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BRIDGE DESIGN ON DUTCH MERCHANT VESSELS; AN ERGONOMIC STUDY

PART III: OBSERVATIONS AND PRELIMINARY RECOMMENDATIONS

(ERGONOMISCHE STUDIE BETREFFENDE DE BRUG VAN NEDERLANDSE KOOPVAARDIJSCHEPEN)

(DEEL III: OBSERVATIES EN VOORLOPIGE AANBEVELINGEN)

by

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BRIDGE DESIGN ON DUTCH MERCHANT VESSELS; AN ERGONOMIC STUDY

The results of the first phase of this study are summarized in three communications, e.g.:

34 S Part I: A SUMMARY OF ERGONOMIC POINTS OF VIEW (DUTCH) (ERGONOMISCHE UITGANGSPUNTEN)
A. LAZET, H. J. SCHUFFEL, J. MORAAL, H. J. LEEBEEK and H. VAN DAM

35 S Part II: FIRST RESULTS OF A QUESTIONNAIRE COMPLETED BY CAPTAINS, NAVIGATING OFFICERS AND PILOTS
J. MORAAL, H. SCHUFFEL and A. LAZET

36 S Part III: OBSERVATIONS AND PRELIMINARY RECOMMENDATIONS
A. LAZET, H. SCHUFFEL and J. MORAAL

VOORWOORD

Dit rapport vormt het laatste deel van een serie van drie, gericht op de ergonomische aspekten van het brugontwerp.

Dit laatste deel is bedoeld als een samenvatting, waarin voorlopige normen en aanbevelingen voor het ontwerp, inrichting en uitrusting van het navigatie komplex van grote tankers, containerschepen en moderne vrachtschepen wordt gegeven. Voorts is in dit rapport een voorbeeld gegeven van een bestek voor de bruginrichting.

De gegevens voor dit rapport werden geput uit een literatuurstudie en bestaande kennis en ervaring van het Instituut voor Zintuigfysiologie TNO, gesteund door de resultaten van een vragenlijst welke werd voorgelegd aan – en beantwoord door – een aantal kapiteins, stuurlieden en loodsen (zie ook mededeling 34 S en 35 S).

De volgende fase van het onderzoek welke nu reeds enige tijd aan de gang is, behelst de toetsing van de eerder genoemde normen en aanbevelingen aan de hand van een statische mock-up. Na voltooiing van dit gedeelte van het onderzoek, zal een dynamische simulatie worden uitgevoerd, waarbij een groot aantal, voor het navigatie gebeuren van belang zijnde, dynamische in- en externe faktoren in de mock-up zullen worden ingevoerd.

NEDERLANDS SCHEEPSSTUDIECENTRUM TNO

PREFACE

This report is the last one of a series of three, dealing with ergonomics in bridge design.

This last part is intended as a summary, giving a number of preliminary standards and recommendations for design and lay-out of wheelhouses and bridges on tankers, containerships and modern general purpose cargo vessels.

Moreover, in the report in question an example of an outline specification for the lay-out of a bridge is given.

The data presented in the report were based on a study of literature and on existing know-how of the Institute for Perception TNO, supported by the results of a questionnaire completed by captains, navigating officers and pilots (see also communication nr. 34 S and 35 S).

The next phase of this study on ergonomics in bridge design, now being under way, comprises the evaluation of the standards and recommendations by means of a static mock-up. After completion of this part of the research, a dynamic simulation will be carried out. Input into the dynamic mock-up is a great number of in- and external dynamic factors, of importance for practical navigation.

THE NETHERLANDS SHIP RESEARCH CENTRE TNO

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PART III: OBSERVATIONS AND PRELIMINARY RECOMMENDATIONS

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Summary

Factors like increasing ship traffic density, environmental pollution and differences of manoeuvrability of each type of ship, make the man/machine relationship more important.
The wheelhouse takes an important place because in this room the man/machine relationship is shaped.
From an ergonomic point of view we tried to find the optimum solution of the wheelhouse-design. In this part of the report the observations on existing vessels are described and with the use of the information from the foregoing parts, preliminary recommendations are stated.

Samenvatting

Verschillende factoren, zoals toenemende scheepvaartintensiteit, milieuverontreiniging, rentabiliteit en verschillen in manoeuvreerbaarheid per scheepstype, benadrukken de mens/machine relatie van het systeem schip.
De brug van een schip neemt hierbij een belangrijke plaats in, omdat daar aan de mens/machine relatie "vorm" wordt gegeven in de breedste betekenis.
Voor deze studie is daarom vanuit de ergonomie naar een "optimale" oplossing van het brugontwerp gestreefd.
In dit deel van het rapport worden observaties aan boord van bestaande schepen beschreven en met de informatie uit de voorgaande delen voorlopige aanbevelingen verstrekt.

Introduction

The Netherlands Ship Research Centre TNO asked the Institute of perception TNO to investigate the ergonomic requirements for the navigation complex of merchant vessels. Particular attention had to be paid to tankers, freighters and container-ships.

It was presumed that the existing knowledge at the Institute would be applied after taking an inventory of bridge designs of existing ships. Analysing the bridges of a large number of vessels would have taken too much time. So the number was limited, and further information was obtained by using questionnaires.

It has to be emphasized that in the first instance the research was directed towards rationalisation of the bridge on the basis of the present situation. This means that existing equipment had to be used, and that the present training of the crew was the starting point.

These were severe limitations. The same applies to the watch of the engineroom, the ship as a whole, remote control of deck equipment, exchangeability of crews, the degree of automation and the use of computers. In a short section some remarks will be made regarding these limitations.

The purpose of the report is to describe in detail a bridge design which is as appropriate as possible from an ergonomic point of view.

1 Observations

1.1 *Bridge design of some existing ships*

In order to know present designs the drawings of existing bridges were studied.

1.2 *Voyages aboard various ships*

Six ships were studied during short "coastal trips" extending from 2 to 10 days. On the average, weather was very good. The areas were harbours, pilotage and coastal waters, so generally an environment were heavy traffic is costumary.

The information obtained during these short trips, and by studying the drawings, is of course limited. In order to be better informed, a questionnaire was composed. The following information was obtained regarding number and duty of the crew on the bridge.

Description of functions and duties, regarding only the navigation (see 2.1.1)

captain:	supervises operations and information displayed
	final decision in difficult situations
	very few actions carried out personally
mate:	supervises operations and information displayed

makes decisions, in difficult situations together with the captain
more actions than the captain

helmsman: only carries out orders in keeping course; the execution of the task is constantly supervised

look-out: stands normally on the bridge-wing

pilot: advice about course and speed
supervises operations and information displayed

Table I. Number of crew on the bridge

	visual range		
area	good	limited	very limited
open sea	mate look-out (at night)	mate look-out	captain mate look-out
open sea, but confined areas with dense traffic	mate look-out (at night)	captain mate look-out	captain mates (1 or 2) helmsman look-out
pilotage waters	captain mate pilot	captain mates (1 or 2) pilot helmsman look-out	captain mates (1 or 2) pilot helmsman look-out
docking berthing anchoring	captain mate pilot (harbour) helmsman look-out	captain mates (1 or 2) pilot helmsman look-out	captain mates (1 or 2) pilot helmsman look-out

1.3 *Questionnaire*

In order to get an impression of the opinion of captains, navigating officers and pilots about bridge lay-out and equipment a questionnaire was used. The questionnaire consisted of 138 statements. The basic material for the statements was gathered during some small voyages with various ships. During these voyages the functionaries on board were interviewed. Their opinions about several topics were used in formulating the statements. Afterwards the questionnaires were mailed to captains, navigating officers and pilots. A hundred and fifteen copies were completed: sixty-seven from captains and navigating officers and forty-eight from pilots.

The answers to the statements could be given by "agree", "no opinion" or "disagree".

By using this questionnaire it was possible to reach many people in a simple way. Also it was possible to put the questions in the same way for everybody.

The 138 statements belonged to one of the following topics:

- some general statements
- perception of the environment
- position of equipment, bridge lay-out
- functioning of instruments and equipment
- reading/operating instruments and equipment
- comfort
- lighting of bridge and instruments
- team work
- training
- task load
- task uncertainty.

The results of the questionnaire are given in Part II of this study. They are to be considered mainly as a starting point for discussion purposes and to see whether certain opinions can serve in helping to design an optimal bridge lay-out. This has to be underlined strongly to withstand the possible misunderstanding that the questionnaire gives the last word in what to design and how. It merely has a function to help in forming a good line of thought in bridge design.

1.4 *Findings by the "Board of Navigation"*

The findings for the years 1970 and 1971 were studied in order to derive conclusions regarding bridge design. This turned out to be very interesting. Also "Recommendations, instructions and warnings for oceangoing and coastal trading-vessels", 1968, was read [21].

It should be noted, that some statements regarding ergonomics have to be considered with some caution. For instance (U 23, appendix to the Nederlandse Staatscourant, 19 april 1971, nr. 74) the judgment of the council: ". . . the question of guilt needs hardly any consideration, because it is clear that the captain during a lonely watch had fallen asleep while sitting . . . that sitting rather than standing or walking is always inadmissible, as it is clear that this can lead to fatal consequences".

In general it is stated here that sitting is inadmissible during watchkeeping; however, it is mentioned explicitly that the watch was a "lonely" one, that the captain was very tired (no sleep during the last 24 hours), and that navigation under such circumstances ought not to be carried out by one man. The possibility of alternate sitting and standing might be very useful for the performance of such a task. A static muscle load can cause pain and fatigue. Therefore such a load is very tiring.

1.5 *Shipping act*

In this act some instructions are given regarding the lay-out of the bridge and the required apparatus.

As fas as the lay-out concerns:

Art. 49.1. The position from which the ship is naviga-

ted must give the helmsman an unobstructed view of the foreship.
Art. 49.2. A navigation bridge must range over the complete breadth of the ship, unless the type of ship prohibits this. From the bridge an unobstructed view of the foreship is required.

Moreover some instructions are given regarding steering gear, engine control, nautical instruments etc. There is no need to go into these details.

1.6 *Study of near-miss cases*

In order to study the causes of accidents, findings by the "Board of Navigation" can be very useful. Also "near-missers" may give indications where human factors are important. It appears, however, that interviewing aboard ships is not the right method to obtain useful data on this subject matter. Only in some specific cases, such as setting the wrong course, or complete misunderstanding of orders by the helmsman, a number of people gave their comments. So in the questionnaire such questions were not asked. However, it might be useful to give it another try in the future.

2 Preliminary recommendations

2.1 *Starting points*

2.1.1 The purpose of the bridge

All people needed for the navigation of the ship, and whose presence on the bridge is necessary, must find an appropriate place on the bridge under all weather conditions. Here navigating means information gathering, information processing, decision making and taking actions, in order to make the most efficient and safest voyage to the next port of call.

2.1.2 The ship-owners' point of view

A number of actions on the bridge are dependent on the philosophy of the "ship-owners". Here it must be stated that for the present design the engine-room cannot be watched from the bridge. There is remote control of the engines, but information about the condition of the engines is lacking. Remote control of deck-equipment is limited to the possibility of dropping the anchor from the bridge. Costs and cost-criteria are not taken into consideration.

2.1.3 Crew members and functions

Based on the data of the project, and also on our own observations, the composition of the crew and the functions for every crew member was according to § 1.2, Table I.

2.1.4 The position of the bridge

The position of the bridge is important with regard to ship motions and the necessity to have an unobstructed view. Ship motions introduce accelerations with a variation smaller than 1 c/s. The graphs in communication 34 S, Ch. 2 do not help very much. The only clear trend is, that the accelerations must be as small as possible. The study revealed answers to the question whether a ship with a stable platform would give a better performance than a conventional moving vessel for the tasks on the bridge. A stable platform would contribute from "some" to "much" better performance according to the study [1]. This influence might be weighted depending upon the moving characteristics and the route of the ship.

The data are too vague to permit clear conclusions. It is certainly preferable to put the bridge in the neighbourhood of the centre of gravity of the ship (about the centre of gravity of the load-line surface at pitching and the weight centre of gravity of the ship for rolling [2, 3, 4, 5]).

In order to be able to observe yawing properly, the bridge should be situated near the pivot point, at about $\frac{1}{3}$ L from the stem.

The view from the bridge

Forward view: an unlimited view ahead is absolutely necessary. However, this is not always the case because the position and size of the cargo gear. If an unobstructed view is required, it is necessary for the naval architect to find adequate solutions.

At what height must the bridge be placed? No answers are found in the literature. From a 1969 study of Shell Tankers on VLCC's it may be concluded that the vertical blind sector in front of the ship was no great problem. During sailing, radar is a good compensation. During manoeuvring and mooring a man fore and aft with telephone communication is sufficient. It remains important to be able to compare points on the horizon or other parts of the surroundings with a reference point on the ship.

View sideways: When passing ships, jetties etc. the possibility to see the water surface on both sides from the navigation position is essential. With present designs of bridge-wings this is not possible. It is therefore recommended that when these bridge-wings are wide they should be located further aft than usual (see Fig. 2.1).

The view of the aft and downwards is also important. Therefore, it is necessary to have as little deck surface as possible outside the floor of the bridge itself. During mooring and manoeuvring near docks and in harbours, it must be possible to look alongside

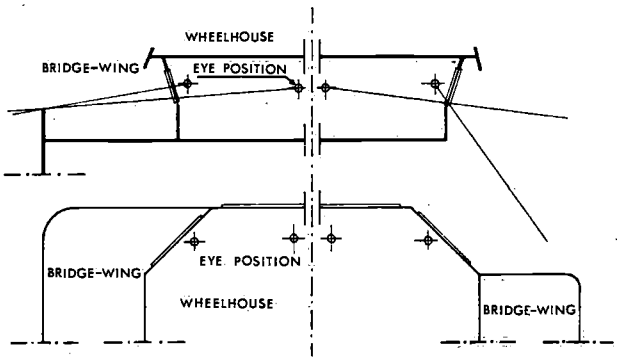

Fig. 2.1. Crosssection and groundplane of a bridge with and without view of the ship's sides, from the wheelhouse.

or almost alongside. The bridge-wing must allow for this. Moreover, it is important that the forecastle and the poop can be seen from the bridge-wing. T.V. as an instrument to extend the view can be very useful. However, distance estimation using T.V. is not possible. There are reports in the literature about mooring a ship with a blinded bridge and using only TV-information [6].

A raised position of the bridge might therefore be an alternative for the use of the bridge-wings, provided the view is complemented by T.V. The position of the TV-camera has to be as high as possible [8]. In that case large bridge-wings can be avoided when a man fore and a man aft are provided.

2.2 *Lay-out of the bridge*

A number of consoles are installed on the bridge. In order to make a design, an estimation of the size, and in particular the required space is needed. In Table II a summary of the required space is given.

Table II. Floor space needed for consoles of groups of apparatus

Description of apparatus	floor space m²	total m²
1. Chart table	2	
Apparatus for position indication	2	
Floor space	5	9
2. Radar	1	
Floor space	2	3
3. Steering position	1.5	
Floor space	1.5	3
4. Navigation arrangement	1.5	
Floor space	1.5	3
5. Communication	1.5	
Floor space	1.5	3
6. Pilot position	1	
Floor space	1	2
7. Indicators	1	
Floor space	1	2
8. Miscellaneous: pantry, doors etc.		5
Total floor space needed:		30

ad 1. The size of the chart table is 2 × 1 m. The apparatus for position fixing (Decca etc.) is put in a console of 2 × 0.6 m, and a reserve console of 1.3 × 0.6 m for omega, loran or echo-sounder. A second chart table is required if not enough room is left on the first one for secondary activities, e.g. writing-up journals etc.

ad 2. Here 2 radar apparatus are envisaged in such a position that one can navigate by radar (blind navigation).

ad 3. These are: the wheel, course information, track plotter.

ad 4. Navigation arrangement: information about the engines, and remote control of the engines. Remote controle here is accepted as a "must" because the advantages have been proved in practice.

ad 5. Communications. The space reserved leaves open the question of whether the apparatus is put in a separate console, or is put together with other instruments in combined consoles.

ad 6. Pilot position. It is tentatively assumed that the pilot needs his own radar during manoeuvring. This opinion is based on the observation that pilot and mate often seem to have different ways of using radar. The pilot also needs information about course, rudder angle, speed and revs/min of the shaft.

ad 7. Information about the ship. On the bridge are required:
bilge alarm
smoke alarm
temperature alarm
CO_2-fire extinguisher control
navigation lighting control.

ad 8. Miscellaneous: doors
seats
pantry
cupboard.

All the above-mentioned apparatus have to be placed on the bridge in the best possible way. The use of the apparatus, and the external circumstances (traffic density, weather) have to be taken into account. Ergonomic requirements and practical experience (study, own observations, sentences by the Board of Navigation) are determining factors in the design.

When one has to perform a task at a fixed position, a combination of sitting and standing is better than merely standing. This is why the helmsman may be seated. The officer of the watch or the captain is less tied to one position and can alternatively be standing or sitting.

A ship is steered from the centre line. Sometimes

this is not possible because of obstructions in the helmsman's field of view. Centre line steering is only important during manual steering, when the plane of the centre line and perpendiculars, or a plane parallel to it, is used as a line of sight.

The investigation showed the wish to have a free passage from starboard to port, particularly when manoeuvring in harbours and channels.

It is essential that two or three people can observe the radar screen at the same time. Daylight filters must not obstruct the field of view. The radar display, the chart and the surroundings have to be compared quickly (according to the questionnaire).

Opinions regarding the positions of the various pieces of apparatus on the bridge vary greatly. In general it seems, according to the investigation and our observations, that on existing bridges the apparatus are spaced too far apart. The question remains, how should they be grouped in an optimal way, and what are the technical limitations in achieving this.

The discussions in literature mainly concern the question: to have or not to have a split-level bridge [12, 13]. Even a three-level bridge was proposed [14]. At the higher level of the "split-level bridge" is the conning position. This level resembles an airplane cockpit. The cockpit idea is based on the opinion that at present the apparatus on the bridge is too much scattered, and that the outside view is insufficient. At the lower level, the chart table, navigation aids and handsteering are located (one can use the automatic steering in the cockpit).

The split-level concept was never fully accepted, neither by Navies nor on merchant ships. The principle is considered out of date and superfluous provided a 360° field of view can be realised in a one-level bridge and thus the conning position is at the same level as the position of the chart table. This was also concluded when designing a bridge for a frigate of the Royal Netherlands Navy [15]. The design is shown in Fig. 2.2 [16].

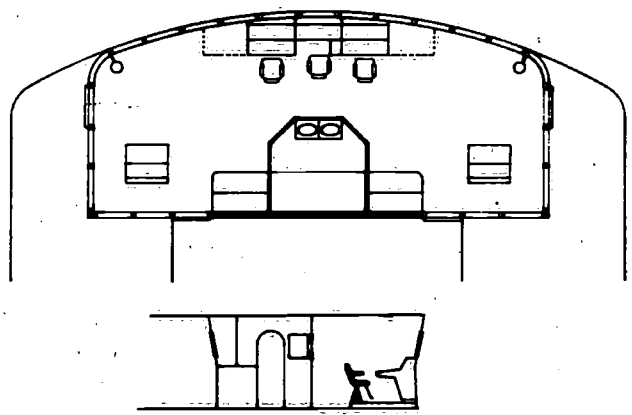

Fig. 2.2. Ground-plan of the new design.

In this design, conning position, chart table position and communication desk are separated, but individually grouped together at one level.

The usefulness of this idea is underlined by several authors [17, 18, 19, 20]. There are, however, different opinions on three points. These are the place of the conning position with respect to the wheelhouse front bulkhead, the function of the helmsman and the communication desk. The latter two will be discussed elsewhere.

We prefer to put the conning console as close to the wheelhouse frontbulkhead as possible. Next to the console, people can stand close to the bulkhead, a possibility which allows one to view the deck. Those who prefer to do this along the full width of the frontbulkhead are in favour of leaving some room between frontbulkhead and console. The advantage of having the console close to the bulkhead is that the man

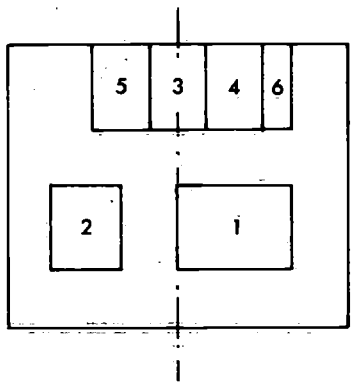

Fig. 2.3. Lay-out of the groundplan of the bridge according to 2.1. The conning position is situated against the front bulkhead.

1 = chart table
2 = radar
3 = conning position
4 = speed control
5 = communication
6 = pilot position

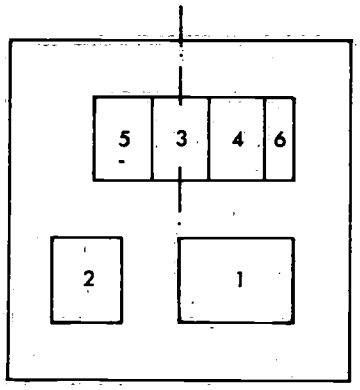

Fig. 2.4. Lay-out of the groundplan of the bridge. There is a gangway before the conning position, which makes obstruction of the helmsman's view possible.

See Fig. 2.3 for the meaning of the figures.

behind the console never gets his field of view obstructed by someone standing before him.

The ways in which the various groups can be located on the bridge are given in Fig. 2.3 and Fig. 2.4, giving the two alternatives, the console close to the bulkhead or with a passage before the console. The relative positions of 1, 2, 4 and 6 with respect to port or starboard is arbitrary. In both designs the depth of the bridge has its own minimum values.

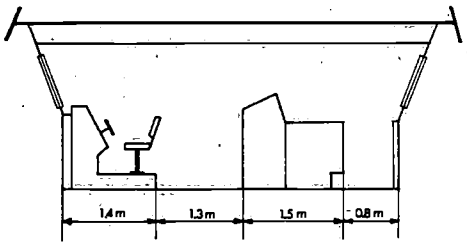

Fig. 2.5. Minimum depth of the bridge with the console against the front bulkhead.

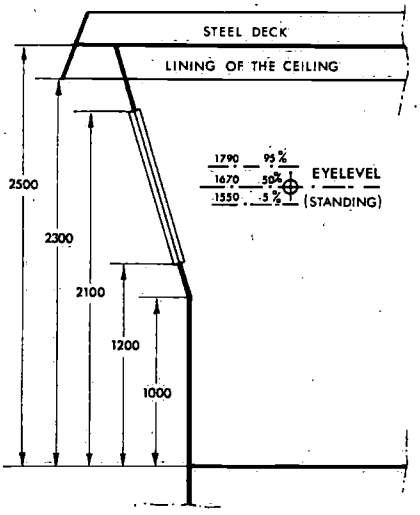

Fig. 2.6. Cross-section through a bulkhead of the bridge. The centre of the windows equals the average eye-level when standing.

2.3 *Design of the bridge*

2.3.1 Shape of front and sides

In the bulkheads the windows have to be placed at an angle of at least 10° in order to avoid reflections in the windows. This must be consequently applied to all bulkheads, and also to the door. The size of the windows must be as large as possible, at least 800 × 800 mm. The central point of the windows must be 1670 mm above the deck, which is the average eye-level of a man in a standing position. It is desirable to have a sunshade outside the bridge.

When filters in front of the windows are used to avoid bright sunlight they must be removed during nighttime. For this reason glass-coatings are not desirable. It seems, therefore, more practical to wear sunglasses when the sun shines. Window heating or thermopane windows are recommended to prevent condensation.

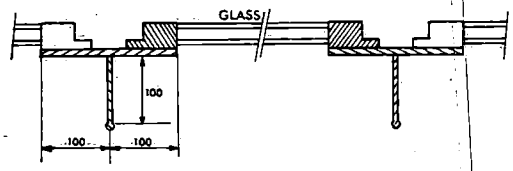

Fig. 2.7. Stiffeners between the windows with maximum dimensions.

The width of the posts must be less than 100 mm (see Fig. 2.7). Then the blind sectors caused by these posts is no more than 10°, and can be overcome by movements of the observers head.

The height of the stiffener must not exceed 100 mm either. It is better not to line these posts in order to retain maximum view outside.

The 10° mentioned above is a factor which originates more from practical experience than from theoretical considerations. If at all possible, the blind sectors caused by the funnel, derricks, etc. must not be more than 10°. A circular-shaped bridge is ideal to limit the obstructions in the field of view. By choosing large windows, and approximating the circular shape by straight segments as shown in Fig. 2.8 sufficient view is maintained.

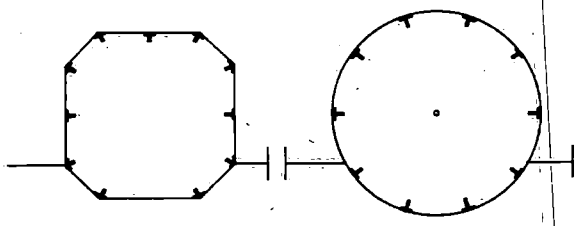

Fig. 2.8. A circular bridge, giving from the centre an optimum view outside. A bridge with straight sides (left) almost achieves this ideal groundplan.

2.3.2 Doors and stairs

In order to avoid draught and the entering of light when entering the bridge by the stairs from inside it is necessary to have a foyer. Further, it is recommended to have red lighting on the stairs and in the hall to avoid influence of the illumination on dark-adaptation. The doors towards the bridge-wings must have sloping windows. For this purpose sliding doors are better than conventional doors.

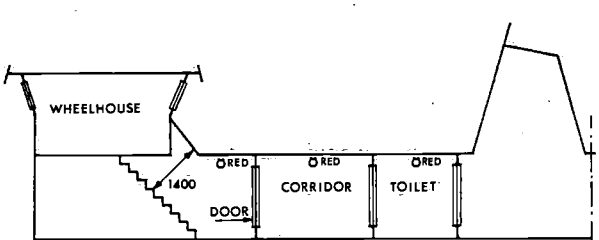

Fig. 2.9. Lighting of the gangway and staircase to the bridge. The door is important to prevent draught.

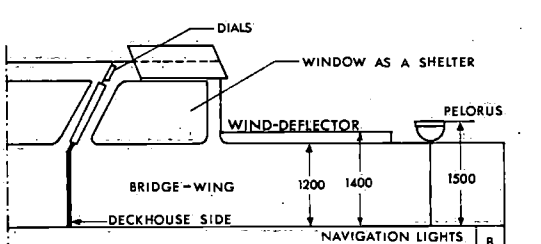

Fig. 2.11. The bridge-wing.

2.3.3 Bridge-wing

The shape of the bridge-wing determines whether one can look downwards upon the water or not. To look alongside it is, however, necessary to extend the bridge-wings up to ship sides. When the breadth is very large, e.g. on supertankers (Fig. 2.10) it is more efficient to have a 360° view from the bridge, combined with T.V. to look downwards along the ship, and with a man fore and aft.

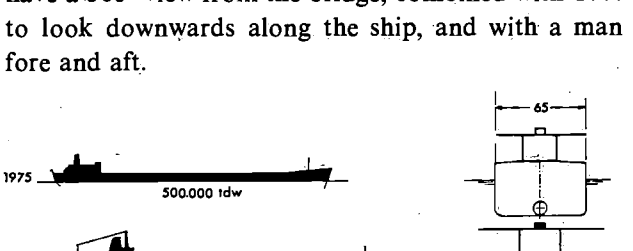

Fig. 2.10. Bridge-wings on ships with a beam larger than 65 m. It is clear that bridge-wings for looking alongside have to be replaced by other possibilities in the future.

Some experience with T.V. was gained aboard ships. However, it is advisable to continue experiments on existing ships in order to obtain confidence with this method before being able to reduce the size of the bridge-wings on large vessels.

The minimum information needed on the bridge-wings are the revolutions of the shaft, a rudder angle and a pitch angle indicator with compatible and legible scales, visible from any position on the wing. The pointer of the revolutions indicator must be pointed to the right when the engines are running ahead. In the case of a twin-screw ship, indicators for the shaft revolutions are required on each bridge-wing and both turning to right when the ship is sailing ahead. Moreover, one needs a pelorus, the airwhistle control and communication facilities with the forecastle, the poop and the wheelhouse. The possibility to operate the bow-thruster from the bridge-wing is useful only when one can look alongside at the same time, and when the other indicators can be read also.

In case of unfavourable weather conditions some shelter is necessary, as well as a wind deflector.

2.3.4 Noise

The "Buiten" noise-level criteria [23] are recommended:

a. open bridge-wing, full ahead NR 75
   open bridge-wing, main engines stopped NR 50
b. inside the wheelhouse, full ahead NR 65 Sil 55
   inside the wheelhouse, main engines stopped NR 55
   (these values are valid for octave-bands with centre frequencies of 250 up to 8000 Hz).

Considering the design with regard to noise there are two starting points:

a. an acoustically "hard" surrounding, which gives a maximal chance of detecting sound signals in fog, and
b. an acoustically "soft" surrounding, which is considered as more comfortable.

When listening to signals in fog one has to be on the bridge wing. Considering the proposed criteria, this is a logical place. Therefore, it is recommended that sound-absorbing ceilings be installed in the bridge. The possibility to open a number of windows is recommended from the point view of detecting sound-signals. One must be cautious not to overestimate the value of detection. Accuracy of direction estimation is limited. Errors of 5° in a forward direction and up to 15° in lateral directions are possible. Distance estimation is very difficult because the observer is unaware of certain characteristics of the source of the sound, e.g. volume and accuracy of direction of the source.

Noise sources such as transformers etc. must be put in rooms away from the bridge.

In order to decrease the noise level on the bridge it is recommended not to connect the funnel with the wheelhouse complex. This avoids transmission of the noise caused by exhaust gases.

2.3.5 Climate

See Part I (communication 34 S).

2.3.6 Colour and material

The following colour scheme is recommended:

Ceiling:	white, with a shade towards green, mat.
Posts between windows:	the same
Lining below windows:	hardwood or painted (pale green, mat).
Console panels:	pale green, mat. (except writing and dial parts)

The green colours have to be chosen in different shades. The main consideration in the choice of the material is that it must not be "glossy". To get sufficient absorption of noise, acoustically soft material for the ceiling is recommended. Special care should be taken to prevent light reflection on the ceiling above the chart table.

2.3.7 Miscellaneous

It should be possible to make coffee.
Red lighting must be installed.
The height of the bench must be chosen in such a way that the horizon can be seen while seated on the bench.
Handrailings must be fitted adequately.

2.4 *Consoles*

2.4.1 Console of the helmsman

We refer here to points mentioned earlier.

a. The helmsman should be seated, because while performing his task he cannot move away from his position.
b. The automatic steering equipment, and the question who operates it.
c. The problem whether a helmsman merely obeys given orders, or steers independent of orders.

ad a. Has been discussed (see 1.4 and 2.2).
ad b. On ocean-routes steering can be done by auto-pilot. In heavy traffic conditions manual control is preferred but automatic control may be used. In that case, the officer of the watch operates the auto-pilot.
ad c. In harbours, channels, etc. manual control is used exclusively.
(Results of the questionnaire:
the helmsman cannot be dispensed with,
the helmsman is not permitted to operate the telegraph,
the helmsman should always be supervised,
the helmsman sometimes does not understand the orders).

The helmsman, who always has to be supervised and, in addition, sometimes does not understand an order, can be considered as an auto-pilot who can steer

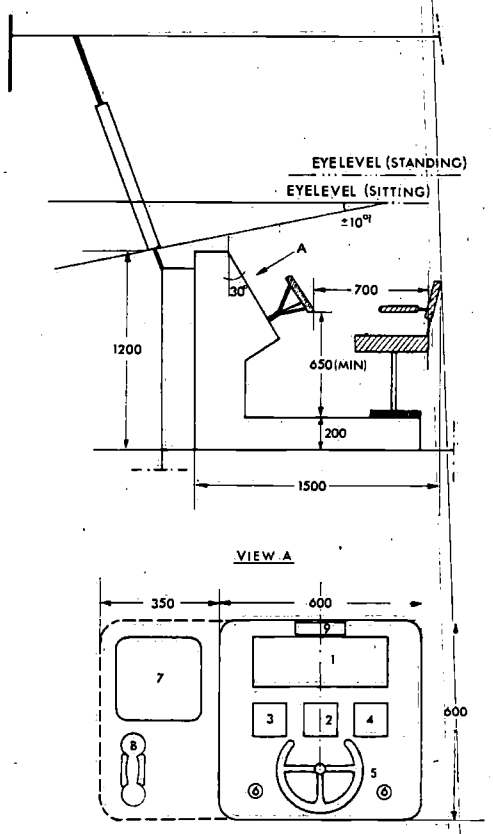

Fig. 2.12. The console for the helmsman.
1 = tape compass
2 = rudder-order indicator
3 = rudder-angle indicator
4 = rate-of-turn indicator
5 = rudder control
6 = steering-gear indicators
7 = electrical repeater of the magnetic compass
8 = emergency steering-telephone
9 = course-to-steer indicator

optimally under various conditions but who may also fail occasionally. The console of Fig. 2.12 is suitable for this type of helmsman.

On large ships it is difficult to detect the first movement to port or starboard and in these cases a rate-of-turn indicator is a useful and sometimes a necessary piece of equipment.

The indicators on steering gear are mostly: in/off/overloaded. Colourcoding is used for "in" (O.K. = green) and "off" (Overloaded = red). It is necessary to signal only in case something is wrong ("all dark principle"). During night-time all unnecessary lighting must be switched off.

Lights indicating "in", which are green or any other colour than red, affect dark adaptation. When they are present for one reason or another, they should be provided with polaroid filters to dim the lights, and should be placed out of the field of view when looking out.

It is the opinion of the authors that the helmsman's

function is only to be performed in heavy traffic situations, and use is to be made of an auto-pilot as long as possible depending, of course, on the quality of the auto-pilot. In very dense traffic the helmsman should be replaced by a qualified officer, who navigates and controls the course (next to the officer of the watch). The advantage is that in critical situations a highly qualified man directly controls rudder and speed.

It remains possible for the officer of the watch to navigate.

In the first, as well as in the second case, one navigates also on points outside the ship, and an unhampered view outside is necessary. In the latter case the console of the helmsman is as shown in Fig. 2.13.

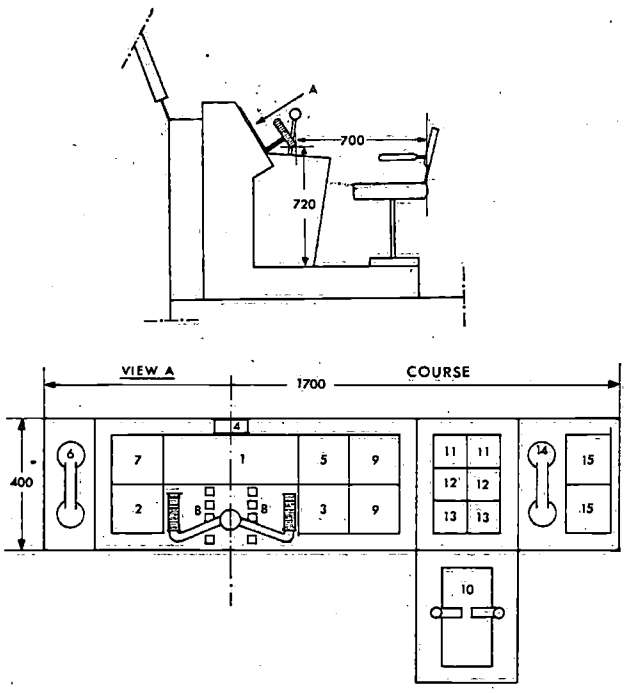

Fig. 2.13. The console for the helmsman on a twin-screw ship. For this case the helmsman should be highly qualified.

1 = tape compass
2 = rudder-order indicator
3 = rudder-angle indicator
4 = course-to-steer indicator
5 = rate-of-turn indicator
6 = emergency steering telephone
7 = magnetic compass (electrical repeater)
8 = steering-gear indicators
9 = auto-pilot
10 = direct engine controls
11 = telegraph indicator
12 = R.P.M. indicator
13 = pitch-angle indicator
14 = telephone to machinery space
15 = emergency telegraph

2.4.2 Officer of the Watch's console

The mate has to perform the following tasks:

- control the speed of the ship and ship's course
- the communication navigation (detection of other ships, general view of information, position indication).

The workplace of the mate is illustrated in Fig. 2.14. It is, as a function of his task, a concentration of apparatus to control course, speed and communication with the opportunity of an overall view. Use of the radar and chart in this position is restricted.

From an ergonomic point of view the optimum lay-out of the mate's workplace is restricted by the existing equilibrium between on the one hand having confidence in – and knowledge of – the possibilities of the instruments and information used on the bridge, and on the other hand the number of crew performing functions that are not yet automated (3.1).

At the moment there is the situation of instruments scattered around on the bridge. In the future there will

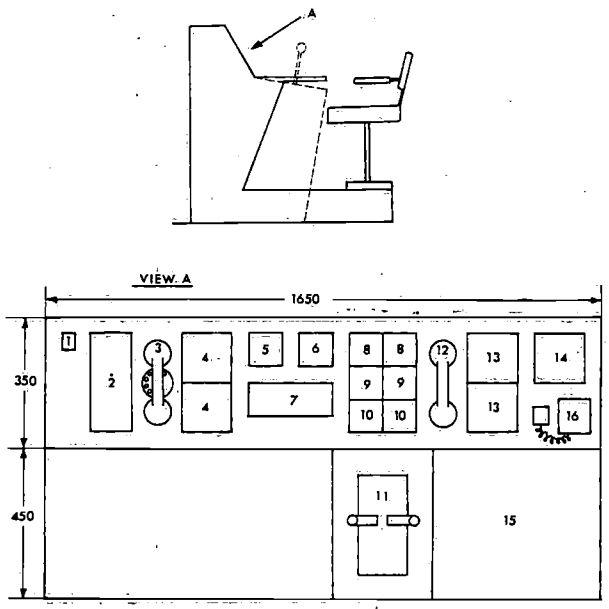

Fig. 2.14. The console for the O.O.W. on a twin-screw ship.

1 = air whistle
2 = intercom
3 = automatic telephone
4 = auto-pilot
5 = course indicator
6 = speed control
7 = alarm panel
8 = telegraph indicator
9 = R.P.M. indicator
10 = pitch-angle indicator
11 = engine controls
12 = telephone to machinery space
13 = emergency telegraph
14 = digital depth indicator
15 = radar
16 = VHF

be a tendency of concentrating instruments in consoles and a decreasing number of crew, due to tasks then being automated.

The console of the helmsman has to be placed next to the one of the O.O.W., charged with the supervision of the helmsman. (Possibility to intervene, shortest speaking distance.)

In the case of the helmsman only having to execute rudder or course orders, the console of the Officer of the Watch should have the lay-out given in Fig. 2.14.

The advantage of this lay-out is that the mate can sit or stand, has a general view of information (dials), can take action on mistakes made by the helmsman (Torrey Canyon [25]) and can verify the environment with the PPI. The information flow remains uninterrupted during a longer period.

Behind this type of radar only a standing position is possible. This is acceptable because it is not intended to observe the PPI for a longer period, while both pilot and mate have the opportunity to make use of it.

The console for the O.O.W. in the case of a qualified person steering is shown in Fig. 2.15.

The system components (helmsman, mate) are arranged in series, this implies a decrease of the workload of the O.O.W. (see part I – communication 34 S).

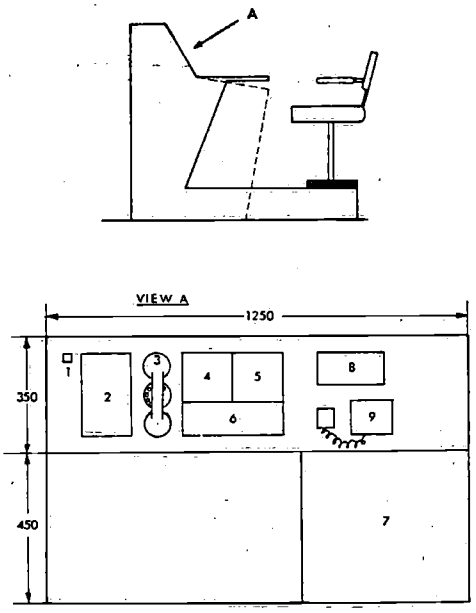

Fig. 2.15. The console of the O.O.W. with a qualified helmsman.

1 = air whistle
2 = intercom
3 = automatic telephone
4 = course indicator
5 = speed indicator
6 = alarm panel
7 = radar
8 = digital readout of the echo-sounder
9 = VHF

2.4.3 The captain's console

The captain is not tied to one position. What he needs is a general view of information, the possibility to reach for the telephones and to observe the radar screen.

One can design a separate place for the captain where he can do all this. This results in a console as sketched in Fig. 2.16.

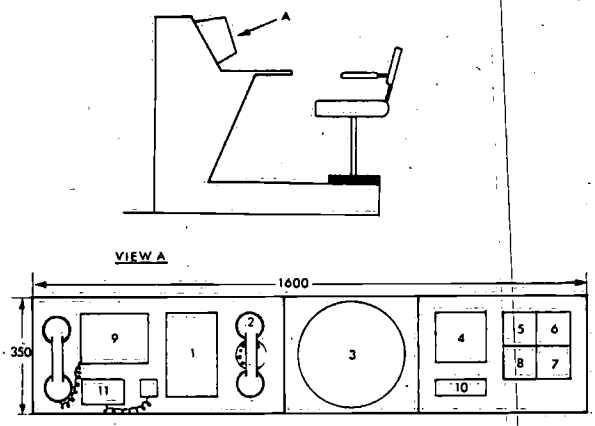

Fig. 2.16. The captain's console, which is an extended console with a radar to verify the near surroundings.

1 = intercom
2 = automatic telephone
3 = radar
4 = compass
5 = rudder-angle indicator
6 = R.P.M. indicator
7 = speed indicator
8 = rate-of-turn indicator
9 = MF
10 = clock
11 = VHF

In this way a separate workplace is created. There are, however, disadvantages. One needs to introduce a 4th radar display, other apparatus must be duplicated, and the captain is fixed to his chair.

In our opinion it is more logical to arrange the

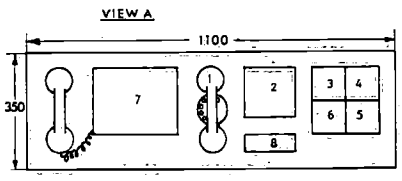

Fig. 2.17. The captain's console. The captain may sit but generally he will be looking at instruments in the other consoles.

1 = automatic telephone
2 = compass
3 = rudder-angle indicator
4 = R.P.M. indicator
5 = speed indicator
6 = rate-of-turn indicator
7 = MF
8 = clock

meters in such a way, that everybody on the bridge can see them; that the captain can make use of the telephones of the officer of the watch and that the captain can view either the O.O.W.'s radar or go to the separate radarcabin.

In case the captain wants to sit down in this latter situation, a chair and a small console with dials can be supplied (Fig. 2.17).

2.4.4 Radar compartment

There are different views concerning the use of the radar and the choice of the most suitable type aboard ships. In this report the diversity of radar apparatus is not taken into consideration because the choice depends too much on these views. From the ergonomic point of view most certainly an objective judgement might be given with regard to the use of radar. Such a contribution, however, would demand a separate study. In this case we base ourselves on the assumption that one or more radar screens must eventually be used simultaneously.

The weak light of the existing radar tubes and the absence of an efficient daylight radar make it necessary to screen daylight. This screening may consist of neutral filters, colour filters or complete screening, a separate radar compartment on the bridge being used.

Neutral filters allow the passing-through of some daylight. In this case the possibility to observe the ship's environment still exists. Colour filters have the same function. They increase the contrast on the radar screen but make it difficult to recognize the colours of other objects.

Another solution is the use of curtains around the radar. In this case it is important that the curtains can be removed in such a way (e.g. in the ceiling) that they do not hamper observation when radar can be used without screening.

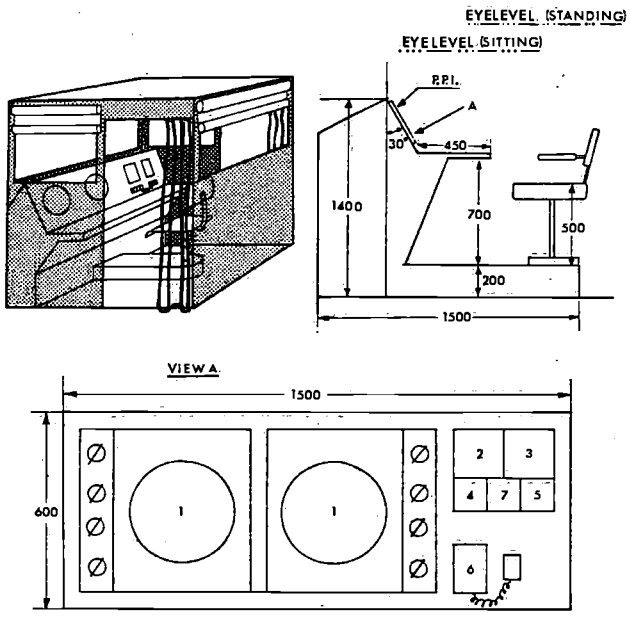

Fig. 2.18. Console inside the radar-cabin. The radar-cabin is to be used for longer observation periods, in which case the sitting position is favourable. Plotting can be done on the table. The table is illuminated in such a way that the intensity contrast between PPI and table is acceptable (a standing position is also possible).

1 = PPI
2 = speed-indicator
3 = R.P.M. indicator
4 = clock
5 = rudder-angle-indicator
6 = VHF
7 = rate-of-turn indicator

Daylight screening of radar in a compartment by means of filters or curtains offers the possibility to compare two radar displays directly without using a viewing-hood. This is an advantage because it prevents a fixed working posture and still enables mutual comparison of the plots.

Verification of the display with the surroundings is difficult or even impossible when a curtained compartment is used. If a viewing-hood is used the surroundings can be observed, however, the consequent quick changes in light intensities from daylight to viewing hood causes fatigue and increases the chance to overlook signals on the plot.

In case of fog during daytime it is therefore recommended to have one or two radar screens with one observer, placed in a compartment screened by either curtains or filters.

At night the screens have to be removed.

If a third radar screen is available, as in this case is indicated for the officer of the watch, it should be provided with a viewing-hood. Other means of screening hamper the general view. The purpose of this P.P.I. is to verify the overall view on the spot and is not meant for navigation during fog. The lay-out of the radar compartment is such that radar observations can be carried out for long periods. It is obvious for reasons mentioned before that the observer should have the opportunity to sit down. Unfortunately most existing radar apparatus do not offer this possibility.

It is sometimes desirable to use a plotting table next to the radar. Furthermore it is necessary to have all information regarding rudder angle, course, speed, r.p.m. of the shaft, and time indication available as well as a VHF (questionnaire). When using a plotting table the illumination requires extra attention; this will be discussed later.

Control of course and speed from the radar compartment appears to us less desirable in view of the number of people present on the bridge during fog.

The radar observer is exclusively navigator and does not execute orders. His attention is only fixed upon the radar screens. Communication with the other crew-members on the bridge must be possible.

Special thought should be given to the duration of radar observation. In principle it should not be more than 30 minutes (Baker, 1962). This presents some difficulties e.g. changing of observer, adaptation to light and vice versa. According to Baker interruptions in a sequence of 4½ minutes observation – ½ minute rest are as effective as 25 minutes observation and 5 minutes rest, during an overall observation period of two hours. When a radar compartment is used the latter solution appears to be preferable.

2.4.5 Chart table

The smallest usable table surface has dimensions of 1250 × 750 mm. Recommended are 2000 × 800 mm and if possible 2500 × 800 mm. In this case sufficient space is available to place time clocks visible from the same position and to put down books without covering the charts. In front of the chart table the console for the position finding apparatus should be situated.

The chart table is not screened by curtains. If a correct choice has been made with regard to the lighting equipment, screening need not be applied. In the chart table should be installed: drawers (1300 × 750 × 100 mm) for the charts, a drawer for the position-finding apparatus, drawing materials, atlases and guides. The drawers should be provided with lighting. To illuminate the chart the light source should be above the chart with controllable light intensity and not under it e.g. using transparent charts. In the latter instance the chart must be especially adapted which is not the case with all charts. With transparent charts the effect of shadows is very inconvenient. It would appear worthwhile to undertake more research concerning charts on which fluorescent colours, lines and symbols are used.

The position of the chart table with regard to the ship's axis is not of great importance [26], however, in combination with the radar position it should be possible to move easily from this console to the radar.

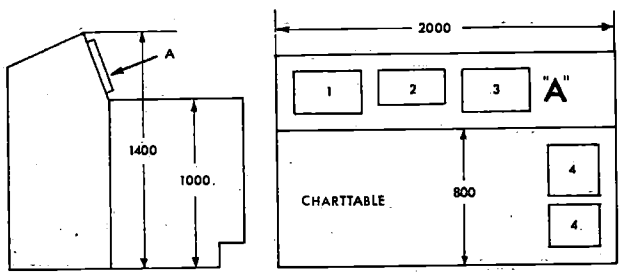

Fig. 2.19. Chart table.
1 = satellite navigation
2 = decca/loran
3 = radio-directionfinder
4 = clocks

2.4.6 Communications

Gathered within easy reach of the officer of the watch and others, the following means of communication should be set up:

- Emergency steering telephone:
  It is rarely used. A plug may be fitted and the telephone itself be put away in a cupboard. A better possibility is to mount it on a panel near the helmsman.
- Telephone communications with the engine-room:
  This communication may also have to function in cases of emergency. It should therefore be constructed independently from other systems.
- Telephone communications with other stations on the ship:
  For this system an automatic exchange is recommended. A list of extensions and the names should be within immediate range.
- Communications with assembly-areas:
  In this case an intercom system could be used with a limited choice of a number of areas e.g. the whole ship, certain parts of the deck, certain parts of the holds.
  Contrary to the previous systems it offers only a one-way communication (from the wheel-house).
- Communications with fore- and aft-deck during manoeuvring:
  In this situation the mate is mainly on a wing of the bridge and he can talk to people on the fore- and aft-ship. Practice shows that usually all orders concerning rudder or engine-room are given via a crew member standing in the doorway of the wheelhouse. This is undesirable. A good solution is the use of a walkie-talkie (questionnaire). This enables the different crew members to move about. In this case it is desirable that helmsman and/or mate at the conning position also can communicate.
- Talk-back loudspeaker system:
  For certain ships it is necessary to have communications with the bridge from fixed positions. This system should be situated close to the officer of the watch.
- VHF:
  VHF communications with the shore and with other ships must be available to the officer of the watch and near the radar.
- MF:
  It is now desirable to have a MF remote-control on the bridge. The most efficient place is close to the chart table.

The availability of a back-up system (sound powered telephone), in case of both the ordinary and the emergency power supply dropping out, is dependent on the point of view of the ship-owner.

The external shape of the telephone system is important. Preference is given to either a receiver only, or a receiver resting on the dial in which case it is possible to illuminate the dial.

When so many telephones are used, the "calling-up" should be accompanied by a system of flashing red lights (8 Hz).

Furthermore a list of all possible extensions should be at hand. There are possibilities to mount all telephone connections in one cupboard only.

2.4.7 The pilot's console

It must be possible for the pilot to have complete supervision of all controls (course, rudder-angle, speed, shaft revolutions) from one fixed position. From this position he should also have an unrestricted view of the external situation and the possibility to verify this on the radar.

In our opinion the position at the right hand side of the officer of the watch is the most suitable. The pilot can use the available displays and radar screen and he has an optimum view all around and down the ship's sides. In this case the mate uses the radar in the radar compartment. In this way the pilot and the mate do not interfere with each other's adjustments of the screens and each retains independent control of the environment.

During fog, in case of blind navigation, use should be made of the radar compartment.

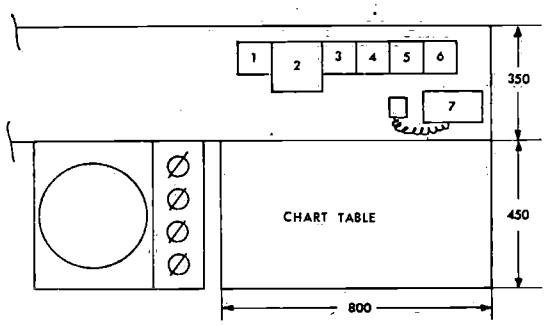

Fig. 2.20. View on the position of the pilot. For the side view see Fig. 2.16. If the dials are not readable from the pilot's chair, they are to be placed in the console in front of him.

1 = rate of turn
2 = course indicator
3 = rudder angle indicator
4 = speed indicator
5 = R.P.M. indicator
6 = clock
7 = VHF

Also in case of doubtful visibility the officer of the watch can make use of the radar compartment.

2.4.8 Cases of alarm

Given the amount and variety of alarm-systems (smoke, temperature, bilgewater, CO_2) and the impossibility of reporting these to the mate, a system is necessary in which only the type of alarm is communicated on the O.O.W.'s console. One acoustical alarm accompanied by a red flashing signal giving the appropriate text would then be given to the O.O.W. This signal must then be reset at the proper alarm-panel which is mounted elsewhere on the bridge.

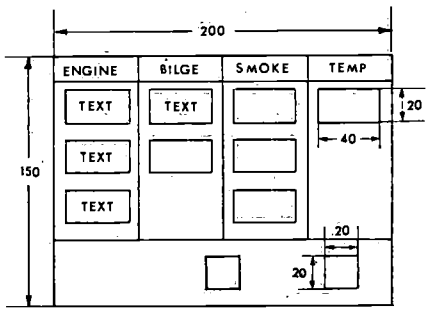

Fig. 2.21. Example of an alarm panel. Each group of alarms is represented by a rectangular warning light. The warning light starts flashing when there is an alarm. When the alarm has been accepted the light glows steadily and acoustic alarm ceases. The colour of all warning lights is red, the text shows the origin of the alarm. A test button and an acceptance button are also placed in the panel.

2.4.9 Miscellaneous

The eventual control of the anchor may be best mounted against the front panel and as far as shape is concerned be adapted to the other consoles.

The indicators of alarms, bilge, CO_2, smoke, temperature etc. are usually of different manufacture and may be situated against the backwall of the wheelhouse (underneath the windows).

Chairs on the bridge should be fixed on a dais of approximately 25 cm in order to raise the eye-level of a sitting man to eye-level of someone standing. In this way all panels can be used in sitting or standing positions. The chair should be adjustable and have both back- and arm supports. All windows should be provided with window-wipers, sprays and heating.

2.5 *Instruments*

General information about the design of controls etc. has been discussed in part I. Dials and scales of controls are to be indicated in white figures and lines on a black background and by night to be illuminated by red

lighting. For every scale it should be ascertained whether they can be read from some distance or from close by.

Instruments which are on sale do not always satisfy the requirements mentioned above, but in most cases they can be easily adapted.

More difficulties arise from the dimensions of instruments and the impossibility of fitting these instruments into a panel. In the past this has led to "finding a place" for each instrument which resulted in an inefficient lay-out. Instruments suitable for building-in and of small size are urgently required with a view to the improvement of the outlined man-machine relationship. In the following paragraphs some remarks will be made about these matters without judging the quality of the manufacture.

2.5.1 Compasses

The use of tape compasses is advisable. They are easy to read and do not require too much room. Round compasses are also useful if they are provided with a separate scale giving a division of 0,1 degrees (course changes may be better observed).

Magnetic compasses should also be readable inside the wheelhouse. Electric scales are preferable because their position may be chosen independently of the actual position of the compass itself.

A pelorus on the bridge is necessary. As this instrument is not suitable for building into a panel, a compass swinging by means of a parallel mechanism in both corners of the wheelhouse is a good solution.

2.5.2 Rudder control

A principal difference in rudder controls exists between follow-up or non-follow-up steering. The research on the control of the rudder as input in relation with course as output is limited with respect to the position of the ship. On ships with great time-constants the influence of this relation is negligible.

Time-dependent steering, however, demands constant attention. This system is not advisable for smaller ships in particular when the helmsman performs other tasks. To keep a straight course an automatic course pilot is preferable to a helmsman. In all other cases a helmsman is indispensable.

2.5.3 The telegraph

In the following sketch a good design of a telegraph is given. In this case there is direct control of the engine and control of the shaft rotation by means of an analogue dial.

A push-button telegraph, which is preferable for several technical reasons, is of equal value to a lever telegraph. Commands and shaft rotation are shown, as far as shipping is concerned, in advanced digital displays.

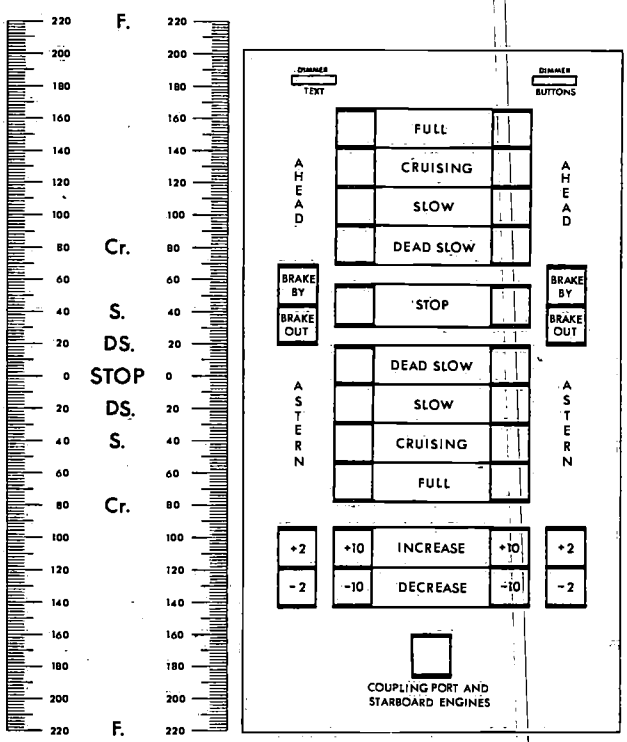

Fig. 2.22. Example of a push-button telegraph (right) and the scale of a conventional throttle telegraph, on a twin-screw ship. For the latter the desired revolutions of the shaft are adjusted with the throttle on the next points or between these. The same is the case with the push-button telegraph at night. In the condition ahead the r.p.m. can be adjusted with the push-button "increase" or "decrease". The other points equal those of the telegraph at left.

2.5.4 Position indication

An investigation concerning the ergonomic aspects of position indication may be illustrated by a publication of Wagenaar [27] "The accuracy of manoeuvring with a decca-navigator under difficult circumstances".

2.5.5 Navigation-illumination panel

The panel showing the circuits of navigation lights ought to be finished according to the "all dark" principle. Only if a light does not function a visual (or possibly acoustical) signal should be given.

2.5.6 Registration apparatus

The course registration, rudder and telegraph-commands must take place automatically. The time consuming way of doing this manually by the mate should be reserved for cases of emergency only.

2.6 *Lighting*

2.6.1 Lighting during maintenance, cleaning etc.

A minimum level of 250–500 lux is advisable, emanating from an even distribution of light.

Fluorescent lamps are very suitable for this purpose.

2.6.2 Lighting of charts

As long as colourcoding on a chart is used, particularly in red, a "whitish" light should be used. In this case a light screening problem is created which can only be solved by choosing the right type of light source. This means that for a general lighting a source should be used which illuminates the chart only and which can be dimmed. The minimum level is 10 lux. The ideal situation is to illuminate only those parts of the charts which must be studied. Reflections on the ceiling are negligible only if the lighting is very low. If the ceilings reflects light it should be painted dark, above the chart table.

2.6.3 Lighting of dials and instruments

White figures on a black background and red lighting are recommended.

2.6.4 Signalling

All signalling of apparatus should be based on the "all dark" principle. This means that a red signal indicates an emergency. On the signal the text of the source of alarm concerned must be printed. This means "in" and "by" lamps on the bridge should be avoided or have a red finish. The latter solution, however, is not desirable. Care must be taken that signals are easily recognized even in bright sunshine.

2.6.5 Lighting of the bridge for night orientation

It is useful to have some light on the bridge for orientation. In this case red lights can be used but should be restricted to the desired spots.

3 Discussion

3.1 *Background of the study and future research*

Emphasis has been laid on the indication of possibilities and on placing data for bridge design at one's disposal. The practical execution was discussed in chapter 2. It was based on the assumption that the commission for this research will be followed by a second in which our proposition for a bridge design might be realized in a mock-up.

In this mock-up it will be possible to analyze the various types of consoles which were discussed earlier in this report for various types of ships: tankers, container-ships and freighters. The mock-up will be visited by a great number of experienced captains and navigating officers, who will be able to give their opinions and to complete a questionnaire. This will enable us to investigate the results obtained by means of the questionnaire which was given as part of this study, more thoroughly.

As a result of the study the floor space of the bridge has to be divided for three distinct groups of apparatus:

- the conning position against the front bulkhead of the bridge containing the steering of the ship and the control of the engine, the position for the pilot and restricted possibilities to plot the ship's position.
- the radar compartment, not constructed against the side of the wheelhouse. It is not relevant whether this compartment is situated at starboard or port.
- the plotting site with chart table and position finding apparatus. Chart table and radar compartment must be close together.

Now, in the third phase of this investigation it must appear how far it will be possible to combine these three groups into one. If this cuts down the number of crew members, depends on the way in which one's task is influenced. Research in this field is possible by providing the phase 2 mock-up with dynamic aspects.

In this mock-up the surroundings (ports, jetties, shipping traffic) can be made visible and steering and navigating may be simulated. Our mock-up simulation technique can be used fully in this case by varying the traffic intensity. With this typical human-engineering research it will therefore be possible to judge the value of the man-ship system based on the effects of a certain bridge design influenced by the surroundings (traffic density, port entrance and the like).

3.2 *Bridge for tankers, container ships and freighters*

On any type the bridge may be designed in the same way without damaging the goal we have in mind (2.1).

Only limitations concerning the available floorspace or the installation of special instruments may modify the design. Fig. 3.1 shows an example. This sketch may constitute the basis for the construction of a mock-up in the second phase of this research. In this stage subjective preferences in particular about the position of consoles at port or starboard will be investigated.

3.3 *Future developments*

Automation aboard ships shows considerable progress. An important aspect in this matter is the question

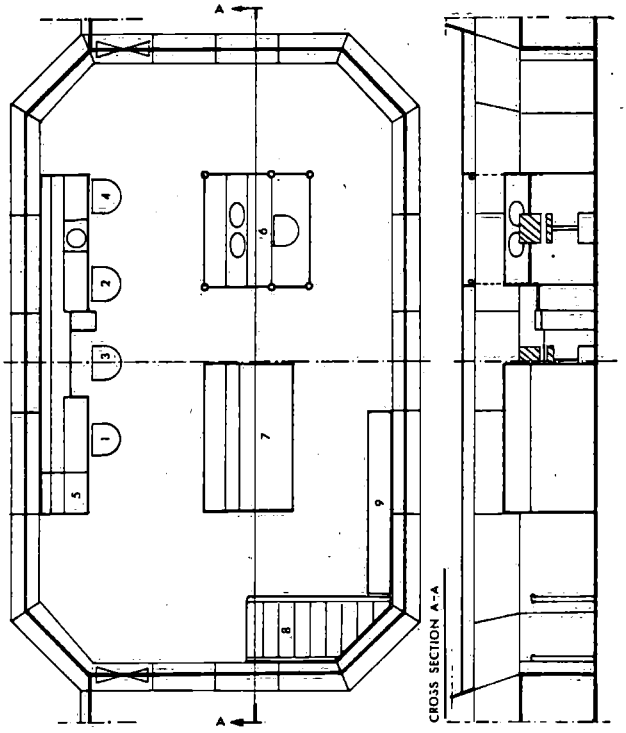

Fig. 3.1. Proposal of the bridge lay-out, dimensions 10×6 m.

1 = captain
2 = O.O.W.
3 = helmsman
4 = pilot
5 = console for anchorwinch-control
6 = radar cabin
7 = chart-table
8 = staircase
9 = pantry and lockers

whether a ship should be either operated automatically or by man. The comparison man/machine in part I illustrates that an ergonomic study may logically contribute to this subject.

Secondary to this is the way in which automatically obtained data are to be presented (a problem which already exists).

Ergonomics can contribute to the urgent need of standardisation of existing apparatus.

Another development which forces us to define the limits of human capacity is the increase in traffic intensity and the ever increasing growth of the ship's dimensions and speed.

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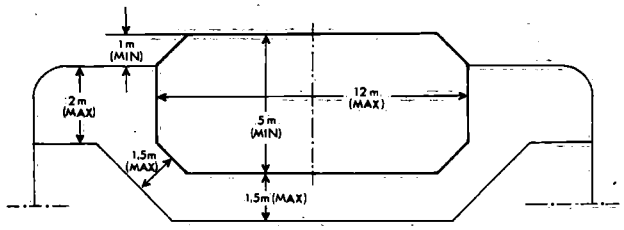
APPENDIX

SPECIFICATIONS FOR BRIDGE DESIGN;

A summary of the preliminary recommendations.

1 Principal dimensions of the wheelhouse

1.1 *Outline of the floorplan*



1.2 *Tweendeck height; 2500 mm*

1.3 *Windows*

All windows slanting 10° outward from the vertical axis.

Windows not smaller than 800 × 800 mm. The central point of the windows 1670 mm above the deck.

An uninterrupted row of windows on all sides of the wheelhouse.

The distance between two adjacent windows should not exceed 200 mm.

The depth of the stiffeners should not be more than 100 mm.

A number of windows, preferably not less than three, should be provided with window-wipers, water-spray and heating.

1.4 *Sun shade*

A fixed flat plate should be fitted around the wheelhouse top as a sun screen.

1.5 *Objects obstructing view from the bridge*

Deck-equipment and near-by objects in the environment of the bridge, particularly funnels, masts, derricks etc., should not obstruct the view for more than 10°.

1.6 *Doorways*

The inner entrance to the bridge should be locked by a door downstairs of the bridge. Behind this door, the passage-way to the accommodation, the toilet, etc., and the toilet itself, should be illuminated by red light. The door to each bridge-wing should be provided with a window slanting outward similarly to the other windows in the wheelhouse.

The passage across the bridge from port to starboard should be kept clear of obstructions.

1.7 *Bridge-wings*

A sheltered position should be created by extending the frontbulkhead provided with an extra window adjacent to the wheelhouse. The bulwark (height 1200 mm) on the bridge wings should be provided with a wind-deflector (height 1500 mm maximum above the deck).

Navigation lights should be fitted in such a way that they do not obstruct people standing at the outer edges of the bridge-wings.

Bridge-wings should extend to the ship's sides, unless it is mentioned otherwise, the front bulwarks being connected to the sides of the wheelhouse more than 0,5 m aft of the wheelhouse-front.

1.8 *Noise*

The funnel should be positioned as far aft as possible and should in no case be connected to the wheelhouse.

The following noise criteria should be applied:

open bridge-wing, full ahead	NR-75
open bridge-wing, main engines stopped	NR-55
wheelhouse, full ahead doors closed	NR-65, SIL-55
wheelhouse, main engines stopped	NR-50

1.9 *Climate*

In the wheelhouse the following conditions should be fulfilled:

relative humidity 30–70%

air speed below 0,25 m/sec, preferably 0,10–0,20 m/sec

temperature between 14°–26° C

ceiling temperature 28° C maximum

recommended temperature 19° C, with a relative humidity of 50%.

1.10 *Painting and materials*

Ceiling: white (off-white to green), mat

Ceiling over chart table: dark (not reflecting chart lighting)

Stiffeners between the windows; white (off-white to green), mat

Bulkhead below the windows; painted (light green), mat or special wood

Consoles: light green, mat
(except writing surfaces and instrument panels)

Consoles: writing surfaces and instrument panels:
green, mat
Floor: dark green
Non of the materials may reflect lights and should absorb noise, as far as possible.

1.11 *Miscellaneous*

Coffee-making facilities

A bench positioned against the after bulkhead and with seating so raised that one can see the horizon from the sitting position, is desirable; minimum depth of the bridge then increases to 6 m.

2 Consoles

The consoles for the helmsman, the mate and the pilot (the captain) should be placed against the front bulkhead.

Radar cabin and chart table are placed behind the first row of consoles. The minimum floor space between the back of the chairs of the first row and the front of radar-cabin and chart table comes to 1300 mm.

2.1 *Lay-out of console*

The lay-out of all consoles should carefully fullfil the foregoing requirements (chapter 2.4).

2.2 *Communications*

All communication instruments are placed in the consoles mentioned previously. Particularly for manoeuvres there should be a walkie-talkie, while the man in the conning position should also have a microphone and speaker. A list of extensions should be provided by each telephone.

2.3 *Miscellaneous*

When anchor winches are controlled from the bridge, the appropriate console should be situated at the front.

Alarm sets for bilgewater, CO_2, smoke, temperature etc., should be placed against the aft-bulkhead (below the windows). From each of these should be a pick up for an alarm signal in the alarm panel of fig. 2.21.

Chairs on the bridge should be adjustable, provided with back and elbow rests and be placed on a raised floor ($\pm$250 mm above the deck).

3 Components

3.1 *Design of dials*

All dials and other instruments displaying information should be provided with white figures on a black background and have red illumination at night.

3.2 *Accuracy of controls*

Throttles and other controls have to be carefully examined for accuracy of control and for the forces excercised in adjusting the control in order to fit the human capabilities.

3.3 *Visual (alarm) signals*

The "all dark principle" has to be applied for all visual signals on the bridge. This results in a red glowing warning light for each alarm specifically, while the text indicates the origin of failure. Stand-by signals should be avoided as far as possible.

4 Illumination

4.1 *Illumination during repair, cleaning etc.*

A minimum illumination level (white and homogeneous) of 250–500 lux. is recommended.

4.2 *Chart table illumination*

The chart table should have white illumination. To provide for light spots of minimum diameter on the charts, special lighting equipment should be applied. Each point of light should have a dimmer and on-off switch.

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