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AN ERGONOMIC DESIGN FOR THE FLYING CONTROL POSITION OF HMAS MEL--ETC(U)
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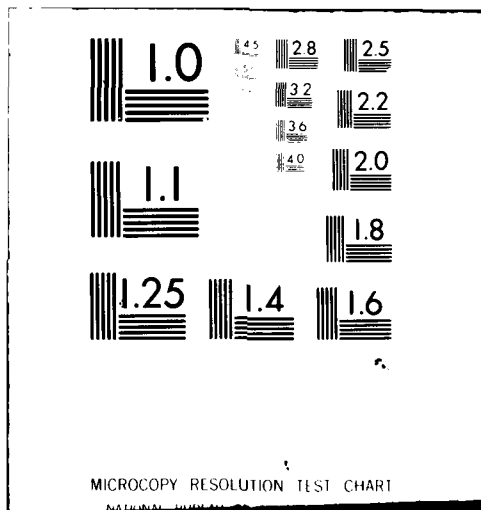
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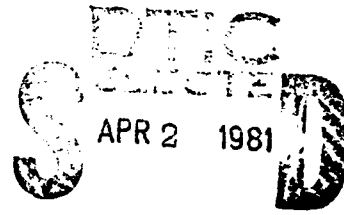
MELBOURNE, VICTORIA

SYSTEMS REPORT 18

**AN ERGONOMIC DESIGN FOR THE
FLYING CONTROL POSITION OF HMAS MELBOURNE**

by

K. W. ANDERSON



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K. W. ANDERSON

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SUMMARY

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Ergonomic deficiencies of the Flying Control Position ('Flyco') of HMAS Melbourne were studied. External downwards vision was found to be inadequate for proper supervision. The operators' seating support and seating posture were poor and unsuitable for use for long duty periods. The desk space was not large enough for writing and reference materials. The instrument panel was unnecessarily cluttered and ergonomically disorganised. Reflections in the windows at night seriously degraded the operators' ability to see external events.

A practical rearrangement was devised and refined with the aid of a full-size timber mock-up. A raised floor and revised desk shape will place the operators' eyes in a more advantageous position for external vision. The desk provides additional clear space also. The revised panel layout exhibits instrument grouping for function and sequence. Some of the existing equipment has been incorporated into those panels, and some has been relocated in less prominent locations. The rearranged cabin layout and the use of instrument hoods are expected to reduce the number of unwanted reflections in the windows.

As well as reducing workload and delaying fatigue, the revised design is expected to be effective in enhancing the supervision and decision-making capabilities of the Flyco staff. It is expected that operational effectiveness and flying safety will benefit from such improvements.

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ABSTRACT

Ergonomic deficiencies of the Flying Control Position ('Flyco') of HMAS Melbourne were studied. External downwards vision was found to be inadequate for proper supervision. The operators' seating support and seating posture were poor and unsuitable for use for long duty periods. The desk space was not large enough for writing and reference materials. The instrument panel was unnecessarily cluttered and ergonomically disorganised. Reflections in the windows at night seriously degraded the operators' ability to see external events.

A practical rearrangement was devised and refined with the aid of a full-size timber mock-up. A raised floor and revised desk shape will place the operators' eyes in a more advantageous position for external vision. The desk provides additional clear space also. The revised panel layout exhibits instrument grouping for function and sequence. Some of the existing equipment has been incorporated into those panels, and some has been relocated in less prominent locations. The rearranged cabin layout and the use of instrument hoods are expected to reduce the number of unwanted reflections in the windows.

As well as reducing workload and delaying fatigue, the revised design is expected to be effective in enhancing the supervision and decision-making capabilities of the Flyco staff. It is expected that operational effectiveness and flying safety will benefit from such improvements.

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1. INTRODUCTION

HMAS *Melbourne* is the Australian flagship and the sea-going platform for the RAN Fleet Air Arm. A 20 000 tonne vessel of the 'Majestic' class, it was modified before commissioning in 1955 to include the steam catapult, the six-degree angled flight deck and the servo-driven mirror deck-landing aid (MDLA).

Fleet Air Arm operations currently involve Douglas Skyhawk A-4 and Grumman Tracker S-2 fixed-wing, and Westland Sea King Mk 50 and Wessex Mk 31 rotary-wing aircraft. The fixed-wing aircraft rely, for launch, on the steam catapult which is angled at one degree to starboard, and for landing, on five arrestor wires.

Commander 'Air' (CA) and Lieutenant Commander 'Flying' (LCF) are senior aviators on the ship's staff and are responsible for overall control and supervision of all aviation activities. Their work station, the Flying Control Position, is known colloquially as 'Flyco'. Resembling an air traffic control tower cabin, Flyco is located in the superstructure on the aft port quarter of the second level above the flight deck. Seven windows allow the occupants to view aft, port and partly forward. Figure 1 shows a plan view of the general arrangement.

In 1976 ARL Cybernetics Group was invited by ship's staff to inspect and comment on some ergonomic aspects of the Flyco operations. These included visual difficulties and workload factors noted by the operators.

Accordingly in November 1976, two members of Cybernetics Group joined the ship for a two-day journey from Melbourne to Sydney. Day-time flying exercises involving both fixed-wing and rotary-wing aircraft were witnessed from various vantage points, including the Flyco cabin. Further exercises (including night-time) were witnessed by one of those members in May and June 1977. Details of procedures and difficulties were discussed with appropriate members of the ship's crew on several occasions. Relevant photographs, measurements and operational details were recorded to assist in the formulation of an alternative design which should be consistent with modern ergonomic principles and economic constraints.

2. FLYCO ACTIVITIES

During flying exercises, the Flyco cabin becomes the prime co-ordinating centre for all aviation activities. When both CA and LCF are present, CA assumes the executive duties while most of the active controlling is performed by LCF. Their duties were observed to include:

- (i) co-ordinating of various preparatory activities in accordance with the prescribed flying schedule, and liaison between the administrators (senior staff of ship) and operators (air and deck crew);
- (ii) computing of launch speed and the required catapult steam pressure for each aircraft for its launch mass, and recording of the actual end speed measured at each launch shot;
- (iii) certifying that all preparations have been satisfactorily completed prior to launch or landing, and operating the traffic signals accordingly;
- (iv) continual monitoring and short term prediction of all relevant parameters (such as ship pitch and roll, relative wind speed and direction) for comparison with the prescribed tolerances for the manoeuvre;
- (v) deciding in the event of such tolerances being exceeded (or any other reason), whether the manoeuvre should be continued or aborted, and the operating of appropriate controls or signals;

- (vi) advising the mirror operator and arrestor room of the parameters for the next landing aircraft, and obtaining confirmation that appropriate action has been completed;
- (vii) performing the usual ATC tower functions for aircraft within five nautical miles; and
- (viii) supervising all aspects of safety and efficiency pertaining to aviation, including the witnessing of abnormal or dangerous incidents.

Physically, the duties of CA and LCF may be categorised as:

- (i) external visual observation;
- (ii) audio communication;
- (iii) reading of instruments and displays;
- (iv) operation of control knobs and buttons;
- (v) calculations;
- (vi) book-keeping; and
- (vii) decision-making.

Other ship's personnel with major aviation responsibilities are listed in Table 1: each of these will communicate with Flyco staff when necessary, usually via an electronic medium. Also, CA and/or LCF communicate with the meteorology office, arrestor room, catapult console, briefing room, aircraft hangars and pilots from time to time.

TABLE 1
Aviation Duties of Some Ship's Staff

Title	Location	Aviation Duties
Captain	Bridge	<ol style="list-style-type: none"> 1. Endorse the day's flying program. 2. Issue and withdraw approval to fly.
Navigator	Bridge	<ol style="list-style-type: none"> 1. Choose ship's speed and heading to maintain a given relative wind speed and direction.
Landing Signals Officer (LSO)	Flight Deck aft port side	<ol style="list-style-type: none"> 1. Assist and advise, via radio, pilots on approach. The LSO is a current squadron pilot.
Flight Deck Officer (FDO)	Flight Deck near catapult	<ol style="list-style-type: none"> 1. Supervise deck movements. 2. Advise deck <i>clear</i> or <i>foul</i> for landing. 3. Signal launch.
Flight Deck Engineering Officer (FDEO)	Flight Deck near catapult	<ol style="list-style-type: none"> 1. Supervise steam catapult mechanism, controls and operation.
Arrestor Crew	Near arrestor wires	<ol style="list-style-type: none"> 1. Unhook wire from landed aircraft. 2. Reset and check wires.
Mirror Operator	MDLA	<ol style="list-style-type: none"> 1. Monitor servo operation. 2. Set mirror height and bias angle to suit next landing aircraft.
Air Traffic Controller (ATC)	Air Direction Room (ADR)	<ol style="list-style-type: none"> 1. Control air traffic outside 5 n miles.
ATC	Operations Room	<ol style="list-style-type: none"> 1. Operate carrier controlled approach (CCA) system.

The Flyco cabin also houses a NCO, called the 'logger', who records actual times of all air traffic movements. In addition, casual visitors may include any senior officer who is not otherwise occupied, particularly squadron commanders concerned with the progress and safety of their aircraft and crews.

When no activities related to flying are being conducted on the flight deck or in the air-space near the ship, the active flying control task can be suspended. During typical air operations, however, such idle periods tend to be of brief duration and irregular occurrence. The positions of CA and LCF are individual senior postings to the ship's staff and consequently LCF can be relieved only by CA performing the active flying control task when his executive responsibilities permit. Extended naval exercises can sometimes involve continuous air activity, requiring that Flyco be manned. It was understood that during such exercises the duty periods for LCF may extend, with brief rests, to 20 hours.

In its operational role, the ship can be exposed to environmental extremes: luminous levels can vary from bright sunlight with high glare levels to dark overcast moonless night conditions when the horizon cannot be seen.

3. EXISTING FACILITY

3.1 Description

The layout of the existing cabin, including the chairs and consoles, is shown in plan view in Figure 2. Entrance is gained through the adjacent sea cabin on the starboard side of Flyco. The bulkheads on the other sides contain fixed windows held in a steel frame inclined outwards at the top at 10 degrees to the vertical.

The lower edge of the windows is about 1.1 m above the floor of the cabin, which is about 5 m above the flight deck. The location of LCF's chair is such that his eyes would normally be located no less than 550 mm from the port window, 750 mm from the forward windows and 900 mm from the aft windows. Figure 2 shows an approximate boundary of the eye positions for most operators sitting comfortably upright.

The main consoles are located adjacent to the aft, aft-quarter and port bulkheads. These consoles contain most of the equipment used by CA and LCF, as listed below:

- (i) circular analogue instruments for ship pitch and roll, and relative wind speed and direction;
- (ii) status indicators for flying authority, *clear* or *foul* deck, arrestor wire setting, jet blast deflector position, external traffic signals, communication channels etc.;
- (iii) knobs and buttons for selection of traffic lights, communication frequencies and channels, arrestor wire settings, emergency wave-off lamp and pistol etc.; and
- (iv) communication equipment including three radio sets, two desk-top intercom sets and several handsets. Table 2 describes the various intercommunication systems.

In the starboard-forward corner, a separate console houses the operational telephone group, controls for 'moonlighting' (faint deck lighting), and instruments which display ship speed and relative wind speed and direction. The logger usually sits adjacent to this console and uses the desk space for his book-keeping. The space to port of the logger and forward of LCF has been used by visiting senior officers at the cost of obstructing forward vision of both CA and LCF.

The only other instruments are a brass analogue 24-hour clock on the starboard bulkhead and a ship heading indicator (of the moving linear scale, fixed-indicator type) which is located on the port bulkhead above the windows.

An overhead air-conditioning duct is aligned athwartships and terminates with a fitting which deflects the air flow through 90 degrees downwards. This is the major noise source in the cabin.

TABLE 2

Major Communications Systems for Flyco Operators

Medium	Other Communicators
Red Phone	Captain
Radio	Pilots, LSO, CCA operator
Intercom (1)	Admiral's Bridge, Captain, ATCs in ADR, Operations Room
Intercom (2) 'Multicom'	Air Operations Section, CCA operator
'Mickey Mouse' deck radio ANSRC/22V	FDO, arrestor crew, aircraft marshallers
Grey Phone	FDEO, 'walkway' operator, catapult console operator
Operational Telephone Group (OTG)	LSO, hangar crew, ACR, Briefing Room, ADR, Bridge, Operations Room

The existing cabin is painted pale blue and the instrument panel is a light grey. Instruments and panel lamps are internally illuminated for night use. Both red and white illumination are used and dimmers are provided. A small, directional, stalk-mounted lamp is used to illuminate the desk. When not in use, the stalk lies against one of the window mullions.

3.2 Deficiencies

From discussion with experienced operators, from observation of routine operations, and from the application of established ergonomic principles, the following design aspects are thought to be deficient and unnecessarily demanding upon the Flyco staff.

(a) *Vision*

For most seated operators, the base of the windows is too high for an adequate external view. Table 3 gives data derived from Sitting Eye Height taken from a recent anthropometric survey of RAN aviators (Ref. 1). Figure 3 and Table 4 illustrate the geometrical considerations for the view to port. It is evident that fewer than 40% of the potential LCF population sitting comfortably upright would have a line of sight more than 15 degrees below the horizontal.

The amount of flight deck obscured from the view of a 50th percentile observer would therefore normally approximate 24 m athwartships, 40 m aft and 33 m forward. This hidden area includes about half of the angled landing-deck. Following a landing approach, important manoeuvres occur in this obscured area. These include arresting (for aircraft coming to a halt) and accelerating and rotating (for aircraft becoming airborne again). The forward view is restricted in azimuth coverage by ducting fixtures on the port side of the superstructure.

(b) *Posture*

To extend visual coverage of the deck, LCF can adjust his chair to be higher than he would otherwise choose. He can also lean forward and crane his neck to place his eyes in a better position. Even a man with a relatively large sitting eye height, such as the incumbent observed by the writer, tends to resort to such postures, which would tend to be uncomfortable and might accelerate the onset of fatigue symptoms.

TABLE 3
Eye Height with Respect to Floor: Naval Aviators
(from 1977 Australian Tri-Service Anthropometric Survey)

Mean:	1233 mm
Standard Deviation:	46 mm
<hr/>	
5th percentile	1161 mm
10th percentile	1175 mm
25th percentile	1200 mm
50th percentile	1230 mm
75th percentile	1262 mm
90th percentile	1294 mm
95th percentile	1315 mm

TABLE 4
LCF's External View in Existing Cabin: Elevation Angle Below Horizon (Degrees)

Posture	Forward View		Port View		Aft View		
	Upright	Craning	Upright	Craning	Upright	Craning	
Horizontal displacement of eyes from viewing window	750 mm	600 mm	550 mm	400 mm	900 mm	750 mm	
Per-centile	Eye height above floor						
5th	1161 mm	4.7 (69)*	5.8 (56)	6.3 (52)	8.7 (37)	3.9 (84)	4.7 (69)
50th	1230 mm	9.8 (33)	12.2 (26)	13.3 (24)	18.0 (18)	8.2 (40)	9.8 (33)
95th	1315 mm	16.0 (20)	19.7 (16)	21.4 (15)	28.3 (11)	13.4 (24)	16.0 (20)

* Numbers in parentheses give the approximate horizontal distance to the unobscured deck in metres.

The chairs also seem to be inadequate for a station at which individuals are expected to remain alert for long periods. The chairs have backrests of small vertical extent; these provide inadequate lumbar and thoracic support. The seat cushions are not contoured correctly. The upholstery is non-porous poly-vinyl chloride (PVC) which becomes 'sticky' in hot conditions. The arm rest height is similar to the existing bench height: this leads to damage to the ends of the arm rests and also prevents

the chair from swivelling when close to the bench. The chairs have insufficient under-thigh support especially for a chair which is pitching. For the sideways-facing operators, this will occur when the ship is rolling. Little lateral support is provided and for a chair which is rolling (i.e. during ship pitch), lateral support is necessary to minimise contractile effort in those muscle groups associated with balance and maintenance of torso and head postures.

(c) *Desk Space*

The available desk area as shown in Figure 2 is manifestly insufficient for the desk duties performed by CA and LCF. The space is used when consulting reference books (such as flight manuals, maps, tables of mass, speed and pressure etc.) and when performing hand calculations or making other notes. Material on the desk must be shifted periodically to allow reference to tables and graphs under the glass surface. The desk-top intercom sets were not associated with the design of the existing workplace and they now occupy prime space, and so reduce the available work area.

(d) *Instrument Panel*

The instrument panel shows evidence of some modifications and additions. Some of these may have resulted from inadequacies in the original design; others may simply reflect the subsequent incorporation of some improvements. Unfortunately, the result is an inharmonious array in which the important and frequently used items are not particularly conspicuous and some prime panel space is occupied by some less frequently used and even disused equipment.

(e) *Communications*

Table 2 lists some of the independent audio communication nets to which LCF or CA have access. A third intercom set, the 'Action Intercom' which is no longer used, is fitted into the panel.

One difficulty with the intercom sets is related to their 'single conversation' capacity which prevents intercom operation, even in an interrupt mode, for other users.

The dedicated handsets seem to be too numerous, contributing both to clutter and confusion.

(f) *Reflections*

During night operations, the instrument and panel lamps as well as status indicators are illuminated, and their reflections in the windows are much in evidence. The images are double as a result of reflections from each surface of the window transparencies. Some of the sources reflect in more than one window, and some multiple reflections are also visible. For the observer inside the cabin, the result is a large number of images, many not easily recognisable, outside the cabin. Because the windows are inclined (outwards at the top), many of the reflections are not seen by a seated operator, but the overhead air duct is reflected in the aft windows and appears as a false horizon.

All of these reflections are most undesirable. Even when the observer can recognise and dismiss the image from his conscious visual scan, the cognitive and perceptual load so imposed is not trivial. Masking of external objects can take place in the directional vicinity of any of the reflections. And where images are not easily recognised, the potential for confusion and deception exists.

3.3 Constraints

In recognition of the economic and financial constraints which might be expected, it was agreed with ship's staff that design proposals should observe the following guidelines:

- (i) that no structural changes to the external bulkheads be made;
- (ii) that no substantial changes to the ships' internal communication systems be made;

- (iii) that replacement instruments and controls should be from the existing Navy Stores inventory where possible; and
- (iv) that existing equipment should continue to be used wherever possible.

4. CONCEPT FOR REDESIGN

To be alert and effective for long periods, the human operator with high workload and responsibilities should be comfortably seated with a good view of relevant activities and have ready access to all the important and frequently used displays and controls. The work station should have adequate desk space and glare-free illumination, and the external visual field should not be overlain by unwanted reflections.

In considering a redesign for the Flyco work station, it is clear that a greater downwards extent of the external view is essential for adequate supervision of important deck activities. Without altering the windows, this can be achieved only by shifting the operators so that the eye positions are higher and closer to the viewing windows. This proposal entails a raised cabin floor to provide the increased eye height instead of requiring the operators to use stools which are difficult to make sufficiently comfortable.

New consoles and desk areas also result from the proposal to raise the floor, and these will be of reduced vertical extent as a result of the reduced distance from the base of the windows to the new floor.

The rationalisation of the consoles should give prominence to the important and the frequently used displays and controls. Occasionally adjusted items could be relegated to less accessible positions. For example, while the radio channel selector and channel indicator should be prominent and easily reached, the radio sets and frequency selectors could be located overhead, where they could be reached from a standing position.

The number of status indicators should be minimised, and the colours red, amber and green should be used according to common convention, i.e.

- red: stop or danger
- amber: caution
- green: go or all clear.

Further, all displays and controls should be grouped for function and sequence.

5. PROPOSED MODIFICATIONS

This section describes the final design recommendations for the Flyco cabin. The design is the final product of an evaluating and adjusting procedure using a full-size timber mock-up. Built at ARL, the mock-up allowed a three-dimensional visualisation of design suggestions, and a realistic appraisal of the reach envelopes, lines of sight, illumination contrasts and reflections for each case. Photographs of the mock-up can be found in the Appendix.

The mock-up was also used in simulation exercises wherein the sequence of activities for particular Fleet Air Arm operations was followed. Naval officers, including the then incumbent LCF participated in those exercises, an operation which proved to be particularly useful.

5.1 Floor

To provide the required cabin floor height, it was decided that a timber false floor with a net height gain of 150 mm was appropriate. Allowing for a desk surface height of 750 mm above the floor, only 200 mm then remains between the desk surface and the base of the windows. This is the location of console-mounted instruments. Any further increase in the floor height would leave insufficient space for those instruments.

To place the operators closer to their viewing windows, the plan view shown in Figure 4 was devised. In addition to placing LCF and CA closer to the port windows, this layout places LCF further forward. The reasons for this forward displacement are as follows:

- (i) to provide more space for CA's desk area which is aft of LCF's;
- (ii) to provide LCF with a better view of launch operations; and
- (iii) to eliminate the physical possibility of any visitor occupying the prime observation space and thereby obscuring LCF's forward view.

It should be noted that the revised layout gives both operators an improved view aft, as well as forward and to port. In the existing arrangement, moving LCF forward would have further restricted his aft view.

The raised floor will also reduce the distance from the floor to the ceiling. To restore this clearance to a value which is suitable for the tallest of operators, the overhead air-conditioning outlet should be placed above the door. The removal of unwanted reflections and noise should also result from that modification.

Figures 5 to 9 show sectional views for the proposed rearrangement. The expected eye positions of the operators are marked and the improvement of visual coverage in elevation is evident. Table 5 gives the nominal viewing angles. The area of flight deck now obscured from a 50th percentile LCF's normal view is now about 6 m to port, 11 m forward and 18 m aft, and even less if he leans towards the relevant window. Figure 10 shows a comparison of the area obscured from LCF's view. It is clear that the proposed modification reduces this area to less than one-eighth of its previous value. If the above comparison is made for the 'leaning forward' posture, a ratio of about one-fifteenth results. In azimuth also, the visual coverage available to LCF would be increased by being closer to the port window. This is most noticeable for the forward view, and a line of sight along the ship's heading would be possible. Some rearrangement for the ducting on the port side of the superstructure (such as a different path or section) may reduce its obstruction of the forward view, and provide a further increase in azimuth. The extended view should aid LCF (and also CA to a lesser degree) in overseeing all deck operations. As a result of the superior view, LCF and CA will be less likely to perform awkward body movements in order to extend their view. An improved posture should result.

5.2 Consoles

The console sections shown in Figures 8 and 9 were designed to avoid obstruction of the lines of sight from normal eye positions to the base of the windows.

The aft-quarter console was placed 140 mm from the window at an appropriate viewing distance for LCF. This allows a greater panel height without interfering with LCF's line of sight to the base of the aft-quarter window. Space for CA's panel is also accommodated by that displacement.

The upper surfaces of the consoles are not horizontal, but perpendicular to the panel or front surface. Compatible with the line of sight reasoning, this feature also discourages the area being used as a shelf for articles which may produce unwanted window reflections.

5.3 Desk

The increased desk area is apparent from the plan view. Much of the increase is located near the forward panels and is expected to be used as LCF's principal writing surface. Under the port windows, a narrow desk space has been included in the design; a wider desk here would compromise the requirement for the eye position to be close to the windows. For CA, a wider desk might be desirable for his paperwork but would place his eyes adjacent to the steel mullion between the aft windows and so interfere with his aft view. As shown, there seems to be space behind CA for a stool or wall-mounted foldable seat to accommodate a visitor without encroachment on the workspaces.

5.4 Panel

As shown in Figure 4, the revised console design entails four instrument panels, viz.: the forward panel, the forward-quarter panel, the aft-quarter panel and the aft panel. These are

TABLE 5

LCF's External View from Cabin with Proposed Rearrangement: Elevation Angle Below Horizon (Degrees)

Posture	Forward View		Port View		Aft View		
	Upright	Craning	Upright	Craning	Upright	Craning	
Horizontal displacement of eyes from viewing window	550 mm	400 mm	300 mm	150 mm	900 mm	750 mm	
Per-centile	Eye height above deck						
5th	1161 mm	21.0 (15)*	19.4 (16)	21.0 (15)	54.6 (4)	13.2 (24)	15.7 (20)
50th	1230 mm	27.0 (11)	35.0 (8)	43.0 (6)	61.8 (3)	17.3 (18)	20.5 (15)
95th	1315 mm	33.6 (9)	42.4 (6)	50.6 (5)	67.7 (2)	22.2 (14)	26.0 (12)

* Numbers in parentheses give approximate horizontal distance to the unobscured deck in metres.

shown in Figures 11 to 14. In addition, one panel of the existing facility, the operational telephone group (OTG), is planned to be retained and located on the starboard bulkhead near the logger. An overhead panel, above the port and port quarter windows, would house radio sets, radio frequency selectors and speakers, as well as the existing ship heading indicator.

Other features of the design which differ from the existing Flyco panel design are as given below.

- (a) The circular instruments are smaller to suit the smaller panel.
- (b) An analogue 60-minute timer has been included to facilitate 'count down' or 'time to go' procedures.
- (c) A digital display of ship time (with facilities for adjustment) has been shown near the logger's station.
- (d) A *launch cancel* facility has been suggested for the forward-quarter panel. This proposes a positive disable in the relay net operating the catapult. A signal lamp should be provided in the walkway to indicate to catapult staff and FDEO when this facility has been used by LCF. Apparatus for reinitialising the launch sequence could be operable from the catapult console or from Flyco. At present, cancelling requires a series of verbal interchanges.
- (e) The traffic lights, Captain's authority lights, LSO advice (i.e. *clear* or *foul deck*) lights, and the arrestor spline setting lights should be retained but located as shown to provide alignment of the green lamps.
- (f) The indicator lamps to advise whether the jet blast deflector (JBD) plate is up or down or in motion should be fitted as listed here:
 - (i) *Launch Panel*. Figure 12 shows the desired layout with blue lamps indicating both *up* and the *down* state. For launch of Skyhawk aircraft, the JBD must be *up*; however for Tracker aircraft the JBD is expected to be *down*. Consequently red and green (with their negative and positive implications) should not be used. An amber lamp should be used to indicate JBD *in motion*.
 - (ii) *Landing Panel*. Figure 13 shows the desired layout with a red lamp indicating *up* as this is always a danger for landing. The green lamp indicates *down* and the amber lamp indicates *in motion*.

- (g) The *wave off* and *Very pistol* buttons have been duplicated to allow operation by either of the Flyco operators. The buttons should be red in colour and the pistol button should be the larger. The labelling should be on the panel rather than the button or cover. The protective cover should be transparent to allow visibility of the buttons, and should be stable only in its normal (down) position. It should be held up by the fingers to provide access for operation.

5.5 Communications

As foreshadowed, the essential communication systems are not proposed to be altered, but some rationalisation of their location, controls and transducers is considered desirable.

(a) Radio

With the sets no longer in the control panel, the redesign allows for channel selection and press-to-talk button, as shown in Figures 12 to 14. This gives both CA and LCF a choice of the three radio sets and uniformity for the two operators. In addition, LCF can operate his radio from either the launch or the landing panel as appropriate.

For both CA and LCF, the radio should continue to operate through their headsets.

(b) Deck Radio ('Mickey Mouse')

If possible, the boom microphone of the radio headsets should be used as an input to the deck radio. Some impedance matching or a pre-amplifier as well as additional switching may be required. The existing loudspeaker and foot switch for press-to-talk should remain.

(c) Walkway Phone and Captain's Phone

For LCF, the grey phone should continue to be used for the walkway intercom. If an on/off switch is desired, it should be an integral part of the cradle assembly. A calling lamp (blue in colour) should be provided adjacent to the cradle on the aft side.

For CA, the red phone used to communicate with the Captain should be used for walkway communication also. A selector switch to allow the dual function will be necessary. The calling buzzer should be retained to allow the Captain to call even when the phone is in use to the walkway. Circuit modifications to ensure matching of impedance and sensitivity may be necessary.

For both the red phone and the grey phone, standard colour-coded phone jacks should be used on the cord ends to allow rapid interchange of handsets.

(d) 'Philips' Intercoms

The two desk-top 'Philips' Intercom sets will remain in use after the rearrangement. The forwardmost of these (the 'Multicom') will be built into the launch panel as shown in Figure 12.

The second (aft) 'Philips' Intercom will remain on the bench between LCF and CA, preferably in a suitable recess approximately 20 mm in depth and no less than 40 mm from the base of the landing console.

(e) 'Action' Intercom System

This system has had little use in recent years and is unlikely to be used in the future, except as a back-up for the second 'Philips' Intercom. Consequently, the system should be retained but not in prime panel space.

With the microphone attached to a suitable lead and the amplifier and speaker mounted in a suitable box, the system could be mounted overhead, or on the starboard bulkhead, or even under the bench on the aft-quarter bulkhead.

(f) *Operational Telephone Group*

As stated previously, this system should be relocated on the starboard bulkhead, and operated by the logger. Jacks for the handset could be placed under the desk between CA and LCF, but it is expected that the handset would normally reside on the OTG console.

(g) *Flight Deck Broadcast*

The existing system is to be retained, with the microphone attached to a flexible stalk (of length approximately 400 mm) and the *talk* button being an integral part of the microphone fitting.

The base of the stalk should be attached to the top of the launch panel at a point adjacent to the window column (i.e. above and behind the Launch Cancel button).

The on/off switch for the amplifier can be placed in any convenient location either overhead, under the console, or in the corner of the panel.

5.6 Lighting and Colour

To minimise the problems related to night-time reflections in the cabin windows, the following features are suggested.

- (a) Pilot lamps to indicate equipment operation should be eliminated, except perhaps during specific interrogation. All light sources in the OTG should be extinguished, except when actually selecting or receiving a call.
- (b) Low reflectance coatings should be used for all opaque surfaces. Instrument glasses should have durable anti-reflection coatings. It is not currently practicable to apply such coatings to the cabin windows. For the deckhead and upper bulkhead surfaces, a dark grey (matt 'Middle Graphite', No. 671, (Ref. 2)) should be used. The instrument panels should be a matt grey ('Dove Grey', No. 694, (Ref. 2)) with white lettering. The operators wear dark colours at night.
- (c) Hoods should be used around the internally illuminated instruments and lamps in the forward panel, as they would otherwise produce images in the port-forward quarter view of LCF. Hoods for any lamps in the overhead equipment may also be necessary.
- (d) For general desk illumination, overhead lamps dimmed to an appropriate level should be used. To prevent external illumination and images in the windows, overhead lamps would require an effective directional baffle (Ref. 3).

The problem of excessive differences between inside and outside luminances in daytime would be aggravated by the use of dark coloured surface coatings. To relieve that problem, the following are suggested.

- (a) The operators should wear light coloured clothing and individually-fitted gradient density sunglasses should be available.
- (b) The lower bulkhead surfaces should be painted a pale colour ('Light Aircraft Grey', semi-gloss, No. 627, (Ref. 2)).
- (c) Flood lighting should be used where temperature considerations permit. With appropriate baffles and dimming capability, these lamps could also provide the night-time lighting referred to above.

For the digital clock display, the liquid crystal type is recommended as these provide good contrast for high illuminance conditions. Supplementary illumination for night conditions would be necessary. The light emitting diode type can provide good night-time visibility but may be hard to see in daylight without a hood. Furthermore, their usual red colour contravenes the convention that red connotes *danger* or *stop*.

5.7 Seating

Replacement chairs should be of an ergonomically sound design, unlike many common types of office chairs. They should have a swivel capacity and arm rests. To avoid the arm rests striking the desk (and so preventing full swivelling) the desk top should be of a minimum thickness near the seated positions, and the arm rests should be adjustable in height. Alternatively, the arm rests should fold up to allow full swivelling and egress (Ref. 5).

To allow variation in seating position and the opportunity for relaxation during short periods of inactivity in a long operational session, the seats should have an adjustable rake and head rests. Cushions should be ventilated and contoured. Some lumbar, thigh and lateral support should be provided. It would be desirable to have the chair fitted with a retractable set of castors (or other device) to allow the chair to be rolled horizontally at will, but remain in a fixed position at other times.

6. CONCLUSIONS

The ARL timber mock-up has been used in simulated operations as well as for comparison and visualisation of various layouts. Naval officers with Flyco experience have participated in such exercises. Experience to date indicates that the proposed rearrangement (which places the operators' eyes higher and closer to the viewing windows) fulfills the prime design goal of improving the operators' external view. As well as enhanced overseeing capabilities, postural improvements should result.

Fundamental to the rearrangement are the raised floor and rearranged desk and console. Although much of the existing equipment could continue to be used, an extensive rewiring task seems unavoidable.

The proposed console and desk design also features more desk space, less clutter, better grouping of related controls and displays, fewer unwanted reflections and improved illumination. More suitable chairs have also been suggested.

It can be expected that these improvements to the Flyco ergonomics will be effective in enhancing the operators' supervising and decision-making capabilities and simultaneously reducing their workload and delaying fatigue. It is expected that operational effectiveness and flying safety will benefit from these improvements.

REFERENCES

1. Hendy, K. C. *Australian tri-service anthropometric survey, 1977*. Systems Report 15, Aeronautical Research Laboratories, Melbourne, 1979.
2. *Colours for specific purposes*. Standards Association of Australia, K185, 1968.
3. Anderson, K. W., and Clark, B. A. J. *A directional spotlight baffle for control cabins*. Systems Report 22, Aeronautical Research Laboratories, Melbourne, in publication 1980.
4. Woodson, W. W., and Conover, D. W. *Human Engineering Guide for Equipment Designers*. Los Angeles: Univ. California Press, 1964.
5. Nagle, K. A. and McCarthy, J. V. *Operator seating in River-class destroyer escorts*. Systems Note, Aeronautical Research Laboratories, Melbourne, in publication 1980.

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Several members of ARL Cybernetics Group, as well as the author, made significant contributions to the Flyco project. Group Leader, A. Ross, contributed to the investigation and design phases of the task. B. A. J. Clark offered useful ideas and criticisms, principally on visual and lighting aspects. K. C. Hendy assisted in the design evaluation. In addition, the project could not have progressed without the enthusiasm of the following members of the ship's staff: Cmdr J. Da Costa (CA), Cmdr N. Newman (Cmdr 'Electrical'), and Lt Cmdr J. Campbell (LCF) who assisted in simulation exercises with the ARL mock-up.

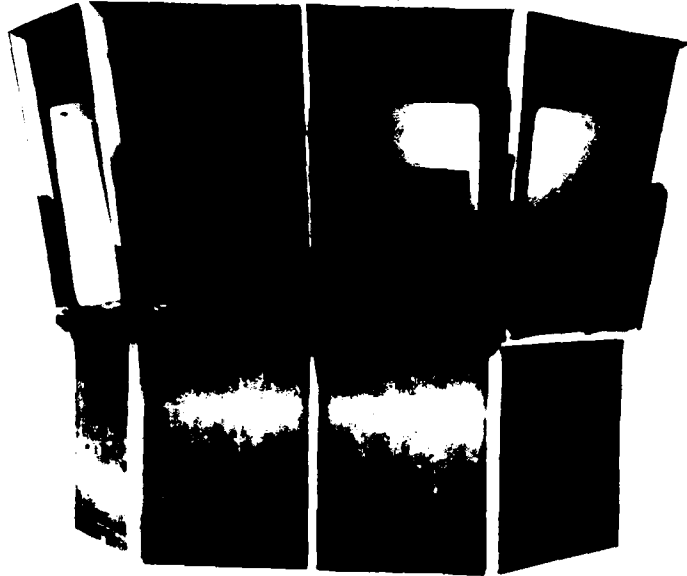


FIG. A1 GENERAL VIEW OF THE A R L MOCK-UP

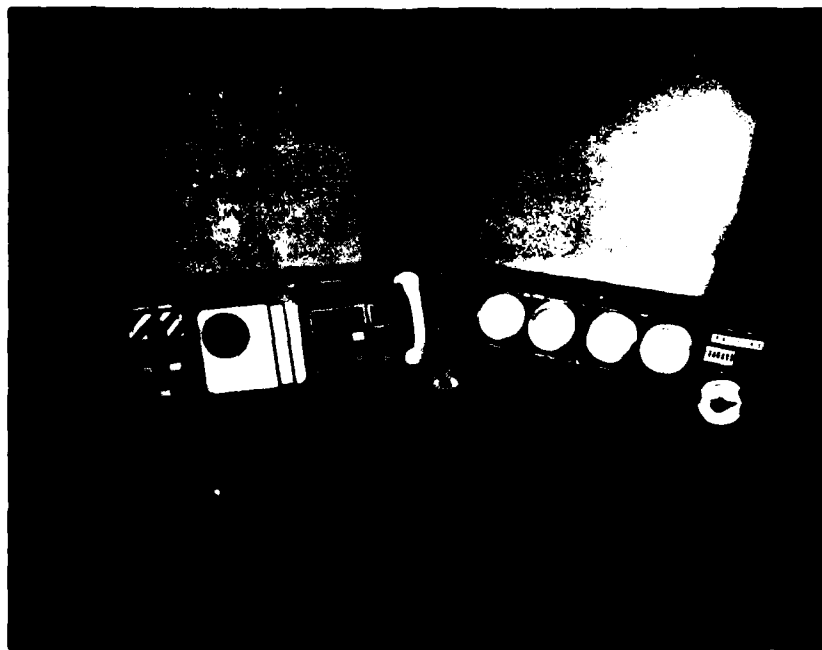


FIG. A2 PERSPECTIVE VIEW OF MOCK-UP OF FORWARD CONSOLES

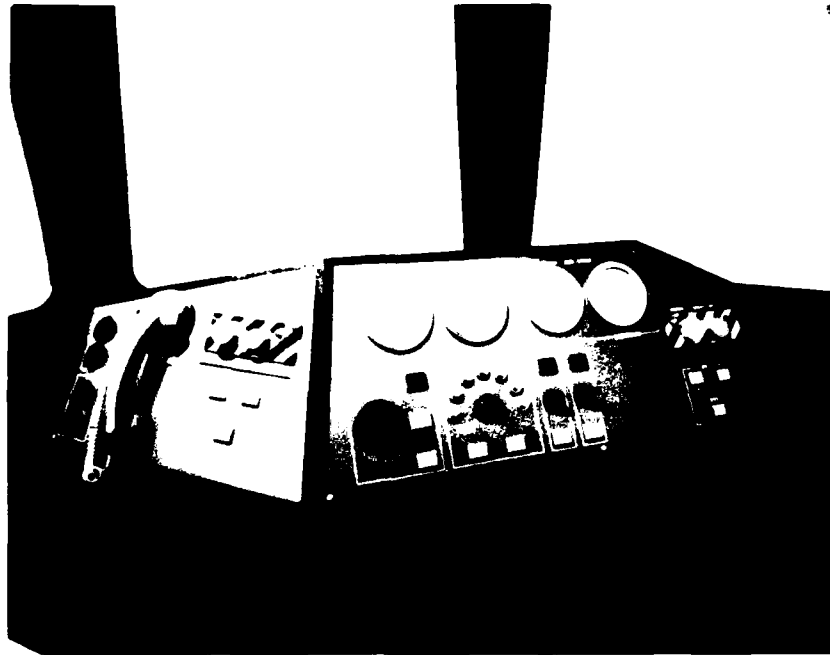


FIG. A3 PERSPECTIVE VIEW OF MOCK-UP OF AFT CONSOLES

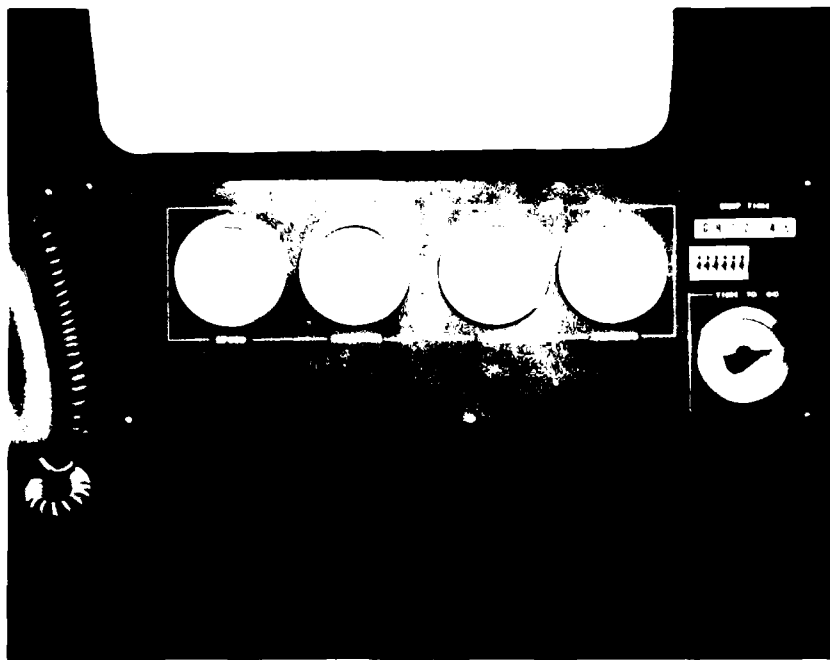


FIG. A4 CLOSE-UP OF FORWARD PANEL

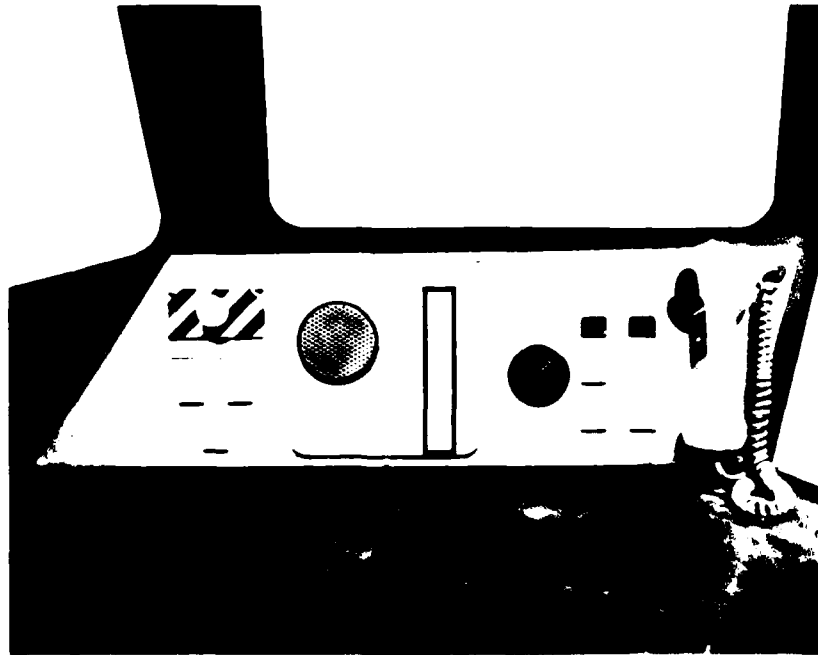


FIG. A5 CLOSE-UP OF FORWARD-QUARTER PANEL

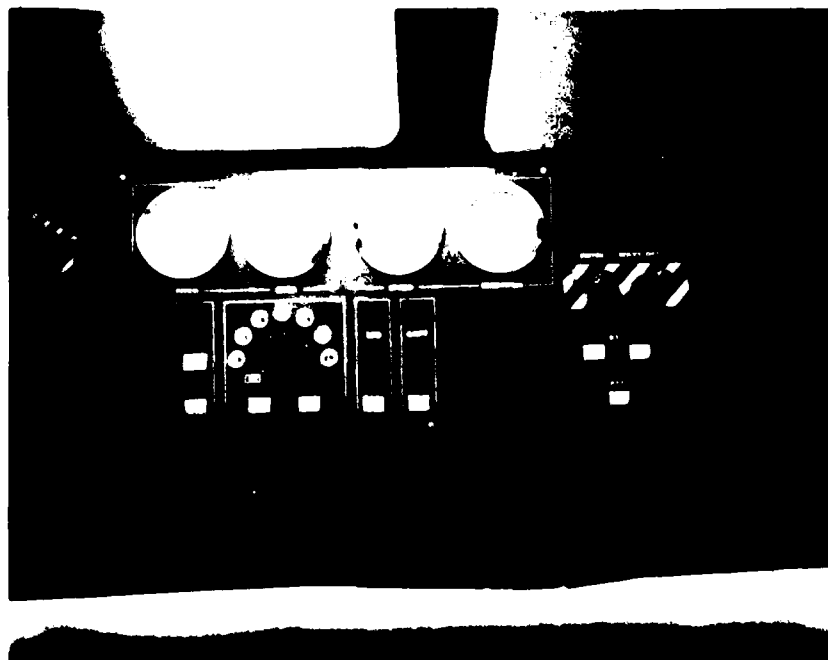


FIG. A6 CLOSE-UP OF AFT-QUARTER PANEL

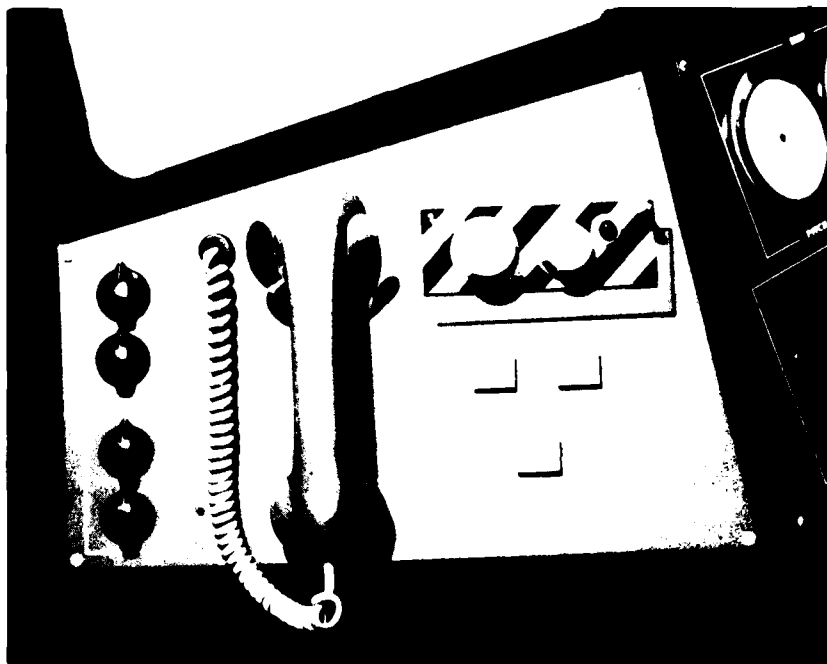


FIG. A7 CLOSE-UP OF AFT PANEL

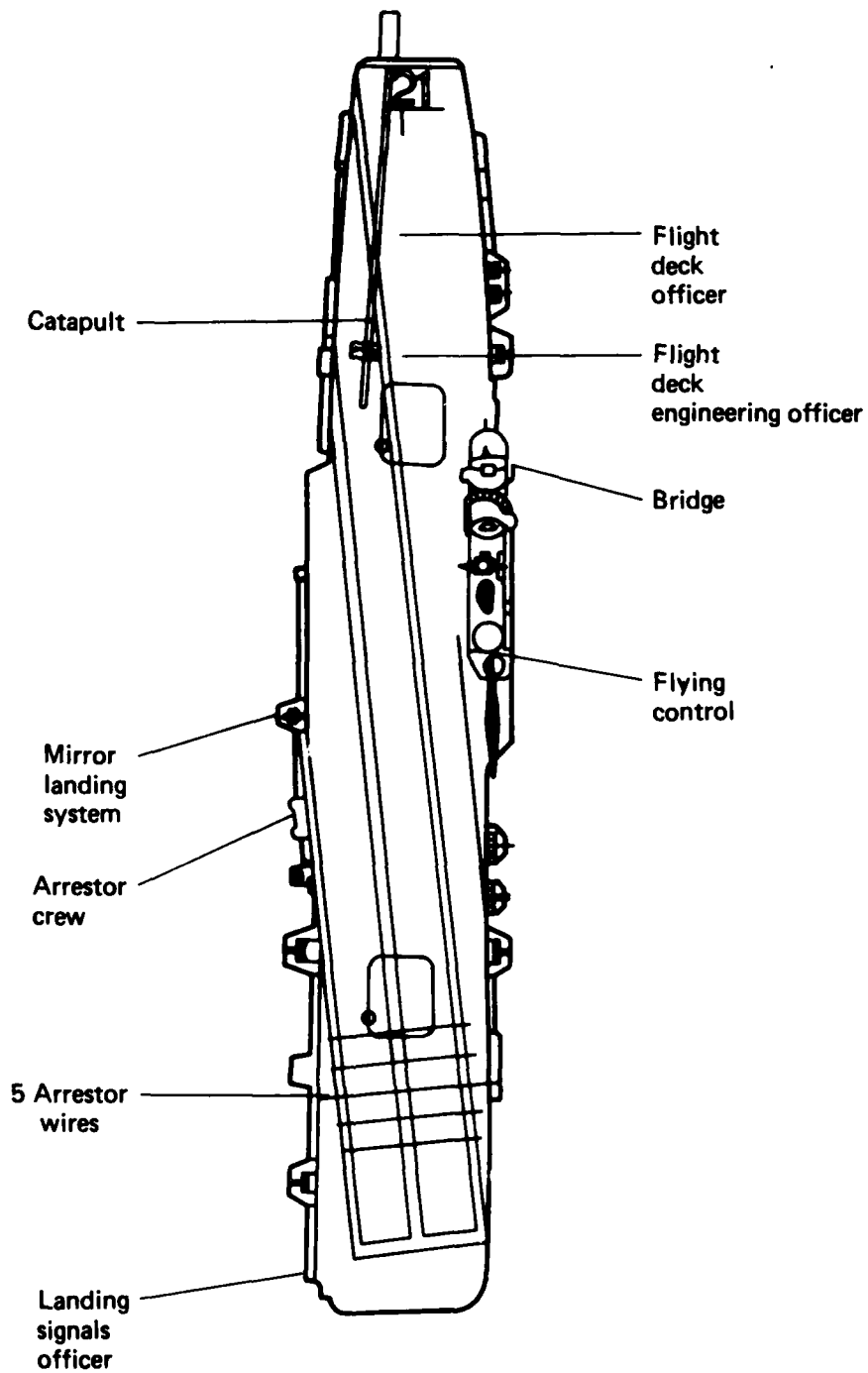


FIG. 1 HMAS MELBOURNE : PLAN VIEW

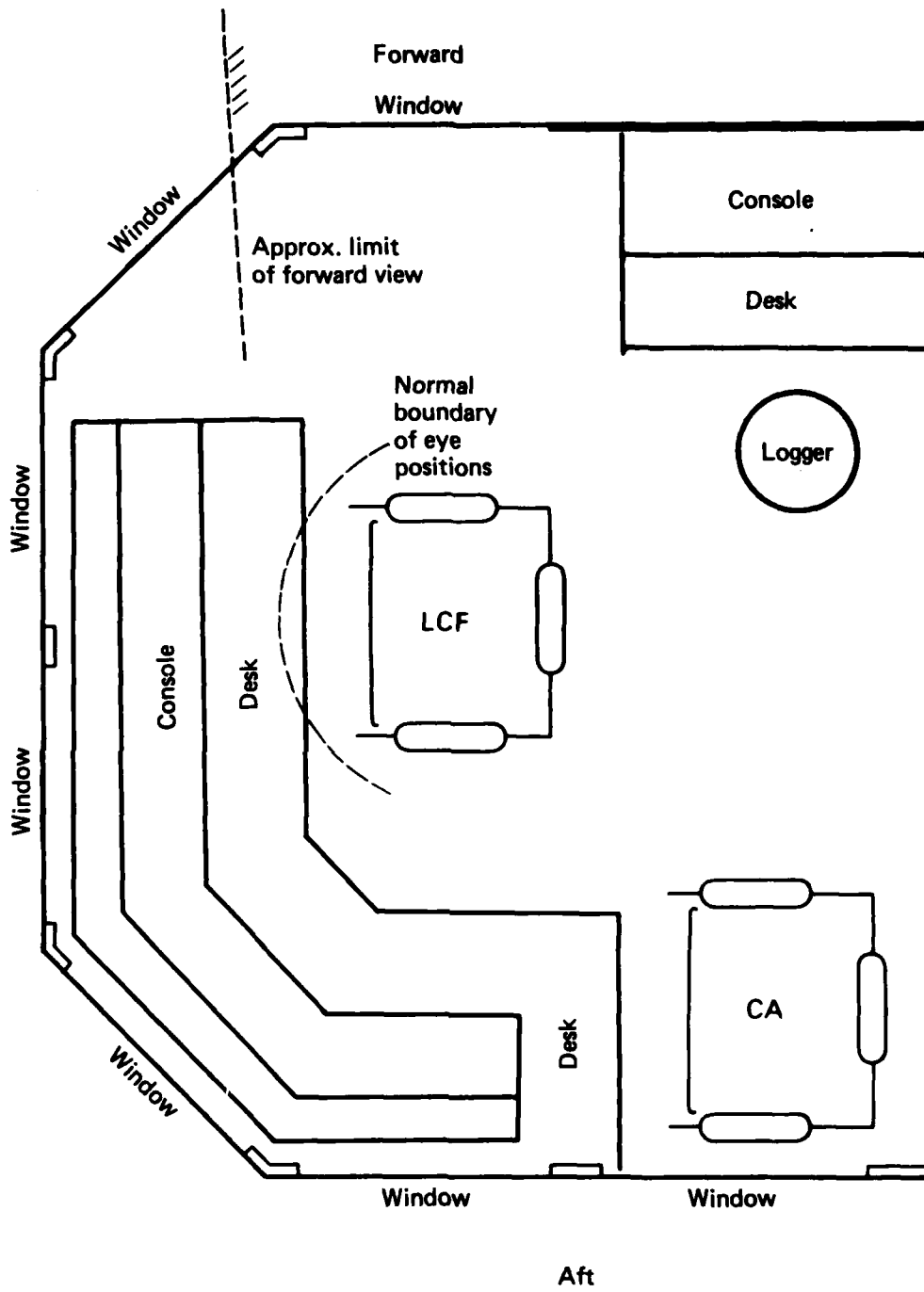


FIG. 2 EXISTING FLYING CONTROL CABIN: PLAN VIEW

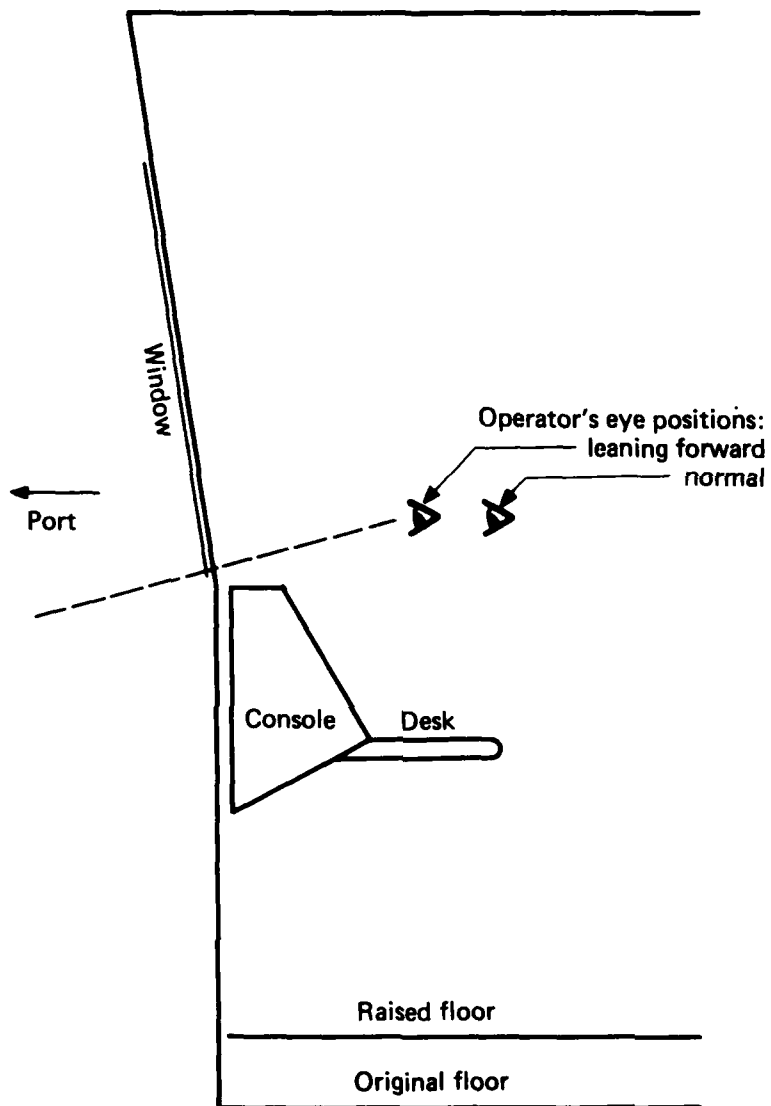


FIG. 3 SECTION OF EXISTING FLYING CONTROL CABIN SHOWING OPERATOR'S EYE POSITIONS

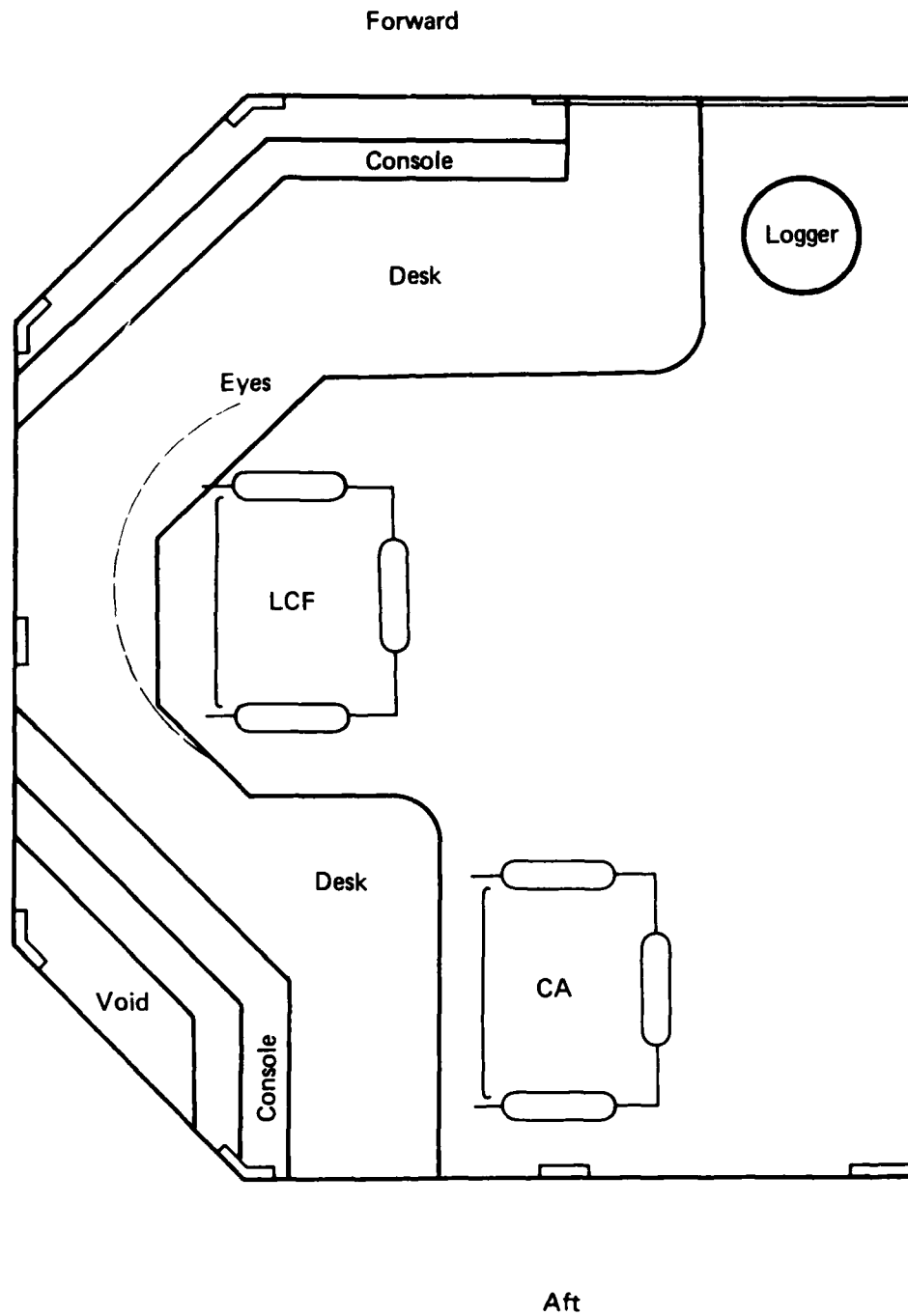


FIG. 4 PLAN VIEW OF PROPOSED LAYOUT SHOWING BOUNDARY OF EYE POSITIONS

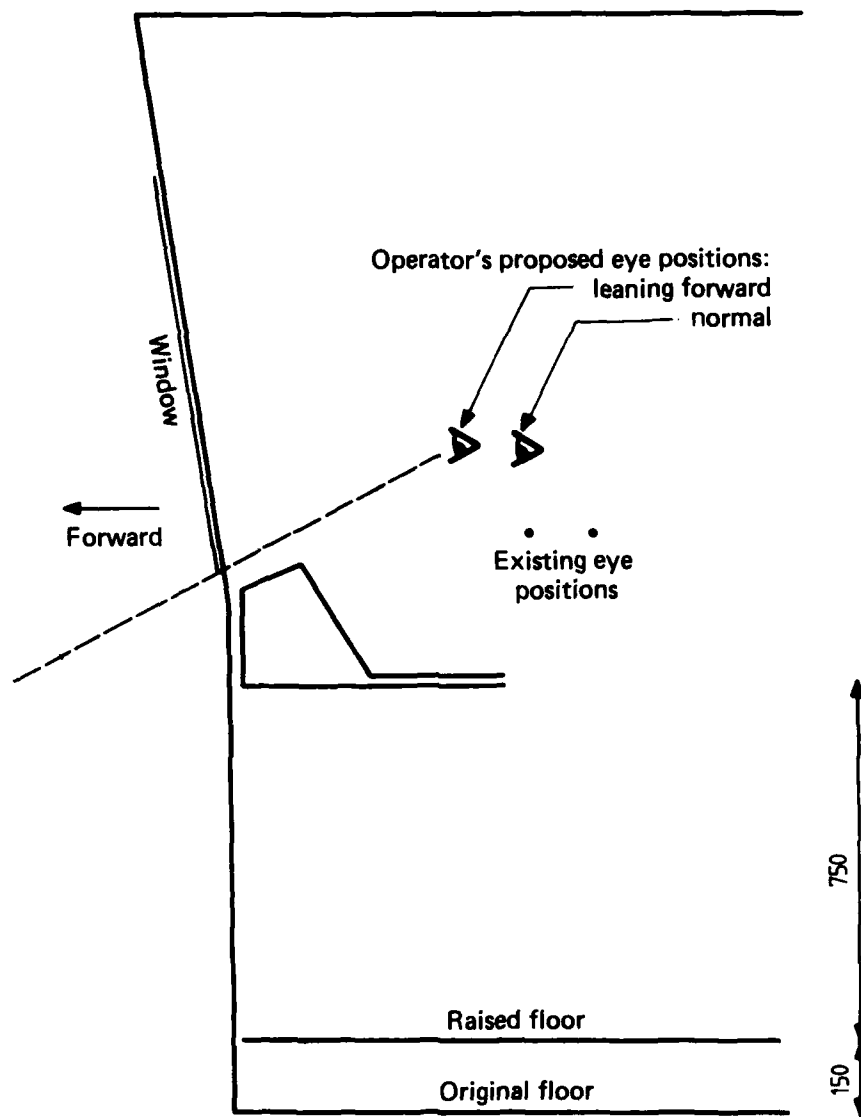


FIG. 5 FORWARD SECTION OF PROPOSED LAYOUT SHOWING THE IMPROVED DOWNWARDS VIEW

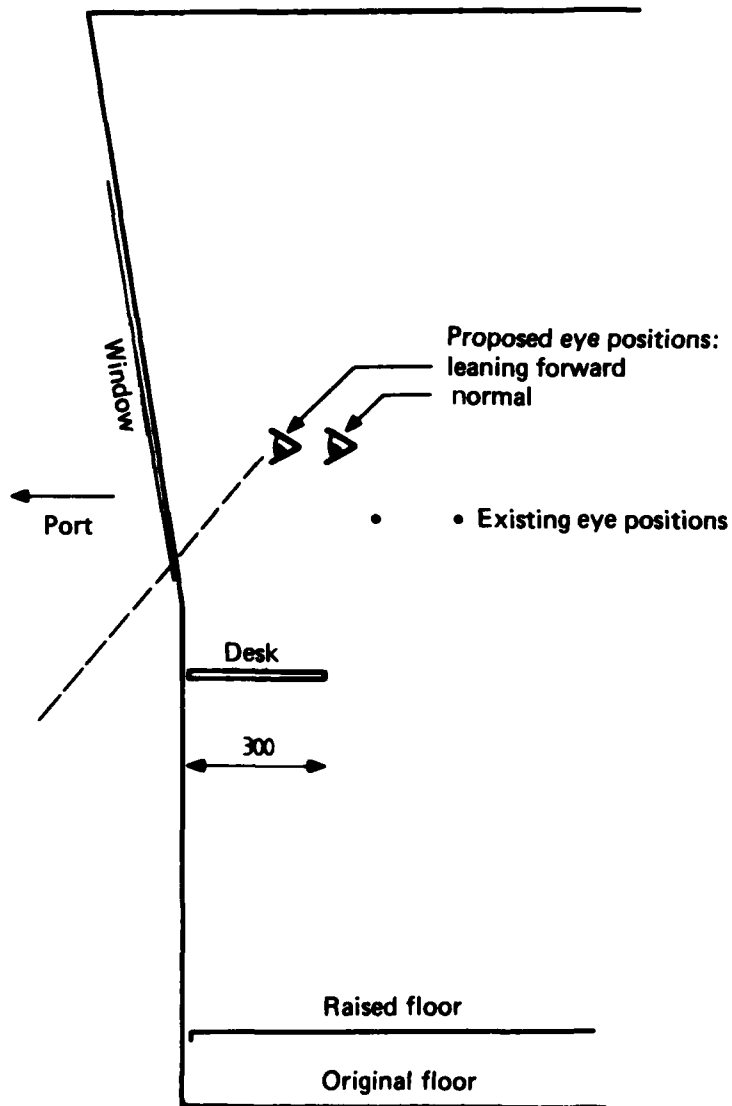


FIG. 6 SECTION OF PROPOSED LAYOUT SHOWING VIEW TO PORT

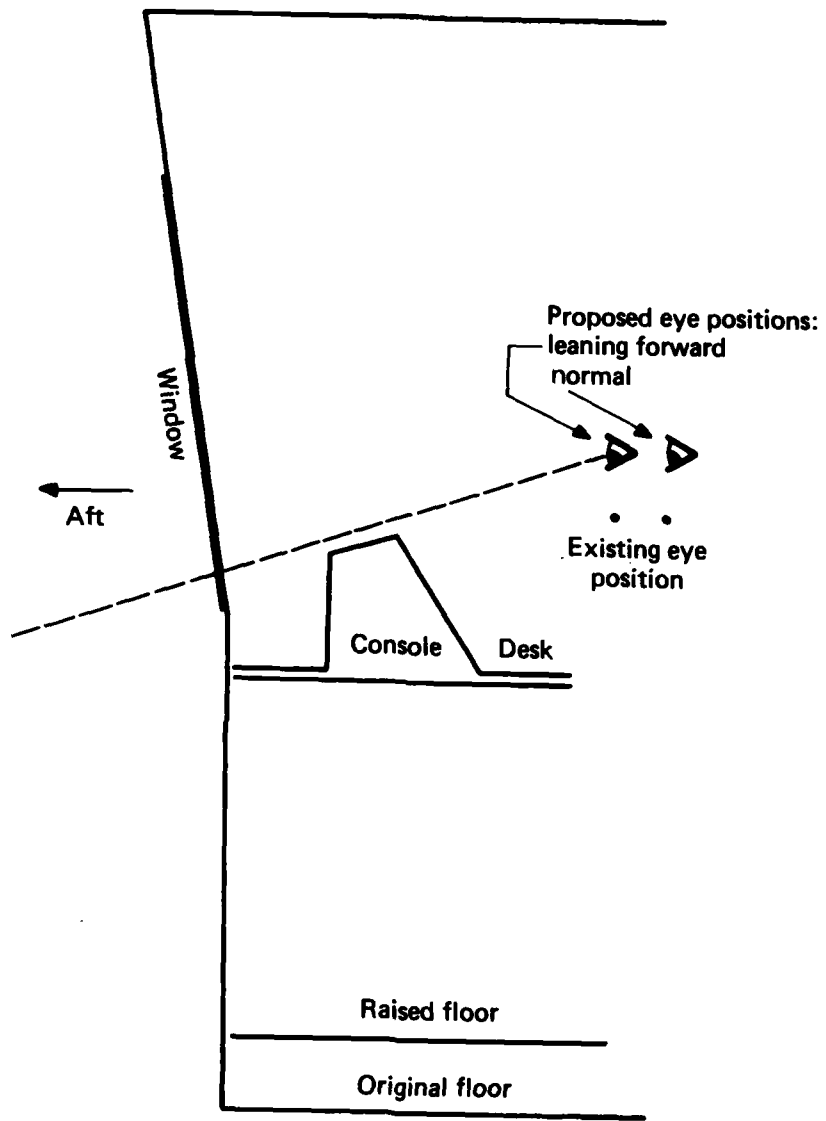


FIG. 7 SECTION OF PROPOSED LAYOUT SHOWING IMPROVED AFT VIEW

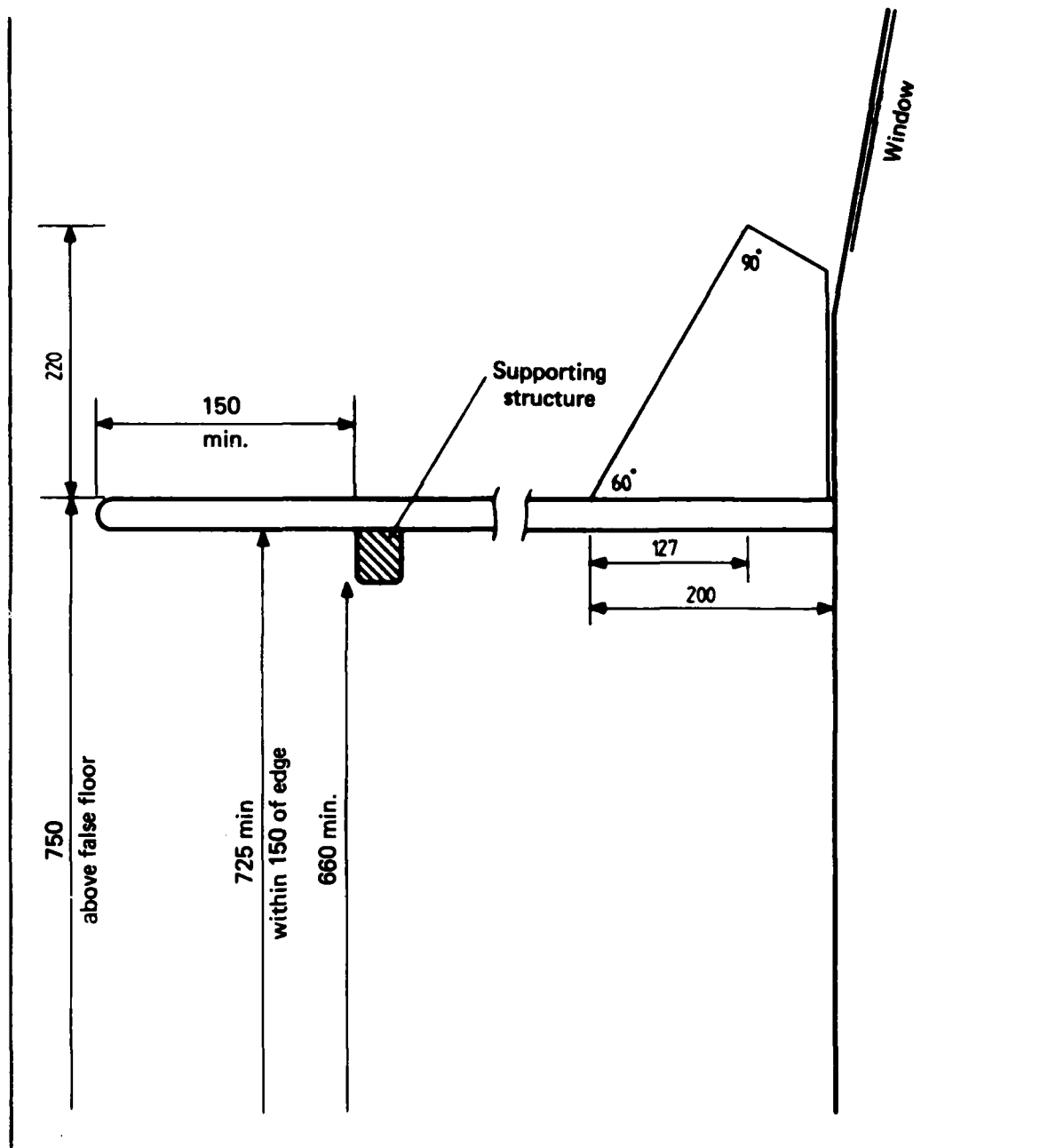


FIG. 8 DIMENSIONS OF FORWARD CONSOLE AND DESK SECTIONS

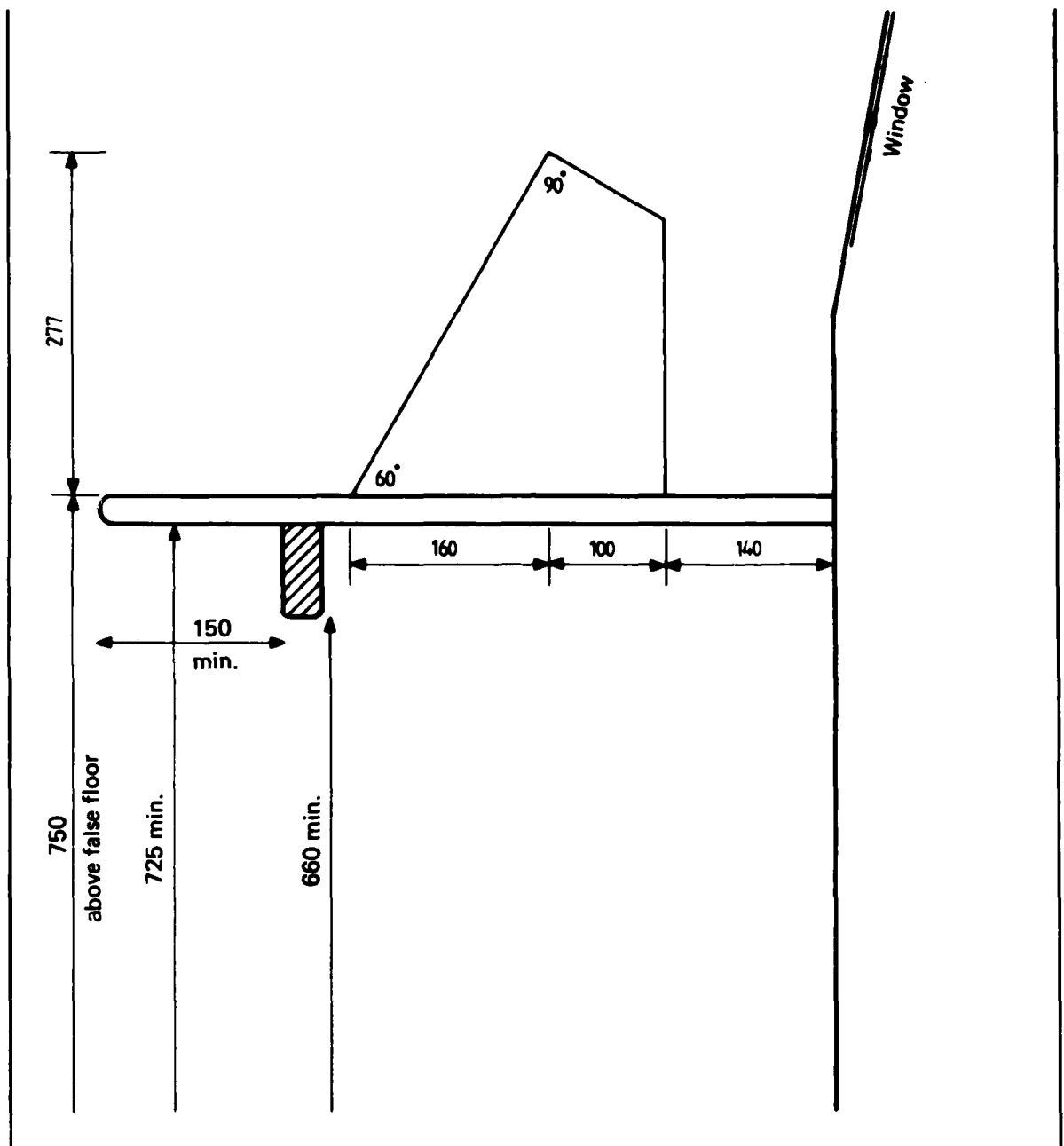


FIG. 9 DIMENSIONS OF AFT-QUARTER AND DESK SECTIONS

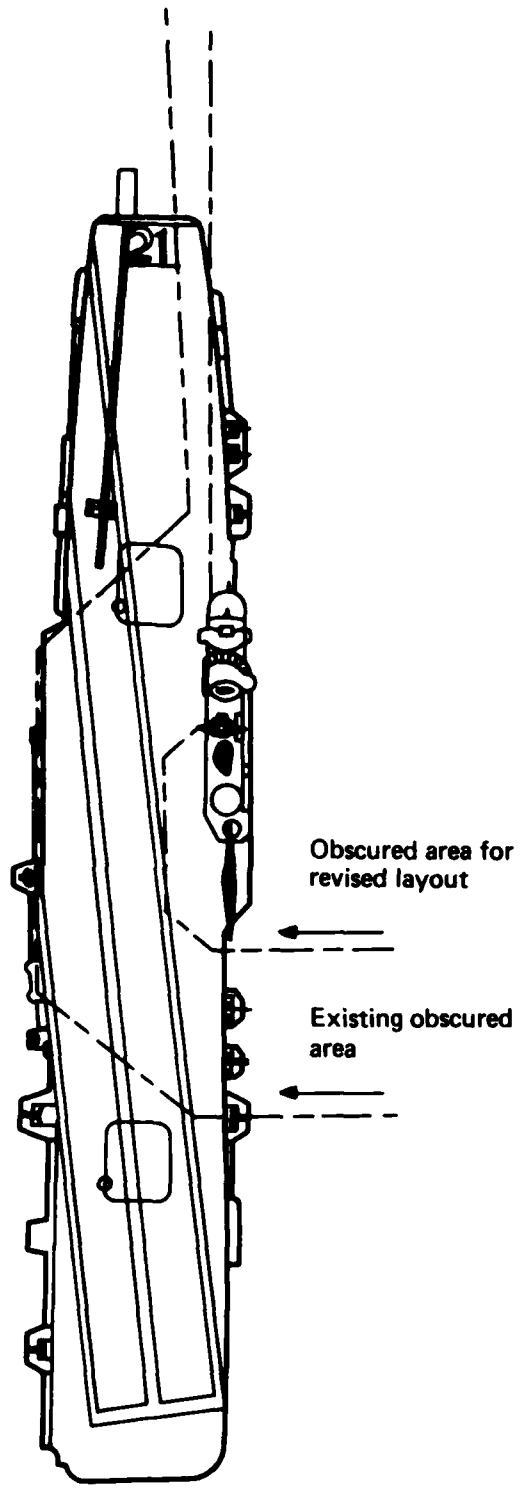


FIG. 10 OBSCURED FLIGHT DECK AREAS: COMPARISON FOR VIEW OF A 50TH PERCENTILE NAVAL AVIATOR SEATED UPRIGHT IN THE FLYING CONTROL CABIN

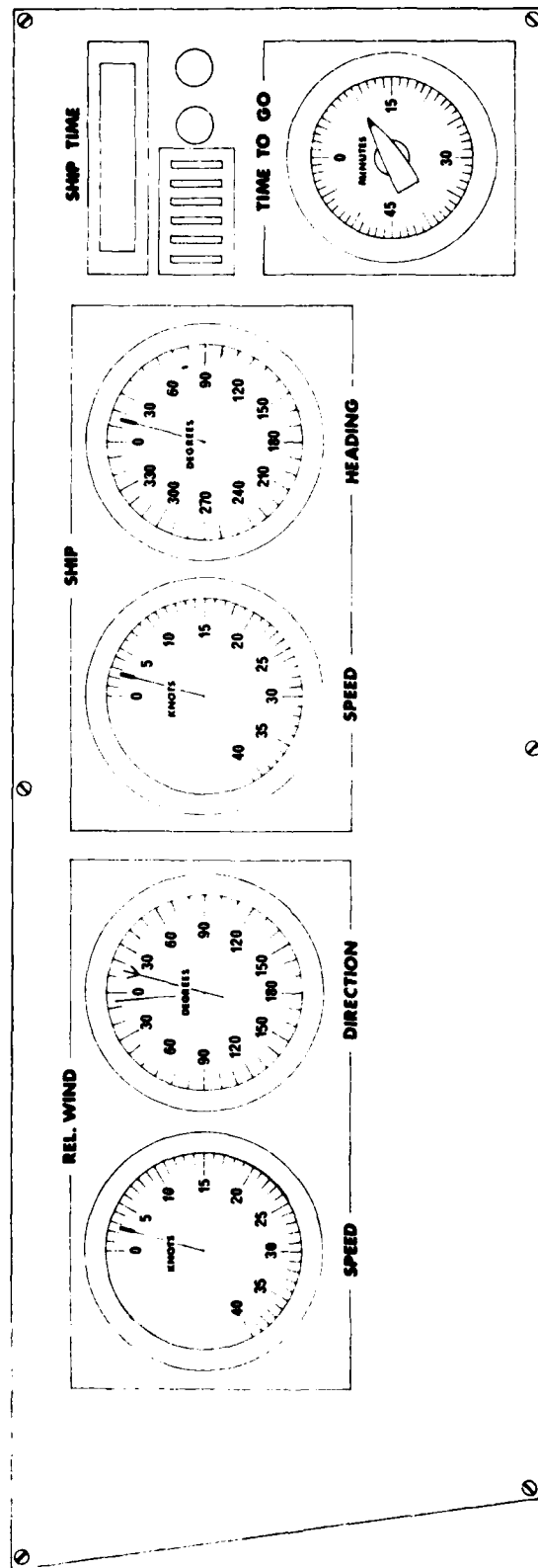


FIG. 11 PROPOSED FORWARD PANEL LAYOUT

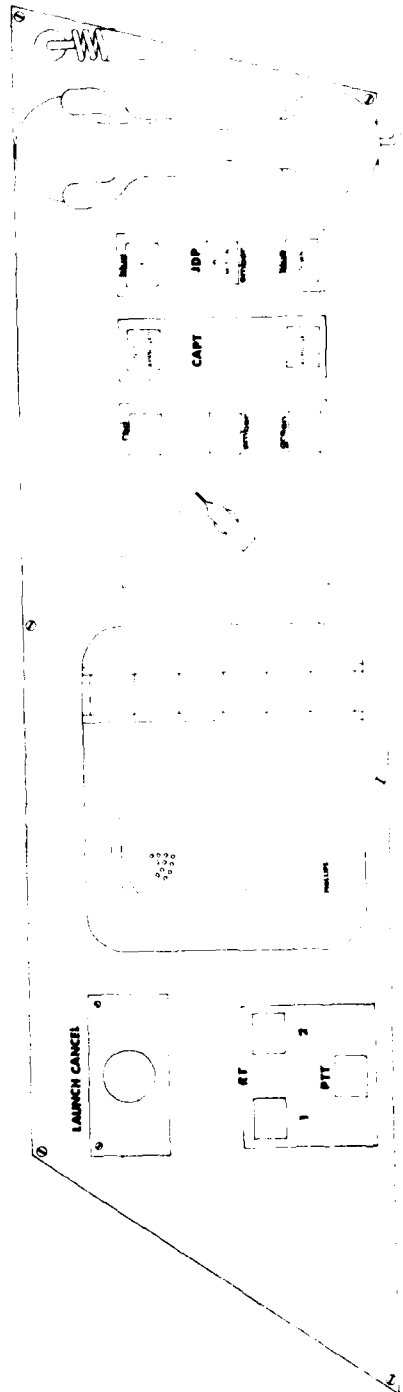


FIG. 12 PROPOSED FORWARD-QUARTER PANEL LAYOUT



FIG. 13 PROPOSED AFT-QUARTER PANEL LAYOUT

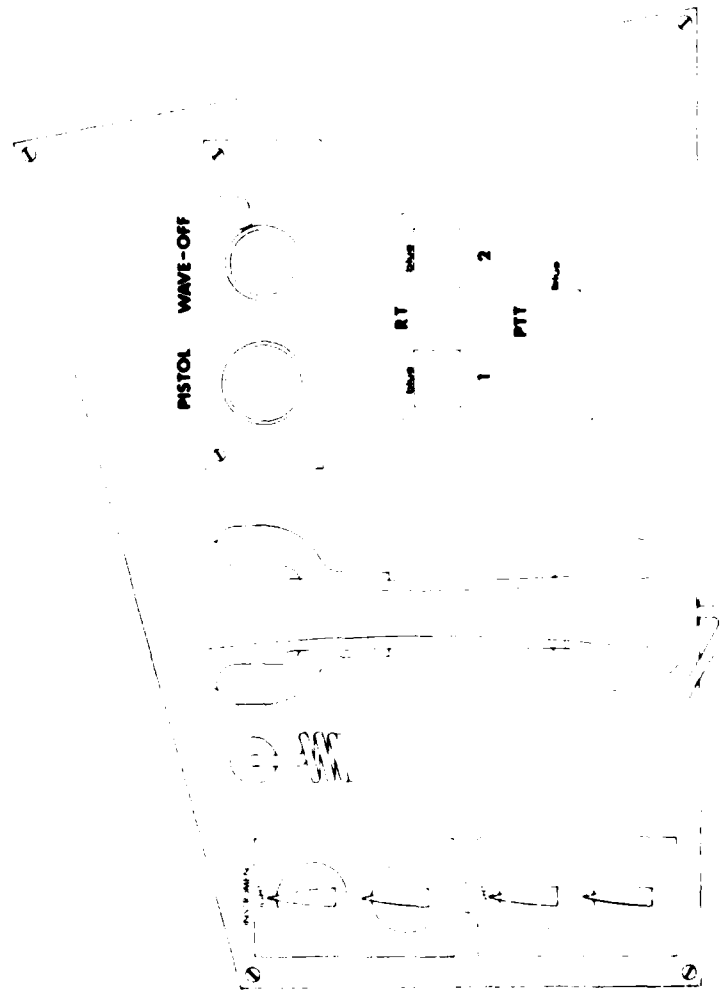


FIG. 14 PROPOSED AFT PANEL LAYOUT

ABBREVIATIONS

ACR	air control room
ADR	air direction room
ARL	Aeronautical Research Laboratories
ATC	air traffic controller
CA	Commander 'Air'
CCA	carrier-controlled approach
FDEO	Flight Deck Engineering Officer
FDO	Flight Deck Officer
Flyco	Flying Control Position
LCF	Lieutenant Commander 'Flying'
LSO	Landing Signals Officer
MDLA	mirror deck-landing aid
OTG	operational telephone group

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