Innovative Ship Design: Implications for Pacific Rim Shipping

Helen B. Bendall
Senior Lecturer
University of Technology Sydney

Abstract:

A new Australian ship design could well be the technological innovation needed to encourage a surge of new capital investment into the maritime industry

The maritime industry has been suffering for some time from a succession of recessions in shipping. Steadily falling profits have meant that needed investment to replace ageing tonnage for many owners has not been possible. Commercial investments in shipping are very long term so managers must be able to structure appropriate financing packages which will allow them to stay competitive in a very volatile environment It is the same long-term "risky" environment in which the finance provider will have to assess the merits of the project. The differences in approach between the owner and the financier in this difficult scenario underlie some of the problems facing the industry today.

The paper outlines factors determining the investment decision, particularly the influence of technological change from a historical perspective and considers the types of financial structures that have been used in the past. It covers briefly the need for capital in the 1990s and outlines the traditional sources available and discusses their applicability to the industry at the present time

The hatchcoverless ship is used as an example of a technological innovation in liner shipping and the ship building industry, particularly in short sea trades. The West Pacific rim trades generate demand for many feeder services to support the round the world container shipping operations. These intra-regional services require relatively small container ships. Ships involving short sea trades spend a relatively large proportion of round voyage time in port To illustrate the impact of faster port turnaround on voyage profitability, a voyage cost analysis has been developed showing operational advantages of the new innovative hatchcoverless ship

Contact Author:

Dr H B Bendall
University of Technology Sydney
PO Box 123
BROADWAY NSW 2007

Telephone: (02) 330 1990
Fax: (02) 330 1551

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Shipowners in the liner trades over the years know that financial returns in shipping are cyclical and irregular, tending to rise and fall with world trade flows. The cyclical nature of shipping reflects the fact that shipping is a service industry and prices (freight rates/charter rates) are derived in the product market. Frequently it has been necessary to ride out the bad times when trade was suffering due to recessionary forces while awaiting the upturn and a return to profitable voyages

Astute owners would invest in new shipping when prices for new buildings and the second hand market were low during trade cycle troughs. When world trade is down there is a fall in demand for shipping so the prices of ships themselves fall. This investment was timed hopefully so that ships would come on line just as the market began to pick up thus ensuring for the owners' greater profitability from lower capital costs. A new ship usually takes at least a year from order to delivery. Owners could make additional profits by selling their older tonnage at a profit just as their new ships were coming on line. This is a variation of the old "buy in gloom, sell in boom" rule.

Well that was the theory. The current recession in liner shipping has been an extended one especially from the point of view of the long established lines in the western world. Many old established owners have ships in their fleets which are approaching 15 to 20+ years old. The median age of container vessels has increased from 0 - 4 years in 1973 to 5 - 9 years in 1983 and 10 - 14 years in 1992 See Appendices.

Although in liner shipping, vessels are not the sailing "time bombs" waiting for the bow to fall off as did the tanker, *Kirki*, or disappear without trace as have 6 bulk carriers off the coast of Western Australia during the period January 1990 to August 1991, many liner ships are reaching the end of their productive life

Replacement investment must happen eventually although many of the older container ships have extended lives through re-engining or "jumboising". What is stopping many current shipowners from "biting the bullet". What will be the spark that ignites this new investment surge?

The shipping industry is fundamental to the world's economy as shipping currently carries 80% of all world trade. Ships as we know are extremely capital intensive and therefore should be an important lending area for banks and other financial institutions.

Why then are owners' hesitating? Obviously many shipowners may wish to update their fleets but are having difficulty in raising finance. What then are financiers looking for?

The owner has different objectives from that of the financier.

The shipowner as borrower of funds would like to see:

1. a **minimal equity contribution** (if the project goes well, he makes a very high return on investment, ROI ..... if it goes wrong the owner will not lose very much);

2. **minimum collateral/recourse** to himself (if it goes wrong he does not lose much: the more collateral available, the greater the opportunities for raising more finance);

3. a **maximum loan period** to match the life of the asset;

4. **cheapest cost** of finance;

5. a **fast response time**, a **full range of added products** and **regular financial advice** from his financiers and

6. **minimal documentation**

In contrast, the financier has an approach which will be almost opposite to that of the owner. He would like to see:

1. a **substantial equity contribution** so if it goes wrong the financier minimises his potential loss;

2. **maximum collateral/recourse** to lessen his risk and stop owners borrowing too much from elsewhere;

3. a **minimum loan period**;

4. **maximise cost of finance**;

5. a **slow response time**;

6. be **paid for any additional services and advice**;

7. maximum **documentation to cover against any eventuality**.

However, the high risk perception of the industry by financiers has meant that raising funds to buy ships has become more difficult in recent years. Ships can be moved from one market to another. As the ship itself is a moveable tangible asset, in theory it should be viewed by the financier to be "safer than houses". One problem lies with the fact that ships because of the of their "moveable" nature are indeed not subject to any one legal jurisdiction. The financier is thus extra wary that the asset may be confiscated for a number of reasons in a country where the legal system may be unsympathetic to claims by the owners.

Demand for shipping does fluctuate with world trade flows and has increased roughly in parallel with growth in world GNP. Indeed a recent analysis of the largest 11 container carriers has shown that there has been a 8% pa growth in TEUs carried since 1987, although the carriers' return on assets have averaged only 0.4% (Adams,1992).

The principle problem for traditional liner fleet owners has been on the supply side with national prestige being a contributing factor whereby many emerging nations have sought to build their own shipping fleets through generous government grants and shipbuilder subsidies. This has added to the length of the recessionary cycle in the industry by creating over tonnaging, driving down freight rates and thus operating cash flows. Yards have offered very competitive prices to fill their order books. Older ships instead of being scrapped have been available at bargain basement prices, encouraging new operators to enter the market. The existence of FOCs has extended the working life of sub-standard ships by allowing re-registration simply by changing the registry. Established lines' profitability has fallen thereby restricting their ability to fund new replacement tonnage and so many have maintained their services with aging fleets.

In answer to this vicious cycle ship operators have sought to lower their operating costs even more - the lowering of operating costs increases profitability. There are a number of ways to achieve this. For example they can "lean" on port and terminal operators for cheaper rates or perhaps manning can be reduced. These no doubt will improve the situation marginally. However without a major technological change in ship design or cargo handling the main avenue open to shipowners is through increasing the cargo carrying capacity of their ships as have the carriers in the tanker and dry bulk sector. Investment in large container ships in the range of 4000+ TEU, particularly for around the world services by some big operators has occurred in recent years. Pushing to the limit the concept of economies of scale P&O has proposed a post panamax 6000 TEU vessel. Evergreen stated that they believed that a 20 000 TEU would be in service by the year 2000 (Mulrenan,1993). The vessel would never actually come into port but would be serviced off the port by feeder and bunker ships. Perhaps a little in the realms of science fiction.

How have these operators been able to finance larger ships while other operators have not?

Generally those engaged in new investments during the last few years have managed to raise finance to build these ships on the basis of strong balance sheets supported by a diverse range of operations outside shipping. There are tremendous advantages in being able to raise finance in this way. As the ship itself is not mortgaged or its specific cash flow used as security, (ie finance supported by a contract of affreightment) disposal of the vessel and the purchase of a new vessel does not involve messy financial and legal transfers of the mortgage etc. eg NOL's balance sheet has been considered so strong that they have been able to borrow funds for non-specific assets based only on the security of a "negative pledge".

As this investment from the perspective of the financier is not ship specific what will other shipping lines have to do to be able to encourage funding of their projects?

The two determinants of any investment are risk and return with preference going to that which gives the highest return for the lowest risk. The last great investment boom in liner shipping occurred in the late 1960s and 70s when we experienced an exciting revolution in cargo handling(Bendall and Stent,1987,1988).

What factors were present in the 1970s to encourage shipowners to invest in these ships?

The impetus then, as for any other capital investment was the belief that these radical new designs constituted a technological revolution in cargo handling which would ensure greater returns on investment. These ships would increase productivity, lower costs and thus increase the shipowner's cash flow. Shipping lines had generally been funded from cashflows and owner's equity up to this period although since the war some lines had been forced to take on some outside debt. Indeed many of the lines were still family owned and controlled. Unfortunately then, as now, shipping had been experiencing an extended recessionary period. In order to finance these new ships plus their fleets of containers it was necessary to form consortiums of established lines.

Thus investments are driven by the economics of the venture. The surge of new investment was driven by a radical change in technology which reduced cargo handling costs significantly. Reduced costs equals higher profit.

What we need now after a period of declining profitability is an exciting innovation which will lead to lowering of costs and will generate greater returns for the owners.

The hatchcoverless container ship, designed in Australia in 1986 has been judged by Lloyds to be one of the most significant advances in ship design this century (Smithsonian Institute,1991).

In fact Australia has been well represented in innovative ship design over the last three decades. The Kooringa was the first custom designed container vessel in the world and went into service on the Australian coast in May 1964. Productivity gains were incredible. The round voyage time between Melbourne and Fremantle was reduced from 30 to 14 days. Eight permanent men in Melbourne and 6 permanent men in Fremantle replaced 100 men generally employed for a 3½ day week. Cargo handling costs, as a percentage of total costs, fell from 42.5% for breakbulk operations to 8% (Stoneham,1970).

The new hatchcoverless container vessel is not just a conventional container ship without "lids". The concept involves not only the deletion of hatchcovers and coamings, but has as well a radical change in hull design. The first ship built to this new design was the "Bell Pioneer" owned by European Container Shipping, ECS. It went into service in October 1990 and has generated a remarkable improvement in profitability for its owners. The 301 TEU capacity ship was designed for short sea trading. It has reduced port turnaround times, increased voyages per year and has significantly lowered labour and port costs.

Technical Aspects

In conventional containership operations the practice is to carry a significant percentage of the containers mounted over hatchcovers. This practise exposes the units to damage from racking forces and weather and involves expensive twistlocking and lashing. All upper tiers are exposed to the elements and overside losses occur. The number of containers lost due to this aspect of ship operation has caused concern for insurers. The motivation for stacking containers on deck is economies of scale but many factors associated with this practice increase the operating costs of the ship and reduce returns for the shipowner.

The ability to stack containers on hatch covers increases in relation to the depth of the ship. Modern large container ships such as the post-Panamax C-10 class ships belonging to American President Lines have the capacity to carry 4300 containers in tiers of eight high below the hatch covers and five high stacked over the hatch covers.

The strength and hence the weight of the hatch covers has now reached the point where hatchcover weights are at the maximum lifting capacity of shore cranes. Increasing stack size to their safety limit has meant that either shore cranes lifting capacity will have to increase or the hatchcovers will have to be reduced to cover only one or two cells. The effect of these restrictions is to increase cargo handling times because shore based cranes have to remove the hatchcovers and land them ashore temporarily. The cargo handling time lost due to the crane movements in removing and replacing the covers will be a function of the number of covers to be removed. In the case of the United States Line's American New York no less then 57 pontoon covers must be handled in this way (Ellis, Gillies,Fisher and Wittwer,(1990). The stacked containers on the hatchcovers have to be lashed and unlashed contributing to workloads and cost of labour. It can be frequently hazardous. As well the increased height of the containers increases the weight, cost and maintenance of lashing devices.

An additional effect is that the hatchcovers and coamings and associated structure need to become heavier as the depth of the ship increases. As a result the vertical centre of gravity of the ship is altered by the increase in structural weight, necessitating the provision for liquid or solid ballast in the double bottom or lower wing tanks to ensure adequate stability (Rapo,1989).

The hatchless container concept with is elimination of hatchcovers and coamings was designed with a view to overcoming many of these constraints. It has a radical change in hull design. By extending the ship's side tanks it provides full protection to the entire container stack from "green water" Increasing this depth allows a reduction in scantlings as it has the effect of a girder. Construction is simplified because of the deletion of the coamings, their stiffeners and hatchcovers themselves.

Computer simulation as well as controlled scaled model laboratory testing at the South China Scientific Research Centre, Wuxi, proved the viability and safety of the hatchless design. Simulated sea trials with ship speeds up to 15 knots and with complete loss of power proved the safety of the ship design even in a confused sea state equivalent to a winter North Atlantic force 11 gale. On the Bell Pioneer's delivery voyage the vessel encountered a typhoon, two days after leaving Japan. The ship took on even less water than design calculations, model tests and computer studies had indicated (McDermott,1992).

With holds 2 and 3 flooded which is a condition which would send a conventional ship to the bottom the tank report simply states that the ship's motion is safe in the sense that any water which is shipped over the sides "flows freely in and out of the freeing ports with no additional sinkage or squat observed" (Gu,Hu,Min and Qlan,1989).

The Bell Line Ship was designed for a particular trade. The owners required a ship built to carry 5 or 6 containers below deck. However the original tests were carried out on a design carrying 9 containers below deck.

Although these extensive tests and now operational experience have shown that "green water" will rarely ever enter the hull, each hold is equipped with a series of non-returning flooding valves or freeing ports though the ship's sides on each side. These are located at a height above the load waterline equivalent to the freeboard of a conventional container ship. Should the hold become flooded to this level, the water will drain back to the sea through these non-returning control valves.

The hold tank top is designed to minimise free surface effect by using longitudinal vertical plates with face bars positioned between each row of containers. The transverse sump tank is situated at each end of the hold. The sump tanks are drained by duplicated automatic bilge pumping arrangements, as well as connections to the ballast pumping system to deal with accumulated spray or rain or to cope with a damage situation (Ellis et al,1990).

The operating experience of the Bell Pioneer has shown that other than for test purposes, the main pumping system has never had to be operated while the strip pumps have been use for only 2% of the time including initial and routine testing (McDermott,1992). despite the ship encountering regularly force 10 weather conditions.

Cargo Handling Efficiency

The Bell Pioneer serves five ports between Ireland, the UK and Continental Europe, operating with a crew of 7 The accessibility of the container cells has resulted in substantial savings in total port time. With conventional designs multiport operations often necessitates overstowing cargo which can cause extra delay and additional cost. During the reloading process the hold must be filled first. A heavy container delivered late must be stowed on the hatch creating an adverse stability factor.

In the absence of hatchcovers the movement of cargo is facilitated since once a single cell is empty the crane can return a container in every subsequent movement The design will allow the placement of heavy containers low in the ship with the minimum of movements thus avoiding the need for vessels to carry any water ballast. The commercial advantage of this is obvious Computer simulations have shown that it is possible that an "open" vessel carrying 56 containers in an athwarthship cell bay would load the entire bay in 64 cycles as against 94 cycles in a conventional container ship (Ellis and Wittwer, 1992)

There are 4 holds on the Bell Pioneer with one hold fitted with conventional steel water tight hatchcovers to satisfy some of their customers who had always stipulated "below deck stowage". Number 2 and 3 hold are divided mid length by skeletal bulkheads which provide access to the controls of all refrigerated containers and to the tank top, the skeletal bulkheads are fitted with sockets for thirty power sockets in two hold and thirty in three hold.

Cell guides extend vertically upwards from tank top to just above coaming height. In short sea container trades containers may be handled in and out of cells on a daily basis so the cell guides are of prefabricated construction and are designed to be substantially more robust than traditional angle iron guides thus minimising potential delays and stoppages caused by distorted guides (McDermott,1992). With the flexibility of prefabricated cell guides a mix of twenty or forty foot containers can be carried. It is possible to convert to any configuration or size easily should any other length become standard. In conventional containerships any modification to the standard will require major reconstruction of guides and hatchcovers. The possibility of containers jamming in cell guides is obviated by the installation of an Intering heel-correction system which prevents the vessel heeling beyond half a degree during cargo operations.

Terminal turnaround times have been of average 25% quicker than for equivalent TEU capacity ships and the Bell Pioneer has achieved 602 TEU moves in 5 hours on 2 gantries. Cargo operations commence the moment the ship is alongside and departure takes place no more than 10 minutes after the last container comes on board. Captain Kenny, Managing Director of Bell Lines reported that "the average port turnaround time for off loading 330 TEU and loading the same number has been eight hours. Our conventional R class vessels which carry 130 TEU need the same time for the same operation (loading and unloading containers). We have virtually halved our turnround time with the Pioneer"(Gillies, 1992. p2).

Western Pacific rim shipping services are characterised by a large number of relatively short distance trades linking the main trading ports between Japan, South Korea, Taiwan, Mainland China, Hong Kong, Southeast Asian countries and Australasia. In addition to intra-regional trade there are growing feeder services catering for the huge intercontinental container ships. These round-the-world service ships only call at a few major regional hub ports between Singapore and Japan. As intra-regional trade increases the demand for small flexible container ships must grow also and the hatchcoverless container ship is the obvious choice for the new investment

Ships involved in short sea trades spend a relatively high production of round voyage time in port. In some trades port time can be more than 50% of round voyage time, ie. the ship can spend over half its working life in port on cargo handling operations.

To illustrate the impact of faster turnround on voyage profitability a voyage cost analysis based on a short sea route has been developed. This theoretical study is based on very conservative assumptions but shows clearly the operational advantages of the design over conventional technology. This is not an example of technology for technology's sake. Capital investments must be commercially viable and the hatchcoverless containership fulfils all the requirements. For no additional building cost, the design offers operators greater rewards.....an investor's dream.

The hatchcoverless container ship design could well be the technological innovation needed to encourage investment in the industry. For ships in feeder services or vessels which call at a number of ports the reduced time in port and subsequent fall in operating costs will mean increased returns for owners. The "*Bell Pioneer's*" operational performance has succinctly disproved the old adage that *pioneers live in mud huts*

Simulated Case Study

Comparison of a "simulated" 1000 TEU containership service - short haul compared with a hatchless ship of similar capacity.

Average load 750 TEUs each way

Voyage data

	Standard ship	Hatchless ships
Port	8 days	6 days
Sea	14	14
Total	22	20

	Standard ship		Hatchless ships
Voyage expenses			
Cargo expenses	$600 00		600
Port charges	120 00		96 00
Fuel	100 00		100 000
Charter	315 000		286 000
Container costs	95 000		95 000
Management	45 000		45 000
Total operating costs	$1 275 000		$1 222 000
Savings per voyage	$53 000	or	4.2%
Voyages/year	16.3		18.0

or 10.4% increase in vessel producitivity

Notes

1 Port charges: approximately 75% of port charges are time sensitive. Thus an Average port cost of $30 000 per call will fall by an amount according to a formula
4 x[(30 - 6)0.75 + 6] x $1 000

2 Charter rate is calculated at the rate of $US10 000/day.
Exchange rate $A1 = $US0.70

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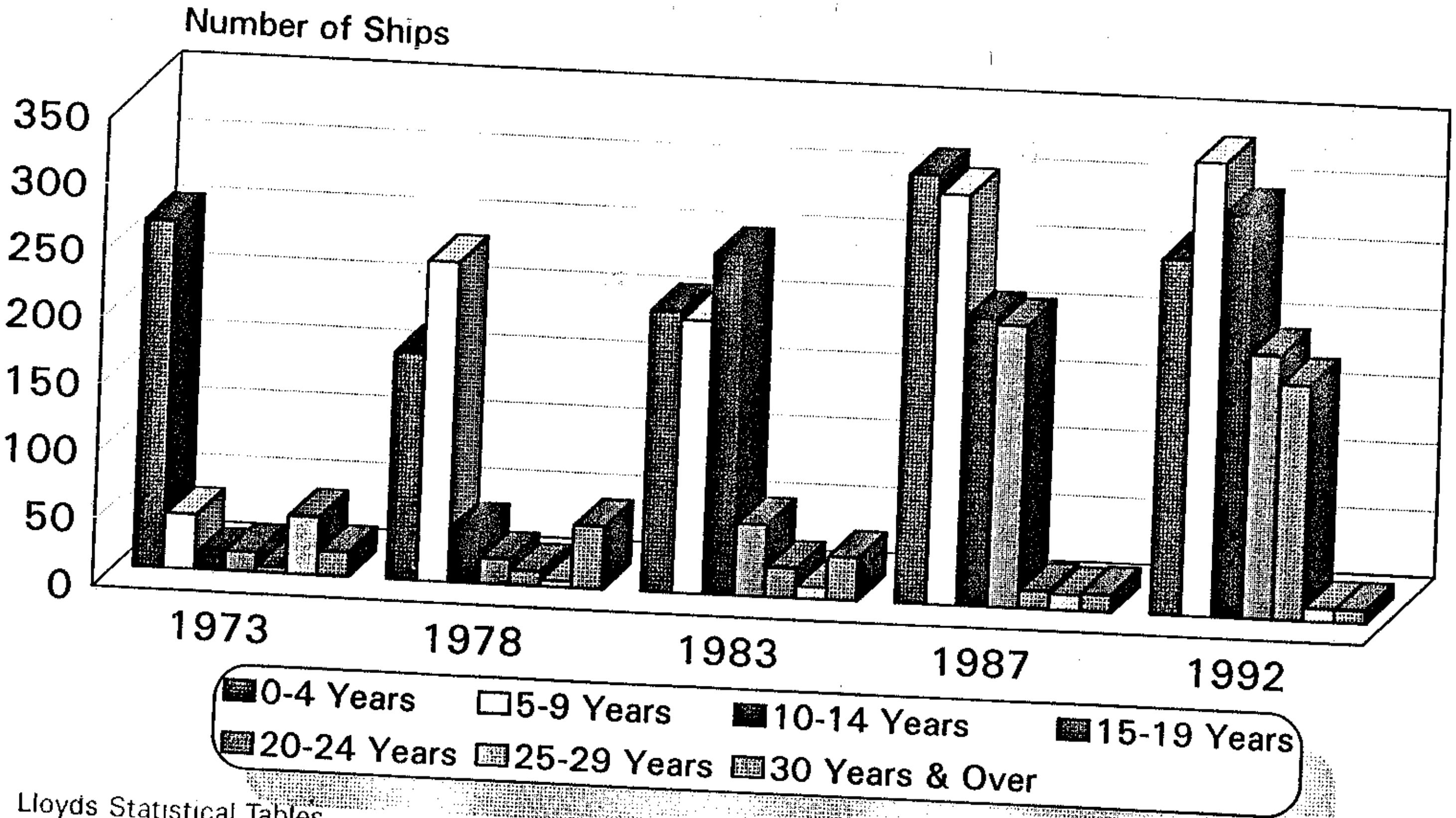
Containership Age Analysis - Vessels

Divisions by Age



Source: Lloyds Statistical Tables

MariTrade

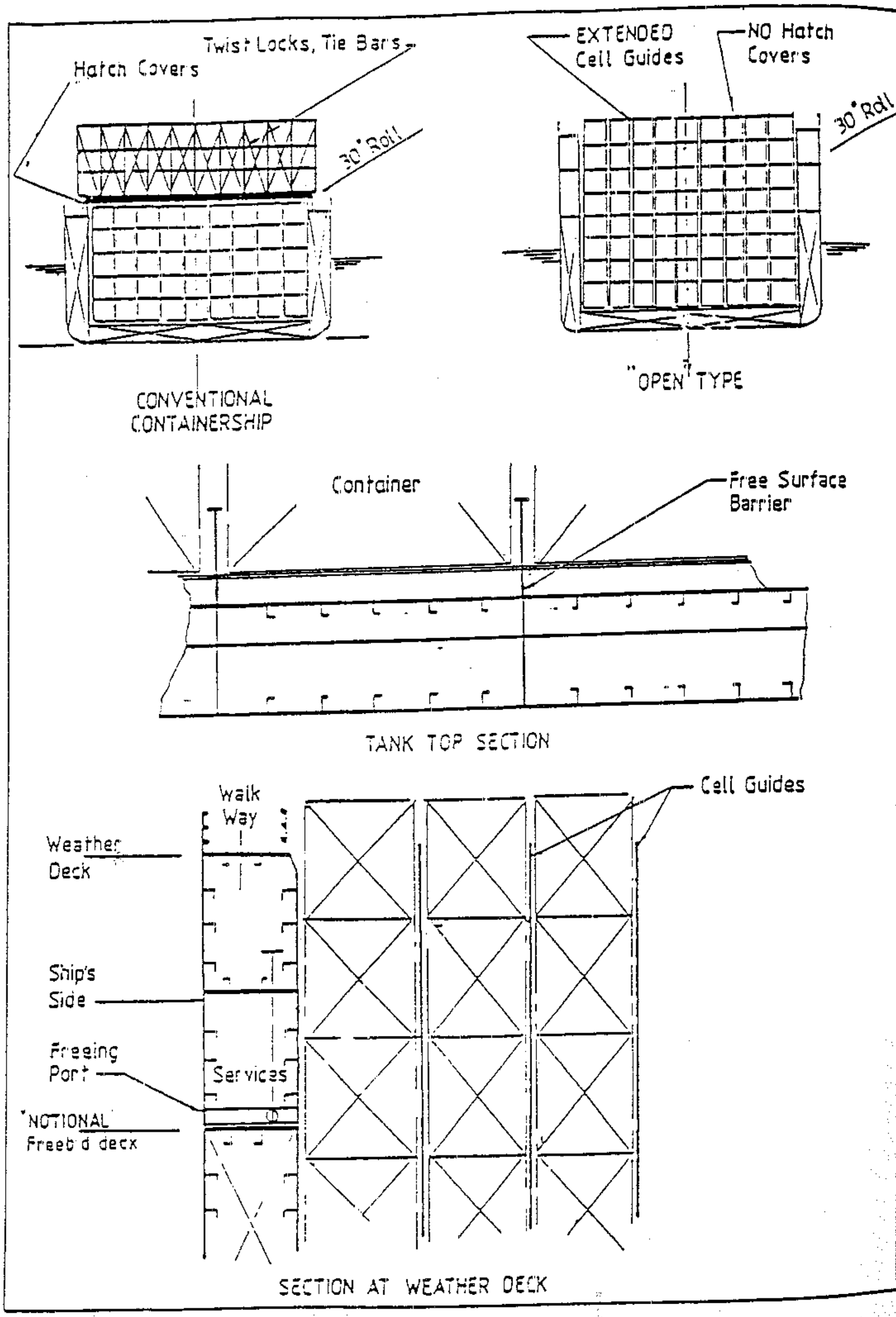

Hatch Covers
Twist Locks, Tie Bars
30° Roll
CONVENTIONAL
CONTAINERSHIP
EXTENDED
Cell Guides
NO Hatch
Covers
30° Roll
"OPEN" TYPE
Container
Free Surface
Barrier
TANK TOP SECTION
Walk
Way
Cell Guides
Weather
Deck
Ship's
Side
Freeing
Port
Services
NOTIONAL
Freeb'd deck
SECTION AT WEATHER DECK

FIGURE 1.

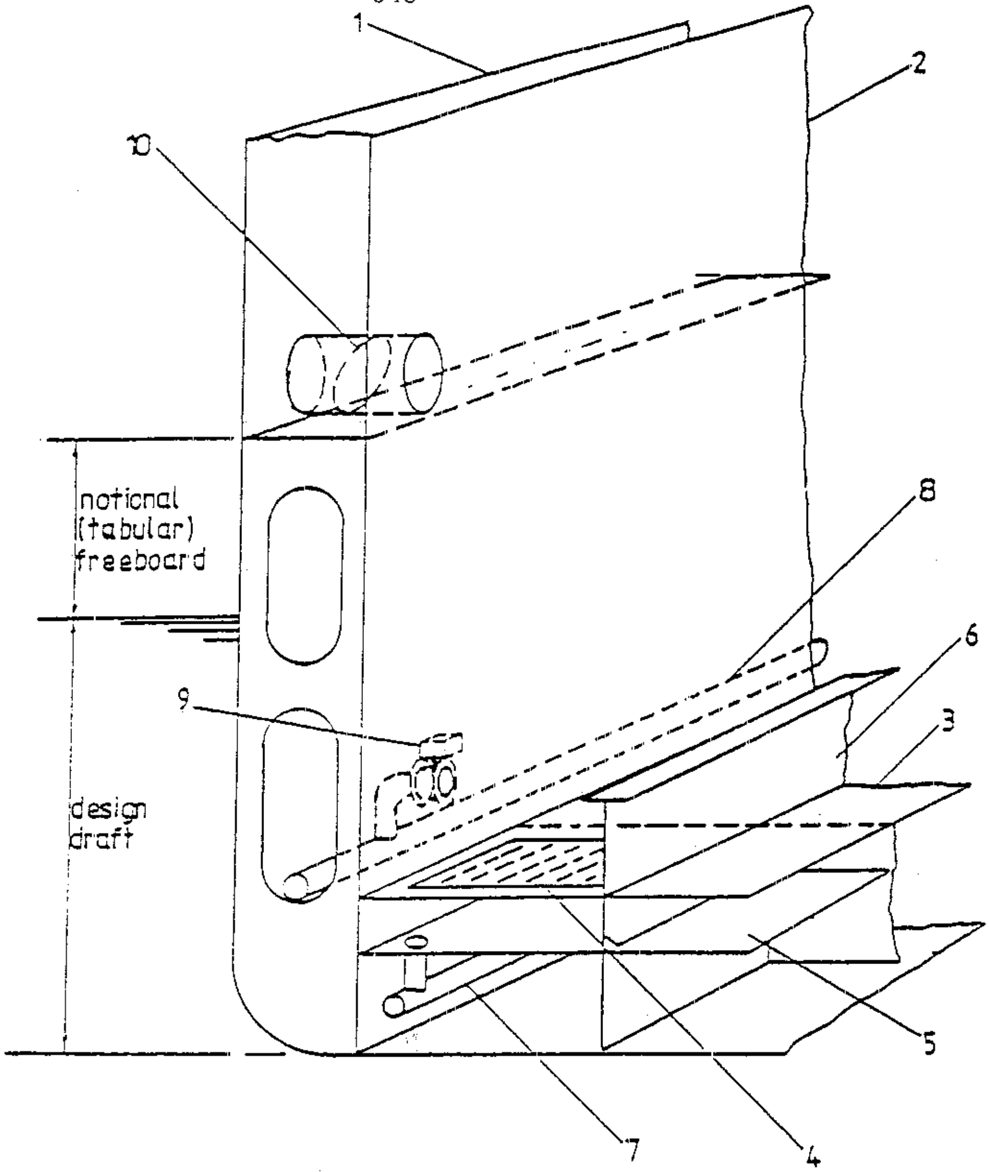


FIG.2

1 Ships side plating
2 Side tank inner plating
3 Tank top
4 Perforated bilge strum plate
5 Transverse bilge sump
6 Free surface control longitudinals
7 Bilge line
8 Ballast line
9 Remote-operated ballast valve
10 Non-return flooding control valve