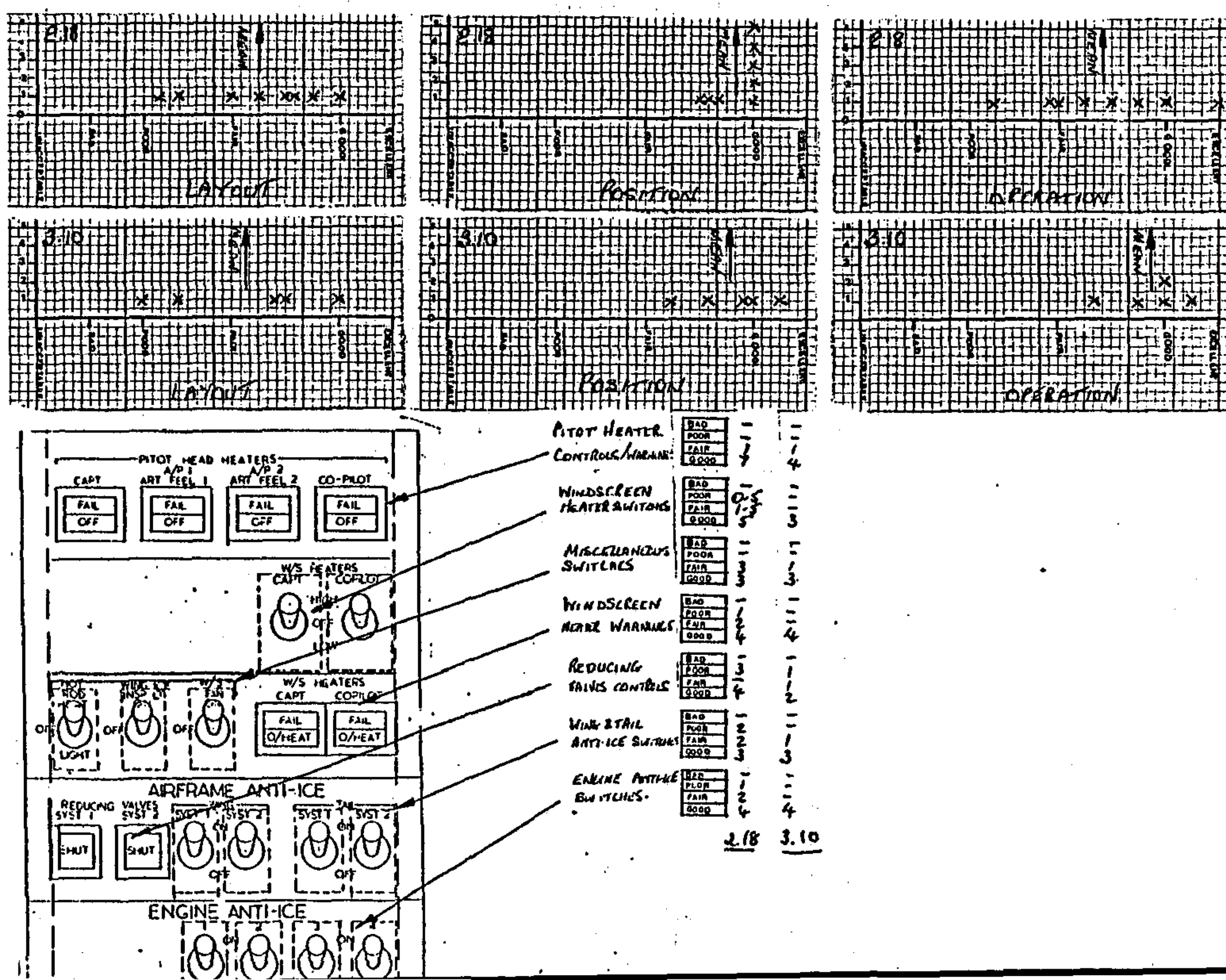
2. Very clear and easy to use with no problems of misidentification (1 pilot)

3. Labelling above the buttons is very difficult to read from the P2 seat (1 pilot)

4. Liked the split legends (1 pilot)

One pilot did not make any comment.

2.18 & 3.10 HOW WOULD YOU RATE THE LAYOUT POSITION AND OPERATION OF THE ANTI-ICE SYSTEM CONTROL PANEL?



2.18 & 3.10 **Pilots' Comments**

(2.18)

1. Would prefer windscreen heaters:-

FAIL O/HEAT	HIGH LOW OFF	FAIL O/HEAT	(1 pilot)

2. Would prefer HOT ROD, ICE INSP LT, W/S FAN on row above (1 pilot)

3. Pitot heaters (buttons) have to be looked at for a positive check (1 pilot)

4. Would like more pushbuttons (1 pilot)

5. Reducing valves not obvious (1 pilot)

6. System 1 wing anti-ice switch is too close to syst. 2 Reducing Valve button.

7. Panel layout should reflect the system like the display (1 pilot)

8. A very time consuming panel (1 pilot)

9. A sensible and logical layout (1 pilot)

10. Confusion of surface (airframe) and engine switches (1 pilot)

One pilot did not make any comment.

(3.10)

1. Standardise all switches down for off.
   e.g. w/s heaters HIGH / LOW / OFF (1 pilot)

2. Overall a simple panel to use (1 pilot)

3. Suggest putting the w/s fan switch alongside the w/s heater switches so all windscreen switches are together (1 pilot)

4. The Reducing Valve 2 button and the Airframe Anti-Ice System 1 toggle are too close together (1 pilot)

5. The layout of the panel could reflect the layout of the system (1 pilot)

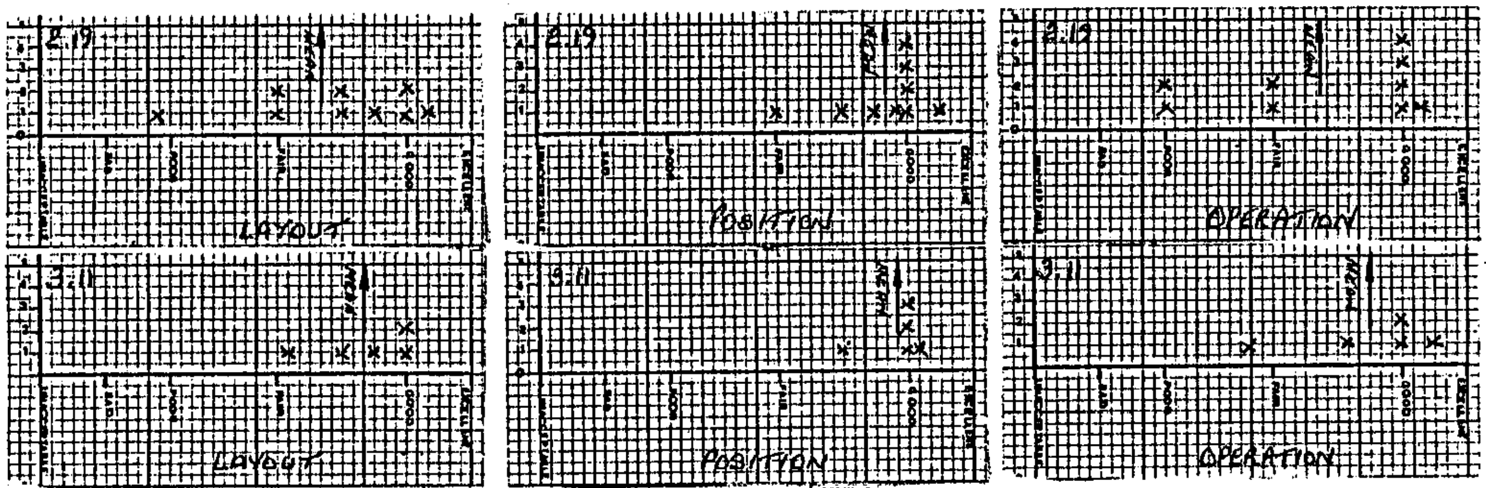
Observer's Notes

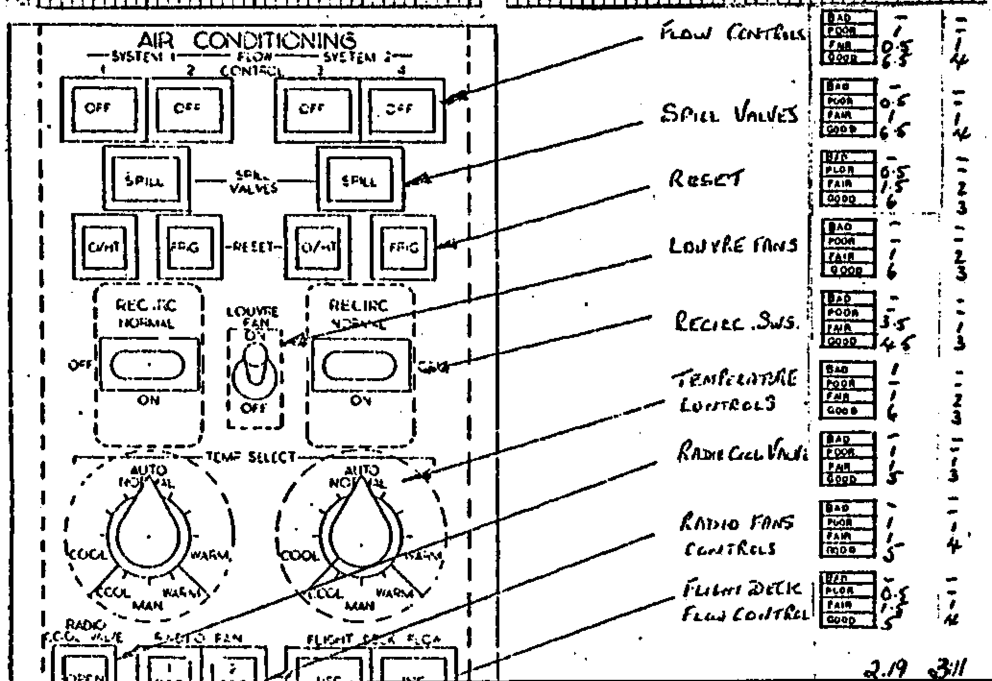
1. During preflight checks pitot heaters were selected off instead of on (2 pilots)

2. Switched off pitot heaters instead of windscreen heaters (1 pilot)

3. Caught the anti-ice controls when switching on the cabin cabin notices (1 pilot)

2.19 HOW WOULD YOU RATE THE LAYOUT, POSITION AND
& OPERATION OF THE AIR SYSTEMS AND AIR CONDITIONING
3.11 PANEL?





2.19 <u>Pilots' Comments</u>
&
3.11 (2.19)

1. Labelling of temperature controls is poor (1 pilot)

2. Fairly good in operation, but radio cooling and fan controls do not belong on this panel (1 pilot)

3. Always a chance of pressing wrong button (1 pilot)

4. Happy with manual control of valves (1 pilot)

5. Manual control of valves is time consuming (1 pilot)

6. Simple to take a generator off line when it is working (1 pilot)

Three pilots did not make any comment.

(3.11)

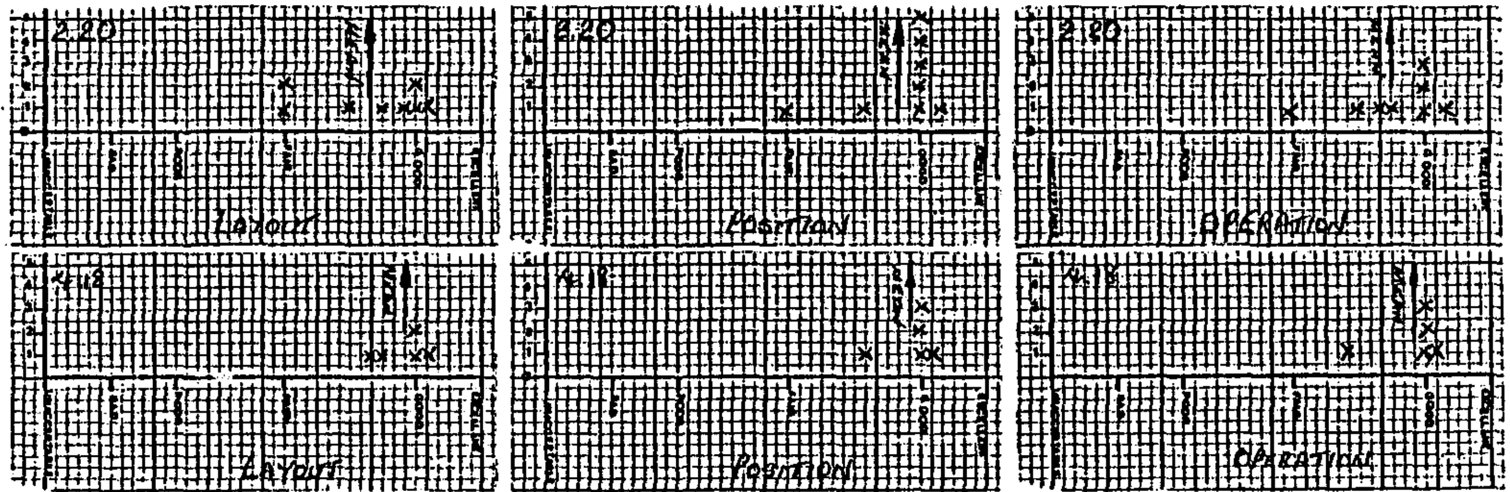
1. Layout quite good (2 pilots)

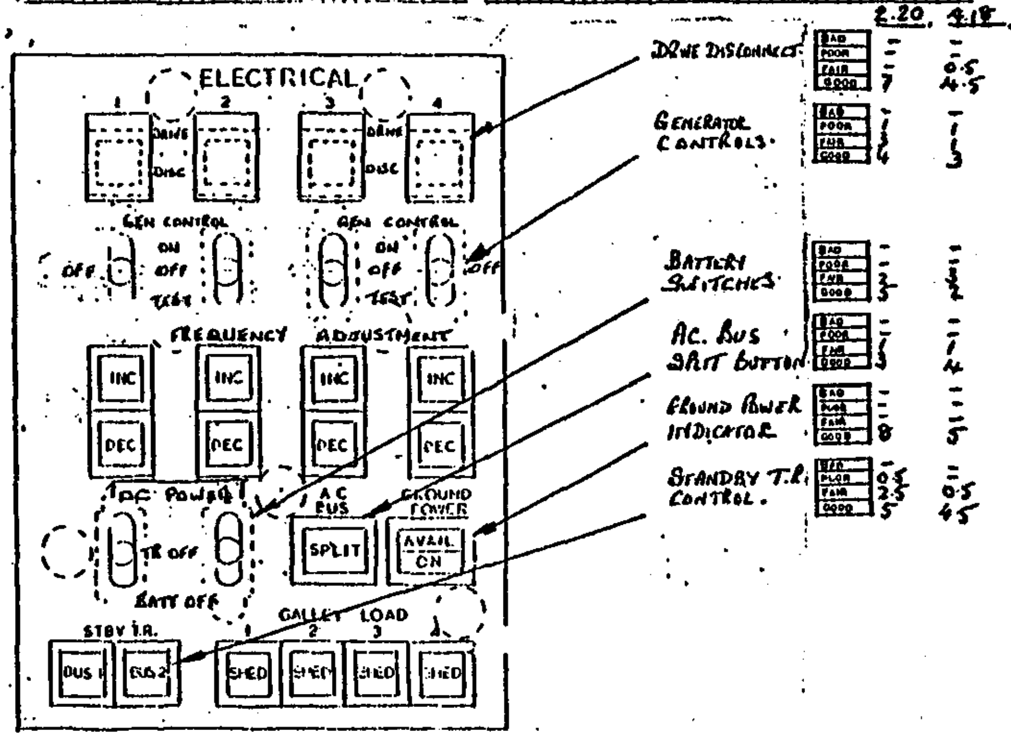
2. Labelling is poor and lettering is "crowded" on the panel (1 pilot)

3. Labelling of the recirculating fan needs improving (2 pilots) Suggest ON (1 pilot)
NORMAL 
OFF

4. Would like some improvements to layout of panel (2 pilots)

2.20 & 4.18 **HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE ELECTRICS CONTROL PANEL?**





2.20 &
4.18 **Pilots' Comments**

(2.20)

1. GEN controls need better identification with locking switches to avoid inadvertent switch off (1 pilot)

2. STDBY TRU should be more prominent (1 pilot)

3. STDBY TRU different philosophy to Reducing Valves (1 pilot)

4. Frequency adjust wastes space (2 pilots)

Five pilots did not make any comment.

Observer's Note

One pilot selected ground power off instead of ON during preflight checks.

(4.18)

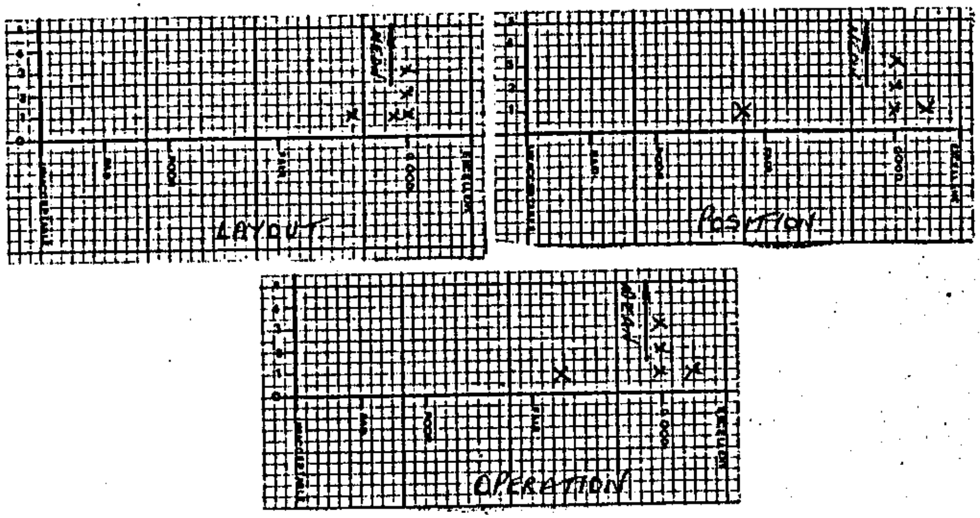
1. Would like a light when the generator is off-line (2 pilots)

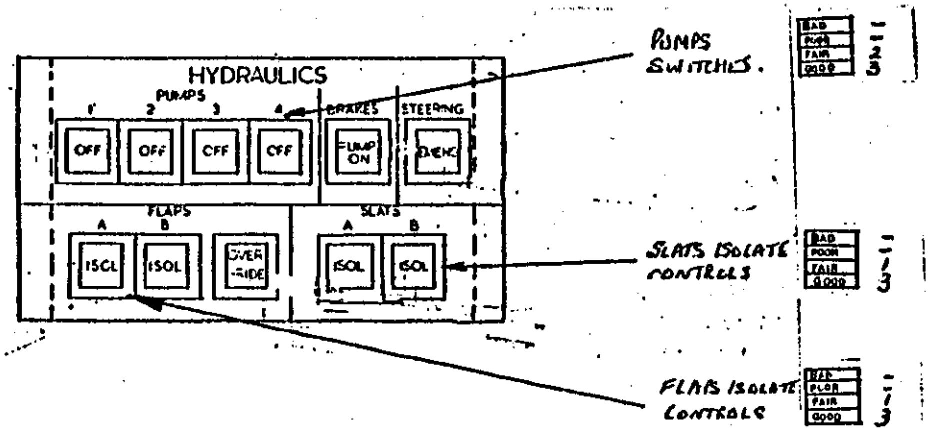
2. Panel needs "marrying" more to the CRT format (1 pilot)

3. No problems anticipated (1 pilot)

One pilot did not make any comment.

4.17 **HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE HYDRAULICS SYSTEM CONTROL PANEL?**





Pilots' Comments

1. Emergency steering should be near the steering controls and not in the roof (1 pilot)

2. Danger of inadvertant operation (1 pilot)

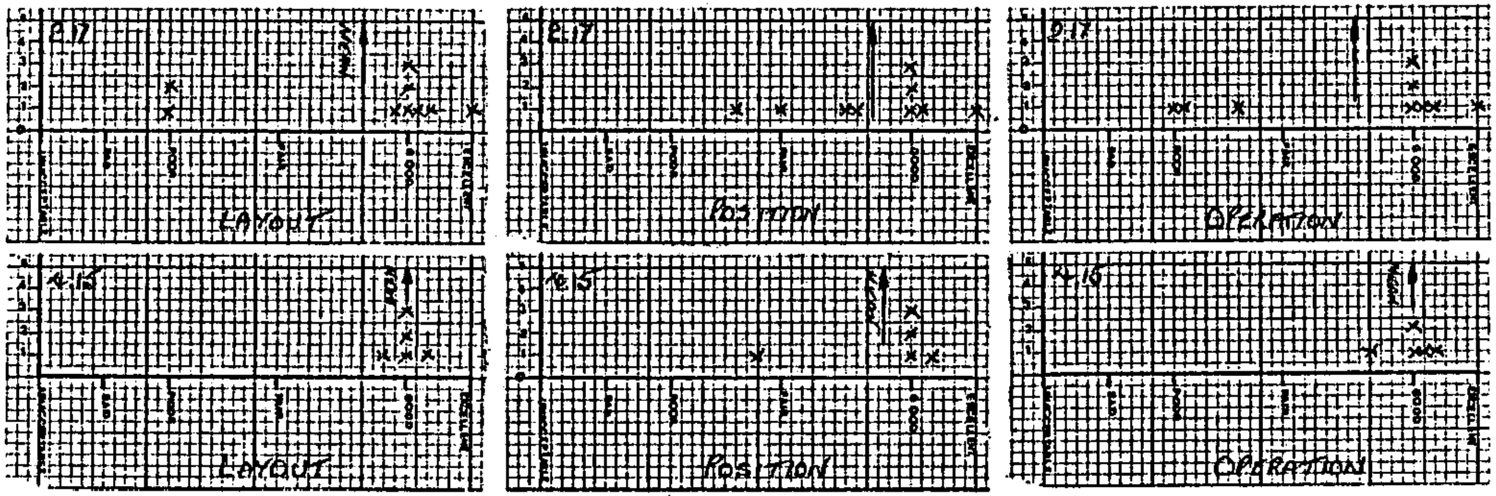
3. When a system was off the white light was partially transmitted through adjacent buttons (1 pilot)

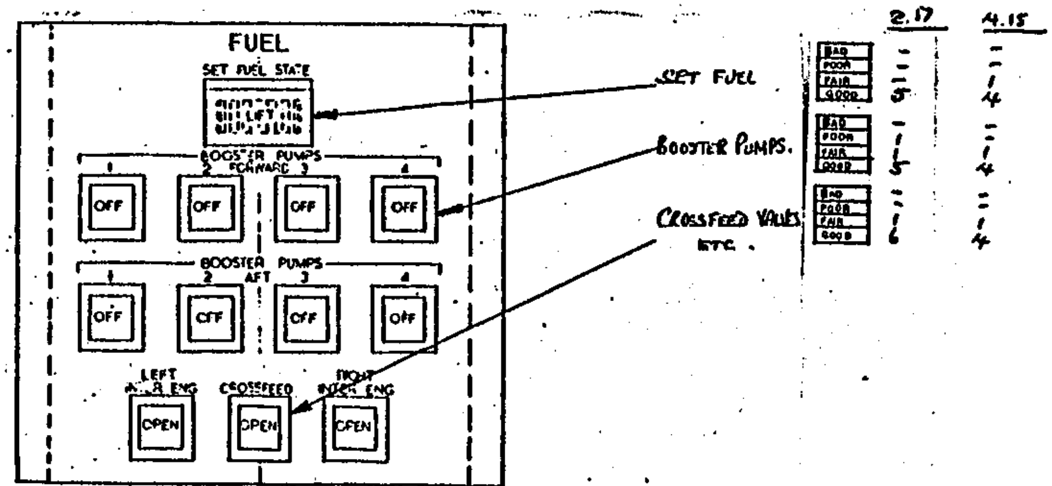
4. Although only the pumps were used, the panel was clear and simple to use (1 pilot)

5. All the buttons are alike, suggest the pump controls could be different if they have to be operated for inflight shut-down (1 pilot)

All pilots commented

2.17 & 4.15 HOW WOULD YOU RATE THE LAYOUT POSITION AND OPERATION OF THE FUEL SYSTEM CONTROL PANEL?





2.17 Pilots' Comments
&
4.15 (2.17)

1. Would prefer all systems to have mimic diagrams associated with the switches, but realise this will take more space (1 pilot)

2. Each system panel should have its own "signature" for easy recognition (1 pilot)

3. Difficult to read from across the flight deck (2 pilots)

4. Should be on P2's side of roof panel as he is major user (1 pilot)

5. A simple panel to operate (1 pilot)

6. Warnings required on panel for low pressure (1 pilot)

7. Booster pumps and cross-feeds can be mis-selected too easily (1 pilot)

Four pilots did not make any comment.

(4.15)

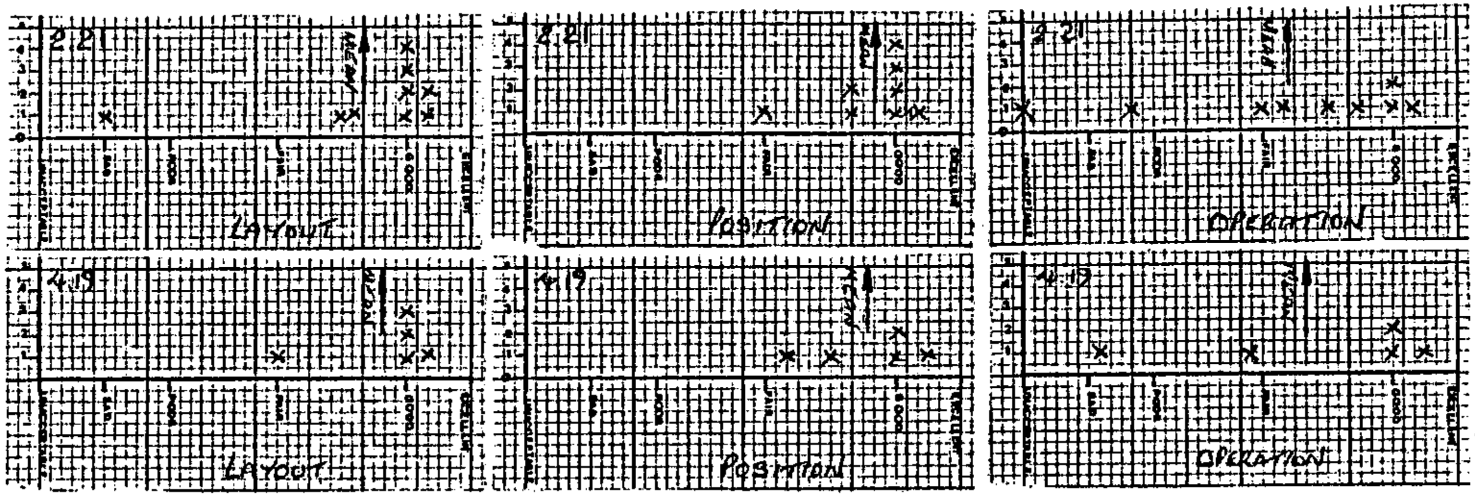
1. All important buttons could be inadvertently operated - suggest all buttons should be recessed (1 pilot)

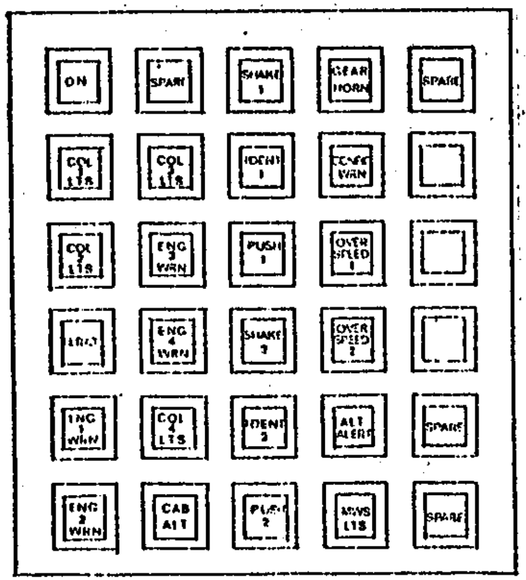
2. Simple, clear and easy to use (1 pilot)

3. Do not like practice of switching booster pumps off on three engines when fuel balancing (1 pilot)

Three pilots did not make any comment.

2.21 & 4.19 HOW WOULD YOU RATE THE LAYOUT, POSITION AND OPERATION OF THE TEST PANEL?





2.21 Pilots' Comments
&
4.19 (2.21)

1. Each light should remain on until the next button is operated (1 pilot)

2. Operation makes one's arm ache (7 pilots)

3. Didn't find any arm ache (1 pilot)

4. Check list wording should agree with centre (3rd) column (1 pilot)

5. Test drills on check list should allow for a check of all lights in column 4 (Audio Warning) without reference to check list (1 pilot)

Two pilots did not make any comment.

(4.19)

1. The present method of holding the test button on is unacceptable, latching would help (3 pilots)

2. Possibly only one button is necessary if the details are put on the CRT (1 pilot)

3. Philosophy is satisfactory, but it is possible to miss a missing warning (1 pilot)

4. No arm ache (1 pilot)

(4.19 continued)

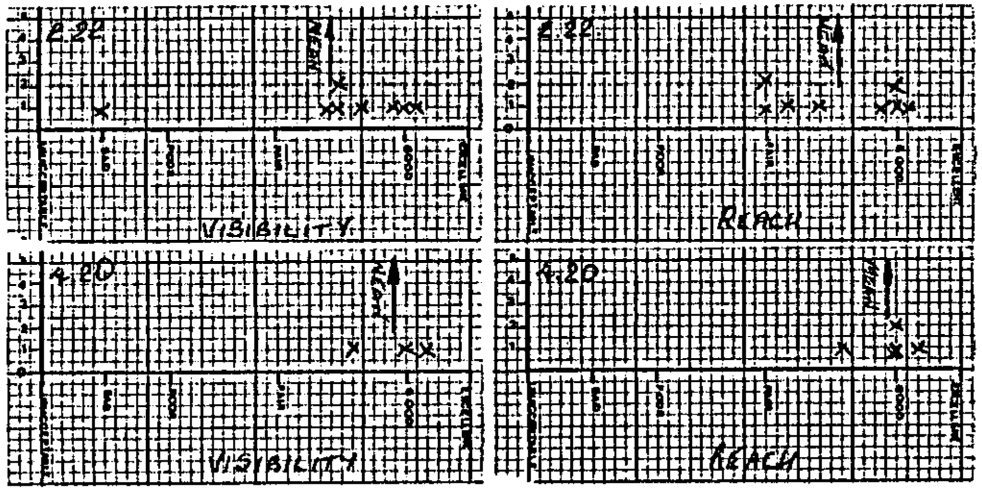
5. Check list should reflect one line-one light consistency. Check list should just sat 'Test Panel' and 'Test complete'. (1 pilot)

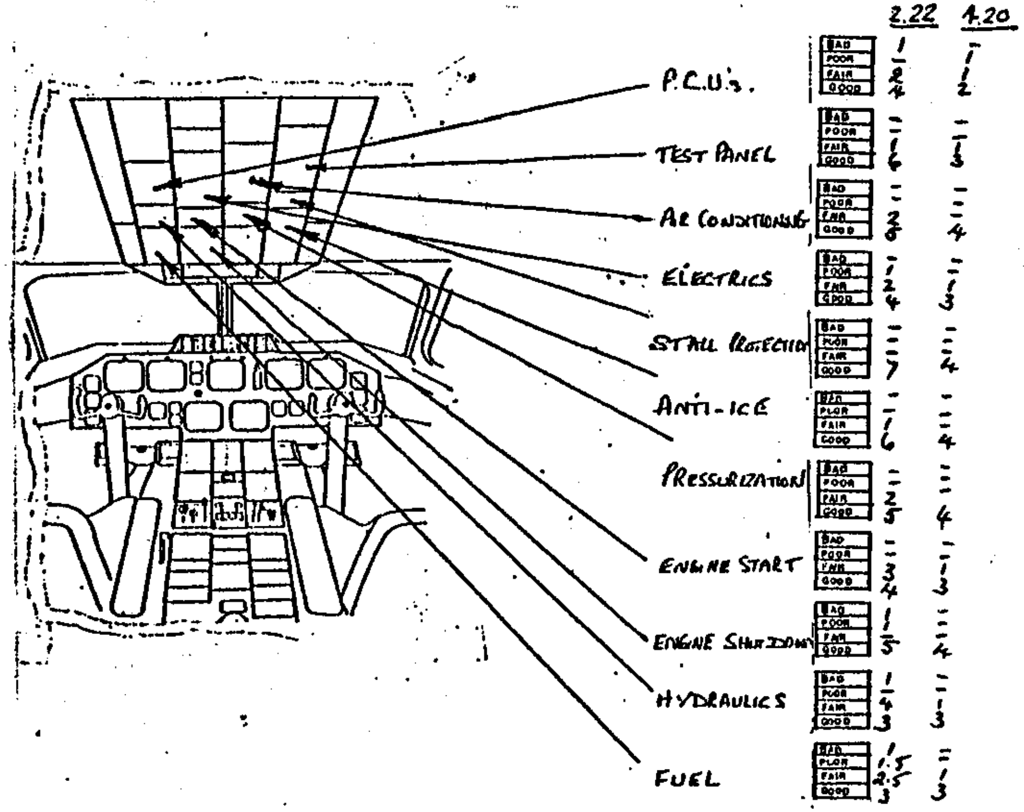
6. Lights in the push buttons on the roof panel can easily lead to confusion and the wrong action being taken (1 pilot)

7. Have to reach too far back to operate col.3 lights from P1 seat (1 pilot)

All pilots commented.

2.22 & 4.20 HOW WOULD YOU RATE THE VISIBILITY AND REACH OF CONTROLS AND INDICATIONS GENERALLY ON THE ROOF PANEL?





Pilots' Comments

(2.22)

1. Recognition would be aided if there were stronger demarcation lines between separate systems (1 pilot)

2. Hydraulics and Fuel controls are not close enough to P2. - Line of sight of Fuel behind shut down handles. (1 pilot)

3. Could catch sleeve on shut-down handles (1 pilot)

4. Possible to inadvertantly operate fuel system if pilot banged his head (1 pilot)

5. One fuel booster pump indicator was hidden behind No.1 shut-down handle (1 pilot)

6. PCU captions difficult to read from P2 seat (1 pilot)

7. Visibility of switches not good (2 pilots)

8. It would be better if the whole panel could be moved further forwards to bring to more ahead of the pilots (1 pilot)

9. Outside rows are a stretch from opposite seat (2 pilots)

Three pilots did not make any comment.

Observers' Notes

One pilot inadvertantly operated fuel system by banging his head (see comment 4).

(4.20)

1. Visibility varies from poor to good (1 pilot)

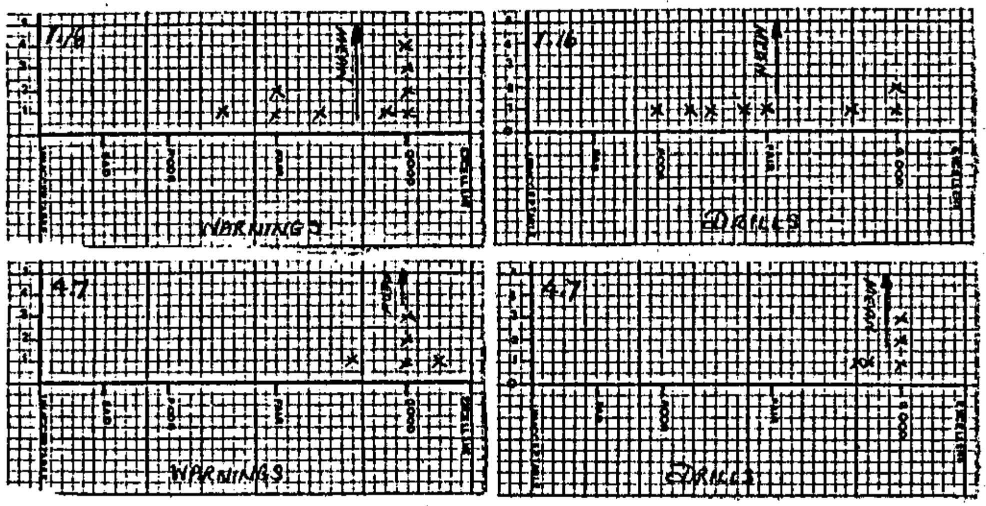
2. Reach too far to panel extremes, could be problems in cases of incapacitation (1 pilot)

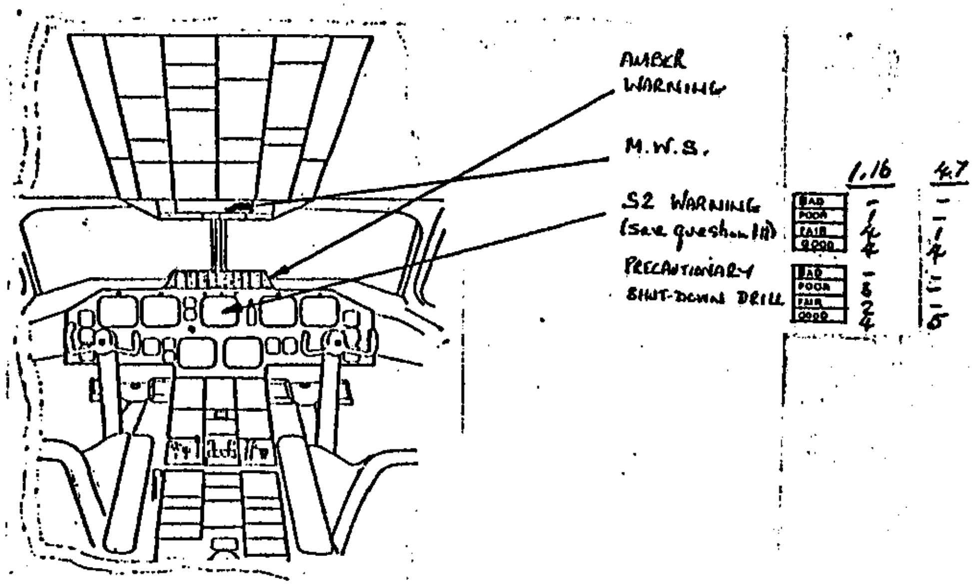
3. Four panels wide for the roof is the limit, would prefer only three (1 pilot)

4. Fuel panel should be on P2's side of the flight deck (1 pilot)

2 pilots did not make any comment.

1.16 & 4.7 HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE REVERSER UNLOCKED WARNINGS AND THE CONSEQUENT DRILLS?





Pilots' Comments

(1.16)

1. Some of the actions could be more easily handled by P1 (1 pilot)

2. "Attempt to stow" does not mean much (1 pilot)

3. Need to know instantly which engine is at fault (1 pilot)

4. Shut-down drill involves a lot of "widespread" actions but this is not altogether unusual (1 pilot)

5. Reverse fail warning could be more dominant - perhaps flashing inverted (1 pilot)

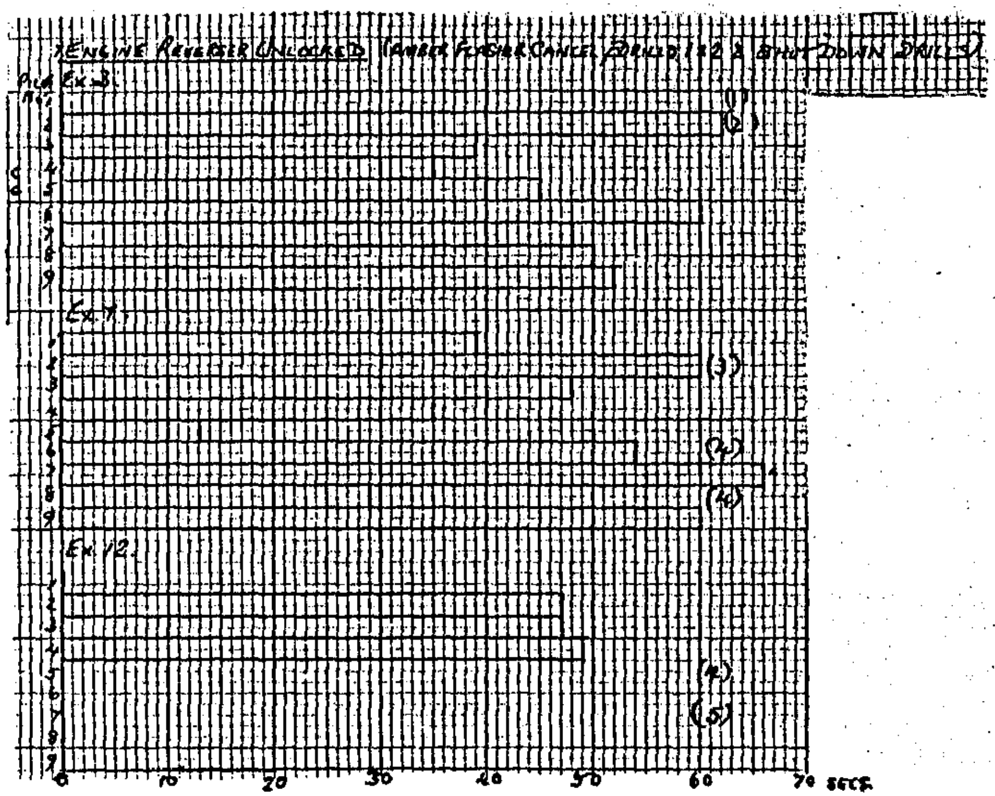
Four pilots did not make any comment

(4.7)

1. A clear indication and the drill was easy to follow (1 pilot)

Four pilots did not make any comment

ENGINE REVERSER UNLOCKED



NOTES

(1) Fault not presented

(2) Difficulty in locating Hyd.Pump control

(3) Hesitated, and then carefully identified engine

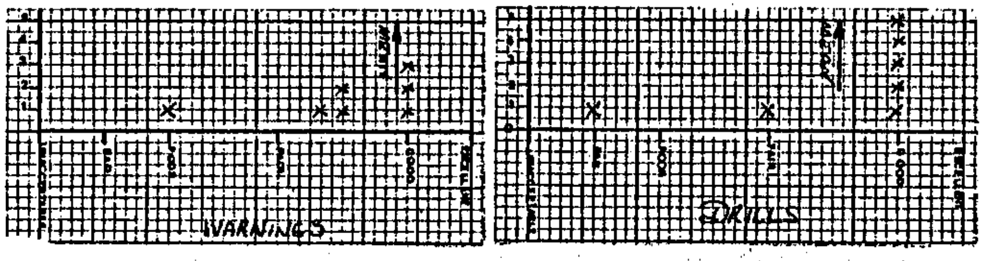
(4) Emergency shut-down instead of precautionary shut-down drill.

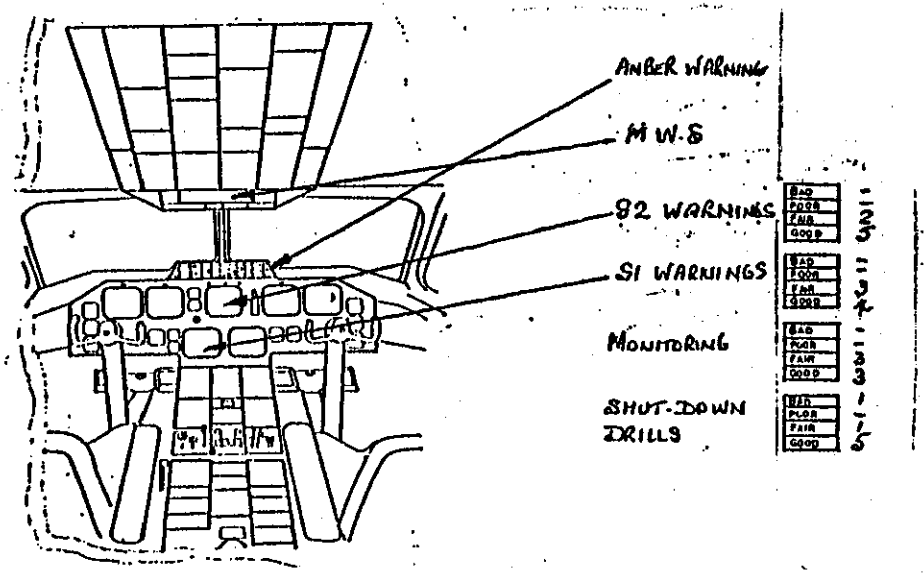
(5) Drill not completed correctly

Pilot Nos.1,6,8,9 not used in exercise 12

Monitoring System faulty for Pilot No.5 in Ex.12

1.18 HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE OIL LOW PRESSURE WARNINGS AND THE CONSEQUENT DRILLS?





Pilots' Comment

1. Confused when the amber warning changed to a red warning. (1 pilot)

2. Quite easy to determine failure and action appropriately (1 pilot)

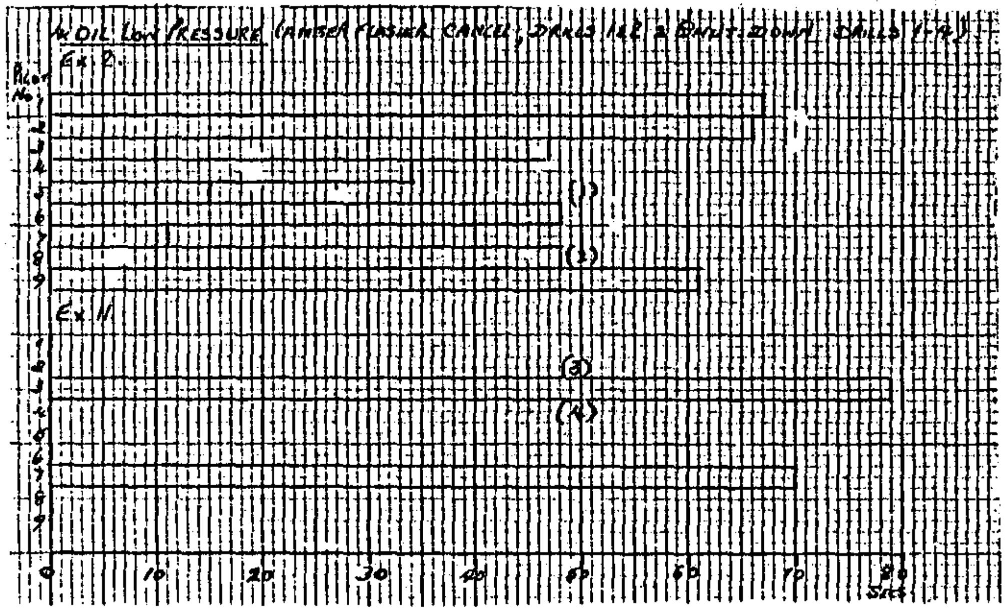
3. Colour would improve the display (1 pilot)

4. One has to know whether to look up or down for the warning. Looking down with a control in the roof is not as good as if the warning control and display were grouped together (1 pilot)

5. Different drills for amber and red warning are potentially confusing and unnecessary (1 pilot)

6. Monitoring requires a deliberate reading (1 pilot)

ENGINE OIL LOW PRESSURE



NOTES

(1) Shut hydraulics valve instead of pump. Also switched OFF wrong generator.

(2) Emergency check list performed in error.

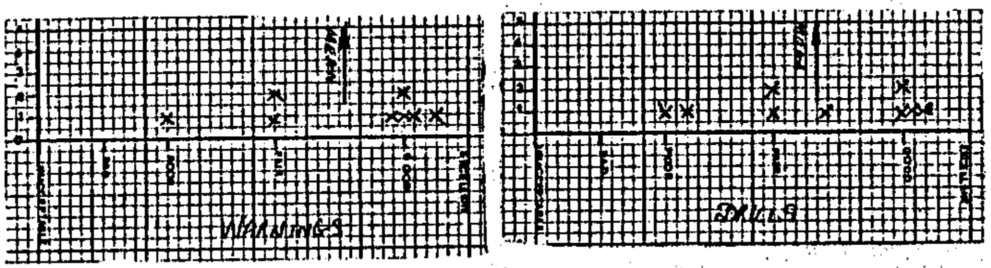
(3) Drill not completed

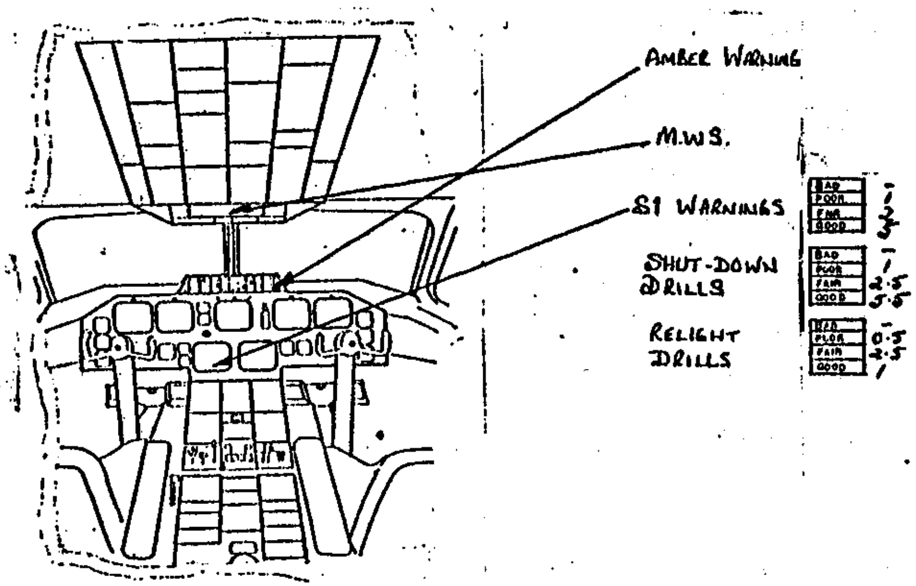
(4) Co-pilot assisted pilot with drill.

Pilots Nos. 1,6,8,9 were not used in Ex.11.

Monitoring system faulty for pilot No.5 in Ex.11

2.11 HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE VIBRATION WARNINGS AND CONSEQUENT DRILLS?





Pilots' Comments

1. Engine Vibration should select single engine display as priority (1 pilot)

2. Shut-down drills simple and easy to remember (1 pilot)

3. Shut-down drill requires care to select correct switches (1 pilot)

4. HYD and FLOW both bring on an associated light the generator ought to do the same (1 pilot)

5. Vibration, warning should be more dominant (1 pilot)

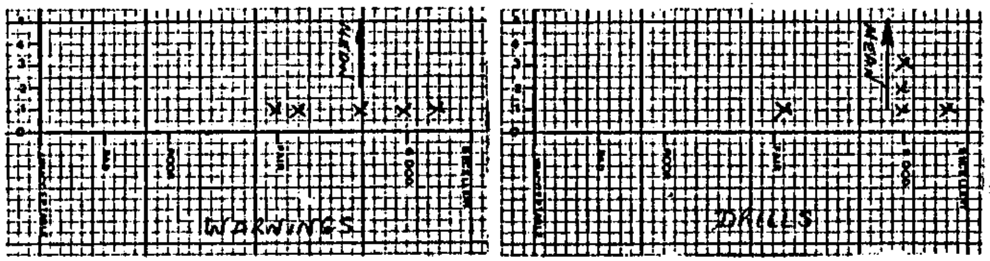
6. Do not like different drills for precautionary and emergency shut down (1 pilot)

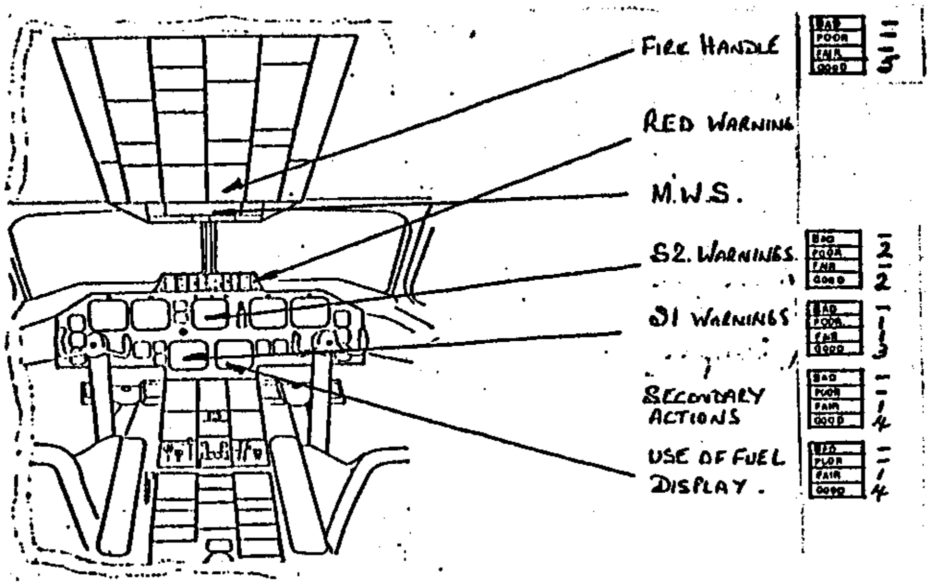
Four pilots did not make any comment

Observer's Exercise Notes

1. Throttled back the wrong engine
2. Did not do any fuel balancing

3.8 HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE OVERHEAT WARNINGS AND THE CONSEQUENCY DRILLS?





Pilots' Comments

1. Would like to see O/H come up underneath (on the lower part of) the All Engines format (2 pilots)

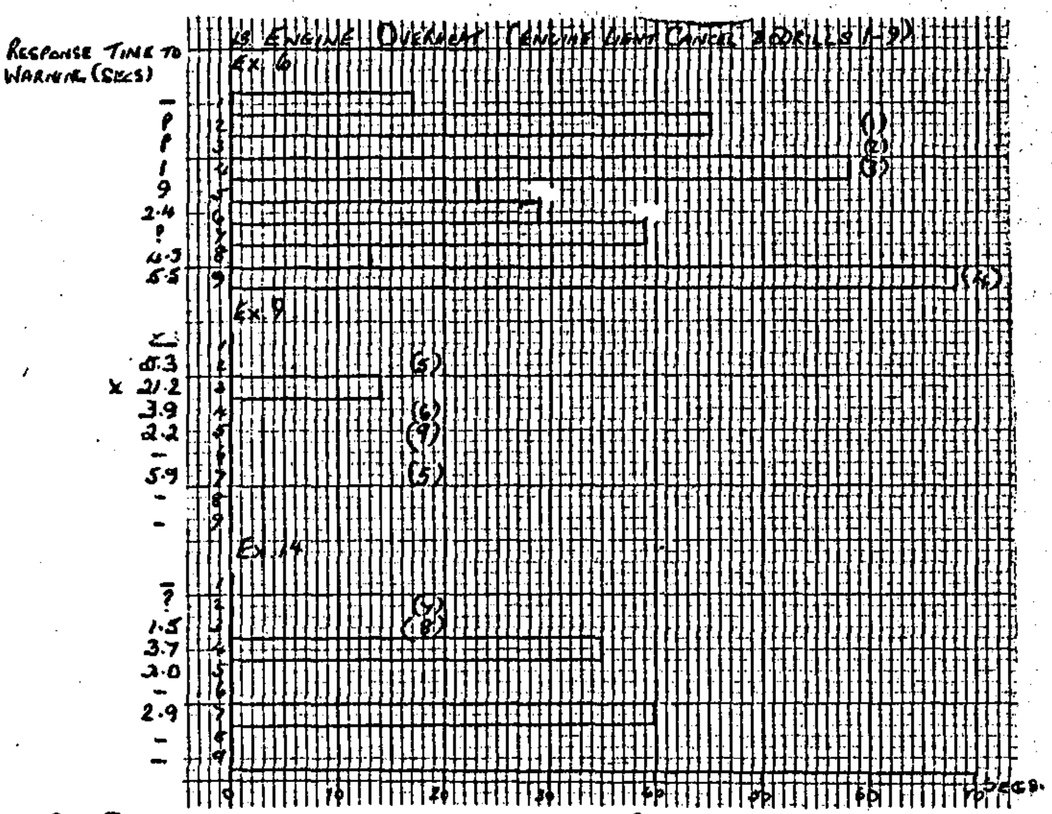
2. Fuel System format is easy to monitor, but would like an asymmetry warning on the Status format (1 pilot)

3. Identification of which engine is overheating is difficult (1 pilot)

4. Would prefer FIRE, VIBN (as well as O/H) Warnings on the All Engines display (2 pilots)

5. Hierarchy of warnings is satisfactory, but further thought is necessary on the 'looking'. (display inhibit) (1 pilot)

ENGINE OVERHEAT



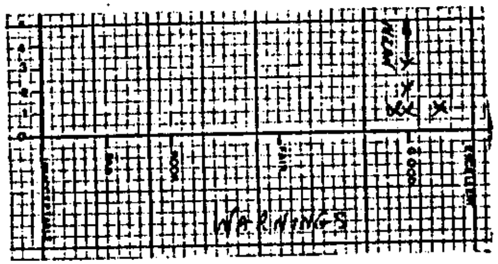
C - DENOTES TIME TAKEN FROM COMPUTER PRINT-OUT
P - DENOTES PROMPTED BY CO-PILOT.
x - DENOTES DOING APPROACH CHECKS.

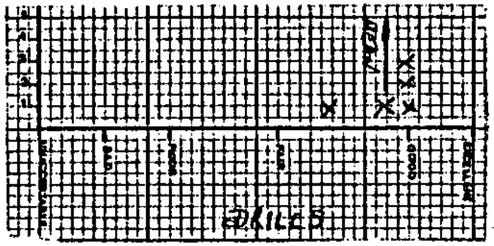
NOTES

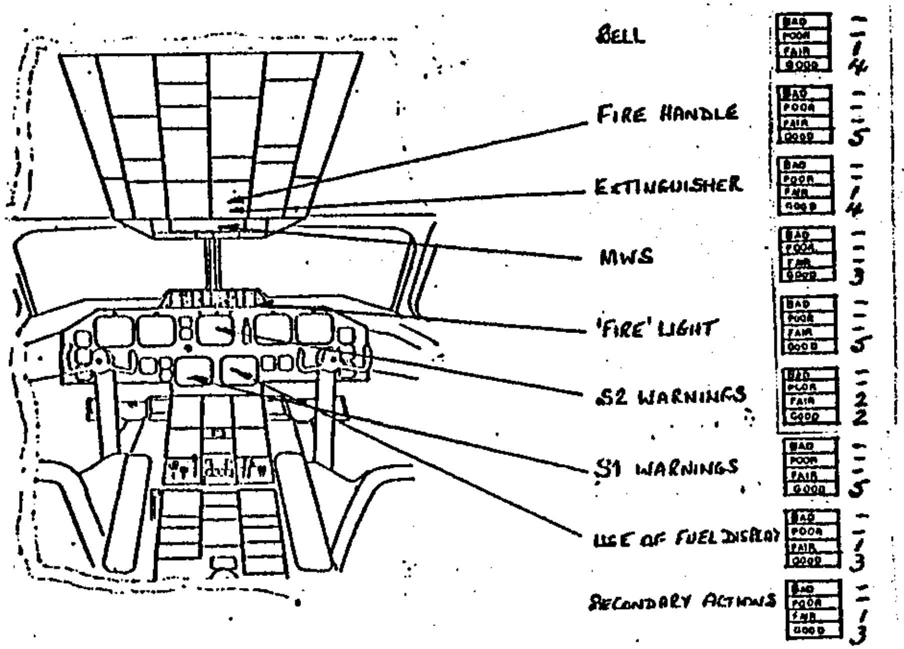
(1) Confused by the warning
(2) Had to be prompted
(3) Had difficulty in identifying engine
(4) Had difficulty in identifying failure as the display inhibition caused confusion. Once identified, drill was carried out from memory.
(5) Light failed in shut-down handle
(6) Hydraulics valve omitted from drill
(7) Fire fault injected in error
(8) "Generator off" omitted from drill
(9) Confused warning with low pressure. Had difficulty with the display hierarchy.

Pilot Nos. 1,6,8,9 were not used in exercises 9 & 14
Monitoring system faulty for Pilot No.5 in Exs.9 & 14.

4.5 HOW WOULD YOU RATE THE EFFICIENCY OF THE ENGINE FIRE WARNINGS AND THE CONSEQUENCT DRILLS?







Pilots' Comments.

1. A 'FIRE'caption is required on the "All Engines" format (2 pilots)

2. The shut down drill was good (1 pilot)

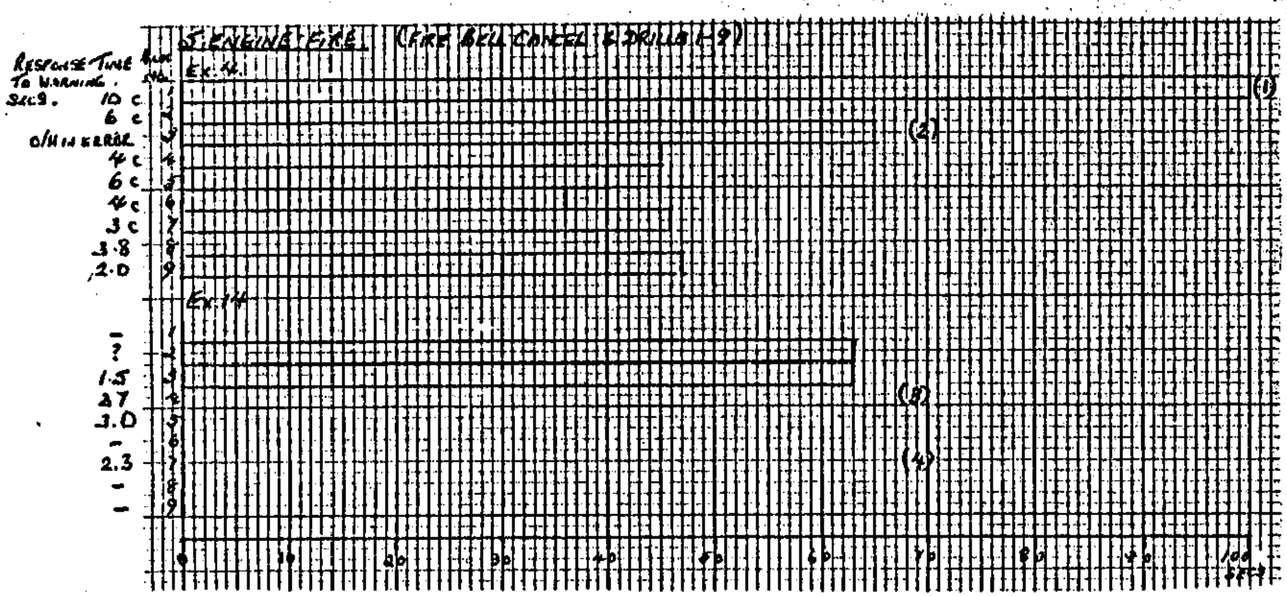
3. Did not use the information on the two engine formats before doing the drill (1 pilot)

4. Think booster pumps should be part of the secondary actions and not the vital actions. Do not like to switch off the booster pumps in case the wrong engine is shut down (1 pilot)

5. Selected generator to TEST instead of OFF after engine fire (1 pilot)

One pilot did not make any comment.

ENGINE FIRE



C - DENOTES TIME TAKEN FROM COMPUTER PRINT-OUT.

NOTES

(1) Delay due to display fault

(2) Pilot commented that he almost fired the extinguishers before the fuel valves had shut.

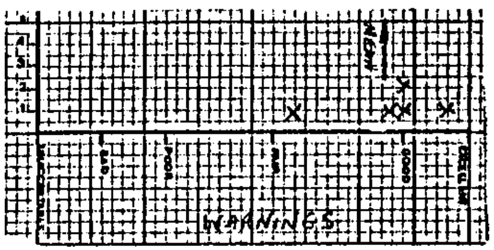
(3) Observer extinguished fire after 1st shot in error.

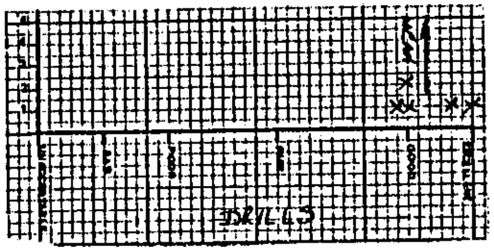
(4) Drill not completed

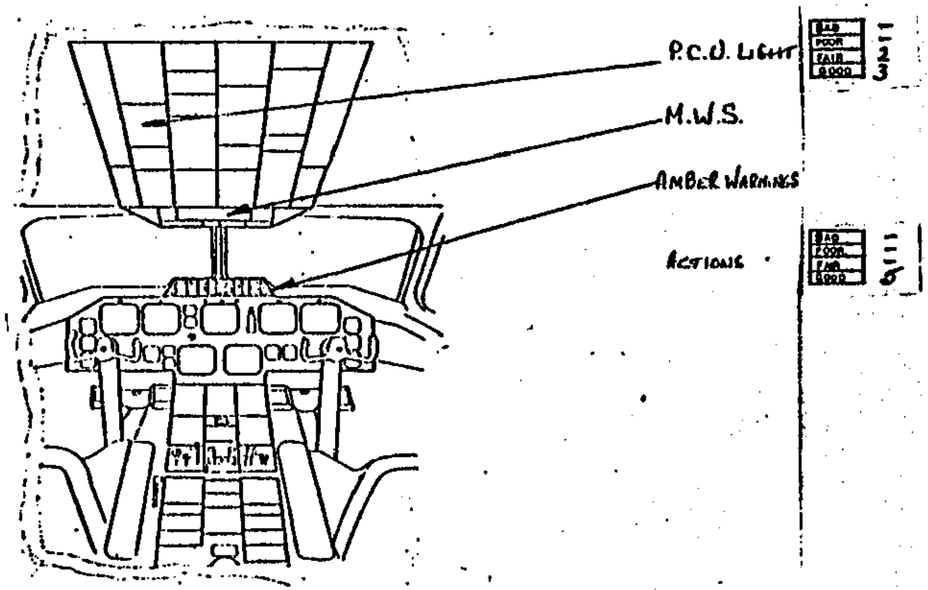
Pilots 1,6,8,9 did not do Ex.14

[The fire drill requires an interval of 30 secs. between 1st & 2nd shots.
2 shots were required for this exercise]

4.4 HOW WOULD YOU RATE THE EFFICIENCY OF THE PCU FAIL WARNINGS AND THE CONSEQUENT DRILLS?







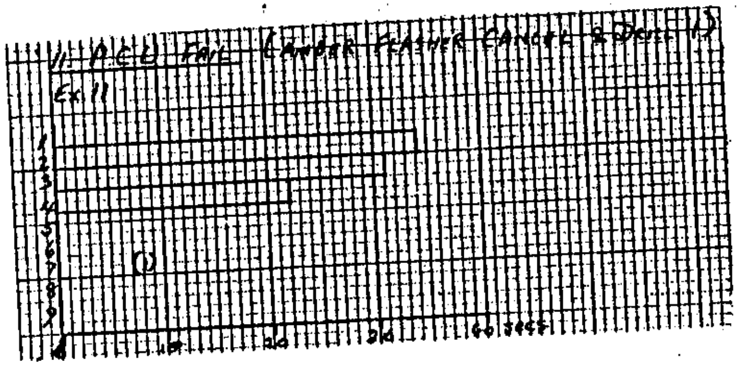
Pilots' Comment

1. Clear indication and a simple drill (1 pilot)

2. Difficult to read the labels above the push button (1 pilot)

Three pilots did not make any comment

PCU FAIL



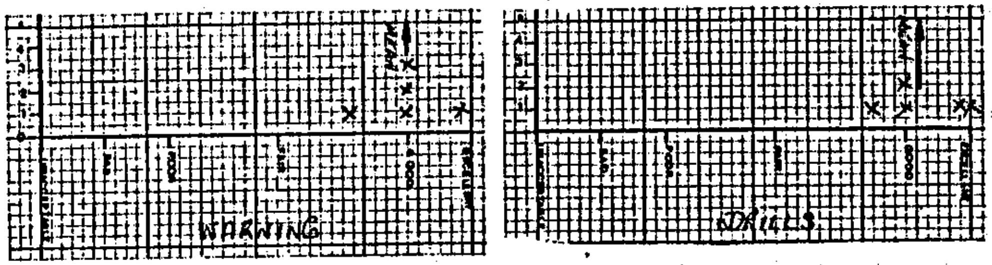
NOTES

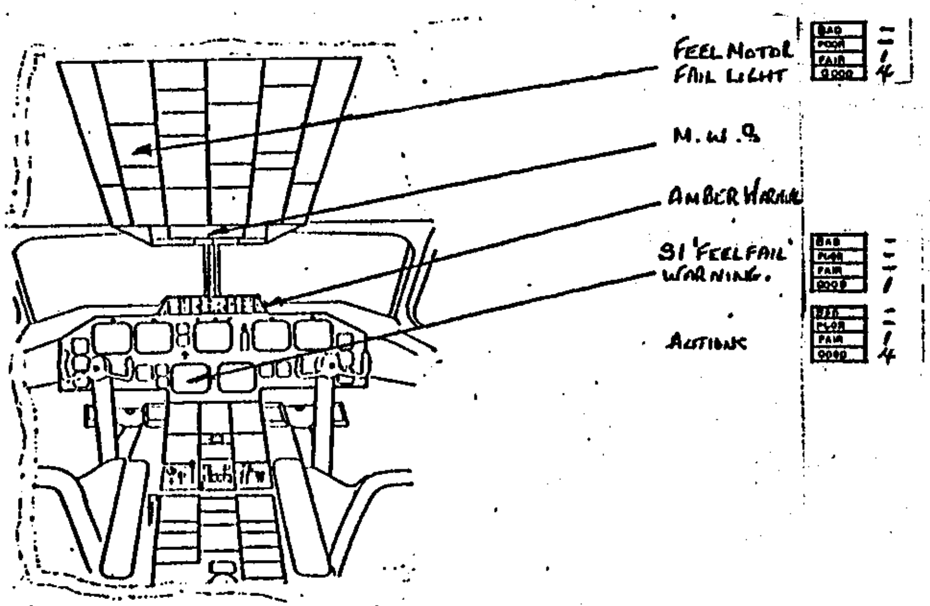
(1) Drill not completed

Pilot Nos. 1,6,8,9 did not do Ex.11

Monitoring system was faulty for Pilot No.5 in Ex.11

3.2 HOW WOULD YOU RATE THE EFFICIENCY OF THE FEEL MOTOR FAIL WARNING AND THE CONSEQUENT DRILLS?





Pilots' Comments

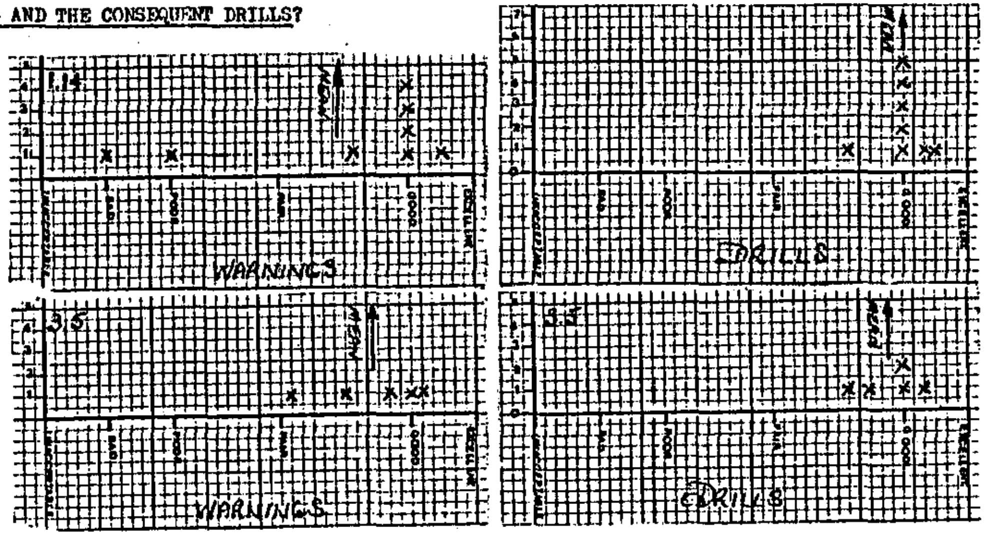
1. A feel caption on the hydraulics display may be an improvement (1 pilot)

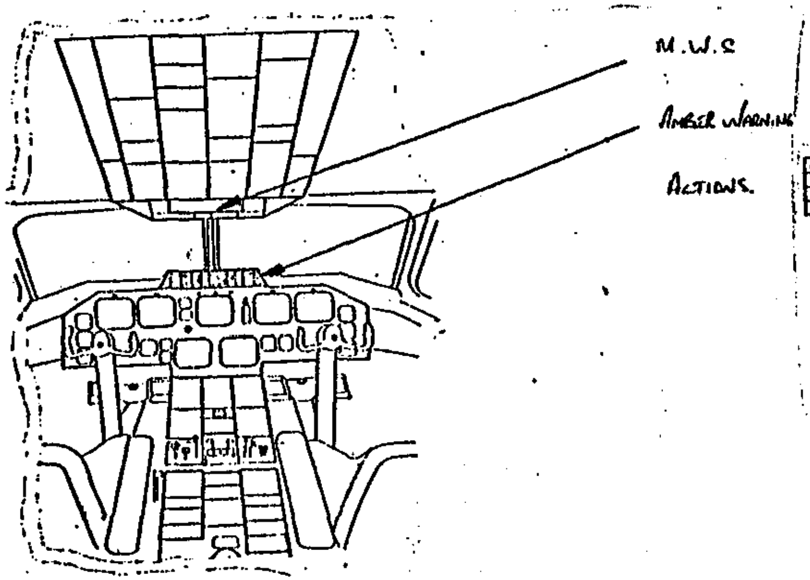
2. Indications and drills were simple (1 pilot)

3. Engraving on illuminated button difficult to see from right-hand seat, but as the only required action was to push the light there should be no problem (1 pilot)

Two pilots did not make any specific comment.

1.14 **HOW WOULD YOU RATE THE EFFICIENCY OF THE ICE**
& **DETECTION WARNING AND THE CONSEQUENT DRILLS?**
3.5





	1.14.	3.5.
BAD	–	–
POOR	–	–
FAIR	–	2
GOOD	7	3

1.14 Pilots' Comments
&
3.5 (1.14)

1. It seems an unnecessary complication to have to operate reducing valves and individual anti-icing switches to operate to airframe anti-icing (1 pilot)

2. Ice Detection requires anti-ice format which should come up automatically (2 pilots)

3. Icing conditions should be shown on format irrespective of anti-ice settings (1 pilot)

4. Ice warning should not stay on after anti-icing is switched on. (2 pilots)

5. Possibility of confusion between Ice Detection and Anti-Ice Failure warnings (2 pilots)

Three pilots did not make any comment.

(3.5)

1. Would prefer to select Anti-Ice format before doing actions (1 pilot)

2. Ice warning on Anti-ice format would be an advantage (1 pilot)

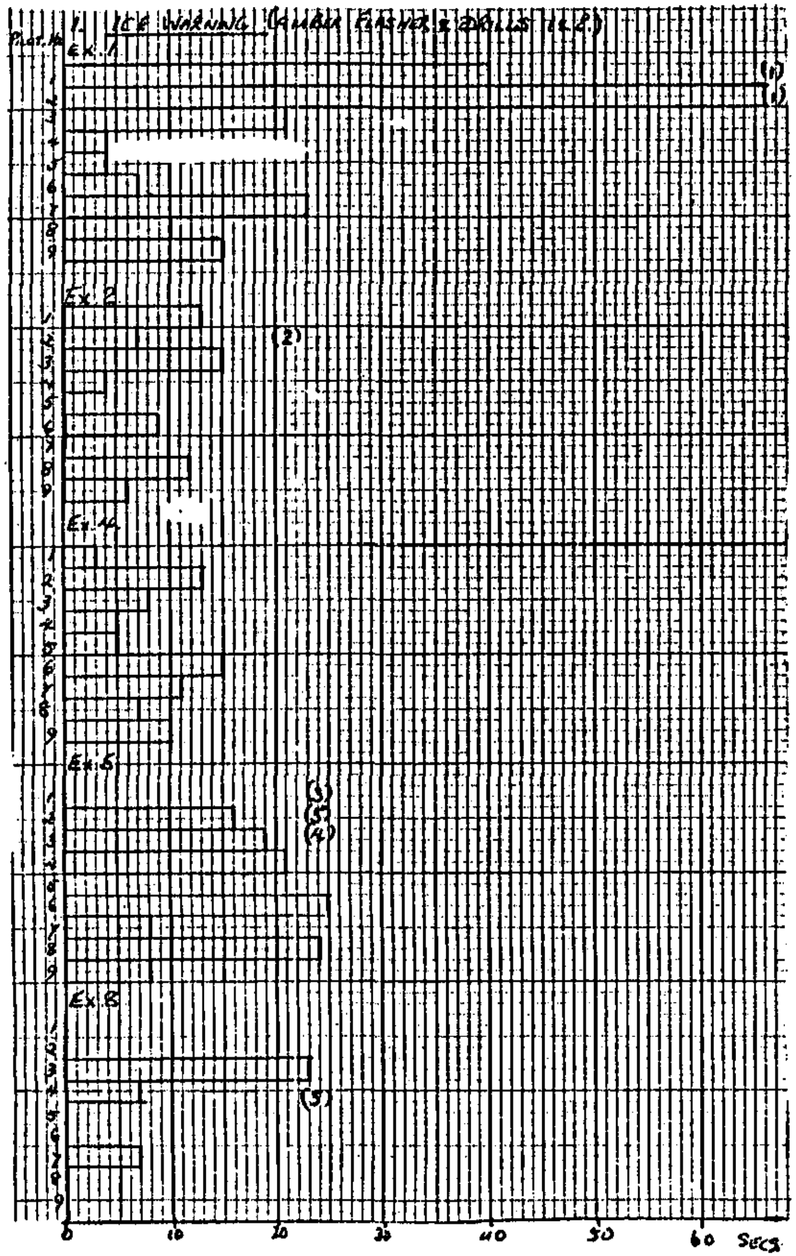
(3.5 continued)

3. Initial warning very clear and actions simple, but not so easy to see when Ice Warning goes out (1 pilot)

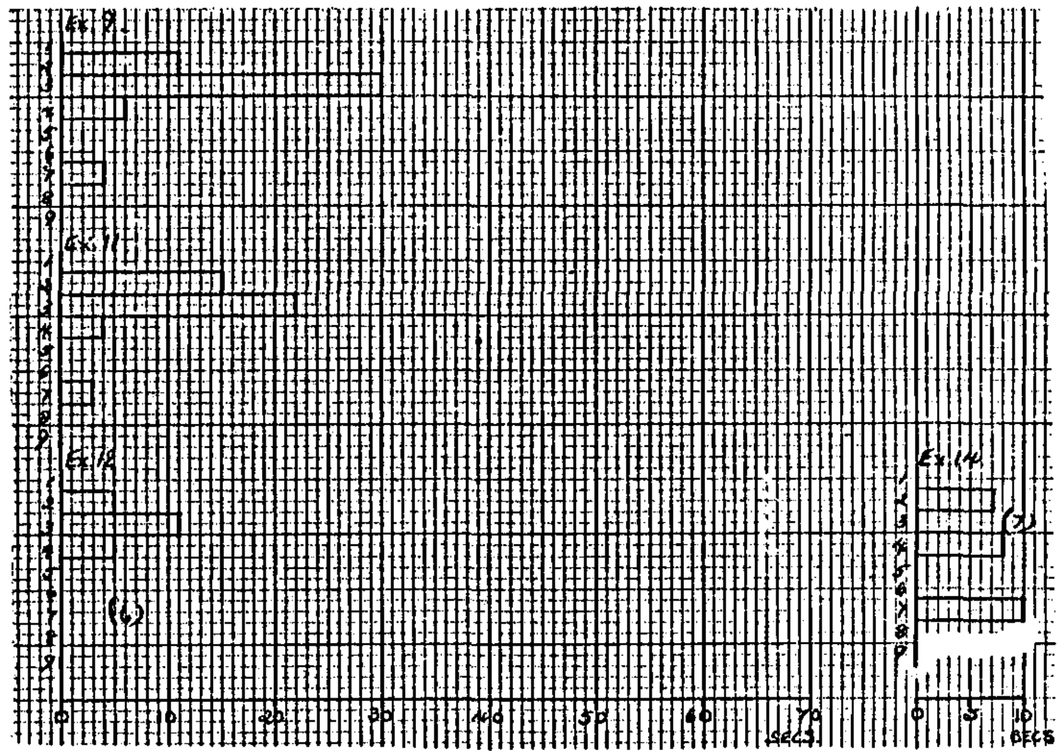
4. Ice Detection and Anti-Warning too close, but did not get confused (1 pilot)

5. Ice Warning should not come on when anti-ice is selected (1 pilot)

Two pilots did not make any comment.



ICE WARNING



NOTES

(1) Unfamiliar with MWS system

(2) Drills done from memory

(3) Exercise not given

(4) Drill done from memory, but wing anti-icing switched on then off, then on again

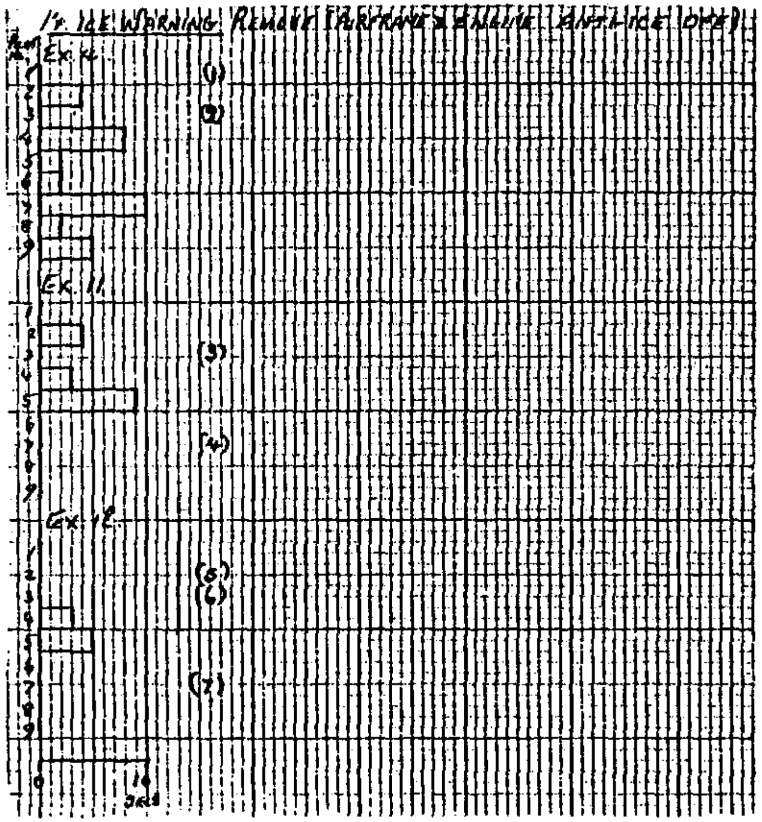
(5) Cued by observer's stop-watch "click"

(6) Drill not completed

(7) Anti-icing already on

Pilot Nos.1,6,8,9, not used for Exs. 8,9,11,12,14
Moritoring system faulty for Pilot No.5 in Exs.8,9,11,12,14.

ICE WARNING REMOVAL

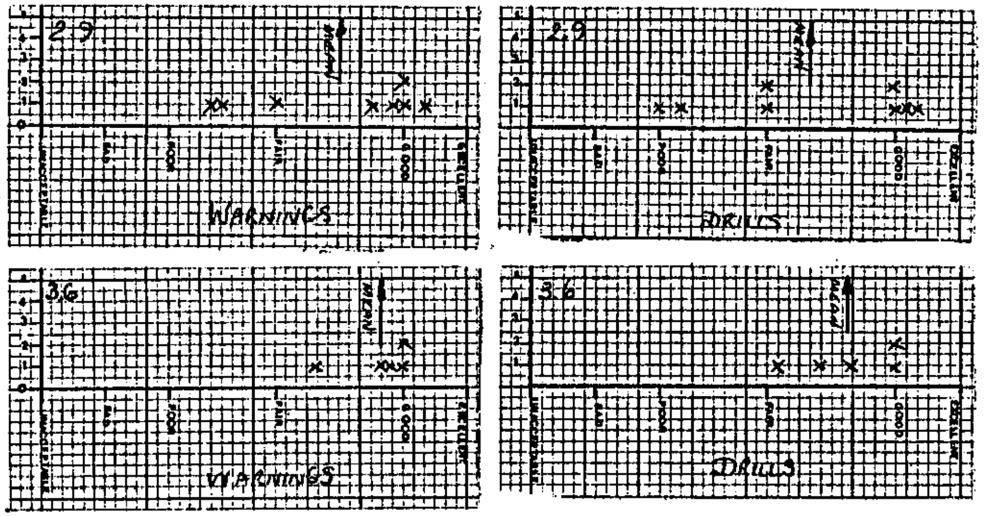


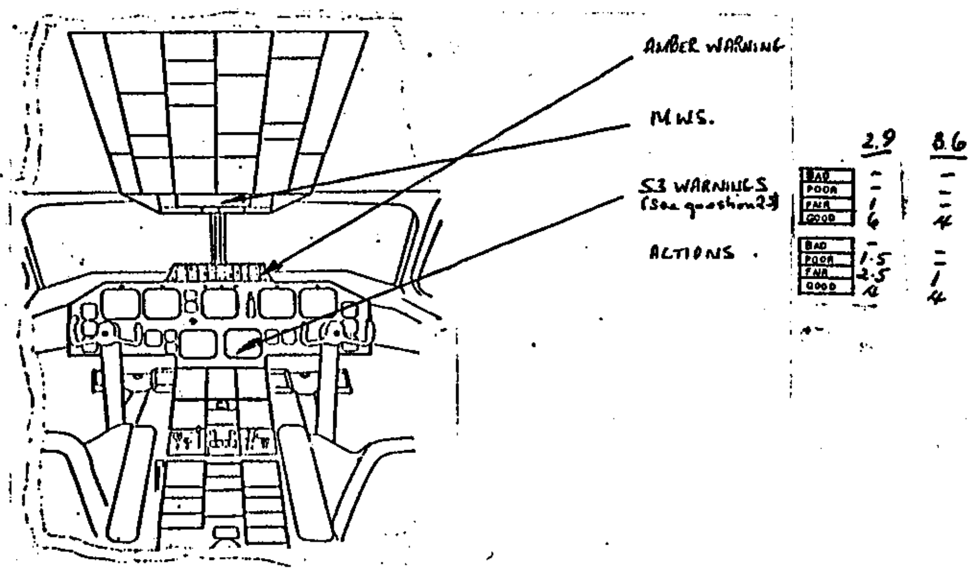
NOTES

(1) Anti-Icing left on for landing
(2) Removal not noticed
(3) Exercise not performed
(4) 2 min 10 secs to notice warning removed - drill time not recorded.
(5) More than 5 mins to notice warning removed - drill time not recorded.
(6) Ice warning not removed.

Pilot Nos.1,6,8,9, did not do Exs.11 & 12

2.9 & 3.6 HOW WOULD YOU RATE THE EFFICIENCY OF THE ANTI-ICE FAIL WARNINGS AND THE CONSEQUENT DRILLS?





Pilots' Comments

(2.9)

1. Ice detection and Anti-ice warnings should be separated on the MWS (1 pilot)

2. Drill seemed unusual. Why cannot just the HP stop valves be closed ? (1 pilot)

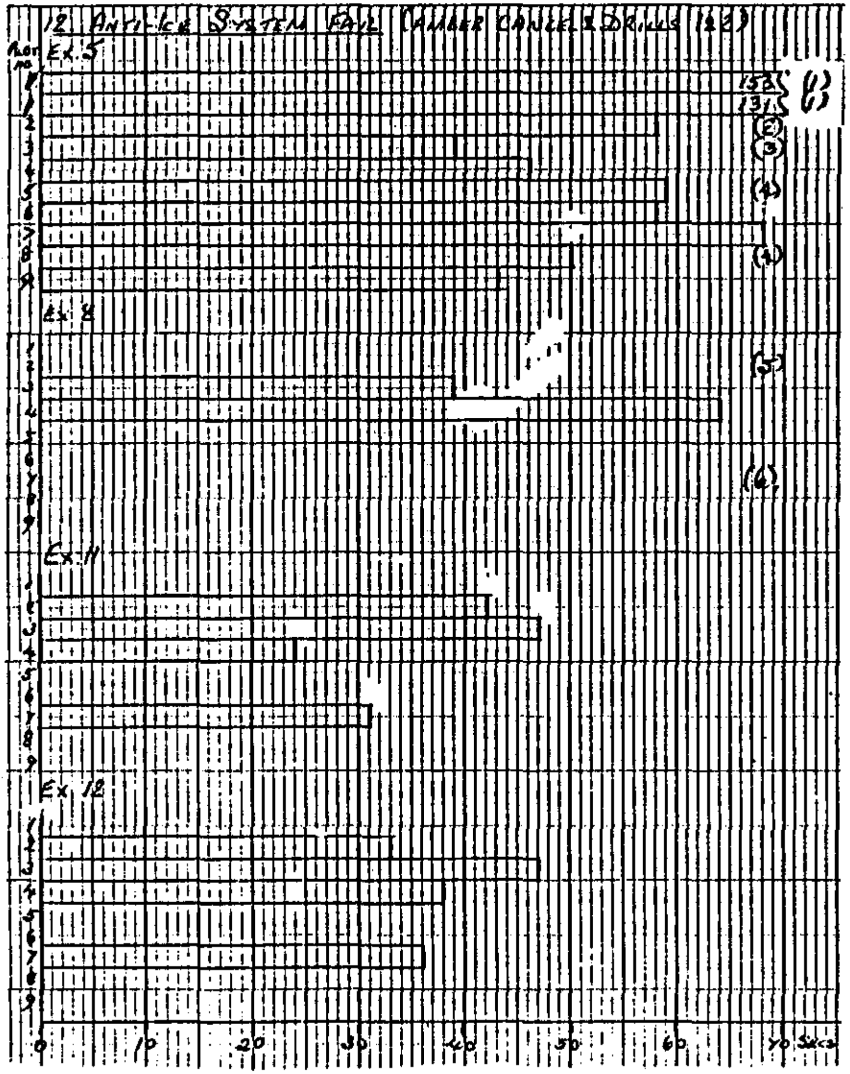
3. Perhaps (Overheat' or 'Overpressure' should be stated on the format instead of FAIL (1 pilot)

4. Drills could be simpler (1 pilot)

Three pilots did not make any comment

(3.6) Five pilots did not make any comment.

ANTI-ICE SYSTEM FAIL



NOTES

(1) Reason is not apparent for these very long times

(2) Closed System 2 valves first instead of System 1 valves.

(3) Drills done from memory

(4) Difficulty in finding reducing valves.

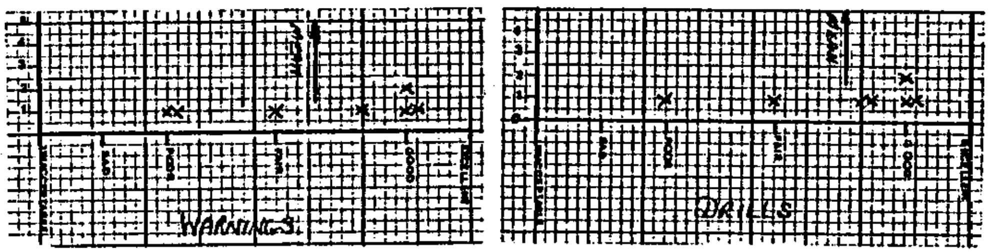
(5) Exercise not done

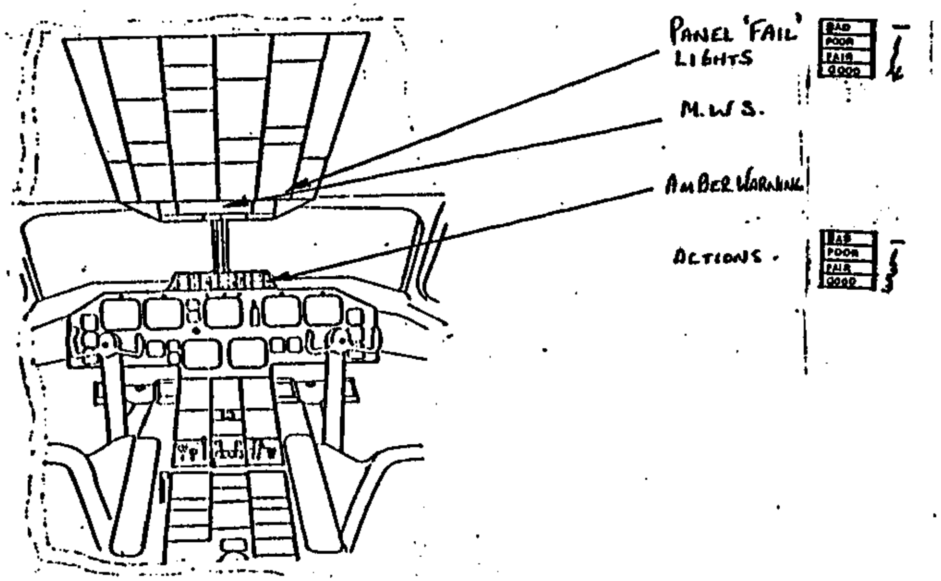
(6) Flow valves operated instead of reducing valves.

Pilot Nos.1,6,8,9, did not do Exs.8,11,12

Monitoring system was faulty for Pilot No.5 in Exs.8,11,12

1.15 HOW WOULD YOU RATE THE EFFICIENCY OF THE WINDSCREEN HEATER FAIL WARNINGS AND THE CONSEQUENT DRILLS?





Pilots' Comments

1. Windscreen heat warning should be separate from other anti-ice failure warnings (3 pilots).

2. Very simple drill (1 pilot)

3. MWS instinctively requires anti-ice display to be called up so windscreen heater-fail indication should be on anti-ice display (1 pilot)

4. Mis-identified the failure (3 pilots)

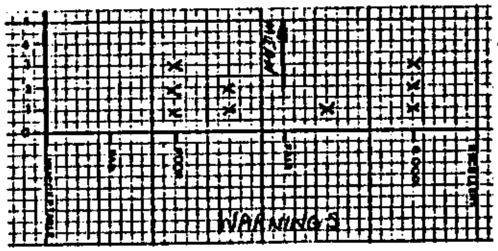
One pilot did not make any comment.

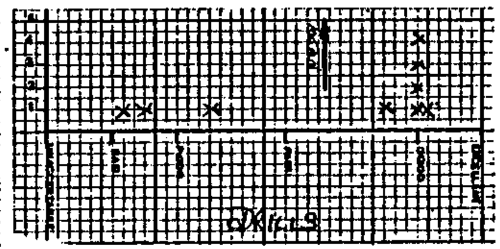
Observer's Notes

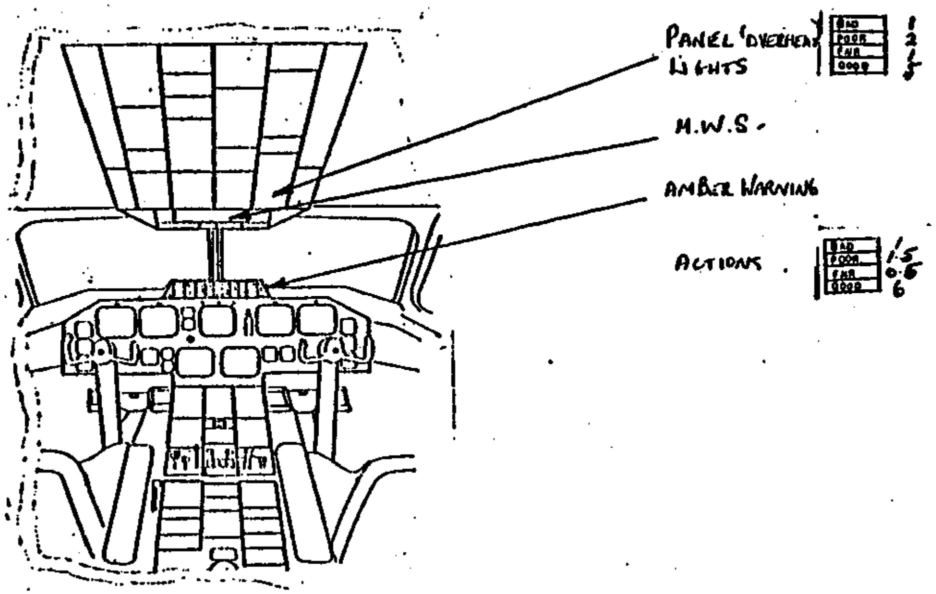
1. Reducing valve operated in error by one pilot.

2. One pilot forgot the speed restriction.

2.8 HOW WOULD YOU RATE THE EFFICIENCY OF THE WINDSCREEN HEATER OVERHEAT WARNINGS AND THE CONSEQUENT DRILLS?







Pilots' Comments

1. A Fail indication would normally require the windscreen heater to be switched off (1 pilot).

2. The warning on the MWS instinctively requires the anti-ice display, but the warning is in the roof panel. The warning is not easily detected so should not be on Anti-Ice Warning light (3 pilots).

4. Simple drill with clear indication of warning (1 pilot).

5. Should be a reminder light after action has been taken, so that speed restriction may be observed (1 pilot).

6. Tendency to go to CRT display before doing drill (1 pilot)

7. ANTI-ICE & ICE DET confusing (1 pilot)

Three pilots did not make any comment

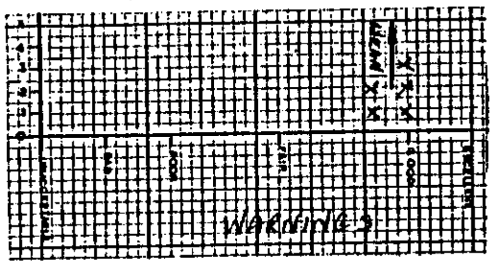
Observers' Exercise Notes

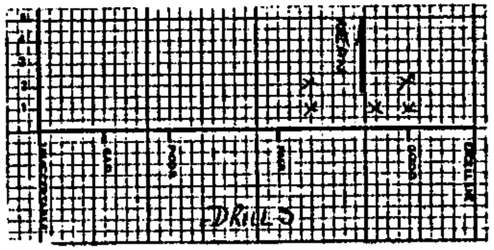
1. One pilot attempted to cancel the warning before he had selected the heat to low.

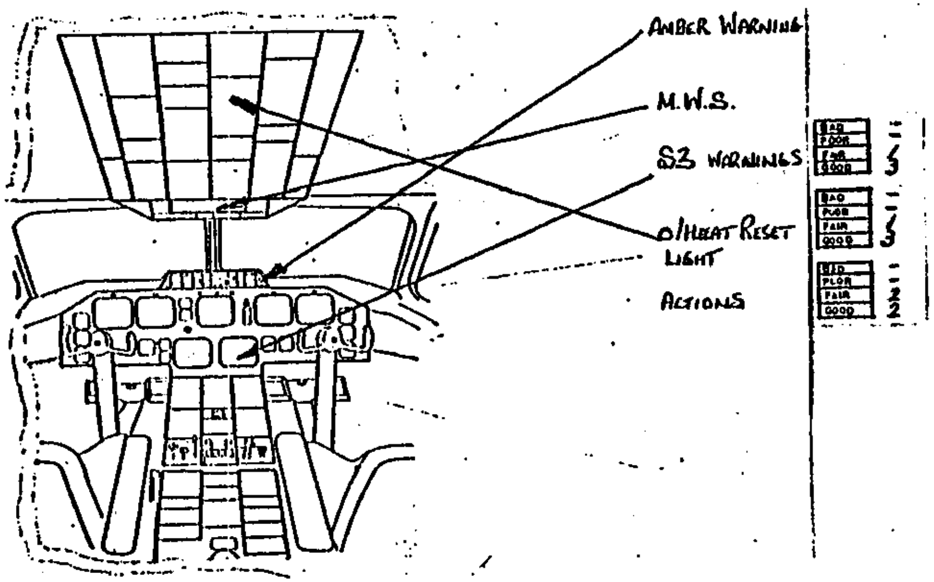
2. One pilot was confused as to what to do.

3. Three pilots forgot the subsequent speed restriction.

4.6 HOW WOULD YOU RATE THE EFFICIENCY OF THE AIR SYSTEM DUCT OVERHEAT WARNING AND THE CONSEQUENT DRILLS?







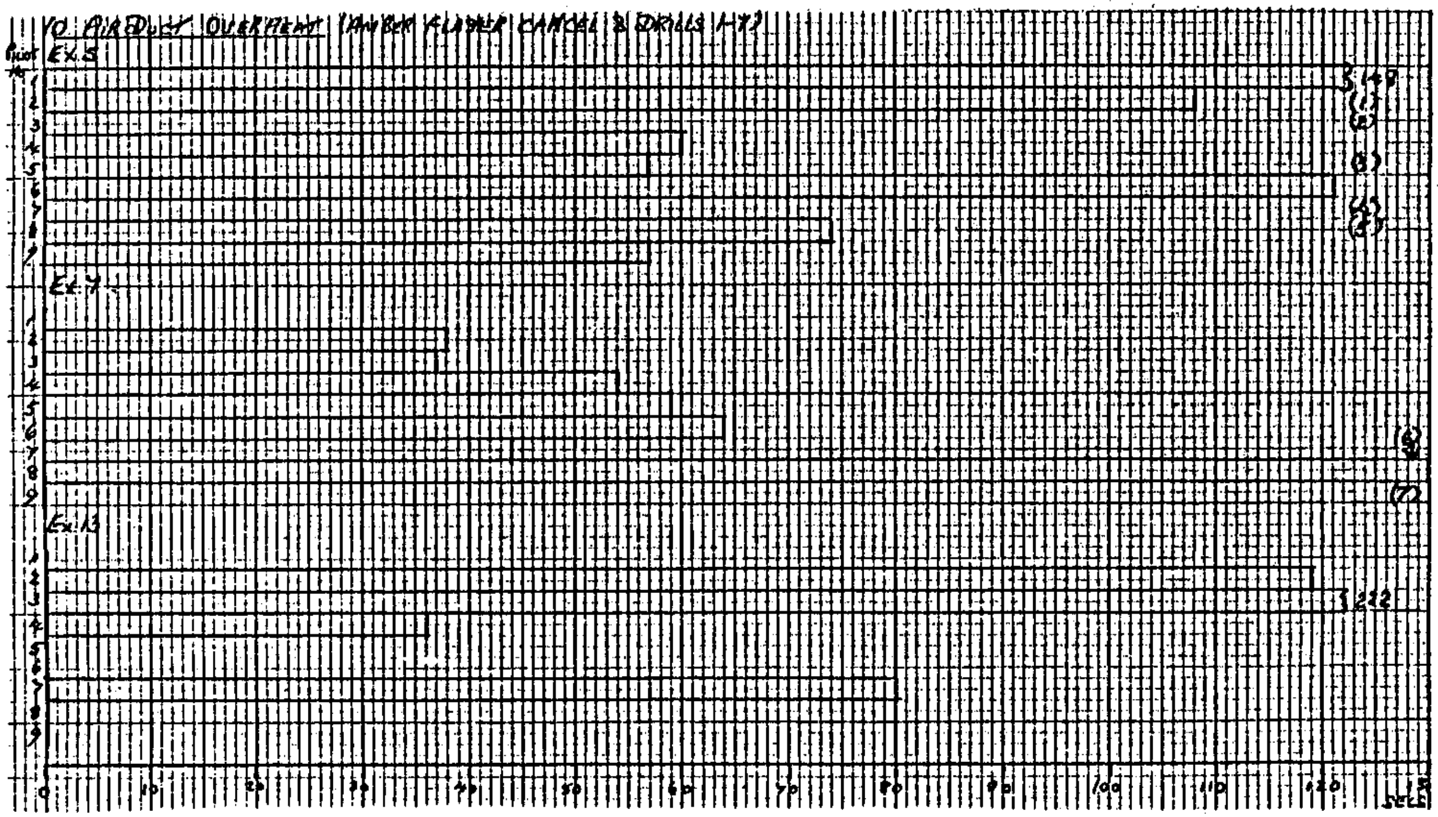
Pilots' Comments

1. The O/H reset light was not seen or appreciated for some time (1 pilot)

2. The drill seems rather complicated but this is probably due to the design of the system, this being an old one (2 pilots)

Two pilots did not make any comment

AIR DUCT OVERHEAT

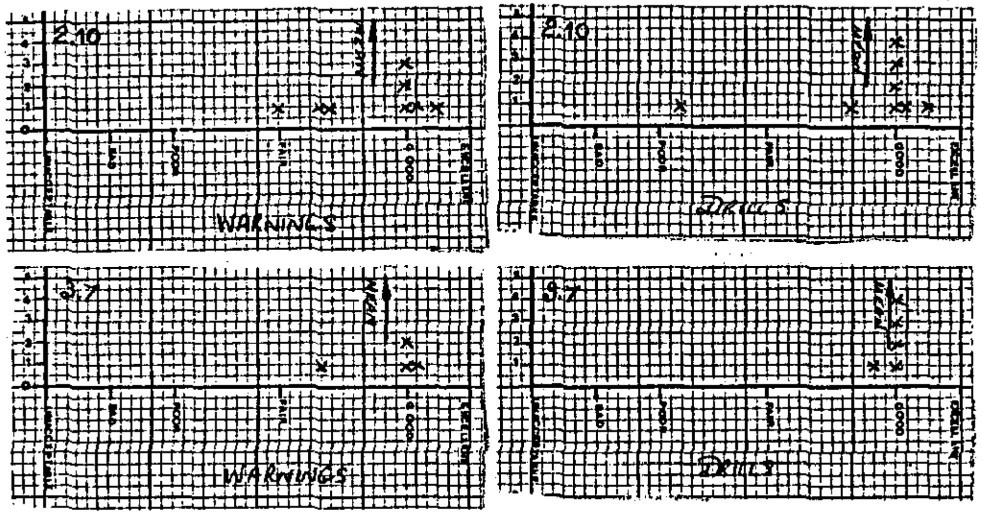


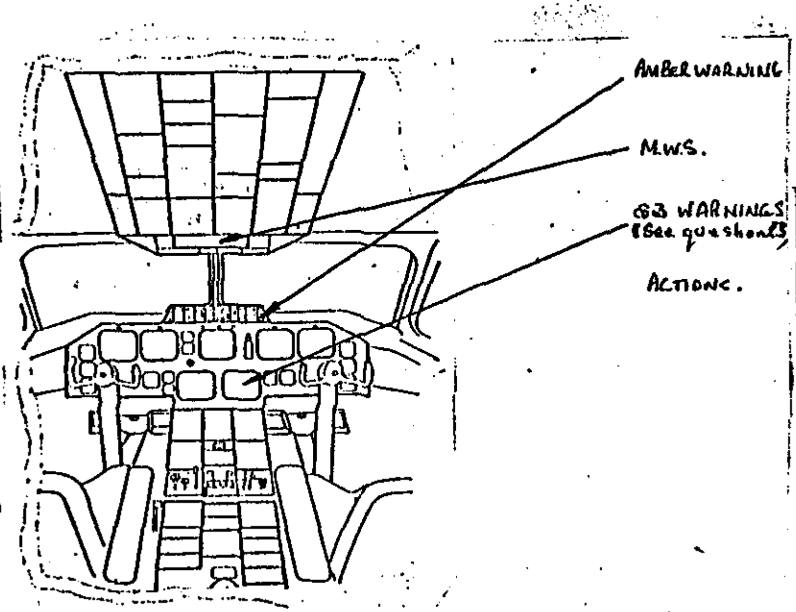
NOTES

(1) Closed wrong valves first
(2) Check list not used and did drill incorrectly
(3) Several warnings appeared simultaneously
(4) Exercise not given
(5) Incorrect drill

Pilot Nos. 1,6,8,9 did not do Ex.13
Monitoring system faulty for Pilot No.5 in Ex.13

2.10 & 3.7 HOW WOULD YOU RATE THE EFFICIENCY OF THE RADIO FAN FAIL WARNING AND THE CONSEQUENT DRILL?





		2.10	3.7
G3 WARNINGS	BAD	–	–
	POOR	–	–
	FAIR	1.5	–
	GOOD	6.5	4
ACTIONS	BAD	–	–
	POOR	1	–
	FAIR		–
	GOOD	6	4

Pilots' Comments

(2.10)

1. Had Difficulty in remembering position of switch (1 pilot)

2. Clear and simple warning and drill (1 pilot)

3. Should not be included in the air conditioning format (1 pilot)

4. Actions should be automatic (1 pilot)

Four pilots did not make any comment.

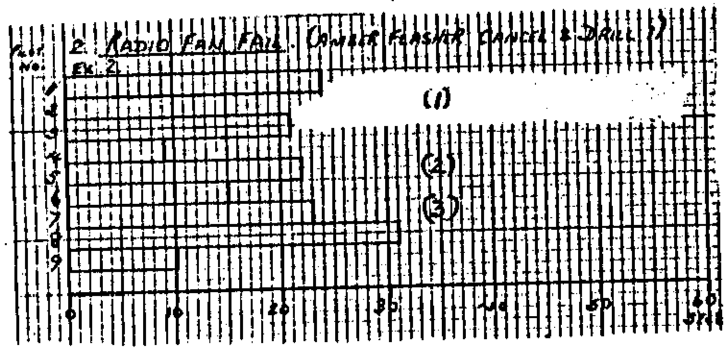
(3.7)

1. Very clear indication and simple drill (1 pilot)

2. Probably no need to have fail warning on display (1 pilot)

Three pilots did not make any comment

RADIO FAN FAIL



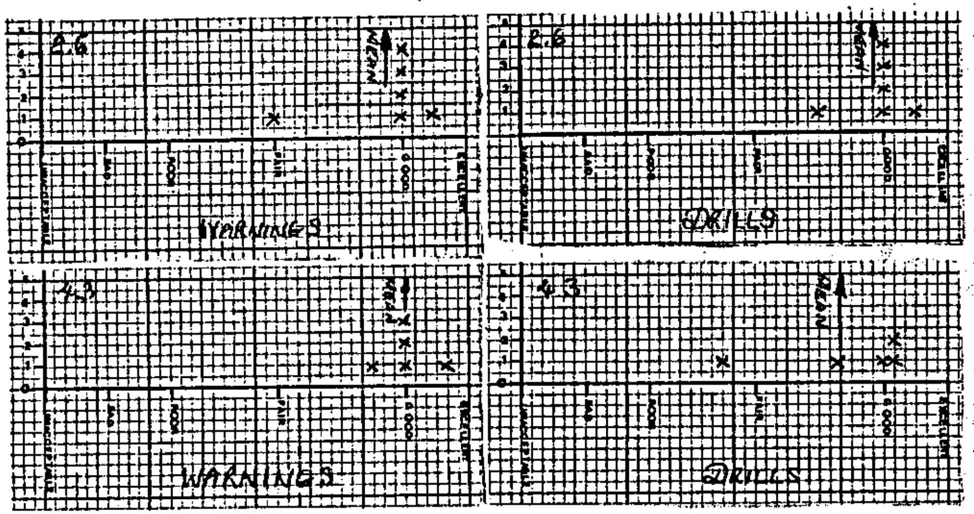
NOTES

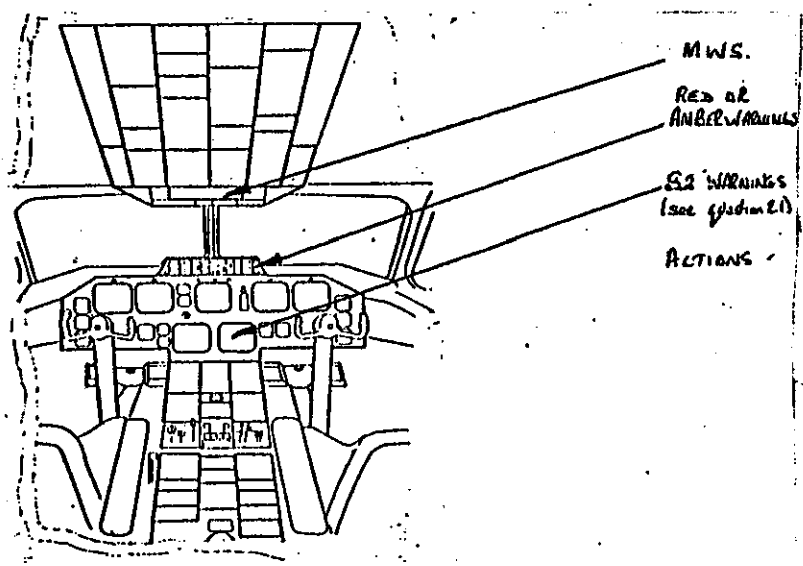
(1) Air Duct o/heat drill in error

(2) Drills done from memory

(3) Difficulty experienced in finding switch

2.6 & 4.3 HOW WOULD YOU RATE THE EFFICIENCY OF THE CSD FAIL WARNINGS AND THE CONSEQUENT DRILLS?





		2.6	4.3
S2 WARNINGS	BAD	–	–
	POOR	–	–
	FAIR	1	–
	GOOD	6	5
ACTIONS	BAD	–	–
	POOR	–	1
	FAIR	0·5	3
	GOOD	6·5	1

Pilots' Comments

(2.6)

1. CSD fail was very obvious and the drill seemed simple enough (1 pilot)

2. Insufficient distinction between CSD & GEN (1 pilot)

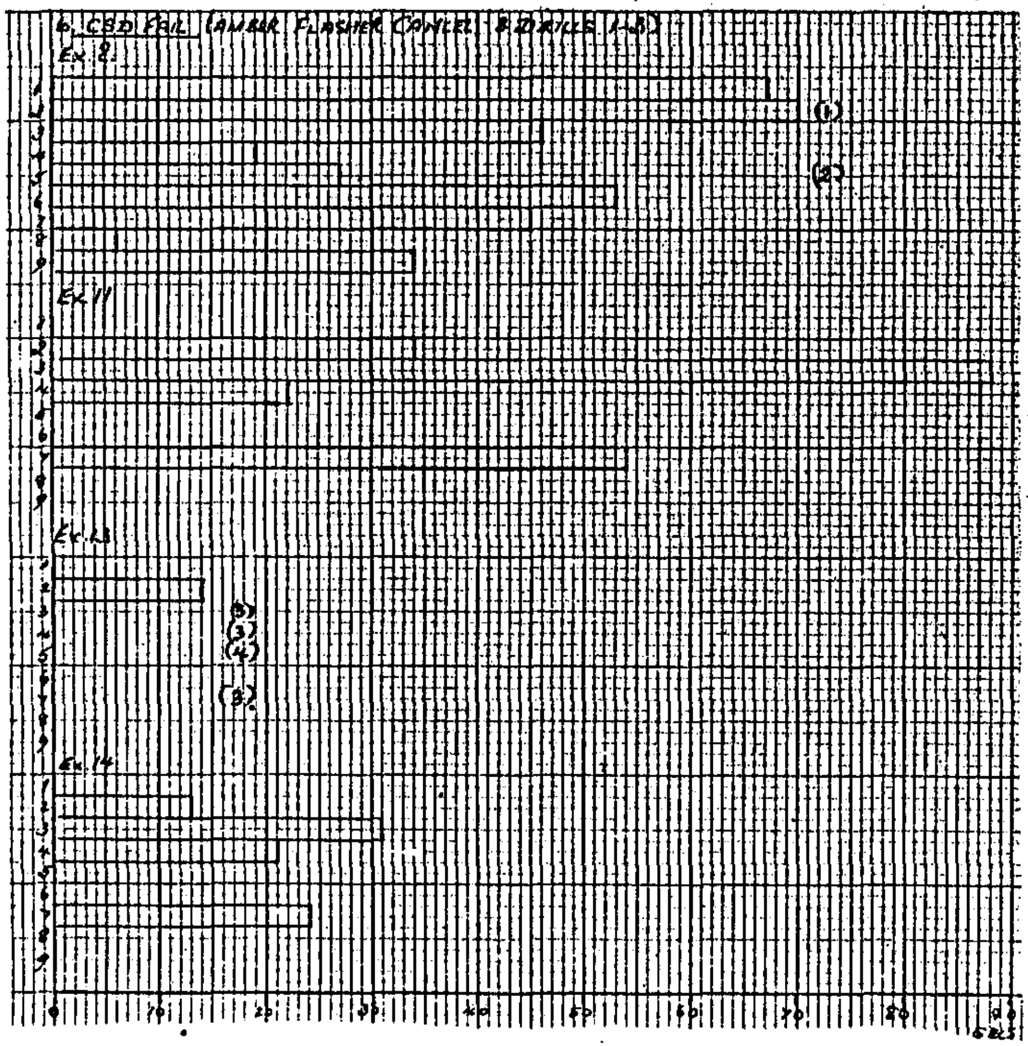
Seven pilots did not make any comment

(4.3)

1. Actions could be clarified by stating electrical load limits (1 pilot)

Four pilots did not make any comment

CSD FAIL



NOTES

(1) Identified failure as a generator fault

(2) Switched off wrong generator, identified wrong engine.

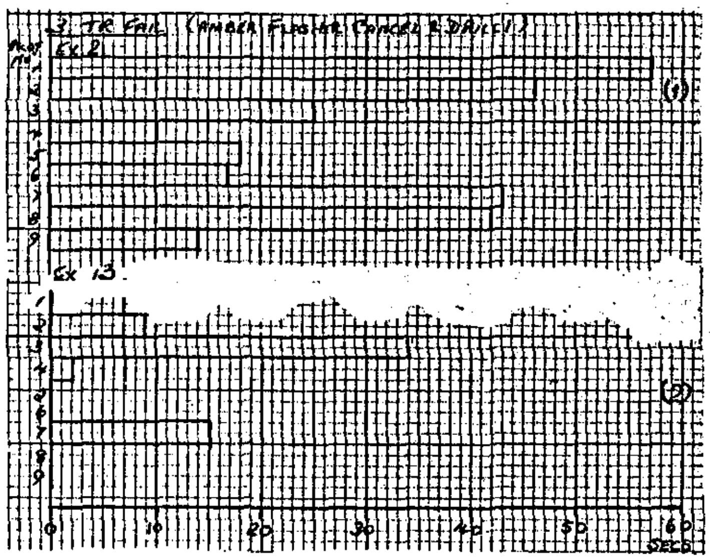
(3) Exercise not carried out

(4) CSD failure was not noticed as amber flasher had not been cancelled from previous failure.

Pilot Nos. 1,6,8,9 did not do Exs. 11,13,14

Monitoring system faulty for Pilot No.5 in Ex.11,13

TR FAIL



NOTES

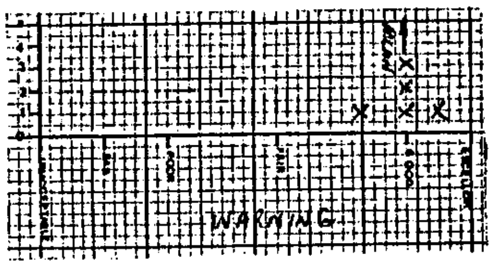
(1) First identified as No.1 GEN.FAIL.

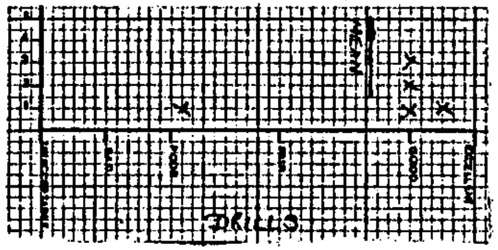
(2) First identified as GEN.FAIL

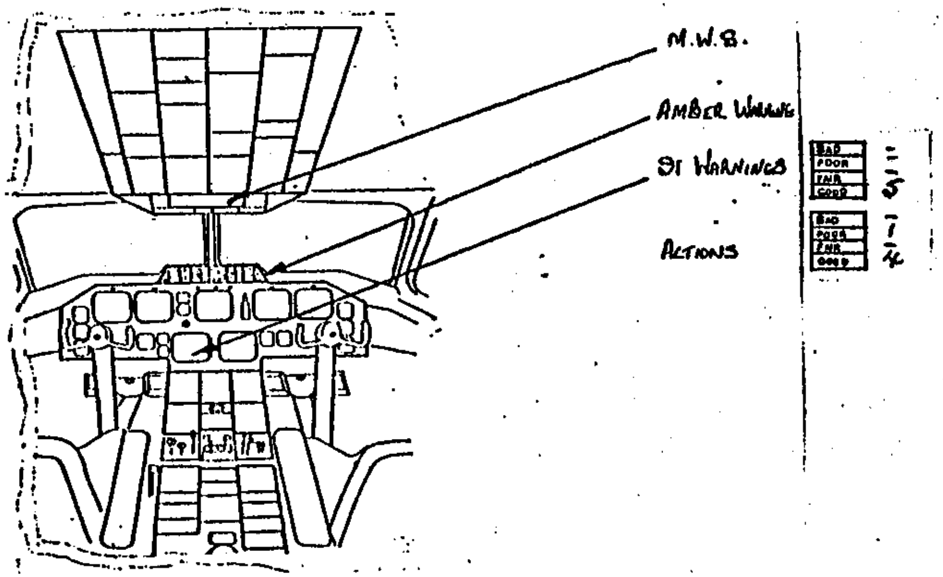
Pilot No.1,6,8,9 did not carry out Ex.13

Monitoring system faulty for Pilot No.5 in Ex.13

3.3 **HOW WOULD YOU RATE THE EFFICIENCY OF THE HYDRAULIC'S OVERHEAT WARNING AND THE CONSEQUENT DRILLS?**







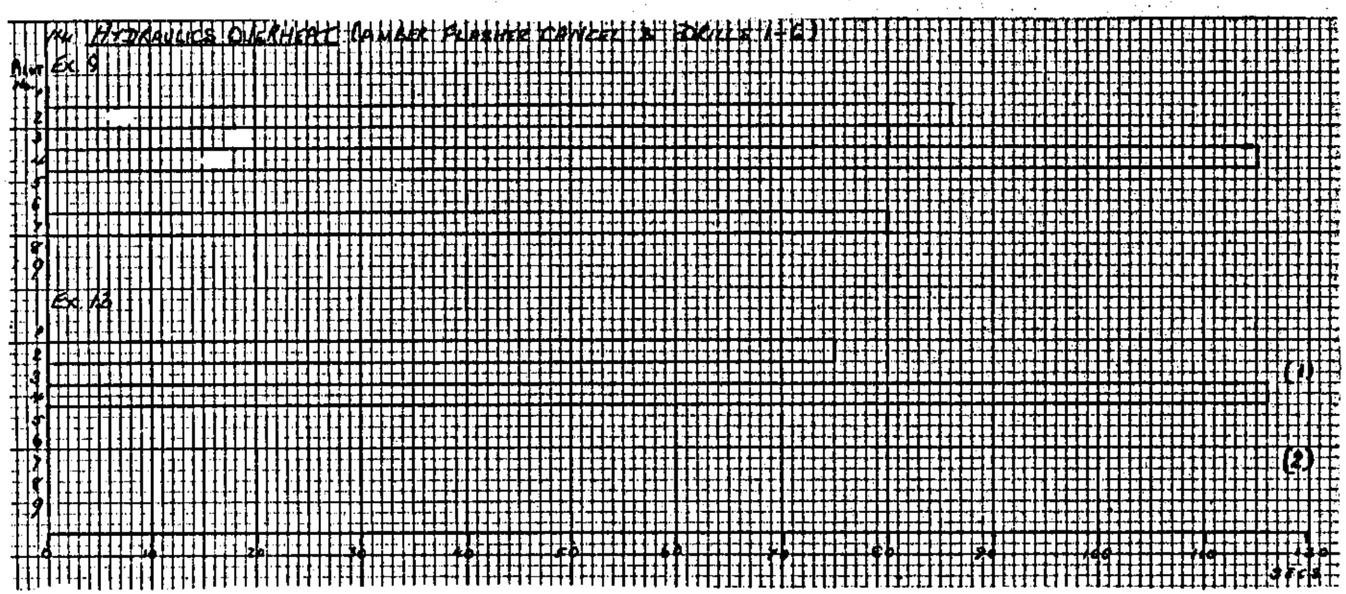
Pilots' Comments

1. Check list was too abbreviated and not easy to follow (1 pilot)

2. Drills were simple and logical to follow (1 pilot)

Three pilots did not make any comment

HYDRAULICS OVERHEAT

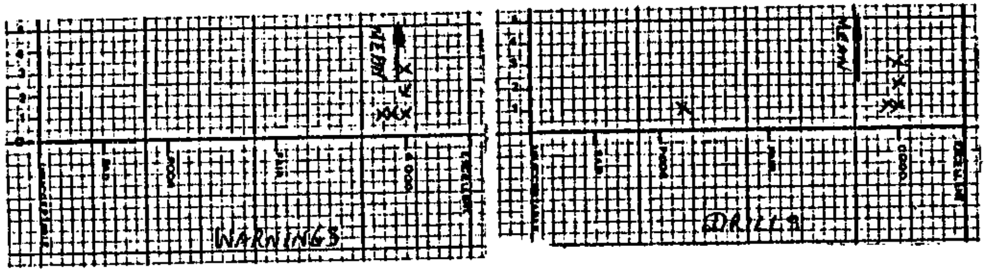


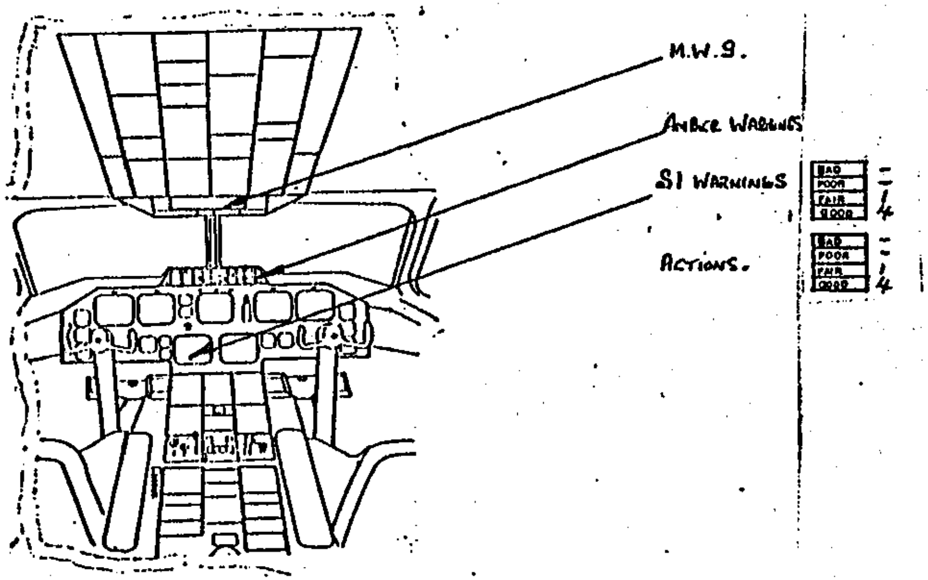
NOTES

(1) Drill not carried out correctly, mistook failure for a fluid leak.
(2) Drill not completed

Pilot No.1,6,8,9 did not carry out Ex.9 & 13
Monitoring system faulty for Pilot No.5

3.4 HOW WOULD YOU RATE THE HYDRAUICS LOW PRESSURE WARNING AND THE CONSEQUENT DRILLS?





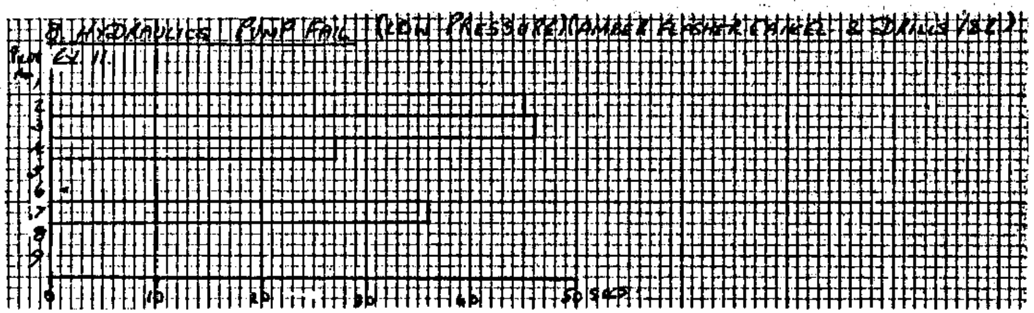
Pilots' Comments

1. Drills not easy to follow as check list too abbreviated (1 pilot)

2. Very simple warning but two LP warnings seem to be too many (1 pilot)

Three pilots did not make any comment.

HYDRAULICS LOW PRESSURE

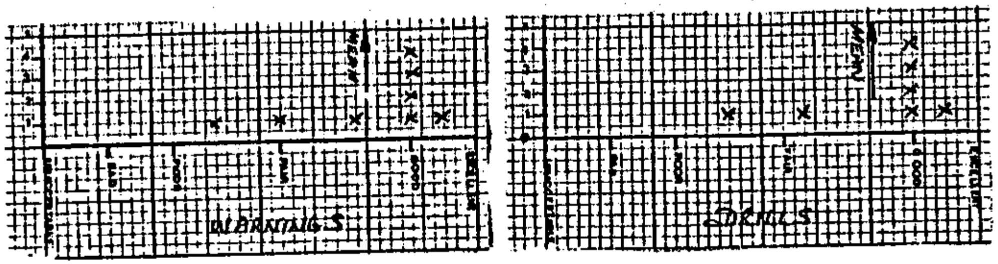


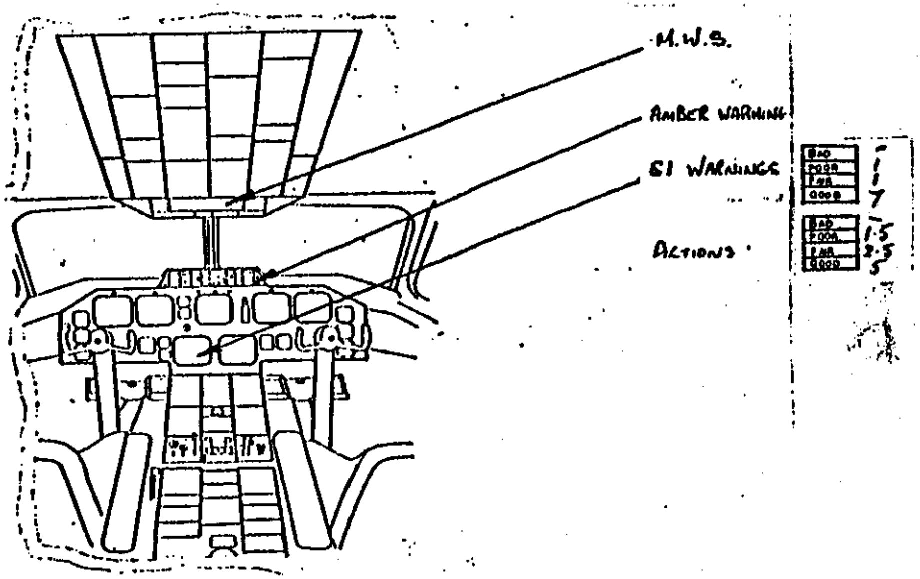
NOTES -

Pilot No.1,6,8,9 did not carry out Ex.11

Monitoring system for Pilot No.5 was faulty.

2.7 HOW WOULD YOU RATE THE EFFICIENCY OF THE FUEL LOW PRESSURE WARNING AND THE CONSEQUENT DRILLS?





Pilots' Comments

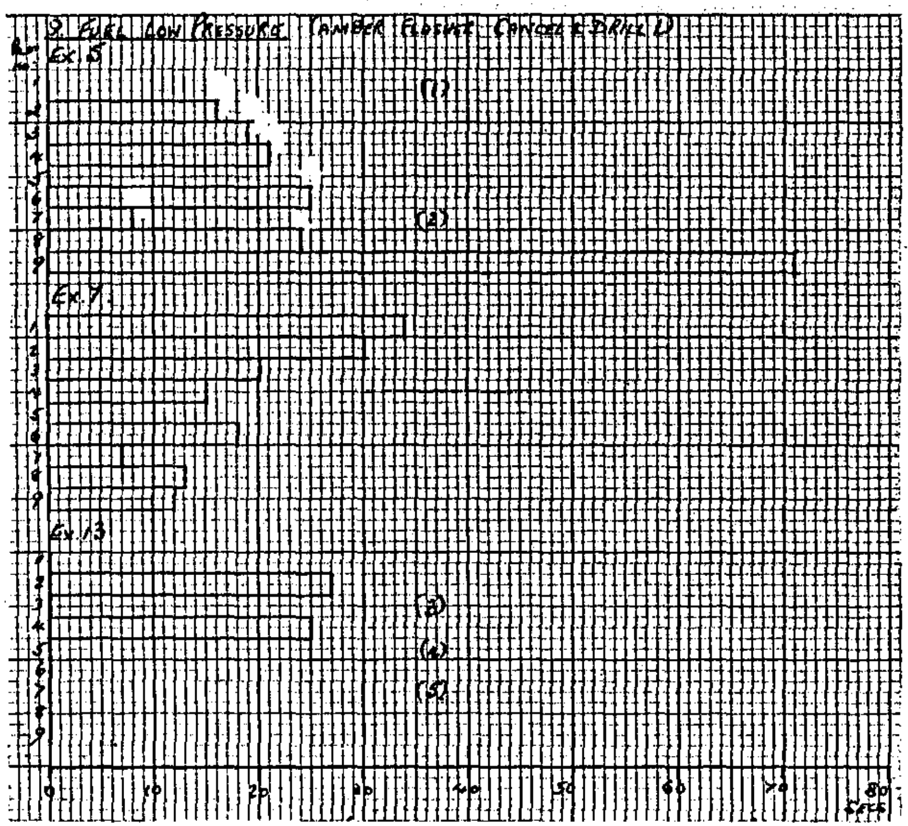
1. Normally one does not switch off both pumps on a running engine at altitude without opening a cross-feed (1 pilot).

2. There seem to be too many warnings with a double pump failure. Would prefer an inverted OFF for a pump failure (1 pilot).

3. Low pressure warnings due to pumps should be on pump switches. This is a general point which means that displays duplicate warnings (1 pilot).

Five pilots did not make any comment.

FUEL LOW PRESSURE



NOTES

(1) Confused with drill

(2) Drill carried out from memory

(3) Drill not completed pilot identified fault as a hydraulics failure, possibly low pressure

(4) Unaware of engine rundown as S2 was inhibited with display failures

(5) Drill not completed. The rundown was only noticed by the Fuel LP warning.

Pilot Nos. 1,6,8,9 did not carry Ex.13
Monitoring system faulty for pilot No.5 in Ex.13

ENGINE RELIGHT

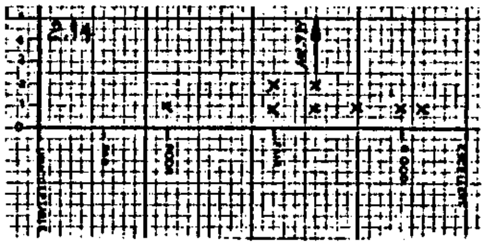
Observer's Notes

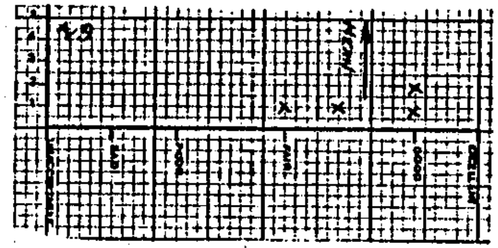
1. Forgot to switch on HP fuel when attempting relight. (1 pilot)

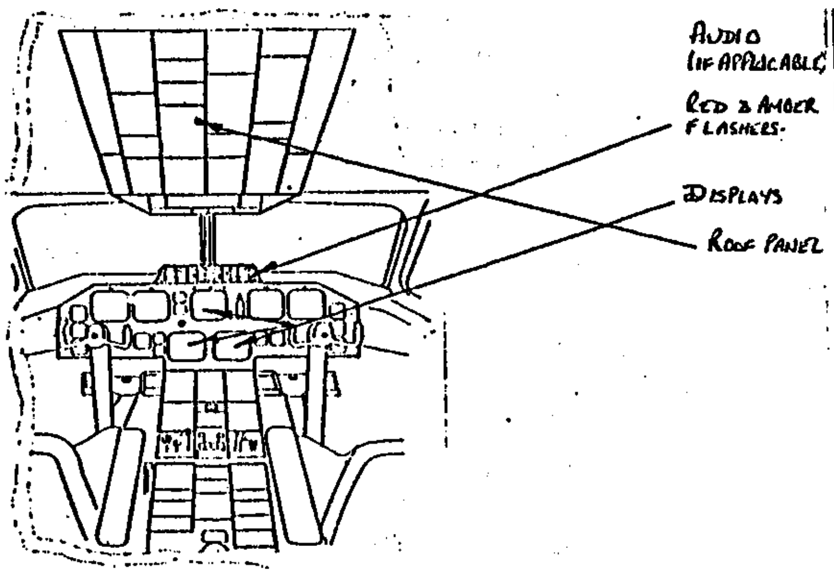
2. Windmilling speed of the engine made the pilot think that the engine had relit (1 pilot)

3. Started to relight wrong engine (1 pilot)

2.14 & 4.9 **HOW WOULD YOU RATE THE PHILOSOPHY AND EFFECTIVENESS OF THE MASTER WARNING SYSTEM?**







		2.14	4.9
AUDIO (IF APPLICABLE)	BAD	–	–
	POOR	2	–
	FAIR	3	1.5
	GOOD	3	3.5
RED & AMBER FLASHERS.	BAD	–	–
	POOR	1.5	–
	FAIR	3.5	0.5
	GOOD	3	4.5
DISPLAYS	BAD	–	–
	POOR	[illegible]	–
	FAIR	4	–
	GOOD	3	5
ROOF PANEL	BAD	1	–
	POOR	[illegible]	–
	FAIR	–	2
	GOOD	3	3

2.14 & 4.9 <u>Pilots' Comments</u>

(2.14)

1. MWS is good (2 pilots)

2. Emergency display philosophy and actions should be standard (1 pilot)

3. The disappearance of the ice warning is not easy to detect (see SDW-63/A/48/295 (1 pilot)

4. The MWS panel would be better between S1 and S3 displays (2 pilots)

5. Roof panel indications clear (1 pilot)

6. With two displays failed did not like the hierarchy of a failure to inhibit the display until the failure was dealt with (1 pilot)

7. The advantage of a dedicated ENG on glareshield is not apparent (1 pilot)

8. The amber attention getters should direct the pilot to look up or down to deal with the failure (1 pilot)

9. Ambers missed for long periods (1 pilot)

10. Cut down on white lights and suggest occulting warnings (1 pilot).

(2.14 continued)

11. System liked, but disagree with philosophy of clearing faults after correct action taken. This denies an unambiguous indication of systems status after selecting Recall (1 pilot)

Two pilots did not make any comment.

(4.9)

1. It is not obvious from the "All Engines" format as to which engine has failed (1 pilot).

2. Concept of MWS is good provided all respective formats are displayed automatically with a warning (e.g. include Ice Detection (1 pilot).

3. Red warnings locking the display will not be a problem when the pilot is conversant with them, as all red warnings involve engine shut-down (1 pilot).

4. MWS panel should be on centre panel (1 pilot)

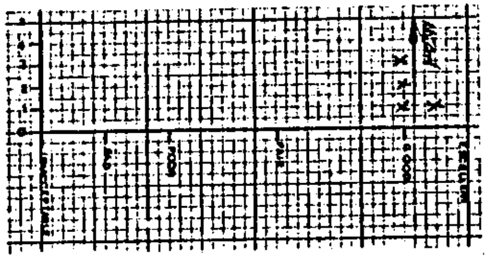
5. Ice detection and Anti-Ice Failure lights are too close together (1 pilot).

6. The philosophy of the PCU split lights would improve some roof panel control lights (1 pilot)

7. "Ice-Detect" should be labelled ICE (1 pilot)

8. On a few occasions looked at displays before MWS panel, thus showing that MWS is incorrectly placed (1 pilot)

4.10 HOW WOULD YOU RATE THE GENERAL PHILOSOPHY OF THE HIERARCHY OF WARNINGS AS PRESENTED FOR THE SYSTEM FAILURES?



Pilots' Comments

1. Philosophy works well for single failures, but for multiple failures more experience is necessary (2 pilots)

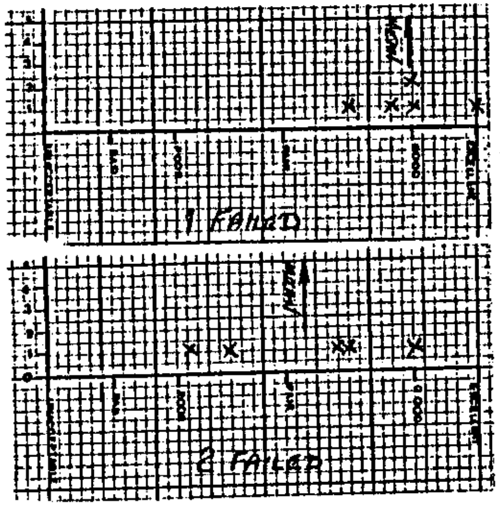
2. Hierarchy needs to be related to the emergency check list to remind the pilot of a cancelled amber warning or alternatively a "Cancel Hierarchy" button is required. (2 pilots)

3. Failures need to be investigated more closely with one or more of the CRT's failed (3 pilots)

4. Documentation CRT could be used as an emergency systems tube (1 pilot)

5. Do not want to be deprived of the "All Engines" format at any time unless there is a very good reason (1 pilot)

4.12 **HOW WOULD YOU RATE THE ACCEPTABILITY OF HANDLING SYSTEMS FAILURES AND MALFUNCTIONS WITH ONE, AND TWO SYSTEM DISPLAYS FAILED?**



Pilots' Comments

1. Difficult to generalise. Each case should be examined in detail (1 pilot)

2. The warning hierarchy helps to deal with a failure when two CRT's are failed (1 pilot)

3. When a CRT is failed it may be beneficial to include more information on the STATUS format (1 pilot)

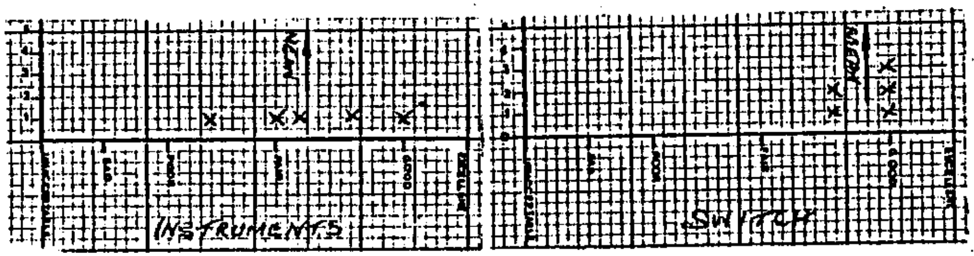
4. If three systems displays fail then it should be possible to use the documentation display for systems (1 pilot)

5. Flame-out indications needed (2 pilots)

6. Logic of engine shut-down with two displays failed is puzzling (1 pilot).

4.13 HOW WOULD YOU RATE THE USE OF THE STANDBY ENGINE INSTRUMENTS IN THE EVENT OF SYSTEMS DISPLAYS FAILURE?

HOW WOULD YOU RATE THE DESIGN AND USE OF THE ROTARY SWITCH FOR THE CONTROL OF THE STANDBY ENGINE INSTRUMENTS?



Pilots' Comments

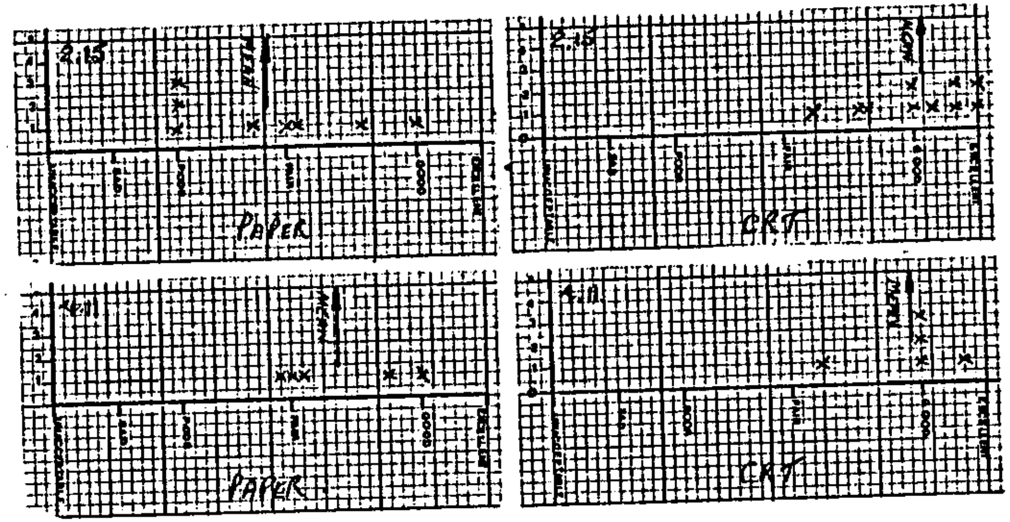
1. The particular instruments shown are not the best available and are difficult to read from the P2 position which is important in a high workload situation (3 pilots)

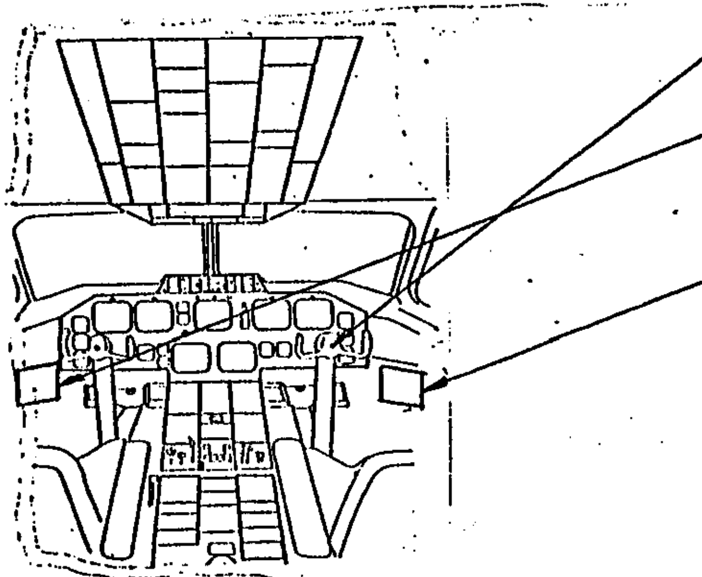
2. Perhaps the standby instruments should be tape scales as the CRT's (1 pilot)

3. Too much parallax (1 pilot)

One pilot did not make any comment.

2.15 HOW WOULD YOU RATE THE TWO METHODS OF PRESENTING PRE-FLIGHT CHECKS? IN ADDITION RATE IN ORDER OF PREFERENCE?





		2.15	4.11
ADVANCE BUTTON	BAD	-	-
	POOR	-	-
	FAIR	2	1
	GOOD	7	4
POSITION OF CRT DISPLAY	BAD	-	-
	POOR	-	-
	FAIR	2	2
	GOOD	7	3
FORMAT OF CRT CHECKS	BAD	-	-
	POOR	-	-
	FAIR	1.5	2
	GOOD	7.5	3

PREFERENCE

-	1	PAPER
7	4	CRT

Q 5)(4.11)

2.15 & 4.11 Pilots' Comments

(2.15)

1. Prefer CRT documentation on EHSI (1 pilot)

2. Would like to "slip-back" before "checks complete" (2 pilots)

3. CRT check list is a great improvement for two crew operation, but still needs development with respect to reliability (1 pilot)

4. Not sure advance button is correctly placed (1 pilot)

5. More Flexibility needed (1 pilot)

6. Content of Paper checks is poor (1 pilot)

7. Incrementing each check on CRT is laborious (1 pilot) (Note by Observer. This pilot operated the roof panel with his right hand and did not keep bringing his hand down to press the check list button)

8. Checks not detailed enough (1 pilot)

9. Wording does not agree with controls legends (1 pilot)

10. Check list button was very bright (1 pilot)

Five pilots did not make any comment.

(4.11)

1. CRT is good, but paper checks are more easily accessible, also easier to go back with paper checks (1 pilot)

2. There is more flexibility with the CRT (1 pilot)

3. Position ideal in EHSI position (1 pilot)

4. Format on Ferranti can be more detailed and code numbers are easily associated with emergency check list (1 pilot)

5. Controls for CRT need improving and documentation appears biased towards CRT (1 pilot)

6. CRT should give greater flexibility of "skipping" checks for emergency approach (1 pilot)

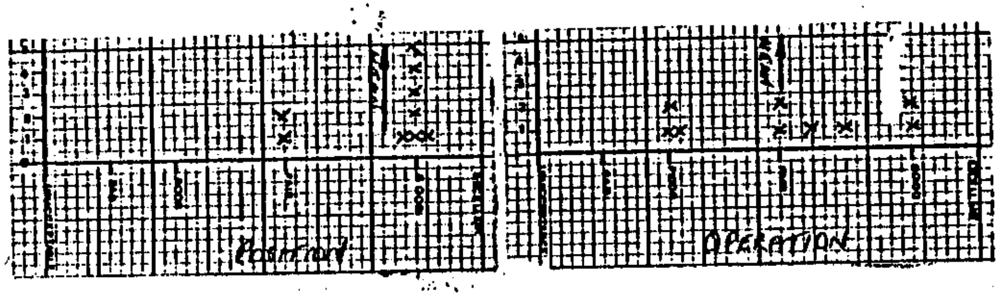
7. Easier for use CRT in F3 position, but Ferranti system is better (1 pilot).

All pilots commented.

Observer's Note

Misuse of box on checks resulted in errors (4 pilots)

2.13 HOW WOULD YOU RATE THE POSITION AND OPERATION OF THE THROTTLES?



Pilots' Comments

1. Friction too high making them difficult to operate over a small band (1 pilot)

2. Large 'dead bands' make precise N2 settings and control difficult. This may be a display problem in that N2 decimals cannot easily be anticipated (1 pilot)

3. No reverse idle detent (1 pilot)

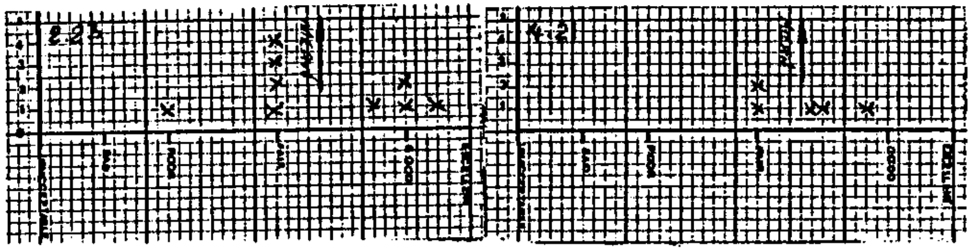
4. Too far back (1 pilot)

5. Perhaps too far forward (1 pilot)

6. Gearing rather high (1 pilot)

Four pilots did not make any comment

2.23 HOW WOULD YOU RATE THE PRESENTATION OF THE ATC?
&
4.21



PILOTS' COMMENTS

(2.23)

1. Becomes boring after a few flights due to repetition. Access to ATIS by P2 was an improvement (1 pilot)

2. Tapes unrealistic. Unnecessary workload (1 pilot)

3. Would not mind if ATC was absent as more interested in system (1 pilot)

4. Reasonably representative of workload on Day 1 but could predict messages on Day 2. Change of heights would increase workload (1 pilot)

5. Not enough background ATC, but good for the price (2 pilots)

6. Very acceptable, but more tapes needed to avoid repetition. More calls initiated by ATC needed. Workload comes in listening for call sign and message (1 pilot)

7. Very good (1 pilot)

One pilot did not make any comment

Pilots' Comments

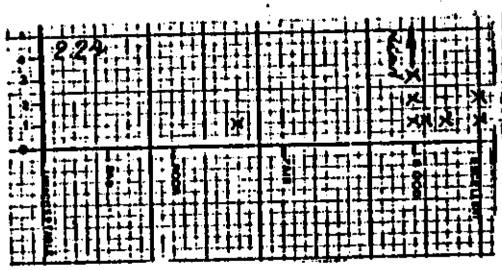
(4.21)

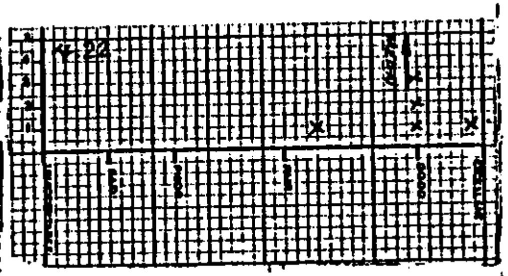
1 The later tapes are an improvement and adequate (3 pilots)

2 The pilot should have a volume adjust (1 pilot)

One pilot did not make any comment

2.24 & 4.22 HOW WOULD YOU RATE THE CONDUCT OF THE EXERCISE?





Pilots' Comments

(2.24)

1. Wanted more familiarisation time (2 pilots)

2. Logical - well organised - clear briefs. Hard worked Logical build up. Briefing good (1 pilot)

3. Very good (2 pilots)

4. Workload at right level (1 pilot)

5. Very realistic, but is not so conscious of the failures as in real life in simulation one gets blase (1 pilot)

6. Well organised, but more time needed. Questionnaires too long (1 pilot)

7. Building up to a realistic workload (1 pilot)

Two pilots did not make any comment.

Pilots' Comments

(4.22)

1. Very well carried out (1 pilot)

2. Exercises well planned for a formal route structure (1 pilot)

3. Display assessment should begin with an assessment of each format with failure indications separately, then in combinations, and then as part of a flight (1 pilot)

4. Questionnaires too long (1 pilot)

5. Workload about right (1 pilot)

Three pilots did not make any comment.

DAY 1 - GENERAL

Pilots' Comments

1. Clipboard operated tabular check list inadvertently (1 pilot)
2. Displays are much improved, (from familiarisation) but too much digital information is presented (1 pilot)
3. General overall workload not reduced but comparable to 1-11 (1 pilot)
4. Monitoring of Systems has a vast advantage (1 pilot)
5. Some parameters are more difficult to read on a CRT than if they were needles on a dial (1 pilot)

Observers' Notes on Exercises

1. Forgot to select an engine format when starting engines (1 pilot)
2. Left booster pumps on a failed engine running with the crossfeed closed before landing (1 pilot)
3. Closed an LP fuel valve in error during flight (1 pilot)
4. Left airframe anti-icing on in approach checks (1 pilot)

DAY 2 - GENERAL

Pilots' Comments

1. Would like to recall all MWS failures before landing to remind pilot of implications of any previous emergencies (1 pilot) (A record of en route failures required before landing).
2. No eye fatigue (6 pilots)
3. Mental fatigue - very low (2 pilots)
4. There is a danger of pilots operating a wrong switch because "failure indication" is remote from the switch (1 pilot)
5. Workload within capabilities - allowing for lack of familiarity (1 pilot)
6. In programme some faults should be injected to give an aborted take-off (1 pilot)
7. Would like more monitoring of trends (1 pilot)
8. Guardedly enthusiastic, but would like more switch lights in roof to lower need for displays (1 pilot)
9. Very enthusiastic for system on a 4 engine aircraft, but remain to be convinced for 2 - engines. CRT Check List very good and also CRT's good for FADI and EHSI (1 pilot)
10. Not sure if design is feasible without colour displays (1 pilot)

DAY 3 - GENERAL

Pilots' Comments

1. Handling, apart from speed and landing, is acceptable (1 pilot)

2. Much further along the learning curve and operations are appearing much simpler (1 pilot)

3. Change in control forces with speed excessive

4. Lateral control forces too high (1 pilot)

5. Difficult aircraft to fly manually

6. Difficulty in trimming the aircraft in pitch and roll during the handling exercise (2 pilots)

DAY 4 - GENERAL

Pilots' Comments

1. Eye fatigue - None (5 pilots)
2. Mental fatigue - Northing unusual

Observer's Note

Cued as to when faults were being introduced either by hearing the fault code being selected or by the microphone isolate switch being operated (2 pilots)

APPENDIX 2

RESULTS OF ELECTRONIC FLIGHT INSTRUMENTS EVALUATION

(SEE CHAPTER 26)

INDEX TO RESULTS OF EFIs EVALUATION

Page

A2.1. Comparison of EADI/EHSI indications with Conventional Instruments (Questionnaire Section A)

A2.1.1. Pilots' Ratings

The pilots' ratings for Section A of the Questionnaire, excluding Question A.19 (considered under Para. A2.5. - General Comments), are shown as dot/bar diagrams.

A diagram is shown for each of the parameters and summarisesthe ratings for all pilots against the same base scale as in the Questionnaire, i.e. ratings on the vertical datum are comparable with conventional instruments with 'worse' ratings to the left and 'better' ratings to the right (as shown in the Key Diagram).

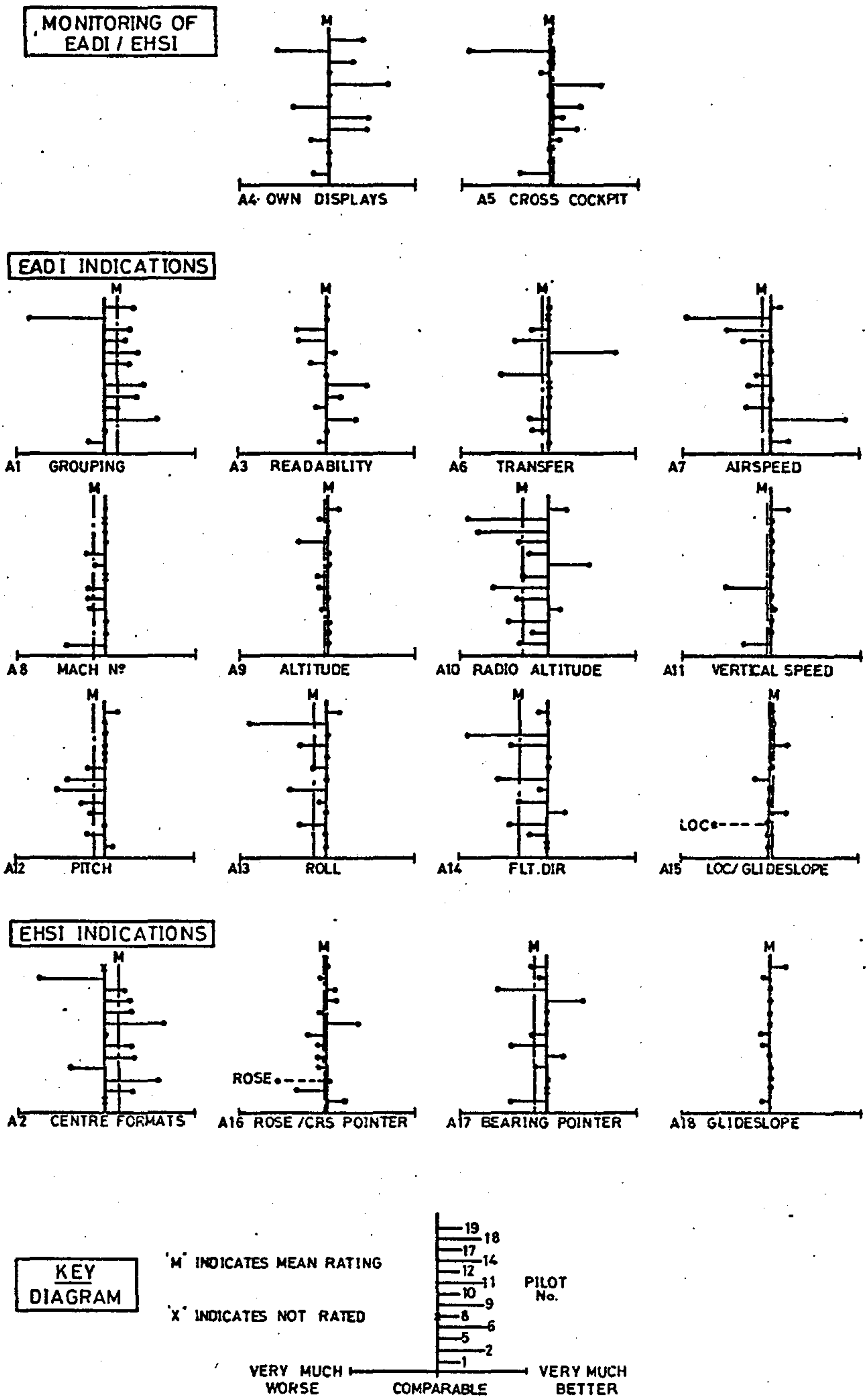
Pilot Numbers, which were used as references in the analysis, are also included in the Key Diagram. The ratings are grouped under the following headings:-

i) Monitoring of EADI/EHSI
ii) EADI Indications
iii) EHSI Indications

Section A was not completed by 7 pilots and these are therefore omitted from the summary chart.

SUMMARY OF PILOTS RATINGS

EXTRACTED FROM QUESTIONNAIRE SECTION A



A2.1.2. Pilots' Comments

The comments are from:- the pilots' notes in the Questionnaires (Q), the debriefing following the exercises (D1), the interview at a later date (D2).

Favourable comments are given first.

	Pilot Nos. Q	D1	D2
Monitoring of the EADI/EHSI			
Own Displays (Q.A4)			
Instrument scan is probably more relaxed as it is easier to look at the EADI/EHSI to get all information rather than scanning single displays.		3	3,15
In some respects responsibility of the instruments is more clearly defined, i.e. the EADI is the flying aircraft and the EHSI is the management of it			3
No problem with lateral scan once you get used to it		7,8,9	
Scanning reduced		19	11
Can see VSI moving in corner of eye			11
Reduced scan might have been physically easier but the mental workload was just as high, possibly higher, because there was more information being computed.		6	3
Analogue easy to scan but not the digits (e.g. Radio Altitude)		9	
Found it annoying to have EHSI on the right. Scan pattern on EADI easy except for centre.		20	
Side-by-side displays increases the amount of data scanned as the pilot is mainly attitude orientated			19
Hard work flying raw ILS. Could be scan being horizontal and it is not as easy to see things in line		17	
Cross-Cockpit (Q.A5)			
No problem at all. Much preferred to look across cockpit for Map rather than select my display			3
Could fly on co-pilot's displays if I had to - on conventionals the parallax is too great.			12
No problem with parallax or cut-offs, therefore cross cockpit monitoring better than some flight decks.		6,8,9,10,11,12,16	11

	Q	D1	D2
Cross-cockpit monitoring practical except extreme outside digits (e.g. '6' on VSI)		7,17	
Was conscious that changes were being made on the displays cross-cockpit but this was not disturbing			5
Small size of Altitude and Altimeter pressure setting digits makes cross-cockpit monitoring difficult. Need to be improved or use reliable comparator.	1	1	1
Question the philosophy of cross-cockpit monitoring function of 3rd. man, and reading of digits, especially Altitude.		1	
Don't necessarily see need for cross-cockpoit monitoring		2	
It was difficult to scan to the other side but no objection to lateral scanning			3
Don't normally cross-cockpit monitor because of poor position of conventional HSI. On this Flight Deck the EHSI was too far away.		20	15
I could not distinguish Map symbols cross-cockpit	16	16	
Worried that cross-cockpit monitoring may be inhibited by anti-glare filters on the CRTs.			5
Cross-cockpit monitoring regarded as essential and electronic switching thought to be a clumsy arrangement			5
Cross-cockpit monitoring no better or worse than conventionals. On the Phase 1 displays there was difficulty.		14	
<u>EADI Indications</u>			
<u>Grouping of Indications</u> (Q.A1)			
Information was generally where it was wanted and the scan pattern was easy.		3,4, 5,6, 10, 12, 14 16	5, 12
No difficulty with small grouping because of impact and readability of electronic displays.			2
Basic T comparable with conventional - still had to move eyes to read parameters		2	19
Readability assisted by Basic 'T' arrangement - better than horizontal scan of Phase 1 display.			7,5
Display is cluttered because have condensed big instruments into small display. Small size of analogues have not got the same cues as conventionals		6	6

	Q	D1	D2
More scanning required than would be necessary - analogue presentations should be more comprehensive (bugs etc.)			7
Too much data in small area - grossly inferior to conventionals.	15	9,11	
Lack of colour denies the pilot the ability to appreciate change as easily as split instruments.	18	14	3
One can keep quite a tight scan especially for the approach but tendency to 'lock' onto one parameter which could be dangerous.			18
Not normal practice to certificate aircraft with handed instruments.		17	
<u>Readability of EADI (Q.A3)</u>			
Easy to read because of grouping on basic 'T'.			2
No dual images or difficulties in reading, definitely an improvement on the Phase 1 displays.		1	
Surprising how easy it was to use small instruments particularly when the first impression was that they were ridiculously small.		16,17	5
Size of analogues seemed too small, particularly VSI, due to dot spacing.			6
Larger conventional instruments easier to read.	8		9
Can read displays sitting back but there is a tendency to lean forward.		11	
Spoiled by lack of stable presentation.	17		
<u>Transfer of EADI format</u> (Q.A.6)			
EADI satisfactory in either position.		12	11
More acceptable to the eye and no column obstruction			12
Acceptable as a reversionary situation but could be more tiring.		5,10 13	
More difficult to scan laterally and needs getting used to.	2	3,5, 14,15	
Lateral scan pattern upset with EADI transferred. Azimuth information required a sideways jump.		4,10	
Should be central for approach although some aircraft do have offset ADIs.			1
Workload higher with EADI transferred.			2
Scan is big and wide, dislike offset ADIs.		18	
With EADI transferred, tendency to over concentrate on EHSI.		17	

	Q	D1	D2
Airspeed (Q.A7)			
a) Analogue			
Conventional, pointer good, useful.		5	2,6
Better than L1011 indication.	1		
Liked method of changing digits on analogue.			5
Small size and pointer cannot be compared with equivalent conventional instrument.			6
Not as good as best servo instruments available.	1		
Pointer could be thicker.			6
b) Digital Readout			
Larger digits required.		18,19	
Digits did not do a lot for me, could be dispensed with when Mach No. indicated.			3
Confused SPD SEL and current speed.		8,9	3
c) Bugs on analogue			
Could read speeds OK, Bugs not missed.	1	20	
Bug or bugs required on analogue, i.e.:-			
One bug for significant 'V' speed required		7	2,9 15
At least two bugs required (V_R, V2 or V1, V2).			5,11
At least three bugs required (V1,V2 and V FLAP UP) or (V1, V1 + 10 for Take-off, V_{TARGET} for Approach)			12,14
At least four bugs required, e.g. V1,VR,V2,VAT	17, 18	8,17	3,6
Lack of bugs could provoke a runway performance penalty.	18		
d) Some suggested possible improvements			
i) Combine Altitude and Vertical Speed.			3
ii) Make Altimeter needle indicate direction to go (curl?)			3
iii) Flash pointer to provide indication of 'approaching' or 'on target' speed.			7
Mach No. (Q.A8)			
Used to this type of indication.		5	

	Q	D1	D2
Not particularly useful or sufficiently obtrusive.	1		6
Poor compared with conventional ASI/Mach No.	8		12
Mach No. target needed on analogue.			7
Should be displayed below 0.5M.		8	
Suggest substituting Mach No. for airspeed above certain speeds, say 350 - 400 kt.			12
Barometric Altitude (Q.A9)			
a) General Comments			
'Tunnelling' must be eliminated for it to be comparable.		1	
Small altitude marks vary in brightness.		11	
Would be improved with colour.			11
b) Analogue			
Like conventional.		5	
Satisfactory, but poorly rated because of doubts about overall altitude presentation.			7
Pointer should be thicker.			6
1000 ft. and 500 ft. datums would be sufficient.			7
Going below zero on Altitude was a bit disconcerting.		12	
Lack of ability to bug Alt. is serious disadvantage.	18	18	
c) Digits			
Want larger digits.		18, 19	
Question 1000 and 100s digits being same size.		3	
Confused SEL and current ALT.		8	3
Radio Altitude (Q.A10)			
Did not like Radio Altitude appearing below SEL as this split 'actual' and 'desired' indications.			5
Not obvious when Radio Altitude comes alive. Is it worth flashing when it comes alive?	8		
Well below standard of high quality mechanical Rad. Alt. instruments currently available.	1,17		
Analogue wanted especially last 500ft. for low weather minima and rate.	9	5,10	15

	Q	D1	D2
Quite appalling and is completely incompatible with the requirements 500 ft. at 6 o'clock.	18		
Would not certificate digital Rad. Alt. alone.		17	
<u>Vertical Speed</u> (Q.A11)			
Liked this presentation - pointer good.		19	3
Background experience influences choice towards a dial/pointer presentation.			2
Pointer could be thicker.			6
Scale rather compact in range 0-1000 ft/min.	1		
Could be misread in 600-800 ft/min. range. Too many equal size dots in a row.		9	
Scale could be misread. Would be improved if '3' and '5' were marked.			11
Indication not as vital as others, could shrink in size, not interested in 'up' or 'down'.		14	14
Vertical streamer indication on Phase 1 format was logical and found very reasonable.			2
Vertical streamer lends itself more to strip indication.			9
Personally liked strip vertical streamer.			11
Bar or strip with 1000 values marked would be acceptable.		14	
<u>Pitch Angle</u> (Q.A12).			
No problem with pitch marks.			14
Movement of 2° marks into next segment quite logical		19	
Removing 2° marks when Flight Director is on is step in the right direction to reduce clutter.		13	5
Scale almost too large.			6
Scale smaller than recent conventional instruments.	2		
Scale ambiguous.		19	
Split or move 2° marks away from centre.		1	
2° marks a nuisance as used to 1° but no difficulty in interpolating between 0° to 10°.		2	
2° marks annoying when they are not required but useful when they are wanted.			11
2° marks should be selectable by pilot.			12

	Q	D1	D2
2^{o} marks required with Flight Director on.	18	16	3
2^{o} marks wanted up to - 20^{o}		10, 12	
2^{o} marks not needed.			1,19
Lack of fixed position for 2^{o} marks destroyed impression of distance above zero and was misread at least once.			7
5^{o} marks would be adequate.			19,1
Need pitch index with digital readout.			7
Sources of irritation:-			
Sudden change of 2^{o} segments.		3	
'Jitter' on Pitch bars.		4	12
Varying brightness of bars.		4,6	
Abrupt appearance of numbers and lines.	16		9,12
Small changes in pitch as it moved over raster.			19
Pitch scale confused with Flight Director pitch bar.		17	
<u>Roll</u> (Q.A13)			
Roll was satisfactory.			19
Roll indication was not precise enough for wings level.		3,10 14,18	3
Not happy about the pointer and scale being reversed. Not as clear as conventional.	9		
Marks not prominent particularly zero datum.	14		3
Bank Angle indistinct in 'flicker'		13	
Scale in 10^{o} steps up to 30^{o}, then 15^{o} steps was confusing. 15^{o} marks should be different.	16		
Small changes in roll indications as it moved over raster made one think that one was altering bank angle.		1,	1,19
Do not like bank marks at top.		5	3
<u>Flight Director Symbol</u> (Q.A14)			
Demanding enough and not confused with anything else.		16	
Better being smaller than Phase 1 format.			6
Rather have uniform cross as it relates to cross-wires.	2	5,10	12,3

	Q	D1	D2
Symbol should be larger and more obtrusive.	1,2, 14,15 17	10,4 18	12, 19
Gets confused with centre square.	8,15	10	
Gets lost behind pitch marks.	17	9	
Gives tunnel vision if one does not know what it means.	—	16	
Poor - contrast virtually non-existent.	17	17,20	
A long way down over conventional Flight Director.			1
Localiser/Glideslope Indications (Q.A15)			
a) Localiser:- Not evident or instinctive enough. Had to think hard which side of localiser one was on.		2,3, 4	
Moving caption gives idea that scale is moving and therefore a tendency to misread.		4,5	7
Confusion for small deviations.	8		
Index had too many different functions.	16		
Need for expanded scale when on ILS.			9
Prefer Loc. Dev. combined on Flight Director.			11
b) Glideslope:- Not attentive enough - pointer too small.			3
Position distracted by adjacent relatively unimportant indications.			3
Not sure about sense of scale.			9
Prefer Glideslope combined on Flight Director.			11
EHSI Indications			
Alternative Centre Formats (ROSE/MAP) (Q.A2)			
Like Map as alternative to Rose - useful as aid either on own display or on the co-pilot's side.	16	11 10,9	12
Map liked but should be kept simple.			12
Desirable that scales selectable by pilot.		11	
No reason for separate formats, could be combined as on Lightening HSI.			3
Not as clear as separate map.			6
L.1011 map is clearer.		9	

	Q	D1	D2
Don't like the idea of different pictures.		20	
Would like the facility to put Map onto S1.		19	
<u>Compass Rose - CRS/TRK Pointer and Deviation</u> (Q.A16)			
a) Rose Format:-			
i) <u>Rose</u>			
Graduations accurate enough with digital readout			7
Heading numbers were clear.		4	
Dots instead of lines for marks affected appearance and use of Rose as a whole and was poor compared with conventional.			5
Suggest increasing contrast between 0 and 5^{o} marks.		4	
Movement of Rose not as smooth as one would have liked.	15	6	
ii) <u>Selected HDG bug</u>			
Symbol not prominent enough.		3	
Prefer arrowhead outside Rose.	13		
iii) <u>CRS/TRK Pointer and Deviation</u>			
Good except for designators (A,V,To,From)			7
To/From designators too small.		16	
To/From designators not good, prefer arrowhead pointing towards station.		4	6
Pointer and deviation bar could be thicker.			6
Cross bar on CRS/TRK pointer did not stand out			6
iv) <u>General Comments</u>			
Too much information presented on Rose format.		2	
Rose data confusing.		18	
'N' on Vertical Nav. Error Scale could be confused as North designator on Rose.	16		
Unhappy with not having present and desired HDG displayed.		10	

	Q	D1	D2
b) Map Format:-			
Dislike lack of full circle for Rose.	2		
Suggest combining compass Rose with one of range rings.			6
CRS/TRK pointer too small.	16		
Not happy about HDG indication.		4	
Bearing Pointers (Q.A17)			
Lack of tails no problem.		5	
Difficult to use because single ended - particularly ADF when wanting back bearing.		4	12 3,7
Length of pointers badly matched, 'V' and 'N' should be much longer.	16		12,3
Confusion with designators 'V' and 'A' because of poor contrast when rotated.	1		3
Missed 'points' on pointers.		10	7
Suggest small letters around compass Rose identifying needle pointers.			3
Difficulty in interpreting pointers because they appeared to be moving slightly.			19
Lack of differentiation between pointers when in same area.	16	4,7, 9,17	
Could synthesize priority of pointers.		9	
Suffer from lack of colour.		6	6,9
Movement of pointers not as smooth as on SPD and ALT.			3
General Comments:-			
Not being able to select No.1 VOR and No.1 ADF at same time is a problem.		8	
Coloured peripheral pointers on conventional instrument much clearer - missed separate RMI.	2,14, 15	18	
Glideslope (Q.A18)			
No comments on EHSI indication.			

A2.2. Comparison with Phase 1 Display Standard

A2.2.1. Pilots' Ratings

The pilots' ratings for Section B of the Questionnaire are shown as dot/bar diagrams.

A diagram is shown for each of the parameters:-

i) Airspeed - analogue and digital

ii) Mach No.

iii) Barometric Altitude - analogue and digital

iv) Radio Altitude

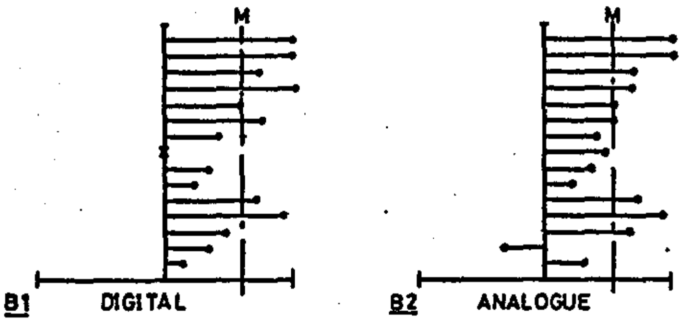
v) Vertical Speed

These summarise the ratings for all pilots against the same base scale as in the Questionnaire. i.e. Ratings on the vertical datum are comparable with the Phase 1 presentations with 'worse' ratings to the left and 'better' ratings to the right (as shown in the Key Diagram).

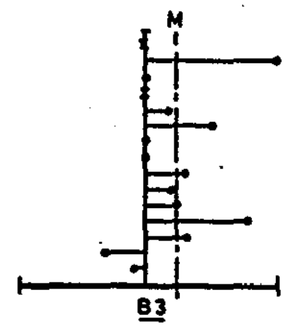
Pilot numbers, which were only used as a reference for analysis are indicated in the Key Diagram and pilots who participated in the Phase 1 format evaluation at BAC Filton (see ref. B.J.Bleach in Para. 3.2.) are ringed.

SUMMARY OF PILOTS RATINGS

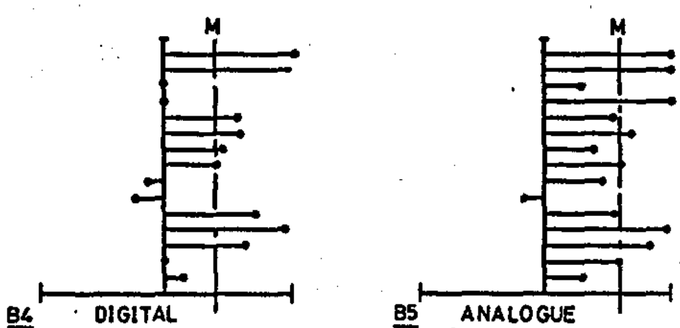
EXTRACTED FROM QUESTIONNAIRE SECTION B



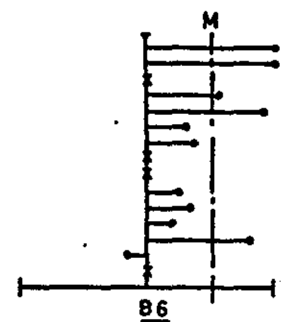
AIRSPEED



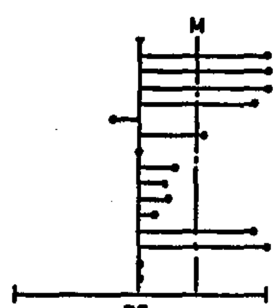
MACH No



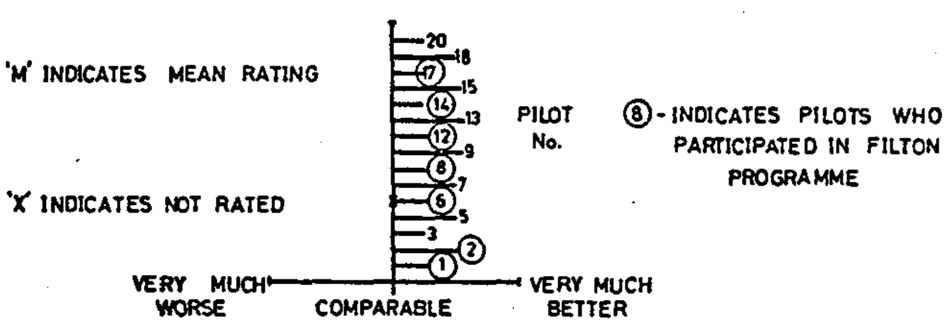
BAROMETRIC ALTITUDE



RADIO ALTITUDE



VERTICAL SPEED



KEY DIAGRAM

A2.2.2. Pilots' Comments

The comments are from:- the pilots' notes in the Questionnaires (Q), the debriefings following the exercises (D1), the interviews at a later date (D2).

Favourable comments are given first.

	Pilot Nos. Q	D1	D2
Airspeed (Qs.B1 and B2)			
Dial/Pointer preferred to tape.			6
Pointer useful below 200 kt.			5
More natural (conventional in areas other than aircraft)			7,9
No pattern information on tape.		5	
Tape better analogue information.			
Mach No. (Q.B3)			
Better - used to this type of indication.		5	
Not sufficiently obtrusive - tends to get confused with other digits nearby.	1		6
Mach Target needs analogue.			7
Phase 1 format tape scale better because it gave analogue information.	2		
Barometric Altitude (Qs.B4 and B5)			
Dial/Pointer preferred to tape.			6
Tape has to be read, therefore not so good.		5	5
Used to conventional dial/pointer.			9
Tape scales for Altitude ought to be better but not seen any satisfactory presentation.			7
Liked SPD and ALT as extension of pitch bar on Phase 1 format		8	
Radio Altitude (Q.B6)			
Better - moving scale on Phase 1 format difficult and not liked.		5	
Vertical Speed (Q.B7)			
Dial/pointer preferred: similar to conventional		5	2,7

	Q	D1	D2
Easier to interpret but more displayed.	8		
Tape scale acceptable - not as vital indication as some others - not really interested in 'Up' or 'Down'		15	
Vertical Speed lends itself more to tape indication.			9
Personally liked tape Vertical Speed but it is difficult to make this non-linear - therefore probably better retain dial.			11
Background experience influences choice towards a dial/pointer but the vertical streamer of the Phase 1 format was logical and found very reasonable.			2
Could see merit in tape scale for pilots training from scratch.			7

A2.3. Pilots' Ratings, Comments, Reading Errors and Reading Times on EADI

A2.3.1. Pilots' Ratings

The pilots' ratings for the EADI, questions C1 to C25, are all shown as dot scales. The ratings are given in the order that the questions appeared in the Questionnaire.

A.2.3.2. Pilots' Comments

The comments are from:- the pilots' notes in the Questionnaires (Q), the debriefings following the exercises (D1) and the interviews at a later date (D2).

	Pilot Nos. Q	D1	D2
C.1. Airspeed Pointer			
Particularly good for airspeed			16
Might have been thicker.			6
Not essential			11
Speed awful. Arrow heads need not mask digits.			19
C.2. Airspeed Analogue Scale Numbers			
A bit small, especially '8'. What about 100 kt. error?	17		
Speed dial needs learning.			2
C.3. Speed Legend (SPD)			
Did not notice SPD occult.	2		
Want a warning of why SPD occulting, e.g. an analogue "barber pole" bug.	8		
Speed occulting probably required audio "support". Unlikely to be adequate on its own.	5		
C.4. Digital Airspeed			
Digital information rarely used. Misread at least once.	3		
Could be larger		19	
Satisfactory			1,2, 5,11 14

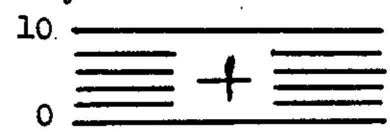
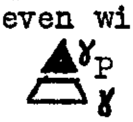
	Q	D1	D2
Confused actual and selected.		8,10	9,15 16
Bigger speed readout wanted.		18	
Superfluous when on Mach No.			3
C.5. <u>Fast/Slow</u>			
Five knot graduations would be better.	9		
Requires mental effort to use. Although nice to have, not necessary.	14		
Prefer to have a discrepancy warning and monitor speed on basic instruments. Danger of being incorrectly set up.	15		
Not used at all	17		11
Fast/Slow confusing.			12
C.6. <u>Mach/Velocity</u>			
Would like to see Mach No. below 0.5M.	8		
Wanted to see Mach No. at 0.5M and above.		8	
Difficult to read, tends to get hidden.			6
Not used much.	9		
C.7. <u>Velocity Target Data</u>			
Data should be 'bugged' on ASI. Often missed the displays changing. Distracting on take-off.	3		
Not used.			6
Do not like the idea of data removed as speed achieved. A good deal more data than on current aircraft. Speed command data can easily be confirmed with real data as presently positioned.	15		15
Bugs not needed.		20	
Some bugs wanted.			2,3 5,6 7,8 9,11 12,13 14,15
Disliked the "jumping" - distracting on take-off.	3		3
Liked or satisfactory.			4,6, 7,10 11,12 19

	Q	D1	D2
Mixed views			5
Liked the disappearing, could do the same on analogue			7
Not sure needed after V2		10	
Had not thought of bugs. Would want V2 retained in case of engine failure. Suggest marker or [ ] to run down over speeds.			16
Cannot bug ASI and Altitude because they are too small.		18	
C.8a. Speed Select			
Speed select could be reflected on analogue display.	7		
Occasionally confused speed select and actual speed.	6,8,9		
Rotary control preferred to slew switches.	14		
Not sufficiently related to analogue.			7
Speed command not used much. One has to be careful not to ignore it when on autothrottle.		8	
C.8b. Magnetic Heading			
Wish to retain magnetic heading on the EADI for ILS approach.	10,13		
Lubber line not clear.	15		
Not a lot of use. Ability to preselect not an advantage.			6
C.9. Altitude Select			
Would like it deleted most of the time.	4		
Possibility of confusion with baro or radio altitude.	8,16		
Too close to radio altitude.	17		
Want rotary controls not slew switches.	14		
Confused with radio altitude.		8,17	19
Possibly should be adjacent to selector.	15		11, 15
Had difficulty with altitude select number.			15
C.10. Rate of Turn			
So close to bank index as to be confusing.	1		
Could be confused with magnetic heading readout error	4		
Not required.	9,15 18		7

	Q	D1	D2
Not looked at much.		8	
C.11. <u>Altitude Analogue</u>			
Cross-cockpit monitoring not feasible with digits shown.	1		
C.12. <u>Pressure Setting</u>			
Not readable across the Flight Deck.	1		
QFE and QNH legends to be more distinguishable.	13		
Switch function good.	14		
Something more positive needed.			11
C.13. <u>Slew Rates</u>			
Think probably too fast.	2,14		
Suggest detent for final adjustments.	2		
Slew controls without tactile feedback require undue concentration.	7,16		7,16
Not liked in principle.	9,15		
Dead space in controls.	11		
Want rotaries.			11 15
Unacceptable.	16,18		
Coarse too coarse, fine too fine.	17		
Slews unacceptable.		All except 14	All
C.14. <u>Digital Altitude</u>			
Cross-cockpit monitoring not possible with these digits.	1		
Possibility of misreading by 1000s feet.	7		7
1000 feet is too great for warning.	9		
Annoying to have "1000 ft to go" warning identical to height violation warning. Something like a heterodyne that quietly grows to a null over last 1000 ft would be more reassuring and a better guidance.	16		
Warning label poor.	17		
Easy to misread.			5
Confused actual with selected.		8	

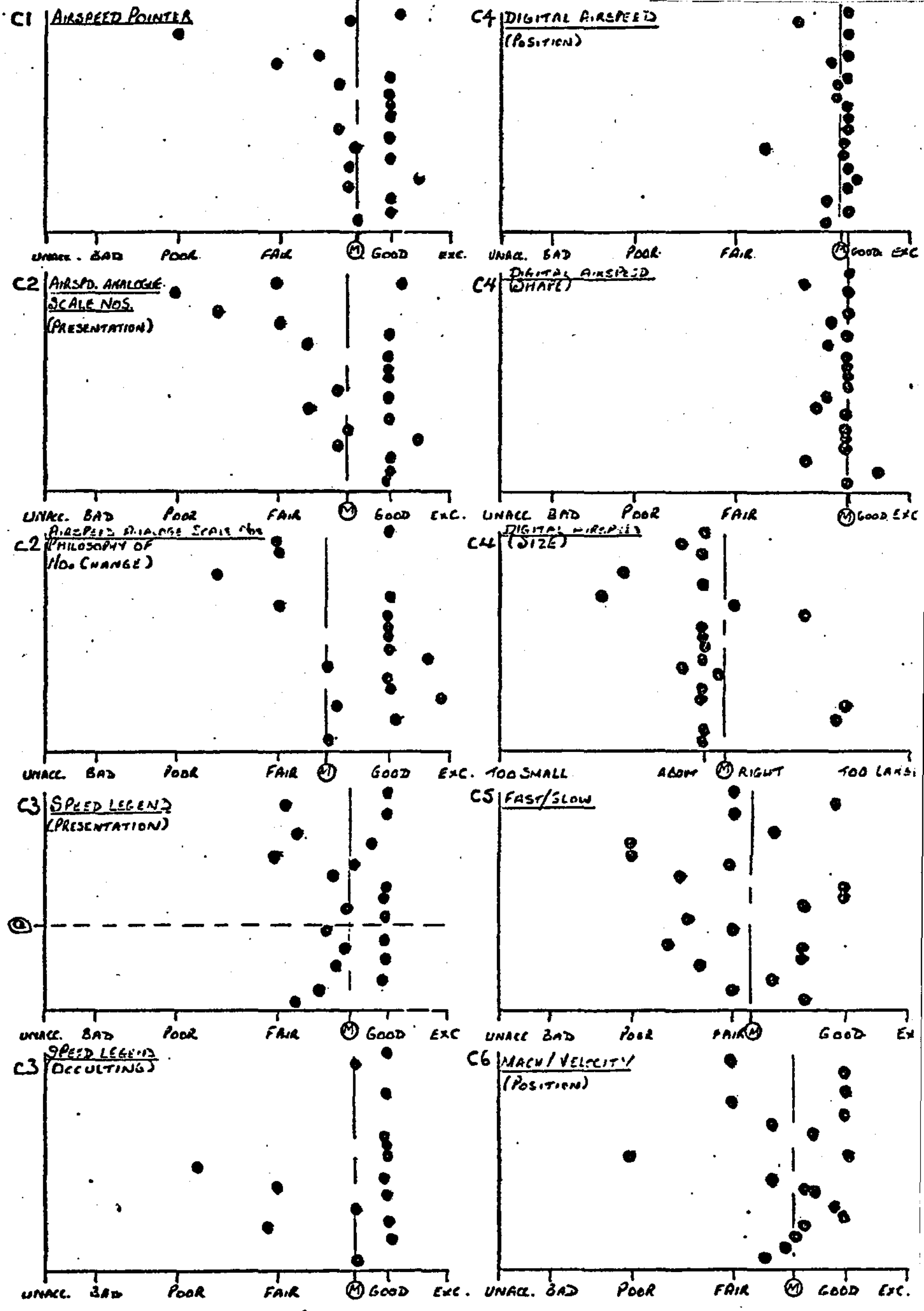
	Q	D1	D2
Satisfactory.			5,11 12,14
Bigger digits wanted.		18	
Numerals not easy to read.			15
C.15. <u>High/Low</u>			
Not a necessary item.	14		2,14
Often superfluous.			3,6
Found sense confusing.	9	18	9
Too small too hold attention when needed and a nuisance when not needed.	16		3,16
Not clear enough, unsure of its use.	15		
Prefer Glideslope on Flight Director.			11
Used only as a Glideslope.		20	16
When at top of scale, merges with altitude.		17,2	
Pointer too small.			16
C.16. <u>Radio Altitude</u>			
Would like the readout to be bigger and higher up display (under the baro analogue)	5		5
Easy to misread.			5,19
'R' made readout confusing.			2,15
Rate missed.			15
Would want Rad. Alt. above ALT SEL.		18	
Not compulsive, should flash when becomes alive.		8	
Would not certificate digits alone.		17	
C.17. <u>Decision Height Warning</u>			
Requires + 100 ft. and + 30 ft DH. Occulting may be distracting.	3		
100ft. above good. DH poor as too little change introduced at DH for good attention getting.	5		5
Distracting when below DH. No warning of DH given. Suggest occulting before DH, solid DH from decision height to 50 ft. below.	6		6
Approaching decision height warning good, below decision height fair.	7		
Not compulsive enough.			1,16

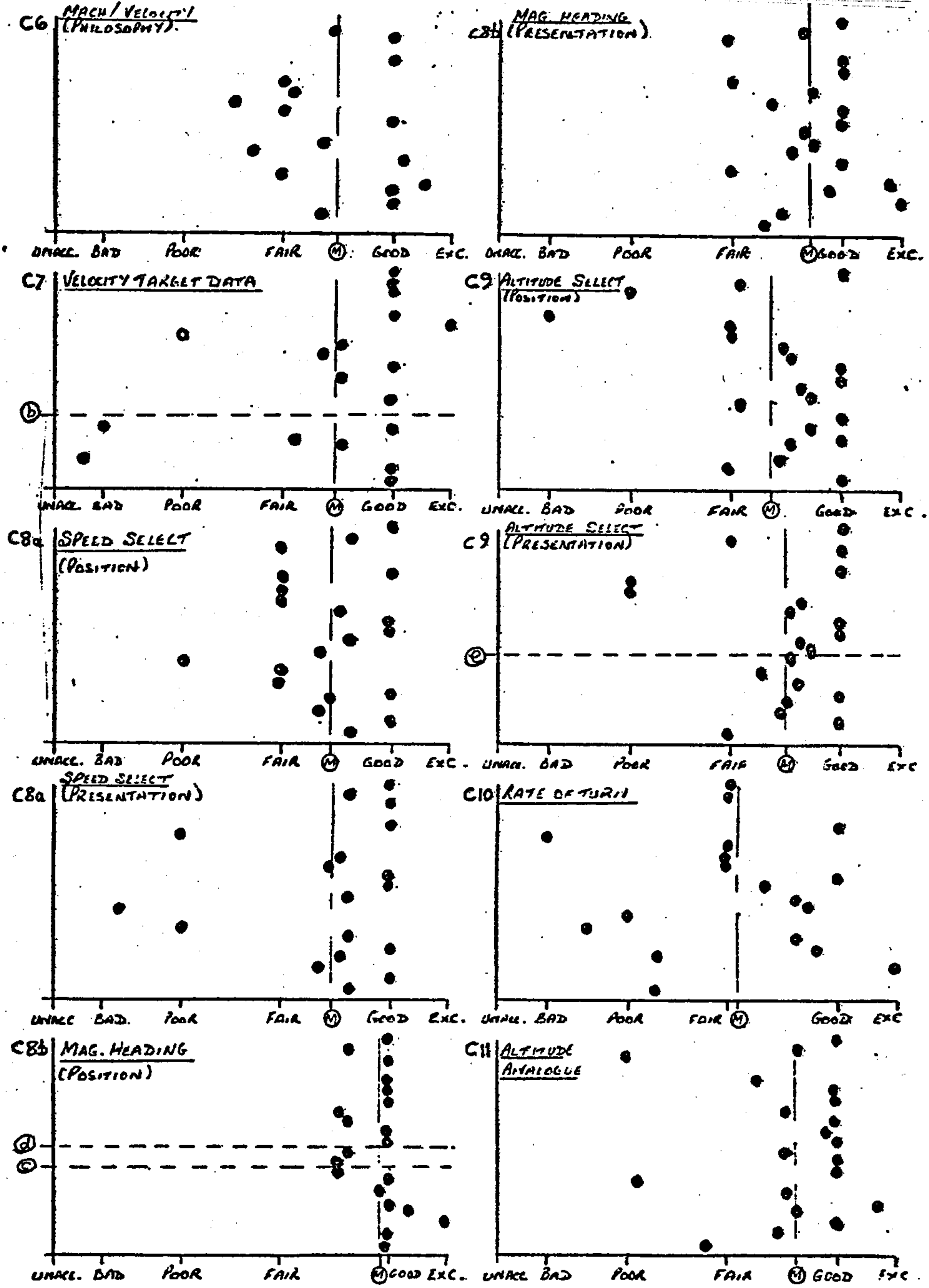
	Q	D1	D2
C.18. Vertical Speed			
Scale too compressed in range 0 ± 1000 fpm.	1		
Less than ± 1000 fpm easy to misread by 200 fpm.	9		9
Easy to misread by ± 2000 fpm, but not important.	16		
Easy to misread, 3 and 5 marks wanted.			11
Could be smaller.			14
VSI difficult to use.			6
Pointer could have been thicker.			6
Of secondary importance.			2
Not sure if dial or strip preferred.			5
Strips preferred.			9,11, 14
C.19. Lateral Path Error			
Confusing to read.	4,5,8		
Too many functions, difficult to read and TKE worked in opposite sense.	16		16
Not instinctive enough. Unnatural to fly line to symbol instead of symbol to line.		4	
Prefer on Flight Director.			11
Scale more expanded than one needs at present.			15
Dependant on main parameters.			1
Easy to misread. Assumed scale moved.			5
C.20. Fixed Attitude Marks			
Clutter made it difficult to quickly find part of display wanted, e.g. Flight Director. Monochrome exaggerates problem.	9		
Vary in brightness with background.	11		
Almost totally redundant, sufficient data from frame.	16	16	
○ rather than □			10
Generally satisfactory.			6
Size of □			3
Gaps between ⌉ ⌈ & □ could be smaller.			19

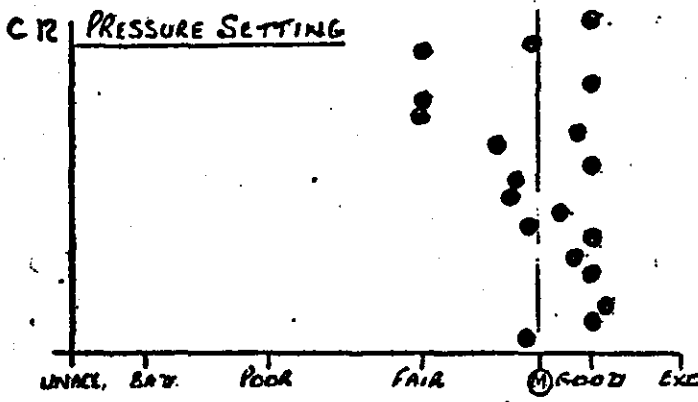
	Q	D1	D2
C.21. <u>Moving Attitude Marks</u>			
10° marks and 2° marks grossly conflict with Flight Director, suggest: 	1		1
Pitch marks too obtrusive, prefer 1° marks.	2		2,12
Zero bank indication lacks precision.	3,14		
Clutter made it difficult to find what was wanted, e.g. Flight Director. Monochrome exaggerates the problem.	9		
Change in scale in bank was confusing.	16		
Removal of 2° pitch marks with Flight Director going in right direction.		5,13	
Missed 2° marks.			3,5, 16
Surprised when 2° marks jumped to next range, may be better to "creep".			3,9
Roll not precise enough for wings level.		10	3
Pitch lines needed up to 20°		10	12
Pitch lines needed down to -10°			12
May need some extra pitch datum marks, e.g. 15° & 17° for BAC 1-11.		13	
2° marks annoying when not required, but useful when wanted. Will be necessary if aircraft has to be set to a x2 value.			11
Roll centre on scale could be bigger, used horizon in turn.			14,15 16
3° dot useful for approach.			16
Liked 2° marks, but 5° would be acceptable.			19
C.22. & C.23. <u>Flight Path Angle & Potential Flight Path Angle</u>			
Philosophy not liked. May be useful for power setting for rate of descent or glideslope, but generally a nuisance.	14		
Clutter produced.	9,14		
Idea good.	9		
Prefer to see γ_p all the time even with the autothrottle engaged. Suggest new symbols: 	16		

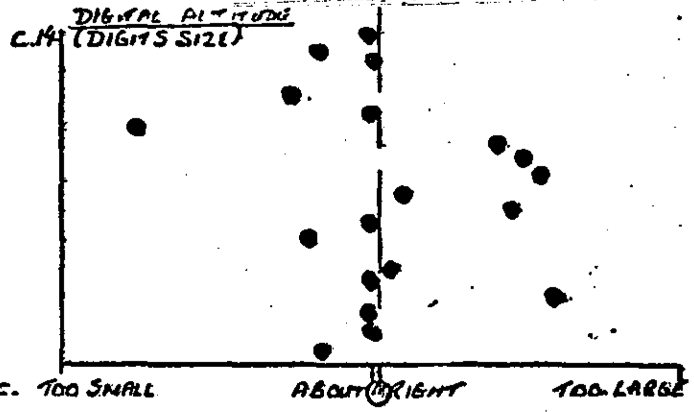
	Q	D1	D2
Need only be displayed on selection.			15
Not used much- may be training.		10	1
Helped clutter to have outboard.		10	
Distracting in level flight.			2
Pot FPA superb, but suggest:			3
Did not like system. Prefer nothing or velocity vector			4
Need getting used to.			5,16
Doubts about FPA etc. Streamer in FPA circle may be better. Lack of fixed position for 2° marks destroyed impression of distance above 0° and misread. Need for pitch index with digital readout.			7
Liked, extension of pitch bar.		8	
Useful		18	9
FPA not obvious enough. Pot.FPA very obvious. Should be coloured, but first class.		18, 20.	
C.24. <u>Flight Director</u>			
Hidden in general clutter.	1		1
Azimuth bar difficult to see behind pitch bars - too thin.	9		9
Like all Flight Directors, it gave no warning of where it was going next or how fast. Suggest a dynamic line similar to the short line which streams past the datum □ and curves its top to R to indicate turn about to commence, e.g.	16		
Pitch bar too small.			2
Rather see a change, say ◇			3
Could be bigger.			4,5, 12,14 15,19
Difficulty in accuracy at low speeds.			6
Suggest a 4° square when on.			2
Would be better smaller.			6
Unbalance on Flight Director between azimuth and roll (thickness). Prefer two longer thinner bars.		10	
Obscures □. Colour would help.			15

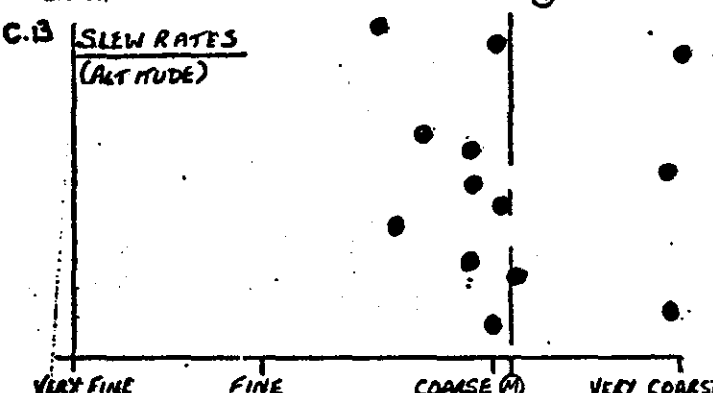
	Q	D1	D2
Contrast virtually nil. Pitch bar same thickness as 2^o pitch lines.		17	
C.25. <u>Urgent Messages</u>			
Could go unnoticed, particularly in times of high workload.	15		1,15
Need to be careful in distinguishing between advisory and mandatory.			3
Quite good or satisfactory.		4	9,12, 19
Glideslope was affected.			5
Message should stay on until situation rectified.			5
Location and presentation acceptable. Each message needs consideration in detail.			5
Unlikely to be missed.			14
Missed Glideslope warning. Less dynamic than flashing lights, by an order.		17	
Colour would help.		17	16

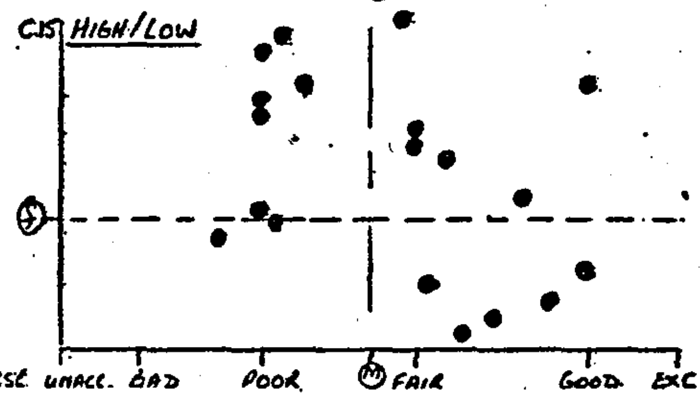

C1 AIRSPEED POINTER
UNACC. BAD POOR FAIR M GOOD EXC.
C4 DIGITAL AIRSPEED (POSITION)
UNACC. BAD POOR FAIR M GOOD EXC
C2 AIRSPD. ANALOGUE SCALE NOS. (PRESENTATION)
UNACC. BAD POOR FAIR M GOOD EXC.
C4 DIGITAL AIRSPEED (SHAPE)
UNACC. BAD POOR FAIR M GOOD EXC
C2 (PHILOSOPHY OF NO. CHANGE)
UNACC. BAD POOR FAIR M GOOD EXC.
C4 DIGITAL AIRSPEED (SIZE)
TOO SMALL ABOUT M RIGHT TOO LARGE
C3 SPEED LEGEND (PRESENTATION)
UNACC. BAD POOR FAIR M GOOD EXC
C5 FAST/SLOW
UNACC BAD POOR FAIR M GOOD EX
C3 SPEED LEGEND (OCCULTING)
UNACC. BAD POOR FAIR M GOOD EXC.
C6 MACH/VELOCITY (POSITION)
UNACC. BAD POOR FAIR M GOOD EXC.

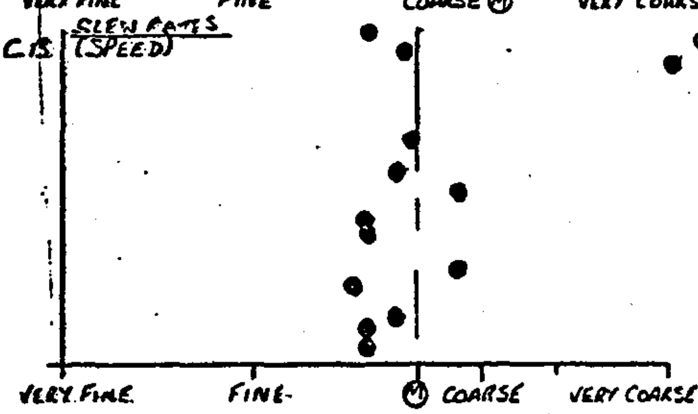

C6 MACH/VELOCITY/ (PHILOSOPHY)
C8b MAG. HEADING (PRESENTATION)
C7 VELOCITY TARGET DATA
C9 ALTITUDE SELECT (POSITION)
C8a SPEED SELECT (POSITION)
C9 ALTITUDE SELECT (PRESENTATION)
C8a SPEED SELECT (PRESENTATION)
C10 RATE OF TURN
C8b MAG. HEADING (POSITION)
C11 ALTITUDE ANALOGUE
UNACC. BAD POOR FAIR M GOOD EXC.
b
e
d
c

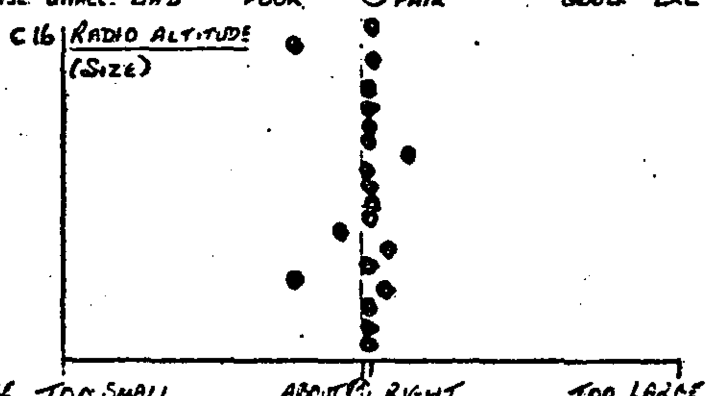

C 12 PRESSURE SETTING
UNACC. BAD POOR FAIR M GOOD EXC.

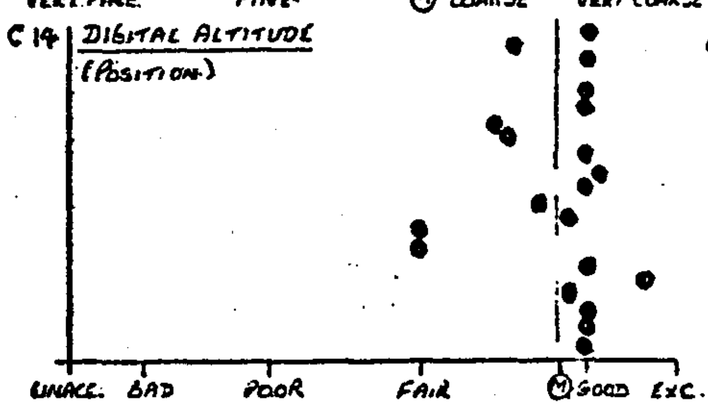

C.14 DIGITAL ALTITUDE (DIGITS SIZE)
TOO SMALL ABOUT M RIGHT TOO LARGE

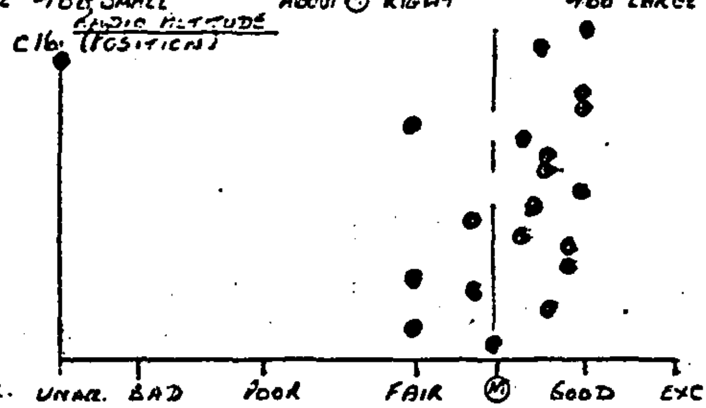

C.13 SLEW RATES (ALTITUDE)
VERY FINE FINE COARSE M VERY COARSE

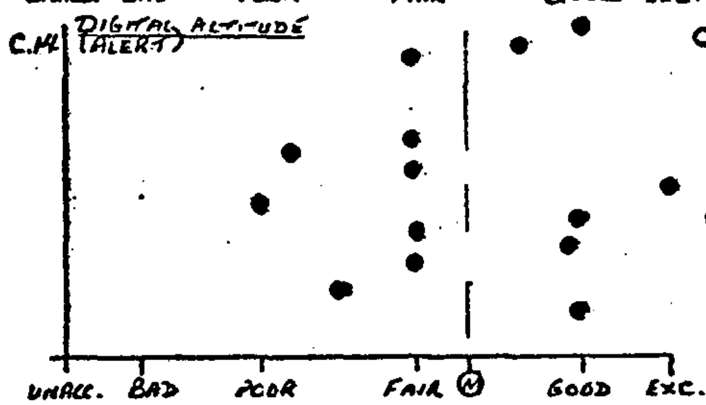

C15 HIGH/LOW
S
UNACC. BAD POOR M FAIR GOOD EXC.

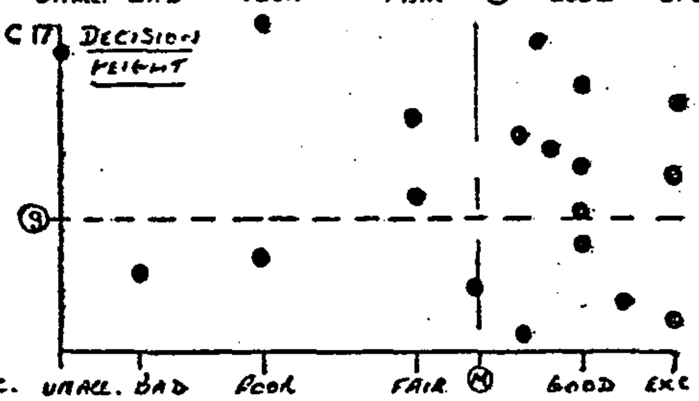

C.13 SLEW RATES (SPEED)
VERY FINE FINE M COARSE VERY COARSE

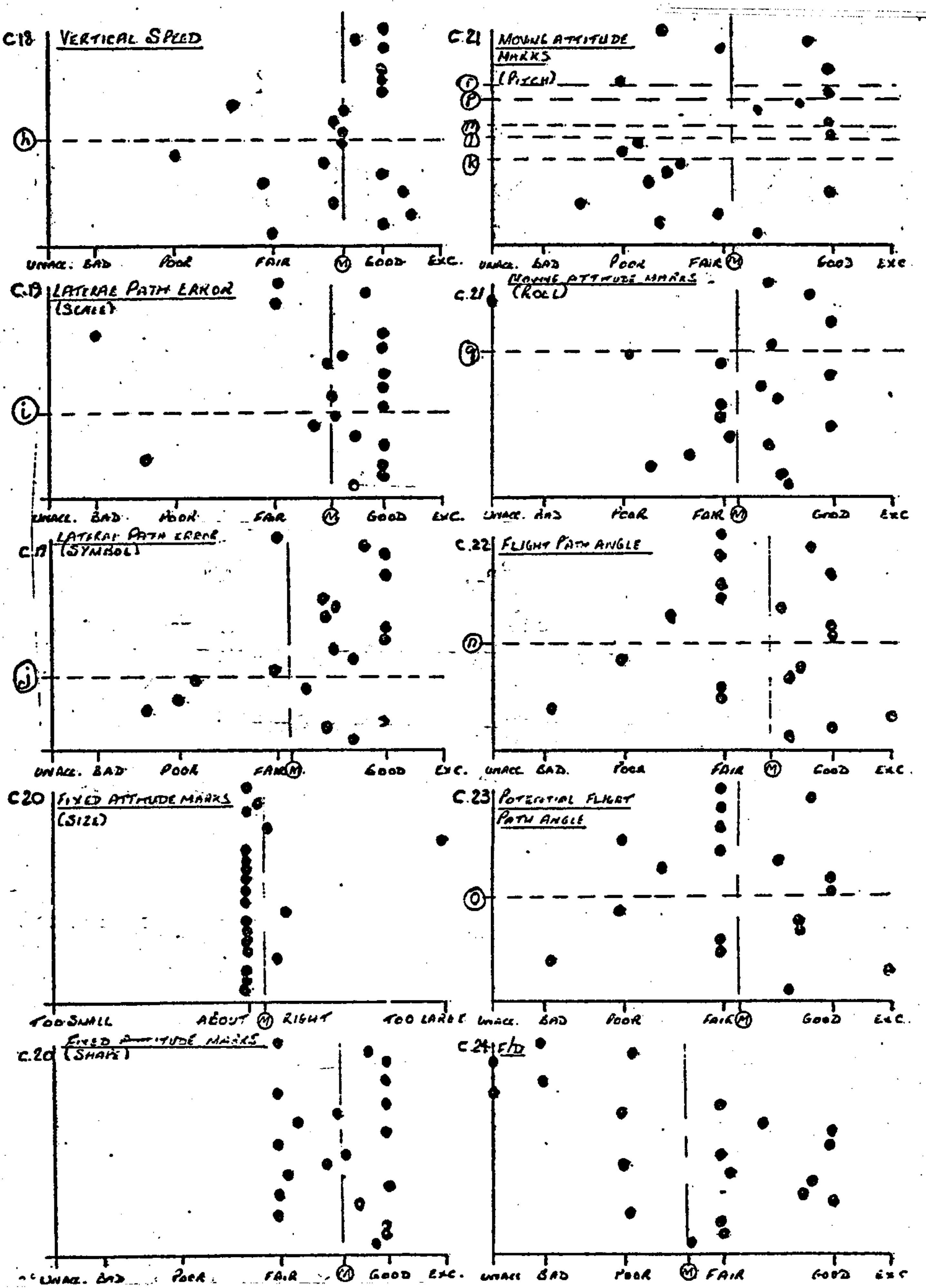

C 16 RADIO ALTITUDE (SIZE)
TOO SMALL ABOUT RIGHT TOO LARGE

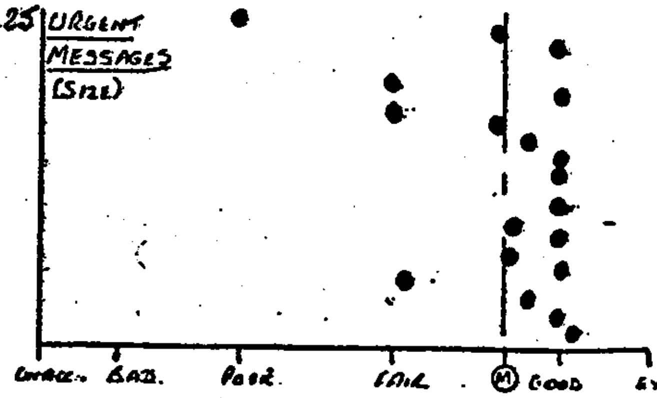

C 14 DIGITAL ALTITUDE (POSITION)
UNACC. BAD POOR FAIR M GOOD EXC.

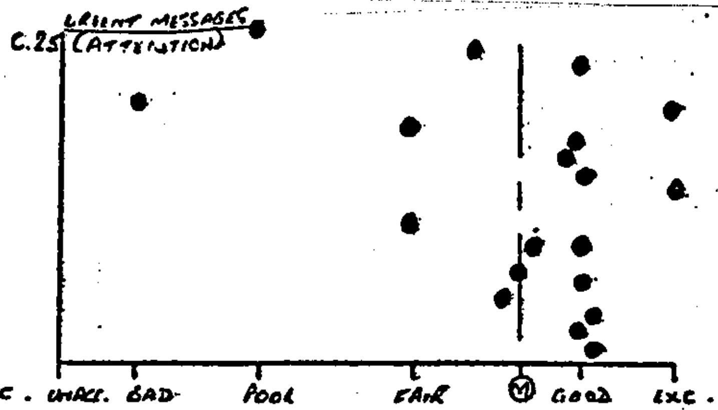

C 16 RADIO ALTITUDE (POSITION)
UNACC. BAD POOR FAIR M GOOD EXC

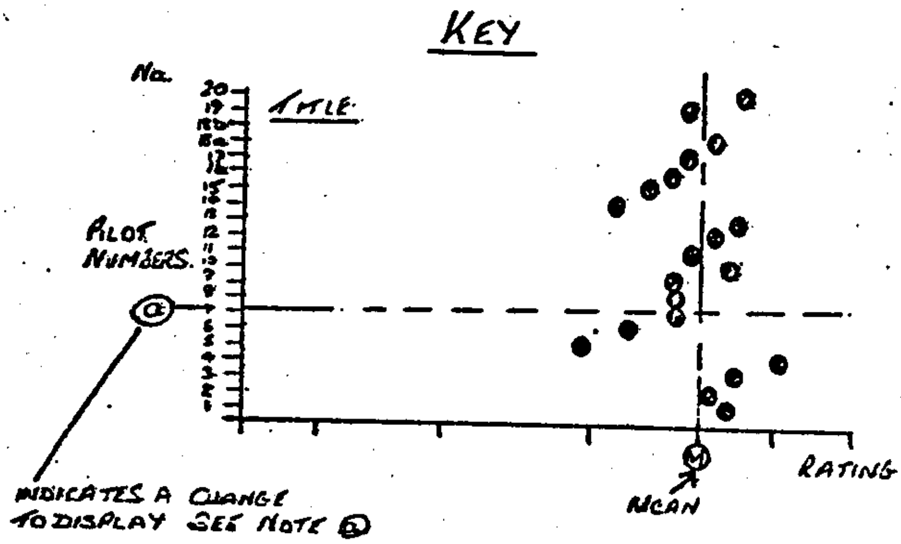

C.14 DIGITAL ALTITUDE (ALERT)
UNACC. BAD POOR FAIR M GOOD EXC.


C 17 DECISION HEIGHT
S
UNACC. BAD POOR FAIR M GOOD EXC.


C18 VERTICAL SPEED
h
UNACC. BAD POOR FAIR M GOOD EXC.
C.21 MOVING ATTITUDE MARKS (PITCH)
l
p
m
n
k
UNACC. BAD POOR FAIR M GOOD EXC
C.19 LATERAL PATH ERROR (SCALE)
i
UNACC. BAD POOR FAIR M GOOD EXC.
C.21 MOVING ATTITUDE MARKS (ROLL)
q
UNACC. BAD POOR FAIR M GOOD EXC
C.19 LATERAL PATH ERROR (SYMBOL)
j
UNACC. BAD POOR FAIR M GOOD EXC.
C.22 FLIGHT PATH ANGLE
n
UNACC. BAD. POOR FAIR M GOOD EXC.
C20 FIXED ATTITUDE MARKS (SIZE)
TOO SMALL ABOUT M RIGHT TOO LARGE
C.23 POTENTIAL FLIGHT PATH ANGLE
o
UNACC. BAD POOR FAIR M GOOD EXC.
C.20 FIXED ATTITUDE MARKS (SHAPE)
UNACC. BAD POOR FAIR M GOOD EXC.
C.24 F/D
UNACC BAD POOR M FAIR GOOD EXC







NOTES:

'SPD CMD' changed to 'SEL'

In take-off mode: If $V > V_1$ remove V_1

$V > V_R$ " V_1 and V_R

$V > V_2$ Display V_2 V_3 V_4 V_{FTO}

In APPR mode 'MAG' → 'TKE'

Large 'TKE' to small 'TKE'

'ALT SEL' to 'SEL' Leading zeros displayed

Vertical error remains at ± full scale instead of being deleted

$\boxed{DH}$ not flashed.

1000 ft/min scale marks increased in size

(j) Lateral error bug from ABC to ABC

Reference | to |

Deviation scaled 2 × VOR or ILS and centre dots removed

2° pitch dots instead of lines

2° pitch lines instead of dots

10° pitch lines thicker

(o) Moved outboard of 10° pitch numerals

-10° + 20° limit on 2° pitch lines

0° roll index from ° to ▮

pitch scale numbers moved slightly to left

A2.3.3. Errors Made in Reading.

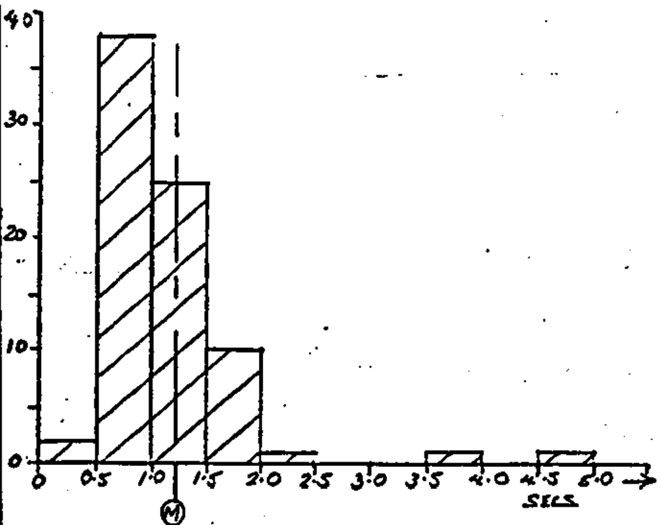
	Pilot Nos. Numbers in ( ) indicate more than one error
a) Magnetic Heading	
Read heading in error.	11,16
b) Rate of Turn	
Read as Track Error	19
c) Glideslope Deviation	
Doubled Scale	17
Misread Scale	3,11,12
d) Radio Altitude	
Read Selected Altitude in error	1,2,5,9,17,19
e) Vertical Speed	
Misread scale	6(2),8(2),11, 14,16,17(2),19
f) Localiser Deviation	
Misread Scale	10,18
g) Pitch Angle	
Misread Scale	9,12,16
Read Flight Path Angle in error	12
h) Flight Path Angle	
Read Potential Flight Path Angle in error	5,9,10,11
Misread scale	5,7,8
Read Pitch Angle in error	4,11(2),12,14
Misread - unknown reason	2,14,16,17
i) Potential Flight Path Angle	
Misread Scale	8,11,13,14,16,20

Prompts given for:	Drift Angle	10
	Localiser Deviation	11
	Rate of Turn	15,19
	Flight Path Angle	19

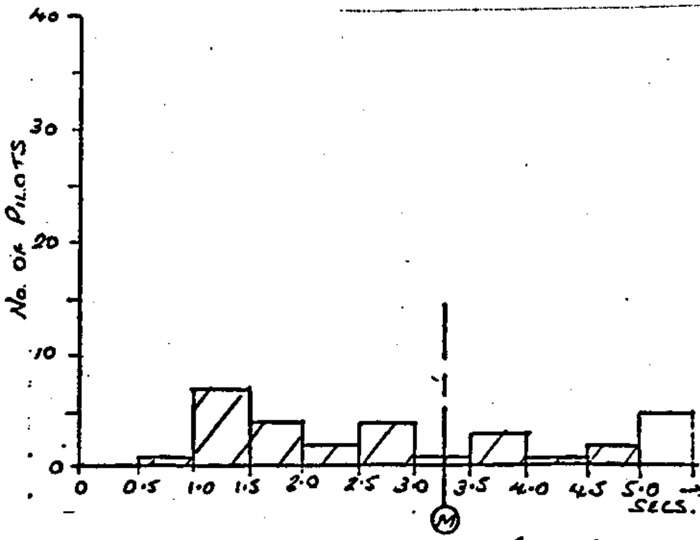
A2.3.4. Reading Times

The Reading Times are shown as histograms on the following two pages.

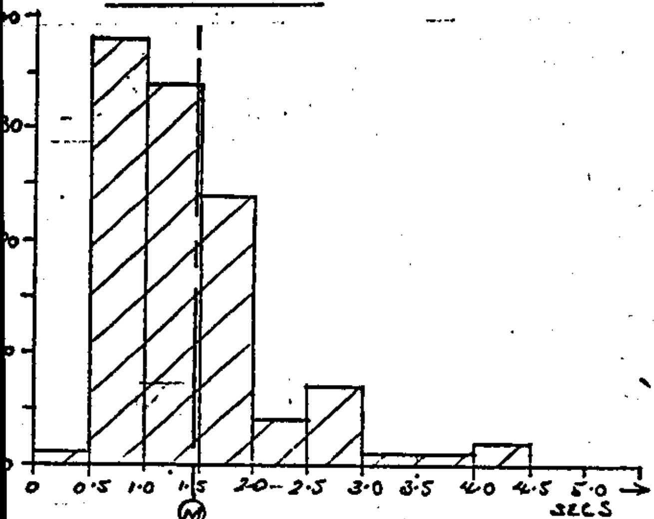
READING TIMES



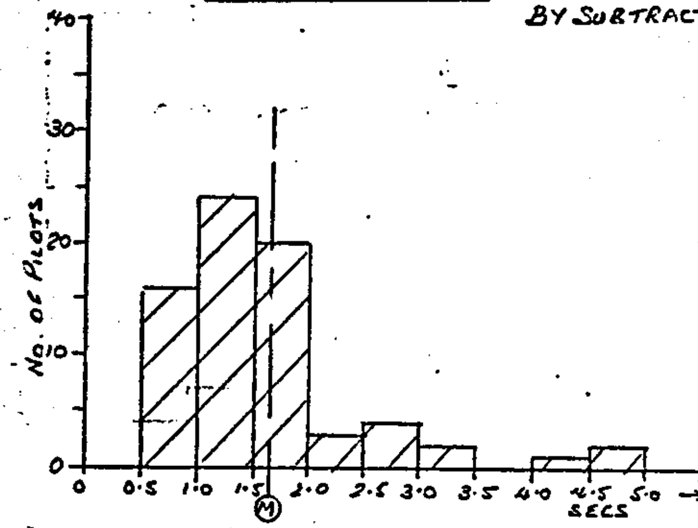
C.1. AIRSPEED



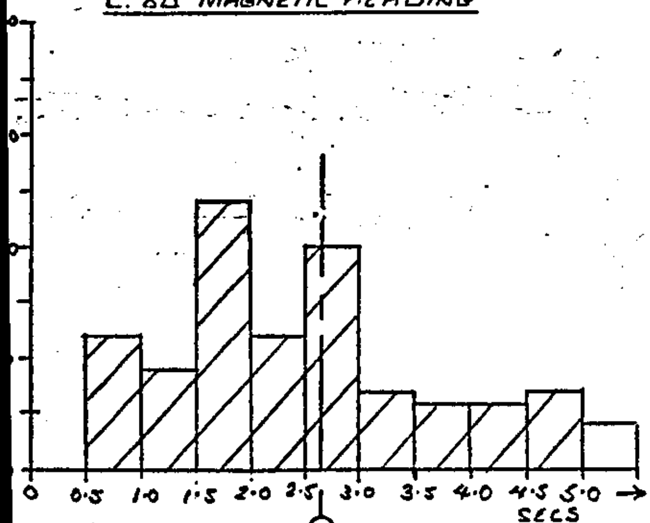
C.5. SPEED ERROR (FAST/SLOW ALSO BY SUBTRACTION)



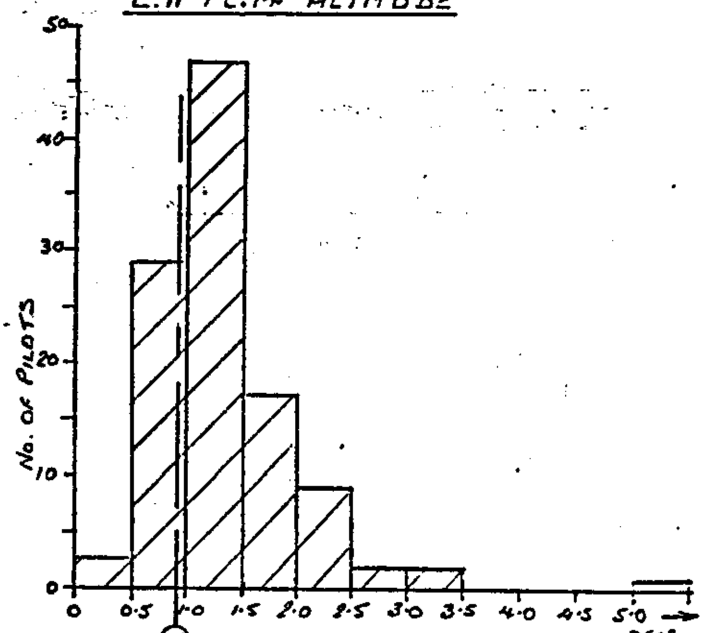
C. 8b MAGNETIC HEADING



C.11 /C.14 ALTITUDE



C.15 GLIDE SLOPE DEVIATION.



C 16 RADIO ALTITUDE

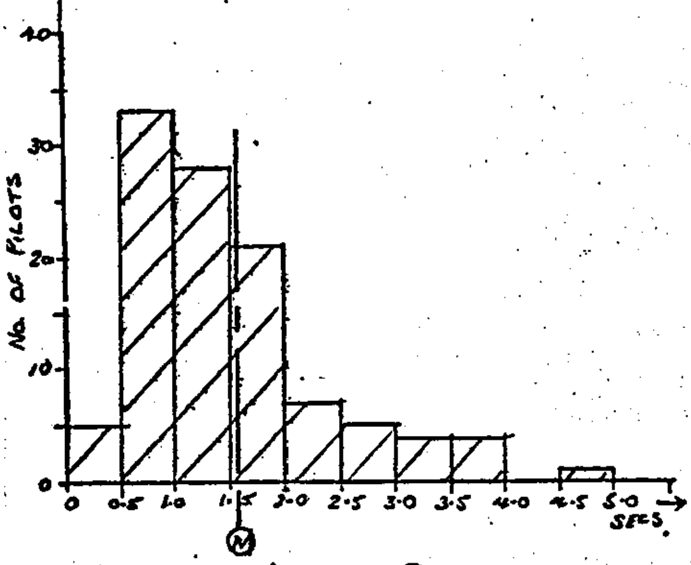
C.8 PITCH ATTITUDE

C.22 FLIGHT PATH ANGLE

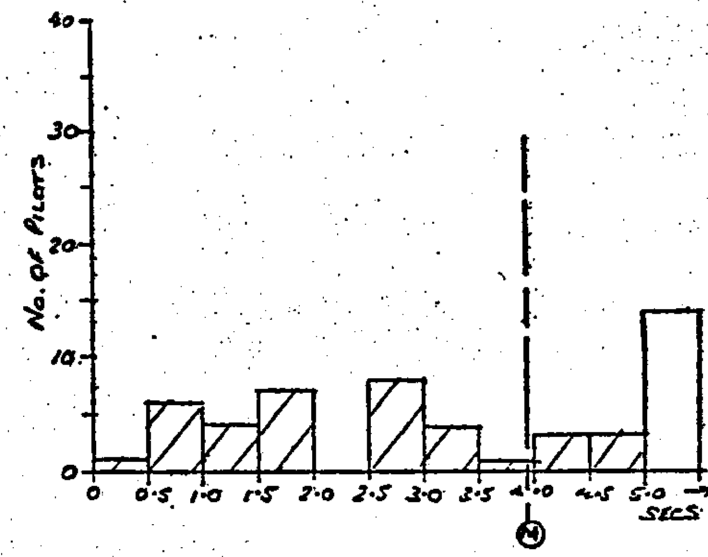
NOTE

M = MEAN VALUE

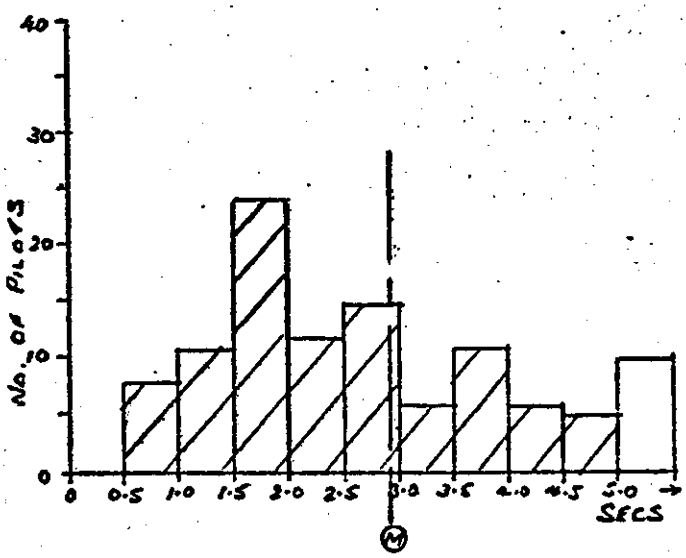
READING TIMES



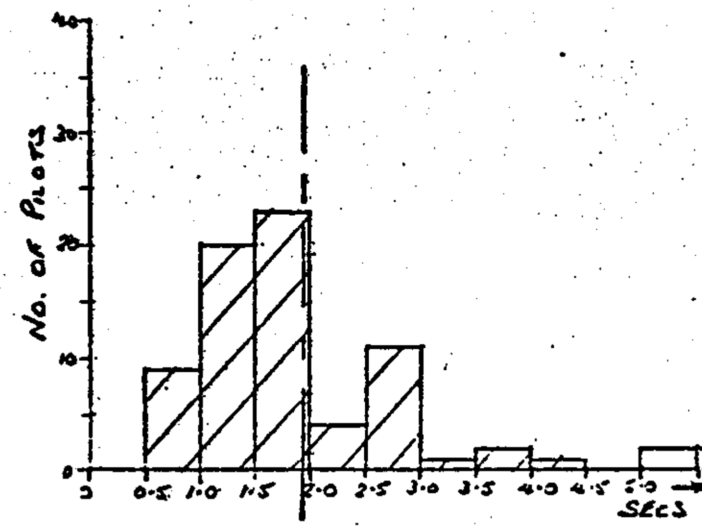
C.18 VERTICAL SPEED



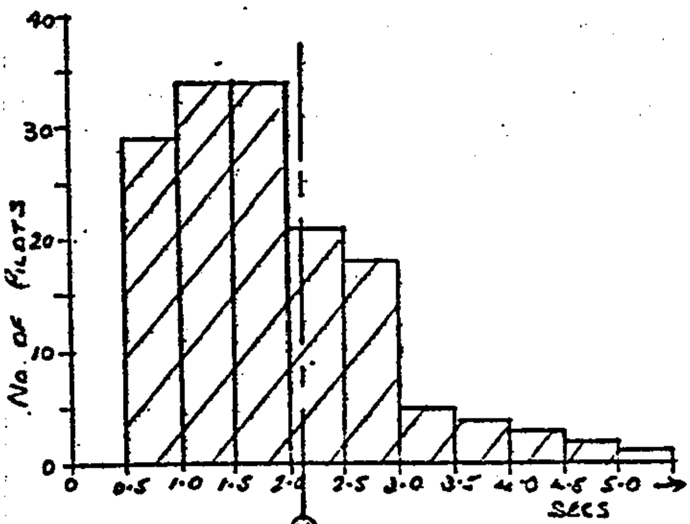
C.19 LATERAL NAV. ERROR



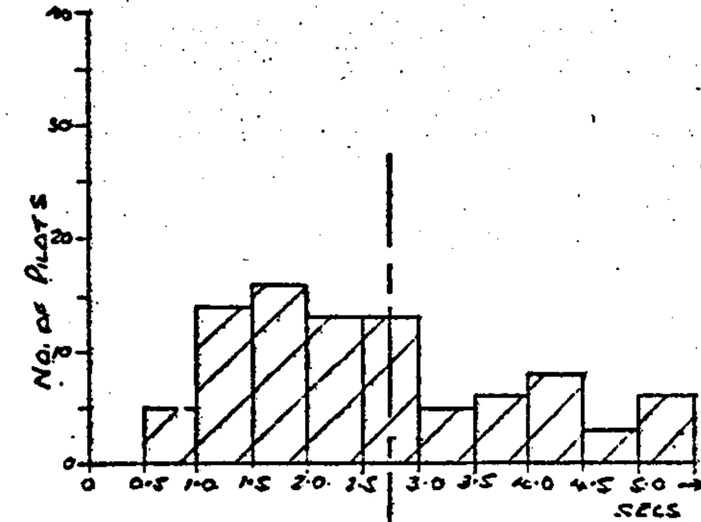
C.19 LOCALISER DEVIATION



C.21. BANK ANGLE (ROLL)



C.21. PITCH ATTITUDE



C.22 FLIGHT PATH ANGLE

NOTE

M = MEAN VALUE

A2.4. Pilots' Ratings, Comments, Reading Errors and Reading Times on EHSI

A2.4.1. Pilots' Ratings

The pilots' ratings for the EHSI, questions D1 to D25, are all shown as dot scales. The ratings are given in the order that the questions appeared in the Questionnaire.

A.2.4.2. Pilots' Comments

The comments are from:- the pilots' notes in the Questionnaires (Q), the debriefings following the exercises (D1) and the interviews at a later date (D2).

	Pilot Nos. Q	D1	D2
D.1. AP/CWS/FD/AT/Pitch Modes/Nav.Modes/ Sync. Indications			
Not obvious enough. Well inferior to mechanical multicolour modes.	1		
Doubts about logic, but probably stem from controller.	3		
Modes did not conform to switching logic.	4		
Modes will be satisfactory with practice. How about pitch over roll?	6		
Liked layout but it would be easier to locate modes with better identification, e.g. colour	13		
Difficult to find quickly. Would prefer a totally different display - even non-electronic	16		
Require too much interpretation.	15		15
Easy to misread	3,14		
AP/FD/AT could be displensed with, except on EHSI failure.			2
Tend to be cluttered.			14,19
Not compulsive enough.		4,18 20	
Would be better on AFCS controller.			3
D.2. ETE/DIS/GND SPD/TAS Indications			
TTG instead of ETE	13		
Time instead of ETE	15		

	Q	D1	D2
ETE not clear. Ground Spd. & TAS superfluous.			3
D.3. VOR/DME/ADF Indications			
Want digital indication of VOR as cannot select VOR and ADF together (may be confused)	8		
No indication of ADF ident.	16		
VOR/DME good. ADF very poor.	18		
Nothing stands out - "has to be looked for"	15		
Lack of identification	17		
Came close to category of only needed to be displayed on selection. Not very effective.			3
Radio information tends to fill up fast.			14
D.4. CRS SEL/DSR TRK/MAG-TRU/HDG SEL/XTK DIS Indications			
Prefer the digital readouts to be by their controls	4		
Close proximity of actual and selected confusing	15		15
Very confusing. Colour coding to match knobs would help.	16		16
Easy to misread			3,15
Changing digits on Mag. Hdg. annoying. Normally fly analogue			2
Does not mean a lot.			12
Separate out 270 CRS SEL — MAG 252 — HDG SEL 242	19		19
Need CRS SEL, not HDG SEL or a digital readout of Mag.Heading	16		
D.5. Weather Radar			
No comments - not assessed.			
D.6. Nav. Mode Indications			
Display lacked impact or attention getting qualities. A lot to be said for a separate panel.	4		
Never quite got used to looking for "arm" and "capture" here.	8		
Took a bit of finding.	15		
Controlling radio identification not very strong.	17		

	Q	D1	D2
D.7. Marker Indications			
All rather lost amongst a host of other information	15		
Not as good as a light.	17		
D.8. Turn Arrow/Next WPT No.			
Did not see occulting.	2,7,8		
90° indication tends to over simplify.	7		
Meaning not clear. Outside peripheral vision when looking at EADI.	16		
Turn Arrow needs improving.			7
WPT arrow quite clear			14
Not noticed, suggest on EADI.			16
D.9. Course/Track Pointer			
Lot of clutter making difficult to find. Same colour exaggerates problem.	9		
Course and displacement bar could be thicker. Prefer a ∧ for "to" and "from", but arrow at end would do.			6.
D.10. Bearing Pointers			
(A) and (V) not sufficiently distinctive, easily mixed.	1	10	5,16 19
Mixed tails (V), (A) and (N) too small and lack impact.	4		
Not very clear	6		6
Lot of clutter making difficult to find. Same colour exaggerates problem.	9		
Do not like double pointer.	9		
Too small. Blotted each other out when close. Suggest different sizes or an overlapping design.	16		
Lack arrow heads.	17		
Easy to misread bearings.			3,15
Could be removed when on ILS.			9
Difficult to use because of single endedness of needles (No back bearing for ADF)			3,12 7,15
ADFs were artificial			19
Tended to "click" around			16

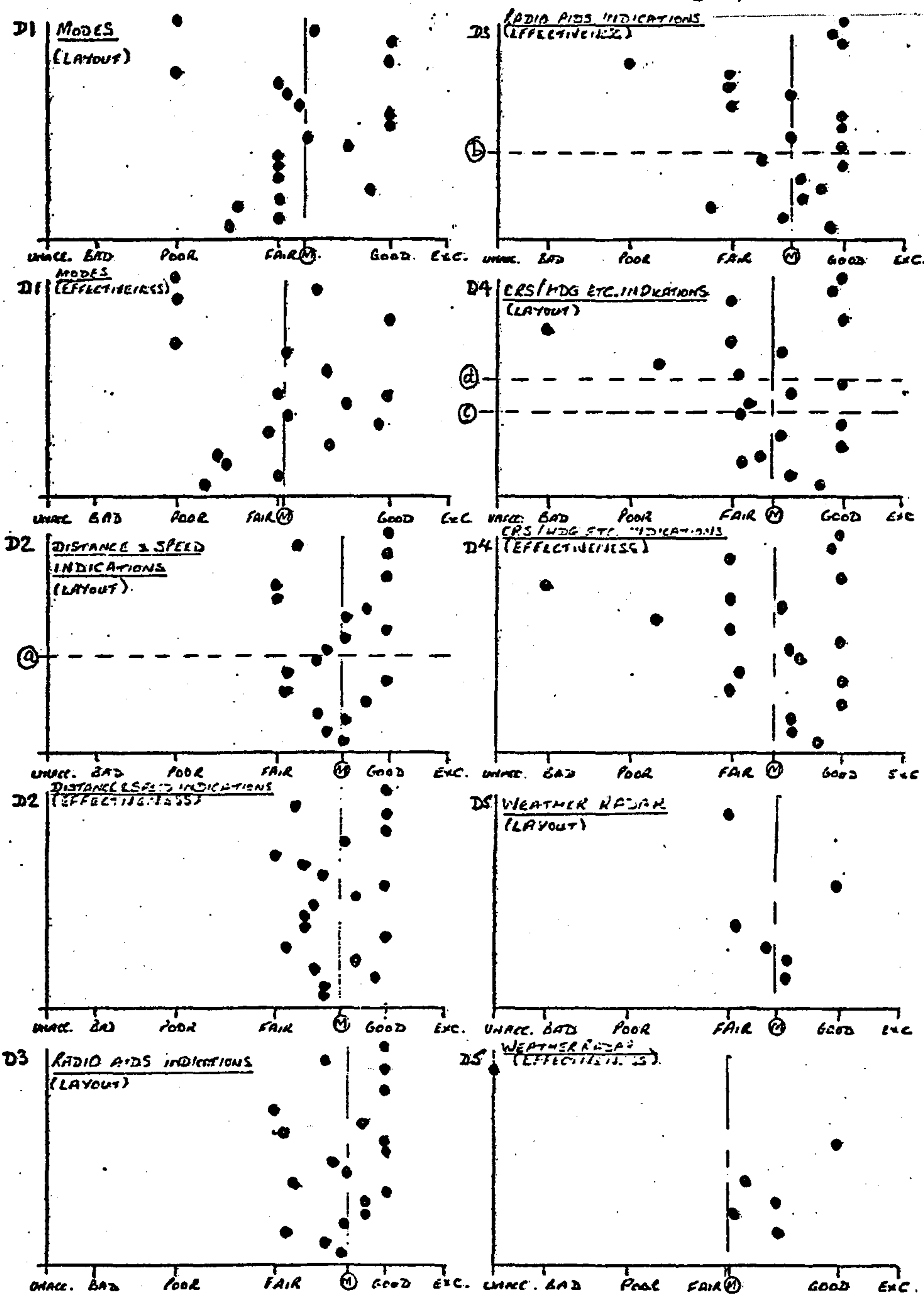
	Q	D1	D2
Used to having a point at end of needle.			2
Room for improving needles.			1,2, 9
D.11. <u>To (T) or From (F) Indications</u>			
No Comments.			
D.12. <u>Heading Bug</u>			
Lacks advantage of colour, and shape is not distinctive.	4,14		
Would prefer 	13		
Has no point for accuracy.	9		
Too small	16		
Lacked differentiation.	17		
Not clear		18	9
D.13. <u>Drift Indication</u>			
Would prefer closer to Rose	5,16		7
Want tail to	6		
Jittery and moved in jerks.	9,16		
Does not always show behind lubber line.	13		
Needs to be more distinctive.	14		
Lacked differentiation.	17		
Drift could be bigger again.			6
Liked		8	
Lost occasionally		13,18	15,16
Should be under Groundspeed.			19
Not clear			9
D.14. <u>Fixed Lubber Mark</u>			
45° marks should be considered.	3		3
D.15. <u>Lateral Deviation</u>			
Assumed scale moved.			5
Cross-bar did not stand out			6

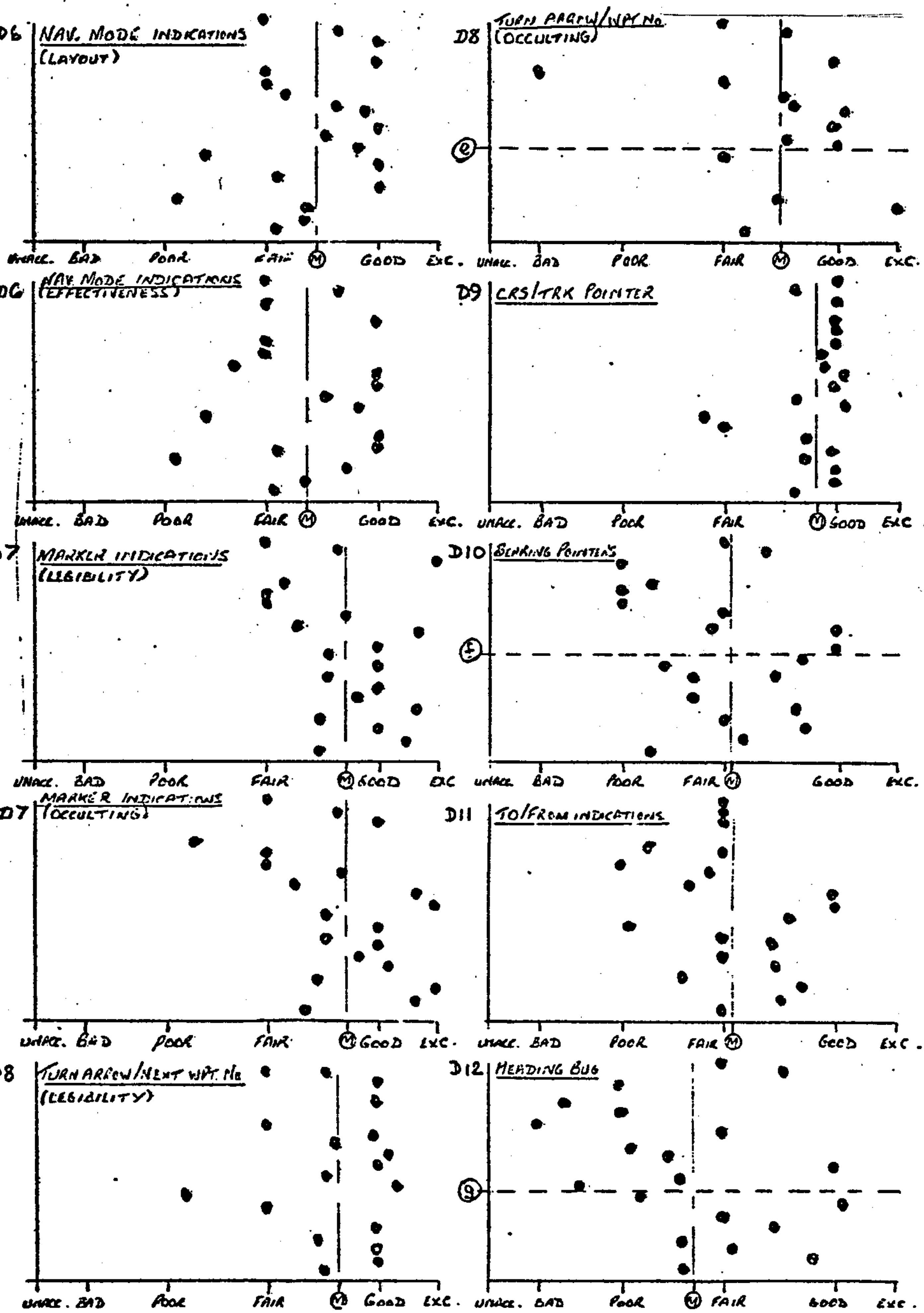
	Q	D1	D2
D.16. Vertical Deviation			
"N↑" beside compass rose looks like North.	16		
D.17. Compass Rose			
Dots not as good as lines for scale marks.	5		
Suffered from random jitter.	16		
Graduations not too clear	4,5		
Movement unnatural			15
Different scanning rates for graduations and numbers			6
D.18. Compass References			
Easy to misread compass heading.			15
D.19. Slew Rates			
Heading difficult to control.	3		
Better balance needed.	6		
Except for dead space, course quite good.	11		
Excellent to have knobs which feel like the symbols they control.	16		
Too much attention occupied.	7,16		
Not liked in principle.	9		
Heading too fast.	14		
Unacceptable		All	All except 4
Heading poor		8	
D.20. Angular Marks (Map)			
Not meaningful	3		
Prefer all angular marks at some range.	16		
D.21. Aircraft Symbol (Map)			
No comments.			
D.22. Range Marks and Scales (Map)			
Range marks predominant.	14		
Suggest compass rose on outer range scale. No reason to distinguish between Rose and Map.			3

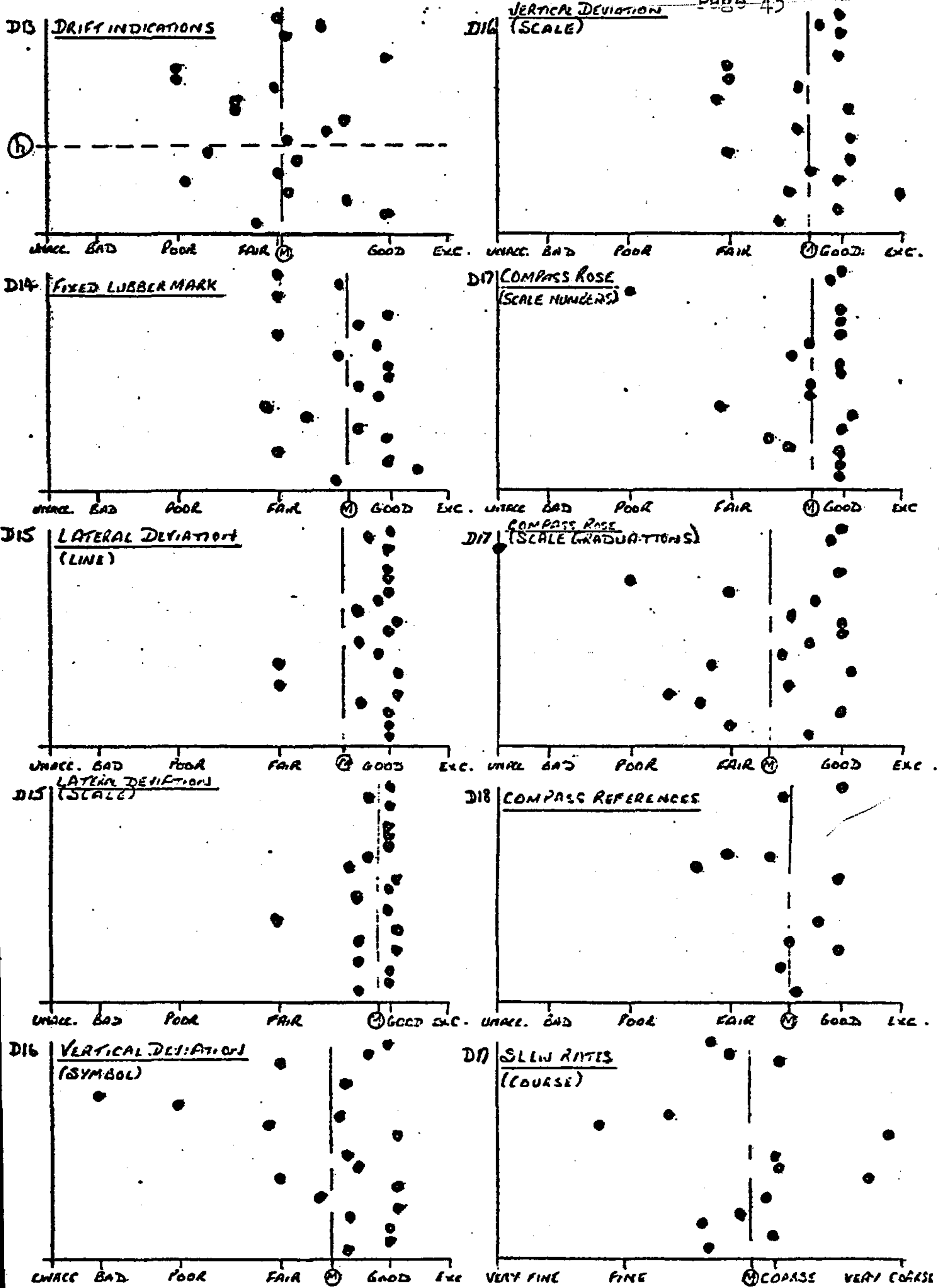
	Q	D1	D2
Range marks good, but range difficult as scale seems spearated from the rings. When "RNG 5" rests on the second ring from the aircraft symbol it might mean 5nm on that second ring.	16		
D.23, D.24, & D.25. <u>Circle, Star, Wheel (Map)</u>			
Could not distinguish one from another when cross-cockpit monitoring.	16		

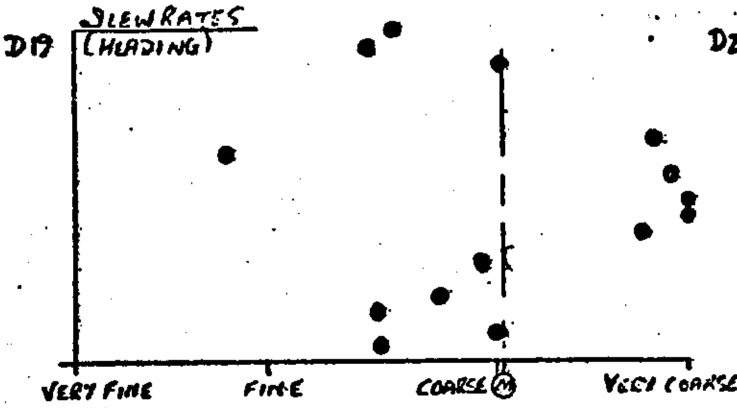
A2.4.3. <u>Errors Made in Reading</u>

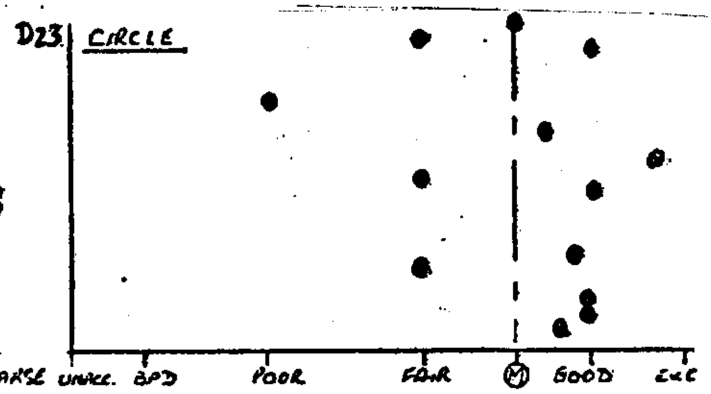
	Pilot Nos. Numbers in () indicate more than one error
a) <u>True Heading</u>	
Gave Magnetic Heading	12(2)
b) <u>Radials</u>	
Read wrongly	2(2), 3(2),4
Read as a bearing.	3,5
c) <u>QDM</u>	
Gave QDR in error	7
Misread	10,13,16,18
d) <u>Drift Angle</u>	
Misread scale	8(2),14(3),15, 18,19
Halved scale	16
Read Track Error in error	10
e) <u>Range</u>	
Misread Scales	9,11,18

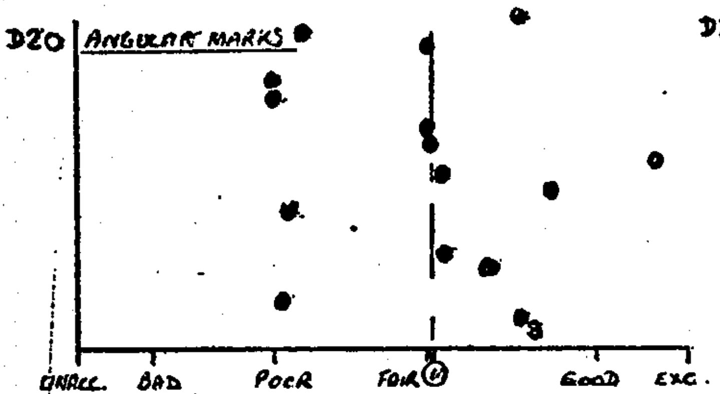

D1 MODES (LAYOUT)
D5 RADIO AIDS INDICATIONS (EFFECTIVENESS)
D1 MODES (EFFECTIVENESS)
D4 CRS/HDG ETC. INDICATIONS (LAYOUT)
D2 DISTANCE & SPEED INDICATIONS (LAYOUT)
D4 CRS/HDG ETC. INDICATIONS (EFFECTIVENESS)
D2 DISTANCE & SPEED INDICATIONS (EFFECTIVENESS)
D5 WEATHER RADAR (LAYOUT)
D3 RADIO AIDS INDICATIONS (LAYOUT)
D5 WEATHER RADAR (EFFECTIVENESS)
UNACC. BAD POOR FAIR M GOOD EXC.
a
b
c
d

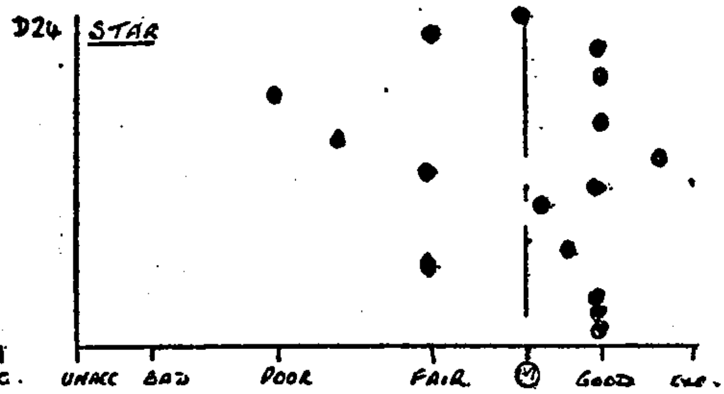

D6 NAV. MODE INDICATIONS (LAYOUT)
D8 TURN ARROW/WPT No. (OCCULTING)
UNACC. BAD POOR FAIR M GOOD EXC.
D6 NAV MODE INDICATIONS (EFFECTIVENESS)
D9 CRS/TRK POINTER
D7 MARKER INDICATIONS (LEGIBILITY)
D10 BEARING POINTERS
D7 MARKER INDICATIONS (OCCULTING)
D11 TO/FROM INDICATIONS
D8 TURN ARROW/NEXT WPT. No (LEGIBILITY)
D12 HEADING BUG

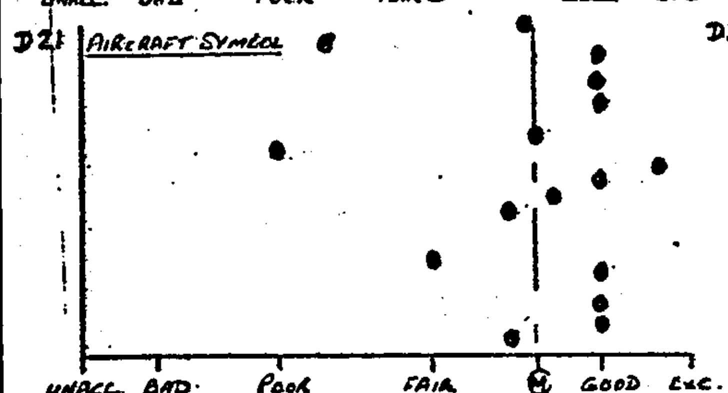

D13 DRIFT INDICATIONS
h
UNACC. BAD POOR FAIR M GOOD EXC.
D16 VERTICAL DEVIATION (SCALE)
UNACC. BAD POOR FAIR M GOOD EXC.
D14 FIXED LUBBER MARK
UNACC. BAD POOR FAIR M GOOD EXC.
D17 COMPASS ROSE (SCALE NUMBERS)
UNACC. BAD POOR FAIR M GOOD EXC
D15 LATERAL DEVIATION (LINE)
UNACC. BAD POOR FAIR M GOOD EXC.
D17 COMPASS ROSE (SCALE GRADUATIONS)
UNACC. BAD POOR FAIR M GOOD EXC.
D15 LATERAL DEVIATION (SCALE)
UNACC. BAD POOR FAIR M GOOD EXC.
D18 COMPASS REFERENCES
UNACC. BAD POOR FAIR M GOOD EXC.
D16 VERTICAL DEVIATION (SYMBOL)
UNACC BAD POOR FAIR M GOOD EXC
D17 SLEW RATES (COURSE)
VERY FINE FINE M COARSE VERY COARSE

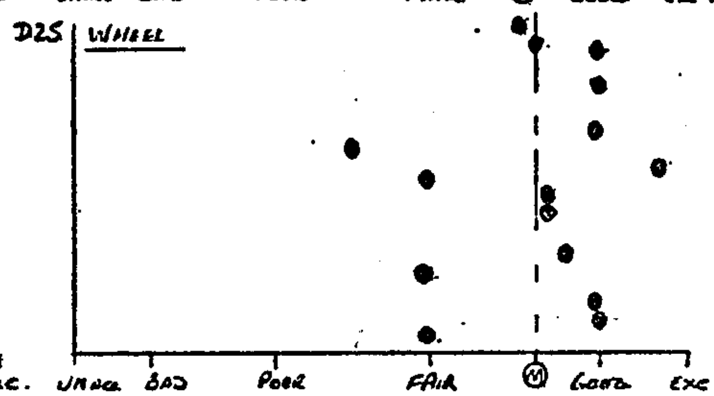


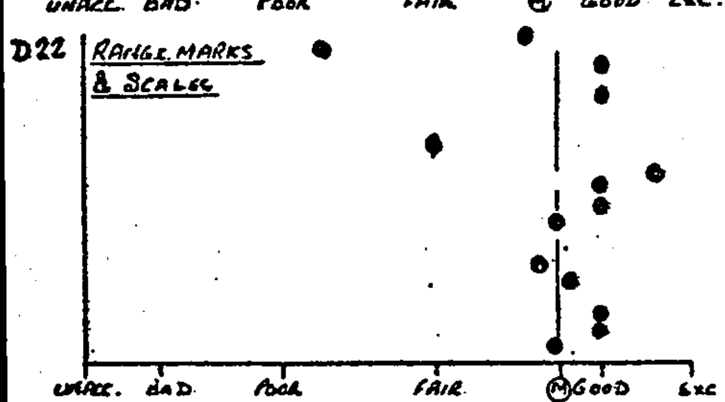










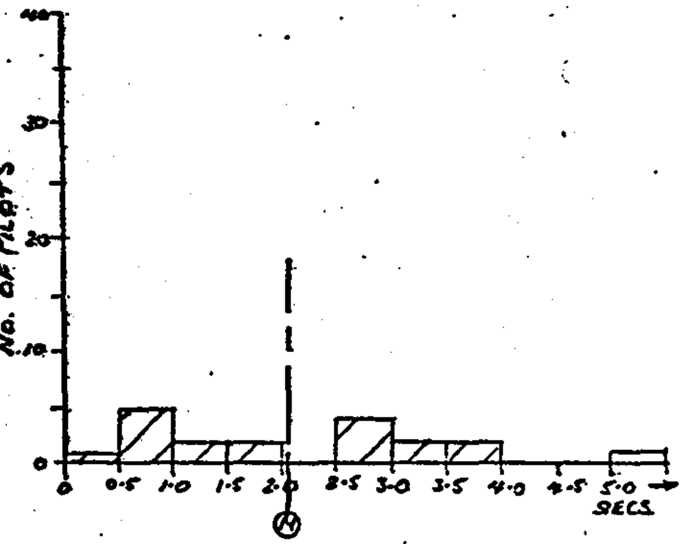


FOR 'KEY' SEE APPENDIX 2, Page 31.

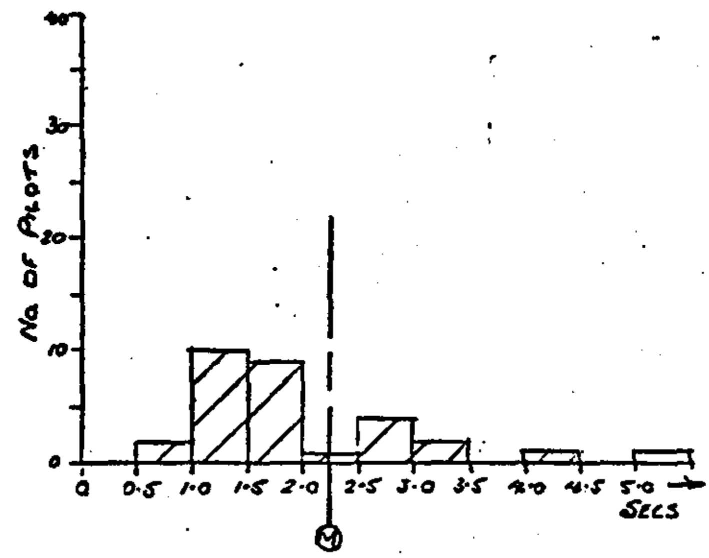
OTES:

- Distance to Next WPT and DME distances include tenths up to 99.9
- ADF numerics larger and leading zeros not suppressed
- Increased spacing between CRS SEL / DSR TRK and numerics and between HDG SEL / XTK and numerics
- CRS SEL / DSR TRK and numerics moved further to left of centre.
- HDG SEL / XTK and numerics moved further to right of centre
- WPT indicator flashes at 1 min. to go and direction in turn indicator flashes in turn with WPT indicator at 15 sec to go
- Priority of course/track bar and bearing pointers: CRS/TRK, Pointer 1, Pointer 2.
- Heading bug moved out from centre.
- Drift bug ▲ to

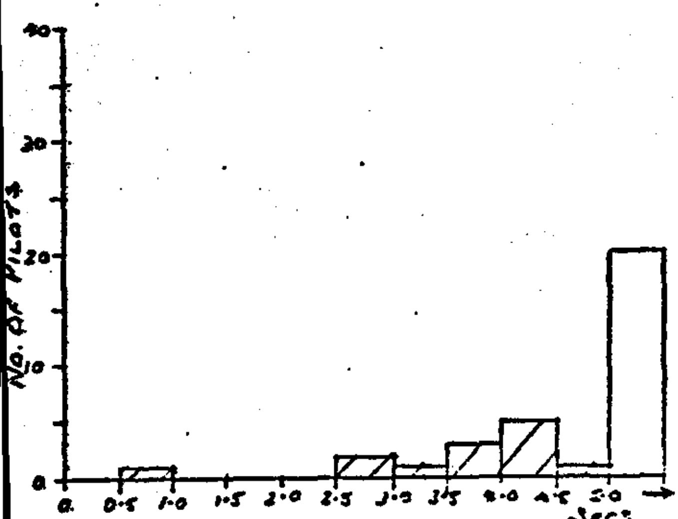
READING TIMES



D3. DME TO 'DET'

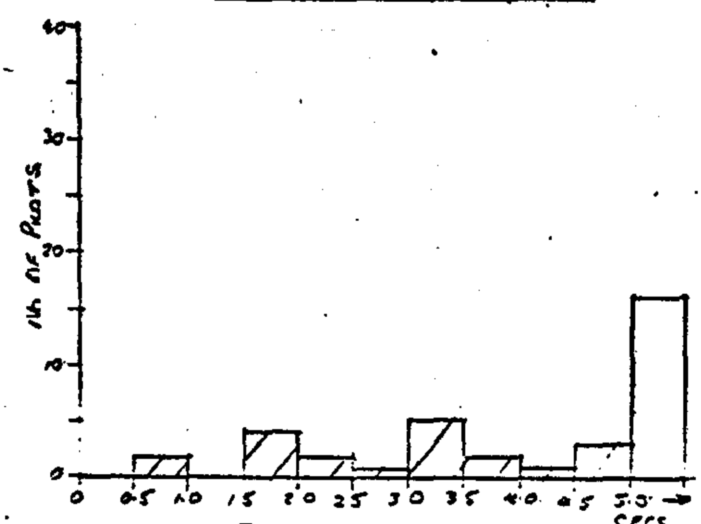


D3 DME TO 'CDG'



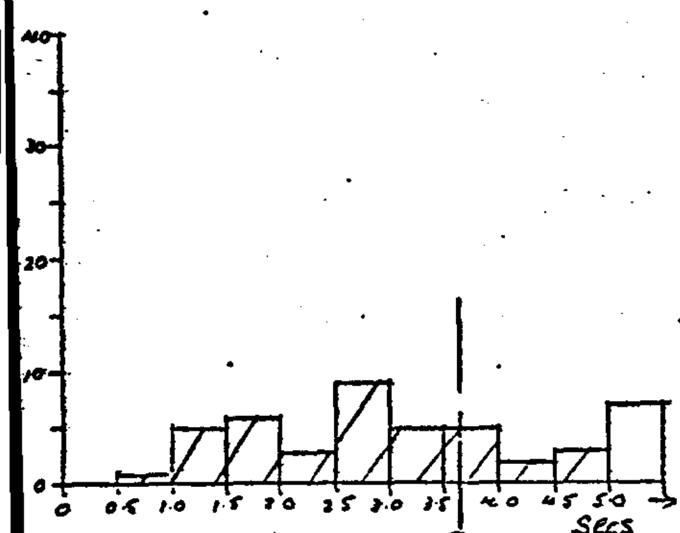
M = 5·8 SECS

D4. TRUE HEADING (REQUIRED A SELECTION IN MOST INSTANCES)



M = 5.3 SECS

D10 QDM TO 'RSY'



D13 DRIFT ANGLE

NOTE:

A2.5. Pilots' Comments as Recorded in the Debriefings.

A.2.5.1. Pilots' Ratings

Question A.19 was not a specific question about the EADI or EHSI and therefore is not included in Paras. A2.1. to A2.4. The ratings to this question are shown as a dot scale.

A2.5.2. Pilots' Comments

Comments of a general nature from both of the debriefings are included here. There were some comments about specific parts of the EFIs which the questionnaires did not cover and these are also included as are the comments to question A.19.

	Pilot No.
1. What are your general impressions of the Electronic Flight Instruments as shown?	
Could be developed into a usable system, but not convinced of advantages over mechanical. Do not see any operational advantages.	1
Generally comparable to conventionals. Simpler than Phase 1 formats. Flew more accurately with them.	2
Favourable	3,5,12,13 14
First impressions marred by some faults.	4
Confusion to start with. Tends to be some duplication which could be an advantage with familiarity. More work needed on HSI.	6
Good - terrific potential	7
Impressed, not so legible as mechanical. No objection to philosophy.	9
Good- flexibility an advantage.	10
Adequate, except Rose. Too much information in a small space on the EHSI.	15
Can fly satisfactorily. Not normal to certificate "handed" instruments.	17
Flyable. Mainly attitude orientated.	19

2. Is lack of Colour a disadvatage?

Colour is wanted. Lack of discrimination is a disadvantage. Limited number of colours would be a substantial advantage.	1
Some parameters may benefit from colour, e.g. V2 and altitude below 10,000 ft., also Flight Director pitch bar. Need to do a comparison to evaluate.	2
Would help, not a serious disadvantage.	3,5
Yes, particularly for needles and bugs on EHSI.	6
Do monochrome first.	7
Some detail, e.g. altitude, would be improved.	11
Yes, blue/brown for Director. Not essential for short range, but creates interest for the eye.	12
Limited amount would relieve clutter.	14
Generally no. Possibly desirable for specifics, e.g. Pitch Scales and Flight Director.	15
Colour necessary. Particularly for HSI, ILS raw data and Flight Director.	16
Lack of differentiation of pointers at top of ADI or HSI - need colour. Warnings better with colour, e.g. ALT ARM and ALT Capture.	17
Would be a tremendous advantage, particularly for HSI. Would make MAG HDG stand out. Also fo Altitude and Speed digits which would increase scan rate. Centre of ADI.	19
Needed for Flight Director, Flight Path Angle, Potential Flight Path Angle and AFCS Modes.	20

3. Is lack of Depth a disadvantage?

There is lack of depth but not a disadvantage.	1,9,11,14
Not conscious of	2,5,
Parallax is always a disadvantage.	3
Mainly in centre of ADI.	7
May be advantages in cross-cockpit monitoring.	12,19
Prefer depth, but not a significant disadvantage.	15
Advantage for training.	16

4. Was there a Reduction of Scanning?

Do not thinks so. These days one has a central scanning technique.	1

Not significant	2
Can fly just on EADI on approach	3
Yes, easier to keep up scan pattern in a smaller area.	5,12
Not particularly	6
Further than Phase 1 formats.	7
Yes, scan within ADI good. Analogues, but not digits, easy to scan.	9
Yes, can see VSI moving in corner of eye.	11
Not conscious of.	14
Reduces scanning, but distracting to have to sort information.	15
Maybe, but workload may be higher because more information being computed.	16
Scan is very big.	18
Reduced, but tendency to lock onto one parameter. One can keep a tight scan on the approach.	19
5. <u>Is the Basic "Tee" the Correct Philosophy to adhere to?</u>	
One should not be constrained, but there is not much room for manoeuvre.	1
Easy to read. Would have been more difficult in a different format.	2
Satisfactory.	3,4,6,12,14, 15,17
Might in future consider combining Altimeter and VSI.	3
Helped usage. Reduced learning.	5,12
Preferable to horizontal layout.	7
Less likelihood of acceptance if too much change.	9
VSI not as vital as others.	14
Helps a lot. Suggest curling altitude needles (2 degrees of freedom)	16
6. <u>What are your comments on Lateral Scanning?</u>	
Tendency to use one instrument.	1
Difficulty experienced in scanning to and from EHSI, but cannot really comment without a representative navigation workload.	1
Better than expected. Could be better. Tend to regard HSI as additional to ADI. Workload higher when displays reversed.	2

More difficult to scan laterally, but never had to as an instrument task. No objection to lateral scan.	3
Conscious that azimuth information required sideways jump - more difficult.	4
Less need for use of EHSI, therefore position less critical	5
New pattern has to be learned, but would get used to it.	6
Prefer to move away from horizontal.	7
Satisfactory.	7,8,12
HSI not scanned much.	9
Was developing	10
Preferred, especially for reversion.	11
Easier than conventional. Advantages in reversion.	12
Conscious of lateral scan, but acceptable. More tiring then vertical, but may be unfamiliarity.	13
Did not like reversed. Improved as went on.	14
No problem with practice. EHSI better located.	15
No objection. Easy to scan to other side for Map.	16
Disliked offset ADIs.	18
Greater distances, but advantages in panel area.	19
7. Did you experience any Tunnel Vision?	
No more than conventional.	1,9,19
Concentrated on centre of ADI. No particular tunnel vision	3
Yes, ADI attitude overpowering. Small analogues too small.	6
None	11,14,15
Conscious of doing fast scan.	12
Looked at centre of ADI a lot, but may be a function of workload rather than tunnel vision.	16
8. Cross-cockpit Monitoring?	
Was a problem due to small size of data.	1
No need	2
No problem	3,7,11,19
Preferred Map on other side.	3
Should be possible. Worried about filters used.	5

No parallax. Amazed at clarity of opposite displays.	9
Rather use co-pilot's CRTs than conventionals in an emergency.	10
To Map easy, could fly using co-pilot's display.	12
None done	14
Cannot see across too well - too far. Better than conventional.	15
Did it for Map, but not all symbols clear enough, possibly too bright.	16
Practicable, except extreme outside digits of F4.	17

9. <u>Is the Philosophy of Producing Formats similar to Conventional Displays correct?</u>

Satisfactory.	1,6,9,11, 12,14,15
Surprised on how easy to use. Doubt if size increase would be of benefit. Arrangements came naturally. A significant feature.	2
Reduces learning.	15

10. <u>Which parameters do you think need only be displayed on selection?</u>

Difficult - did not use HSI much.	1
Seems adequate.	2,12

11. <u>Are there any parameters which could be dispensed with?</u>

None	5,9,11,12,15
Track Heading Error.	19

12. <u>Parameters difficult to understand or use?</u>

None	9,11,14

13. <u>Shading</u>

Satisfactory.	1,5,6,9,12, 14,15
Did not matter much, would be nice to have it blanked. Independent control of brilliance wanted for centre of ADI	17
Sky a bit bright, rather distracting.	19

14. <u>How should the Brilliance and Contrast be Controlled?</u>

Auto for normal operation, manual override for reversion.	1,3,11

Single adjustment with auto level sensing.	2,4
Some pilots would want to make changes to suit themselves.	6
Probably want control in air - a guess.	9
Definitely manual.	12,19
Displays should not be linked. Shading on ADI needs separate control. Auto compensation with manual override.	14
Probably a single manual control.	15
Each instrument control to be set before starting. Auto override.	16
15. Were there any annoying or unnatural movements?	
Change of contrast of ADI. Slight stepping at low roll rates.	1
None	9,11,12,14
Small changes in Pitch and Bank Angles.	19
16. Clarity of Pointers?	
Did not have same discrimination as conventionals.	1
EADI satisfactory.	2,9
A little 'weedy'. No strong criticism.	15
Sizes on HSI badly matched.	16
17. Benefit of Pointers for Altitude, Speed and Vertical Speed?	
Yes.	1,2,3,5,6,8, 14,15,19
Essential for altitude and vertical speed, but not for airspeed although nice.	11
18. Do you prefer dials or strip displays for Altitude, Airspeed and Vertical Speed?	
Dials.	1,2,3,5,6,7,9, 11,12,14,15, 16,19
Vertical speed of secondary improtance.	2
No objection to strips.	12
19. Clarity and Shape of the Alphanumerics?	
No difficulty, except '8s' and '1s'.	2
Satisfactory.	3,11,12,14,15

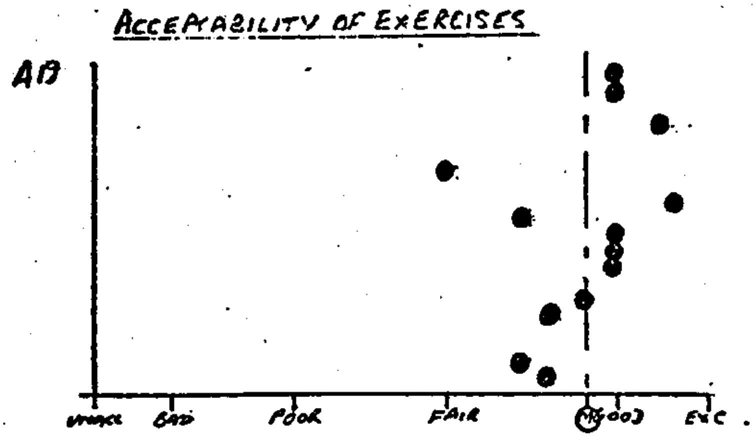
Just large enough.	8
Inverted not as clear, but not sure it matters.	9
Very good.	13
Symbols could be bolder. Not enough contrast between primary and secondary symbols.	15
Captions on Map too small.	16
20. <u>Were any parts of the displays cluttered?</u>	
Problems on HSI.	4
Not conscious of any.	5
All tend to be cluttered. Dials almost too small. Generally liked ADI information in small place, but smaller dials have not got the same cues.	6
Approach on ILS.	7
Arrow heads on HSI.	19
Top of Map.	16,20
21. <u>Usefulness of EHSI Map?</u>	
Map not used.	1,3,5,6,7, 14,15
Worth retaining.	1
Excellent for En-route.	2,5,6
Liked	4,10,12,18, 19,20
Not happy with heading on it.	4
Radial lines, e.g. line up middle would help.	9
Tremendous for appreciation of WPTs etc. Would be nice to select own scale. Cassettes could be used for setting up.	11
Content excellent.	12
Felt some data lost.	13
Essential for orientation, e.g. on runway.	16
Would have liked TRK miles to next but one WPT.	16,19
Scales at top confusing.	19,20
22. <u>Aspects of EHSI not covered?</u>	
Clutter and lack of discrimination.	1

Too much information on Rose.	2,18
CRS bug not prominent enough.	3
23. <u>Remoteness of Controls</u>?	
Not used to being remote.	2
Rather have CRS readout by knob.	4
Satisfactory.	1,7,11,12, 16,19
Confused SPD and SPD Command initially.	8
Prefer adjacent to knob or to have both.	9
No different to conventional.	14
Want readouts for altitude and speed select with controls.	15
Not liked. Unsure need more practice.	18
24. <u>Reach of Controls</u>?	
Satisfactory.	1,5,12,14,16
Right-hand CRS select could be closer to centre.	6,19
Want Left-hand control for Left-hand compass and Right-hand control for Right-hand compass.	6
Radio selectors rather forward.	3,5,9
25. <u>Pushbutton Selector?</u>	
Not fully satisfactory.	1
Difficulty with logic. 3 functions not desirable.	2,17,19,20
Logic satisfactory.	3,11,12
Difficulty in finding 'Off' on VOR/ADF - maybe unfamiliarity. Would like the captions illuminated rather than black on illuminated background. Symbols should be illuminated. Idea sound.	5
Want to select No.1 VOR and No.1 ADF at same time.	8
Marginally acceptable. Found confusing.	9
Prefer rotary.	9,15
Merit in combined buttons and lights.	15
Did not like hidden functions. Would be happier if two captions written on each and light went dark for 'Off'.	16
26. <u>AFCS?</u>	
Very cramped/cluttered.	1,4

Shape coding satisfactory	1,16
Some logic needs clarifying.	3,5,9
Seemed over sophisticated.	6,7
Do not often use lights in buttons.	9
Panel not broken into batches of controls.	9,10,13
Colour coding would help.	17
Switches too similar to cause confusion.	9,10,14
Flight Director switch poor.	12
Autopilot engage switch should be substantial.	12
Warning and engagement states inferior to conventional systems. Failure indications not sufficiently pungent. ARM indication and operation -poor philosophy.	15
Arrangement will only increase workload.	15
Mistook Altimeter and Flight Director switches, also the Autothrottle and Autopilot switches.	16
ALT ARM and ALT Capture too similar.	17
Altitude knob too long, obscures Vertical Speed.	17
Too easy to push HDG SEL button when making a change. Pity cannot have V_{REF} without selecting Flight Director or Autopilot.	17
Confused Altitude with Speed at one time. Some of the philosophy has gone back 20 years. Does not allow fair assessment of displays.	18
There is a problem of parallax. The rows of buttons tend to look like rows of 'soldiers'.	19
Workload very high with AFCS.	20
27. <u>Aspects of Programme found Tiring or Tedious?</u>	
Unrepresentative workload and environment.	1
Poor handling gave too much to do.	2,6,9,11
Missed not having throttles moving when on autothrottle.	3
Difficulty with navigation and assimilating data.	5
Good way of progressively building up.	5
Tasks and programme realistic.	9
AFCS most difficult part.	12
One day was too short.	6,12,14,15

Door opening and light changing outside. People walking about.	16
28. Any Eye or Mental Fatigue?	
Comparable with conventional, but had eye strain and was tired.	1,3
Very tired.	2
None	4,5,6,7,10, 11,12,13,14, 15,16,17,20
Had some mental fatigue, but probably a function of handling and clutter on centre.	9
Less fatigue than with conventional, if anything.	19
29. Any annoying distractions or Flicker?	
None	1,2,5,9,10, 12,14,15,16, 19
Some changes good as they caught one's eye (e.g. fuel).	3
None noticeable with more data displayed.	6
Occassionally flicker on ADI 'sky'.	7
Did notice flicker in peripheral vision, but only distracting to a small extent.	11
Flickering nature of digits changing disturbing (Largely noticed on ground).	17
30. Influence of Handling Characteristics on Ratings?	
Would have been easier with better handling.	1
Did not affect ratings.	3,5,11,12,15
Probably some influence.	6,9,19,20
Concentrated on raw data.	14
31. Had documentation been studied beforehand?	
Yes, in depth.	2,3,5,6
Yes, cursorily.	9,11,12,14, 16
No.	1
32. Did the short briefing affect the assessment of the Displays?	
Satisfactory.	1,3,6,8,11, 14

Hard to store as rate of briefing high.	2,16	
A lot to do in the time.	9	
Did not affect assessments only the rate of making intelligence of the displays.	12	
33. <u>Aspects lacking in the Briefings?</u>		
Logic of some design aspects.	3	
Navigation.	5	
Autpoilot and AFCS.	6,12,19	
34. <u>Preferred Method of Briefing?</u>		
Say ½ hour followed by a ¼ hour demonstration.	1	
Briefing and practice one day, exercises next.	2	
Reading should be mandatory.	3	
Could have got more out of it if simple tasks done.	4	
Demonstration is best method. Brief on philosophy, follow with demonstration.	6	
Would have liked ½ a day before exercises.	9	
Instructor to do it, pilot to follow.	12	
No ideal method	14	
35.and Q.A.19 <u>Further Comments on Programme and Exercises</u>	A.19	D
Cannot make a final definitive assessment without the Flight Director working properly, as this is very widely used for guidance - otherwise a realistic trial, but more than one day needed. Ideally 1 day for familiarity, then a gap and then a ½ day actual assessment.	1	
Tasks too numerous for one day.	2	2
More time needed.	14	14
Not a personally satisfactory exercise, but one could become more adept with practice.	14	
Need a more representative navigation workload.		1
Want more use of autopilot		2
More evaluation of EHSI needed.		3
Lack of time to stop and ask questions.		7



For 'KEY' see Appendix 2, Page 31.

APPENDIX 3

RESULTS OF BACK-PROJECTED OPTICAL DOCUMENTATION DISPLAY ASSESSMENT

(SEE CHAPTER 27)

A3.1. Introduction

This Appendix contains a summary of the comments made, and details of the ratings given, in the Questionnaire on the Documentation Display System. Only 13 pilots completed this questionnaire.

A3.2. Pilots' Comments

The comments from the questionnaires and each of the two debriefings (D1 and D2) are included. Only 11 of the pilots who completed the questionnaire were given the second debriefing (D2).

A3.3. Pilot's Ratings

The pilots' ratings for questions 1 to 9 are given together with dot scales of the ratings for questions 10 to 22.

	Pilot No. Q	D1	D2
Questions 1 to 8 (Layout of Controls)			
Layout of controls reasonable, but better suited to right-hand operation, i.e. fitting to P2 side of the Flight Deck rather than P1.	5		
Question 4 (Page No. Indications)			
Slew buttons too fast. Checks start at No.1, thus usually missed - have to reslew to No.1. Prefer a two button forward-back system	3		
Page No. Indicator should be precisely above corresponding page selector button WINDOW WINDOW WINDOW BUTTON BUTTON BUTTON	7		
Much too fiddly and the differing number of steps on the bottom row is confusing. The rate of change of digits needs getting used to.	10		
Question 5 (Page Selector Buttons)			
Prefer 0 - 9, not 0 - 7	7		
Question 9 (Line Step Button)			
Would prefer one button on the Pedestal accessible to each pilot. Did not like the button on the control column.			14

	Q	D1	D2
Question 10 (Check List Character Sizes)			
Could be reduced		14	6
Question 12 (Emergency Checks on red background)			
Colour/size very helpful		16	
Better than some emergency check lists			2
Question 14 (Charts)			
Print too small	1, 16	12 13 16	14
Cannot see being of any use		20	
Not acceptable, would probably have to be in special form, i.e. a restriction on the amount of information presented would be necessary.			5,11
Question 16 (Screen Brightness)			
Good brightness control for check lists, but changed when using map - no great problem	3		
Brightness on half of the page was satisfactory, but the other half was too bright.			9
Question 18 (Fixed lines for locating items)			
Fixed lines one line too high - top line obscured. Suggest leaving page in position and moving fixed lines down one to first Check. Leave title in position.	3	3	
Prefer to have page static and move fixed lines		17	
Question 19 (Philosophy of Indexing)			
Numbers remembered - should be a quick system	3		
Prefer to be able to wind through index with a thumbwheel and use the Page Enter button to go to the page currently in the fixed lines instead of using numerical codes.	16		
Would be better with a decent indexing system			1
Question 20 (Page Selection procedure)			
Slew button difficult to use		16	
Difficulty was mainly because the buttons were on "zero" and most checks came up on "ones"		1	
If missed had to go all the way round		16	
Tended to forget jump from 7 to 0			5

	Q	D1	D2
Paper Checks faster		6	
The number staying where it was when checks changed pages was satisfactory as one could go back		13	
Button pressing was complex		14	5,6
Prefer a rotary dial selector			6
<u>Question 21 (Emergency Drill Override)</u>			
Philosophy seems good providing the integrity of the switching is high	5,6	9,17, 19	5,6, 8,14
Would like a recall system after the emergency to continue with normal checks	3,14		
A page back button needs considering.	3		
Logic needs discussing			3
In a perfect world it might work, in the real world it is unacceptable	7		
Had some reservations, e.g. Would one misidentify an emergency displayed itself? A better alternative would be an index of emergencies for the pilot to choose the correct one. Better still would be an internal monitor that identified if the wrong emergency page was called up with the emergency being signalled.			6
<u>Question 23 (Potential)</u>			
Will reduce workload	3		
Expensive to do what paper will do		8	
Considerable step forward over paper		9	
Not ideal and a large piece of equipment for a limited use		9	9
CRT infinitely better, equipment is already there and can be used for alterations		9,18 20	2
Has disadvantages but is usable		13	
Easy to use as a Check List but not easy to go back and down another branch of the hierarchy		16	
Would not spend money on it as a separate display		18	
Idea good, but never get all one requires on this display because it is too far from the eye. Would have thought the RCA WX system would be the way it goes.		20	

	Q	D1	D2
Would be of use as a documentation display. Perhaps someday a mag. tape will be used.	1		1
Worth continuing development. Updating a problem			2
Tremendous scope which is far better than the CRT			3
For check lists system has potential, but not for charts. It is worthwhile retaining, but decision is fairly close			6
Liked it for checks			11, 14, 19
The possibility for aircraft information is excellent, but special maps would be needed.			11
<u>Question 24 (Further Development)</u>			
Indexing to reduce workload	5		
Lighting to reduce the amount of uninformative light from the screen	5,9	9	
Presentation of charts to be improved	5,11, 14		
Amendment state must be clearly given for all information	5		
The number selection by button must be improved. The response time for button pressing must be improved and at the same time whilst holding the button down the cycle frequency must be decreased. It is difficult to advance the numbers by single presses of the button and also when holding the button down it is difficult to stop the numbers at the right one.	6,10		
Documentation needed:- weights, performance, diversion requirements, limitations, paper work, maps, charts, systems diagrams, supplementary emergency information.	3,7		
The ability to amend one line or part of one line must be designed into the system so that minor and major amendments can be made at a "stroke".	7		
More logical sequencing of normal check lists. Use of BITE's to reduce numbering of items to be checked where possible.	4		
The problem areas are:- (1) it ties the head/eyes to one narrow corner of the Flight Deck while the check list is in use, (2) How reliable, mechanically, will it be? (3) How easy to amend? (4) Would paper still be needed in the event of failure of the system?	1		
Graticules were visible, display could be clearer		5	

	Q	D1	D2
Integrity - needs possibly an automated lag.e.g. page not displayed until a button is pressed.		9	
Do not like pages changing when illuminated		9,14	9
Integrity must be watched			5
<u>Question 25 (Comment on information displayed)</u>			
Check List contents about right	5		
Print size on checks too large	5,6, 14		
To display charts a much larger screen size is needed	6		
Might be a good idea to keep the screen checks & drills for abnormal management only. There are several occasions when simultaneous viewing of check lists and charts are needed.	6		
Adequate	9,10, 11		
Track orientated standard routes could give a cheap moving map.	3		
All manuals and documentation can be integrated into the system	7		
One function one can do with a CRT that cannot be done with this system is that if one decided to do a check later software can be produced to rearrange the order of the checks.			16
Colour is essential			14
<u>General Comments</u>			
Fault in Ex. 6 identified first by Check List		10,12 16	5
Fault identified first by MWS		7,20	
Fault identified by MWS and Check List simultaneously		11	

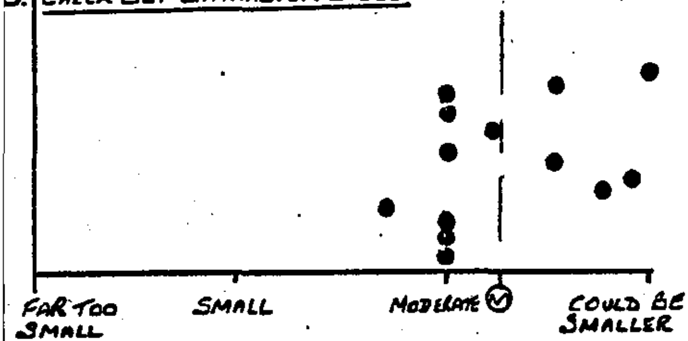
RATINGS

QUESTIONS 1 to 9

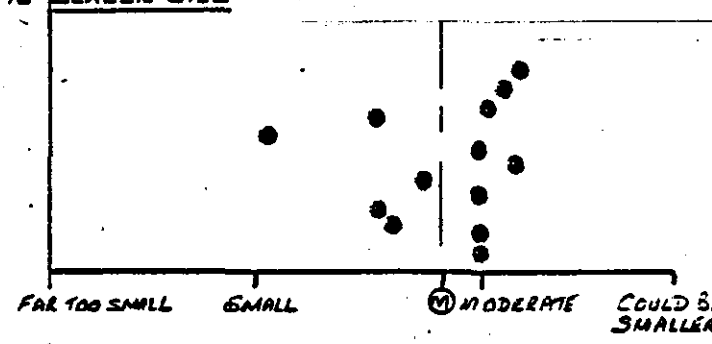
Question No.		1	2	3	4	5	6	7	8	9
Item		Off Button	Brightness Control	Index Button	Page No Indics.	Page Selector Buttons	Page Enter Button	Page Advance Button	Back Page Button	Line Step Button
Position	Bad	-	-	-	1	1	1	1	1	-
	Poor	-	-	-	-	-	-	-	-	-
	Fair	3	3	5	1	3	3	2	3	4
	Good	8	7	6	8	6	7	8	6	7
Function	Bad	-		-	-	2	-	-	-	-
	Poor	-		-	-	1	-	-	1	1
	Fair	1		1	2	3	2	1	1	4
	Good	10		10	8	4	9	9	8	6
Hold-down Function	Bad				1	1			-	
	Poor				1	1			-	
	Fair				2	3			3	
	Good				2 (?)	1 (?)			1 (?)	
Colour	Bad	-		-	-	-	-	-	-	
	Poor	-		-	-	-	-	-	-	
	Fair	2		3	1	4	6	4	5	
	Good	9		8	8	6	5	5	5	
Shape	Bad				-					
	Poor				-					
	Fair				1					
	Good				8					

Question 23 Potential for aircraft operation: Yes 11
No 1

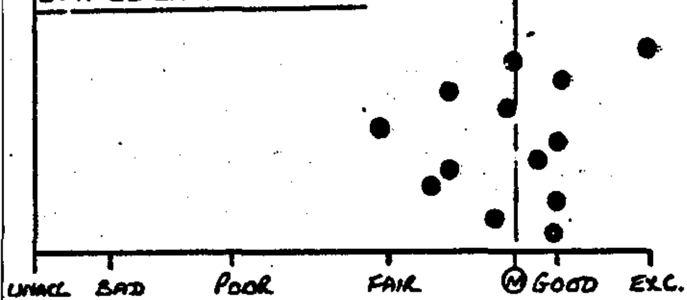
10. CHECK LIST CHARACTER SIZES



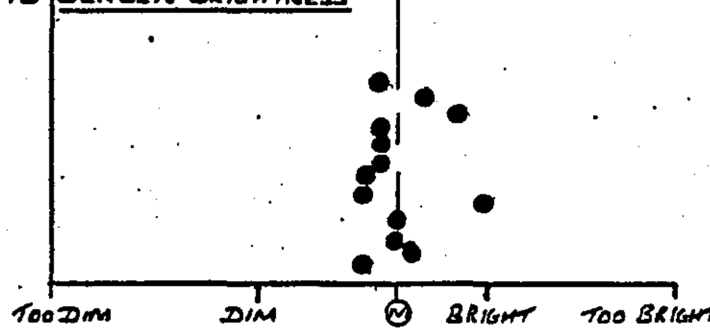
15 SCREEN SIZE



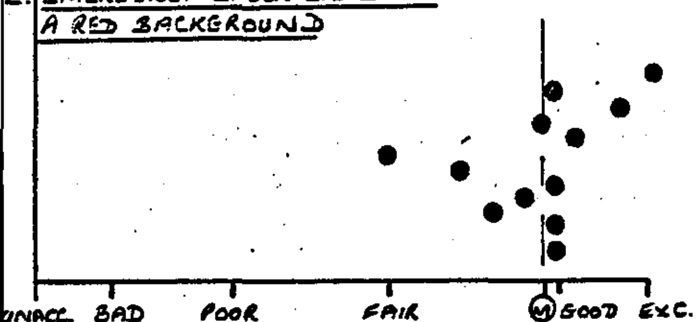
11. CONTRAST OF WHITE CHARACTERS ON A BLACK BACKGROUND



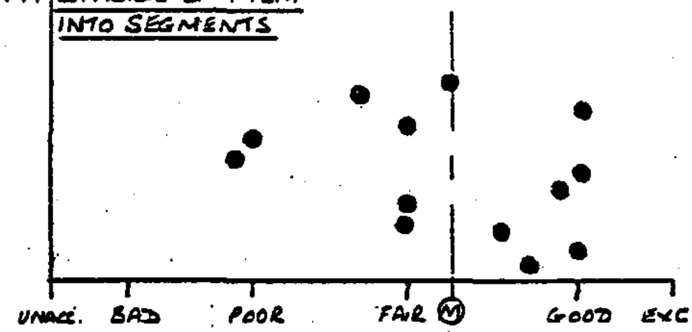
16 SCREEN BRIGHTNESS



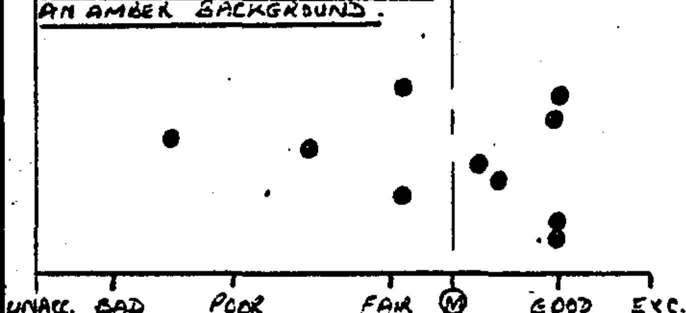
12. EMERGENCY CHECK LISTS ON A RED BACKGROUND



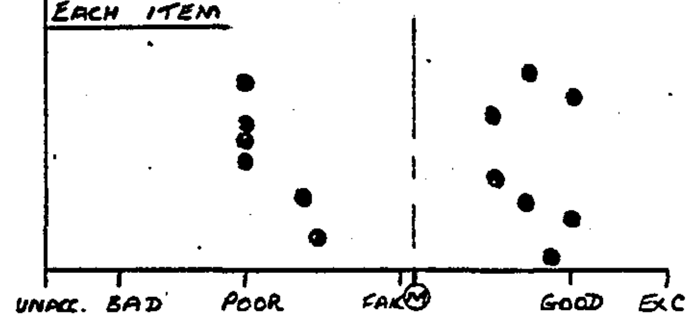
17. DIVISION OF FILM INTO SEGMENTS



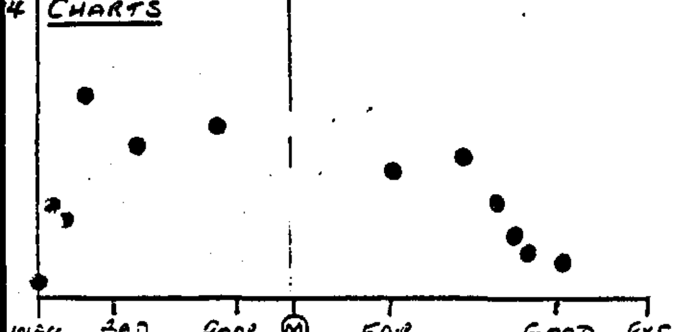
13 EMERGENCY CHECK LISTS ON AN AMBER BACKGROUND.



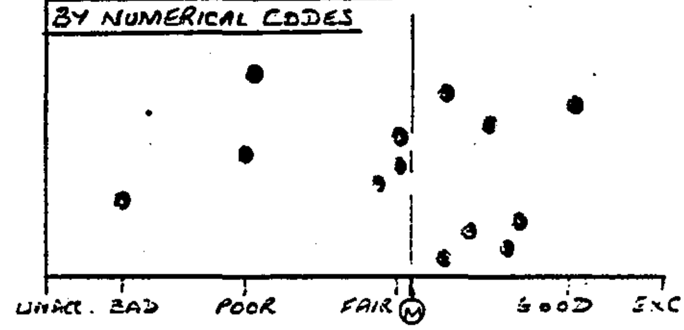
18 FIXED LINES FOR LOCATING EACH ITEM



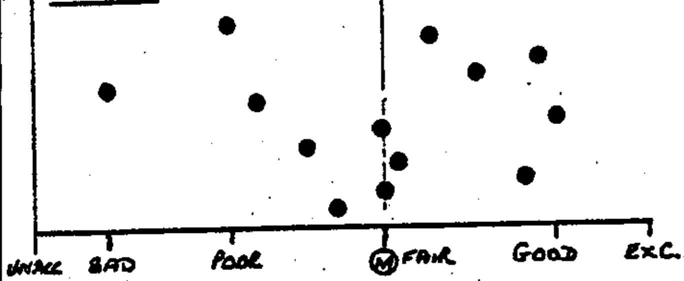
14 CHARTS



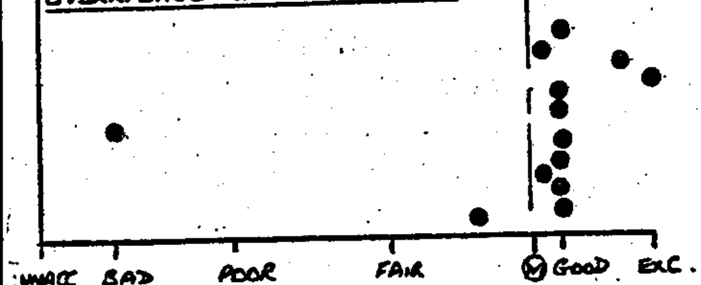
19 PHILOSOPHY OF INDEXING BY NUMERICAL CODES



20 PROCEDURE FOR SELECTING A PAGE



21 PHILOSOPHY OF EMERGENCY DRILL OVERRIDING CURRENT PAGE



22 WORKLOAD ASSOCIATED WITH DISPLAY