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Shipbuilding in the Future

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Shipbuilding in the future

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The growth in world trade and hence the demand for shipping is expected to continue into the 1980s despite the present temporary recession.

Many countries in the Mediterranean and Pacific area and in South and Central America see shipbuilding as their way to start along the road to industrial development, and will be favoured by good climatic and labour conditions which can now be joined to imported modern technology. Conventional shipbuilding will therefore grow rapidly in these countries.

Western countries will be able to preserve their shipbuilding industries by keeping in the forefront of technical development and by a rigorous examination of designs from the production point of view, in order to reduce the labour content, and make the management and control simpler. This means changing from a largely labour intensive craft industry to a capital intensive, manufacturing industry.

In order to sustain this type of industry long runs of similar ships, standard components, modular constructions much of it in production lines, using group technology, will be the pattern in the 1980s. Much research and development is already devoted to these techniques and the industry is already at the early stages of changing over to this type of working.

1. Introduction

Although techniques such as the Delphi method have been used to try to eliminate the subjective elements from technological forecasting, I am not aware of any such thorough exercise concerned with future technical developments in shipping and shipbuilding. This paper, therefore, is my own personal view of a possible and feasible future – one which I think it is worth striving to make come true. I particularly hope to bring out the broad global situation and its steady development, despite local and temporary fluctuations, such as the present recession, and to set the scene for those who come later in this discussion meeting.

The shipbuilding industry supplies ships to the shipping industry which in turn supplies transport services to those in export-import trades, and hence any view of the future of shipbuilding must start with predictions of future trading patterns. Many econometric studies of this kind have been made in Japan, U.S.A., Holland, Norway and the U.K., some of them detailed mathematical models, some rough and ready extrapolations (Onozuka 1968). It is sufficient for my purpose today to take a very broad view over the next decade, extrapolating trends which have become clear since the last war, but being careful to look for the signs of new features to add on, or for reasons for supposing some movements may be nearing their end.

During the last twenty years world population has increased at about $2\frac{1}{2}\,\%$ per annum, and income somewhat faster at about $4\frac{1}{2}\,\%$ per annum. Neither growth rate is uniform over the world, since population growth is low in western Europe and U.S.A. but high in Central and South America and in south Asia, while income growth is high in western Europe, U.S.A. and Japan, but low elsewhere. In the absence of major wars, economic depressions and plagues, it is reasonable to assume that something near to these rates of change will continue for the next ten years, with some slowing up of industrial growth in the West and Japan, and some acceleration in a number of favourably placed other countries. Growth in the world sea-borne trade (i.e. exports) has shown a very close correlation with growth in world income, for the post-war

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period (though not during the depression and the war) and is on average about 8 % per annum. However, this growth is unevenly spread among trades, so that oil cargoes have grown at over 9 % per annum in tons and even faster in ton-miles, and bulk cargoes such as iron ore, coal and bauxite at about 6 % per annum. Completely new trades have been developed in the last ten years in chemicals, in liquid natural gas, and in motor cars and these have grown rapidly. Although still not large in absolute terms, they are on the rising part of a logistic curve. It would be very fortunate if other new trades could be confidently predicted as those likely to grow in importance in the next ten years. Perhaps they would include foodstuffs, liquid nitrogen fertilizers, simple prefabricated building components, and forest products.

Although positive growth rates for the existing major bulk trades should still continue for a decade, they must eventually level off and then decline, due to exhaustion of oil and ore reserves, or to a deliberate policy of conservation and greater re-cycling or, to development of alternative materials or energy sources, or, in the very long-term, development of alternative transport systems. For any major change on a world scale, such technical developments take 20–30 years at least, and we should therefore already know about the early stages of developments likely to affect shipping in the 1980s. However, by about 1990–2000 exhaustion of oil reserves, use of nuclear energy, use of glass, cement and plastics instead of steel for buildings and vehicles, greater use of air and pipelines for transport, will have begun to change the picture for shipping considerably. The biggest changes in shipping and shipbuilding in the next two decades are likely to come from wider rationalization of organizational and commercial arrangements, both within and between the maritime industries in order to get the design and production sides in balance, to keep the costs in real terms as low as possible.

2. World trade and the demand for ships in 1980

All published predictions of world sea-borne trade in 1980 whether optimistic or pessimistic, expect the demand for transport of oil, iron ore, coal, grain and similar low value materials, to dominate the shipping scene and to increase to a formidable level, roughly double present-day demands. This being so there is no reason to suppose the growth in average size of tankers and bulk carriers will not also continue. There will also be a rising requirement for transport of semi-finished goods (iron and steel items, bulk textiles, parts of transport vehicles) where the basic components are mass produced in one country and assembled in another, to be finally used worldwide. Much of this traffic would be carried in containers by the 1980s, using very large ships, on round the world routes serving fixed interchange points, from which feeder services fan out. There will also be a big increase in use of short sea routes for roll-on, roll-off trailers, using land bridges.

The world's sea routes for the major trades (oil, bulk and containers) will in effect have become much concentrated and simplified into a few heavily-loaded virtual pipelines between fixed terminals. However, this obscures the fact that the increase in bulk transport to give this very high absolute level of world trade still leaves the general sector untouched with its traditional trading pattern of small ships with mixed cargoes, calling port to port, continuing more or less at the same level as at present. This sector will raise its efficiency considerably by use of pallets, side loading, and part use of containers, so that the tonnage and numbers of ships required may not grow very much.

The international pressures exerted by regulatory bodies such as I.M.C.O. on safety, by

I.L.O. on raising of crew standards and by U.N.C.T.A.D. on elimination of discrimination, will in my view have technical side effects which will help rather than hinder the general movement I have described towards specialization and concentration.

The most reasonable figures to use for the future demand for shipping services are given in table 1 (from discussions with Maritime Transport Research London). These take account of the recent recession, which has had the effect of reducing previous estimates (based on experience up to 1969), and are unlikely to be improved until world trade has settled down again.

TABLE 1. SEA TRANSPORT DEMAND BY COMMODITY GROUPS 1970–1980

(10^{12} ton-miles)

	1970 (actual)	1975	1980
oil	5	8	12
iron ore and coal	1.5	2	3
general and other bulk	3	3	4
total	9.5	13	19

This transport demand may be turned into ship capacity by use of factors representing their efficiency, which has incidentally doubled in the last decade. For typical large oil tankers and bulk carriers each deadweight ton will provide about 50000 ton-miles per annum. For a general cargo ship each deadweight ton provides about 40000 ton-miles capacity.

The world fleet which is required to provide the transport demand of table 1 is shown in table 2, again in very round figures. Application of the above ship capacity figures does not convert exactly into table 2, owing to ships laid up, partial loads, incomplete cargo statistics, and local traffic (e.g. Great Lakes, short sea routes).

TABLE 2. WORLD FLEET BY PRINCIPAL TYPES 1970–1980

Million tons deadweight (excluding fishing vessels, passenger vessels, work boats and ships under 1000 ton dwt)

	1970 (1 July 1970 actual)	1975	1980
tankers	143	250	320
bulk carriers	76	110	150
general cargo	102	120	130
container ships	2	5	10
specialized, e.g. l.n.g.	2	5	10
total	325	490	620

Note: To compare with other projections given in tons gross the factors are approximately:

for large tankers	1 ton gross ≈ 1.9 ton dwt.
for small tankers and non-tankers	1 ton gross ≈ 1.6 ton dwt.

This may be turned into very approximate numbers of ships (table 3). The general cargo section is the most difficult to predict, as changes in efficiency are slower for this type of ship.

The world shipbuilding industry completed in 1971 some 39 million tons deadweight (1200 ships), (ships over 1000 tons) and had at the beginning of this year an order book of some 140 million tons dwt. (2600 ships) of which 85 million tons (630 ships) are tankers. When these are completed by say 1975 the world fleet will then clearly be something like 500 million tons dwt and of this total, tankers will make up half. The annual output required in 1980 to sustain

Table 3. World Fleet by principal types 1970–1980

(Numbers of ships greater than 1000 tons dwt)

	1970	1975	1980
tankers	6 000	8 000	10 000
bulk carriers	2 500	3 500	5 000
general cargo	12 000	13 000	12 000
container ships	220	900	2 000
liquid gas carriers	280	600	1 000
total	21 000	26 000	30 000

the large fleet which is predicted and allow continuing further growth will be about 50 million tons dwt. This would include, say 20 million tons of large tankers (150 ships), 10 million tons of large bulk or combination carriers (100 ships), 10 million tons of general cargo ships (500 ships) and 2 million tons of specialized container, l.n.g. and similar ships. Shipbuilding on a world scale is thus still a growth industry.

It would seem that there is nothing particularly difficult in the world shipbuilding industry developing physically to provide these ships if required. The changes and pressures will come from the need to keep down costs. By looking in detail at the growth in output over the last few years in certain countries and at their present order books, it is possible to see that there may well be some changes in the international shipbuilding league table. Countries which have formerly only built small ships for the local market are increasing their capability and output. These changes are evidently due to the availability of capital for new yards from government, international banking or commercial sources, to the pool of relatively cheap labour available for training into skilled men, to climatic advantage, and to the possibility of buying designs of small and medium cargo vessels, bulk carriers, and product tankers, as well as of importing the equipment necessary for the yard, and the machinery for the ships. It should be emphasized that these countries will omit the craft phase, and jump straight to using imported up-to-date technology, but will expect to employ fairly large numbers of men.

Thus Spain has, in less than ten years, increased output from 200 000 tons dwt to 1 200 000 tons (including the largest tankers) and already has an order book of 8 million tons, in third place. Greece last year completed 10 S.D. 14 standard ships, and Brazil increased its output threefold from 1970 to 1971 to 14 ships while Taiwan produced its first few ships. The plan to build a modern yard in Korea using British technology has just been announced. Thus these countries and others like them (perhaps Portugal, Bulgaria, Turkey, Egypt, Indonesia, India, Mexico) could quite rapidly raise their production to 15 to 20 ships per year, say $\frac{1}{2}$ million tons dwt each, to provide in total some 5 million tons dwt each year – a major part of the requirements for general cargo ships and small bulk carriers. This is, however, still only 10–15 % of the world annual output. The rest – tankers, large bulk carriers, container ships – are just the types of ship which can be best built by factory methods which Japan, western Europe and U.S.A. are beginning to develop.

3. Development of shipbuilding technology

Ships will only be required if they can fulfil their role of relatively cheap transport for goods of low intrinsic value but large quantity and this means holding or if possible reducing their initial and operating costs in real terms. Those shipyards in Europe, U.S.A. and Japan which

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wish to retain a sizeable share of the future market for both the large and the specialized ships will need to develop their technology to change from a labour intensive to a capital intensive type of industry since it is clear that for the foreseeable future their labour costs are escalating. This will mean greater use of the computer as an aid to design, the use of numerical controlled tools and automation for the production of piece parts and sub-assemblies, and an intensive study of the final assembly and fitting out processes, in order to simplify and streamline them to reduce the labour content, with the development of machines to take over much of the work now done manually.

(a) *Ship design*

The design of ships has changed rapidly in the last decade, as new specialized types have been evolved to meet the needs of a particular cargo and route, when the advantage of rapid turn around and high utilization can outweigh the extra costs of special loading gear or of unbalance in loading on inward and outward voyages (including the extreme case of return in ballast). Then as the type becomes established there is a growth in size of unit, often paralleling the growth in trade itself, as economic advantages win an increasing share of a growing market, and success channels more cargo into these defined ports and routes. The growth in size will only level out when external constraints (insurance, dredging costs, terminal storage costs) become disproportionately high and outweigh the economies due to the increase in size of ship. This may be only a temporary halt, and as the external factors come down into proportion again, growth will resume. Thus tankers of 500 000 tons dwt should soon become fairly normal new building, a few 1-million tonners will be tried, and the 2-million tonner be the next subject of design study.

Moreover, there is normally only a narrow band of optimal design parameters for a given route and duty, and the principles of engineering economics are now well enough advanced for such optimal ships to be designed (the main dependence is on route length and on time in port to load and unload). When found, these optimal designs should be used for long production runs (20, 50, even 100 ships to one design seems now quite reasonable) and it will also be sensible to spend much more time and effort getting the design right, particularly from the production detailing and assembly points of view. Much greater depth of analysis could also be given to reliability of structures and equipment, and should show its cost-benefit eventually in lower insurance, less repairs and greater time in service. This will mean investing in technical manpower to a greater extent than at present.

The increased use of the computer is effectively making the design stage capital intensive, but it is also making it possible for the design to be rigorous and self-consistent, and in sufficient depth and detail, as appropriate to ships costing £10 to 30 million each. Present understanding of the ship design process is very limited and fragmented, and one effect of the introduction of computer-aided methods has been to make design self-conscious and explicit, so that it is now possible to consider an evolutionary process of progressive improvements. These will apply to the whole span from the initial creative design to the detailing for manufacture, and include the interfaces with operations and production. Such improvements can lead to the elimination of a great deal of the tedious manual preparation of data and of routine calculations, to the elimination of many drawings which are no longer required as means for transmitting information since lists and instructions will be sufficient, and to the direct automatic preparation of taped instructions for numerically controlled machine tools, or for drafting machines which will produce those drawings still needed for checking or for use in manufacture. The cost-benefit balance in all this should in due course be strongly positive, but there are other advantages such as reduction in lead time (important for production planning) and the possibility of exploring more alternatives, as well as satisfying the reasonable need of the designer to feel that he has the best possible tools at his disposal. It is only by using the most up-to-date methods that good designers will give of their best, and it is good design that is the key to good production.

Reliable design information is also relatively scarce; better feedback of measurements of performance of existing designs is required, as well as more fundamental work in some areas. We need a better understanding of the sea and its wave systems, and thence to be able to calculate loads in different ship structures. We need to know more about the behaviour of these structures beyond the elastic range and to study failure modes such as buckling, fatigue and brittle fracture. We need to know more about water flow round bluff bodies, and the effects of separation on resistance, steering, and the excitation of vibration via the propellor. We know very little about skin friction and what might be done to reduce it. Because the build-up of information is relatively slow, a pooling of such full scale measurements from many organizations would be helpful. International bodies such as the I.T.T.C. and I.S.S.C. already play a significant part in exchanging such information.

The design of the various shipboard engineering systems and their integration into the total machinery system is an area of increasing importance to the shipbuilder who still has the ultimate responsibility for ensuring that the machinery selected and installed is efficient and reliable. Much remains to be done to analyse efficiency and reliability on a formal and precise basis.

The place where the greatest developments are still to come is in the provision of automation, now well established for the main and auxiliary machinery in the form of un-manned engine-rooms, for other functions such as navigation, collision avoidance, mooring and cargo handling. Experimental work on several of these items is going on in Japan, Sweden, and Norway, and eventually the integrating of these into a complete system will give us the 'minimum crew' ship, with perhaps eight men on board compared to the present thirty. This will bring substantial economic advantage to the owner; and the builder will have to understand how to select and instal this complex equipment, then commission and hand over such a new type of ship. The first examples of such ships will be developed before the 1980s and they could become common as new construction in that decade.

Ships are already very efficient vehicles in unit transportation cost terms, and there are probably only small margins to be gained by changes in the physical parameters. The main barrier to progress comes from the very high cost of raising the velocity term in transport momentum. Certainly, current designs of high-speed craft such as hydrofoils and hovercraft do not seem capable of commercial development as carriers of bulk oil or ore. Nor are submarines the answer, since structural costs, special safety and navigational equipment costs outweigh any savings in power. It will be interesting to hear more from later speakers, about new concepts which might break through this barrier.

(*b*) *Production*

Most modern shipyards have already gone a long way to providing a flow line with fixed work stations for each process, for the production of piece parts and their assembly into stiffened panels which are the basic 'brick' for shipbuilding. There are a good many automatic and numerically controlled machines used in such panel lines, and proper use is made of machinery

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for moving the large quantities of steel involved. The productivity of this section of a shipyard is very high both in respect of machines and men. Such panel lines can be found in the major U.K. yards, and in most west European countries, and in Japan.

A few yards mostly in Japan have taken the next step to provide jigs, handling equipment, specially developed semi-automatic welding gear to build up the three dimensional blocks or sub-assemblies, in workshops with an area dedicated to the construction of each particular type of block. The structure of the ship has been so designed that it can be broken down into a few types of block, which are then repeated.

Only two yards, Arendal in Sweden, and Pascagoula in U.S.A. have so far organized a special work station for the joining of the block into the ship hull as it grows, Arendal by 'extruding' the ship into the dock from the inner end of the building dock which lies within the assembly hall, Pascagoula by building its blocks as complete modules of the ship, joining these on land, and then lowering the ship into the water by a floating dock arrangement. The Japanese yard now building at Koyagi near Nagasaki will be on rather similar principles, with fixed locations for each type of work, but with the actual joining of unit sections being done in a special dock.

Other yards in Japan and Europe have taken a rather different road, and kept the units much smaller, to the stiffened two-dimensional panels, and tried to streamline the method of assembling these in the dock or on the berth, by providing simple lifting and holding gear, and having a mobile work station tower with all the power, air and other supplies, the semi-automatic welding equipment and other power tools available on it. This requires a highly disciplined, well-planned sequencing of all the operations of providing material, tools, information, keeping step with the tower which rolls along the berth or dock with the addition of each new segment of the ship. Recently, such towers have been designed for use inside the cargo spaces.

We are clearly only at the beginning of the movement to rationalize such assembly methods in order to reduce both the labour content, and the time occupying the dock (an expensive capital facility). Interwoven with the placing and joining of the steelwork will be the placing of the piping, trunking, cables and similar outfit material, also the painting, so that this part of the work will be substantially finished when the steelwork is finished.

So that the machinery may be finished to the same time scale, much greater use of shop assembled standard modules will have to be made, so that only the connecting piping needs to be installed after placing in the engine room. Such modular systems have been designed and tried out tentatively already.

(*c*) *Commissioning and tuning*

The increasing complexity and value of ships' equipment requires a more formal planning of the sequence of testing during the build-up of machinery components into assemblies and systems, and finally into the complete ship machinery. Standardization will help keep this within reasonable limits, but for new systems, more time will need to be allocated for this aspect than has hitherto been agreed at the outset, though it may have been used in the event.

(*d*) *Main propulsion*

There is a distinct possibility that a significant step increase in efficiency and a substantial saving in weight and space, could be achieved by using a combined gas-steam turbine as prime mover, with a super-conducting generator/motor as the speed reducing, reversing drive. The first experimental ship engines could be developed within the time scales of this discussion.

The main fuel will, no doubt, continue to be oil, but for the largest ships, nuclear fuel, probably cooled by inert gas passed to a gas turbine, should be in somewhat wider experimental use than at present. In the end, only the extended trials can prove whether its potential for reliability and endurance can be turned to economic advantage.

(*e*) *Materials*

It is difficult to see the replacement of steel as the main structure material by aluminium, glass-reinforced plastic or other composites such as glass-reinforced cement in large bulk carriers, tankers or container ships within the time scale of this discussion. However, there will be increasing use of these alternative materials in places where lighter weight or freedom from need to maintain by regular painting are important. These materials are beginning to enter the industry in two ways, first as the main hull material for small craft, initially pleasure craft, then work boats, and here the size of vessel being built will increase steadily. Secondly, many components of large vessels, which are not part of the main structure, are being redesigned to take advantage of these materials, e.g. deck-houses, catwalks, break-waters, ducting, protective covers, thus increasing the payload and decreasing maintenance costs.

4. Conclusion

To sum up this paper, I would say first that ship technology will still continue to develop, but probably more rapidly in the production field than in the design field.

In design development, there are areas which require serious attention and improvement, both in our fundamental understanding of the physical phenomena, and in the feedback of reliable information on the behaviour of existing designs. Such areas are the sea waves – ship loads – stress in structures system, the buff body flow – propellor – vibration system, the skin friction – boundary layer – separation – resistance system, and the dynamic loads – welded structure, fatigue or brittle fracture failure system.

There are several technologies developing in other industries which might be readily transferred to ships in the next few years. These include gas turbines (particularly if a step function in efficiency could be achieved by adding on a steam cycle to the same shaft), a superconducting generator-motor drive to replace gearing, and the use of glass fibre composites.

The movement towards designs of ships better adapted to manufacture by flow line methods has begun and will accelerate in order that the supply of ships may meet the demand in time and cost. Research and development in many countries of the world is already devoted to this task but the total effort and its quality will have to be increased if effective answers are to be found on the time scales which have been indicated. Problems arise in automation of welding processes, in use of the computer for planning and control, and in simulation of assembly methods.

Three main centres of 'ship manufacture' and of the relevant research have emerged: Japan, U.S.A. (which is still one of the largest shipbuilding countries, mainly naval) and western Europe. If the U.K. entry into the E.E.C. should lead to closer commercial ties with European yards, this could possibly also lead to better coordination of ship research.

In addition to this technical effort to find solutions to the problems of design, production and large scale assembly, a high level of capital investment will also be required. This can hardly be found from within the European shipbuilding industry after its long period of virtually profitless operation. In Sweden some injection of capital has already come from shipowners (customers), in Germany from the steel and engineering industries (suppliers), i.e. from those with an interest in the future of ships. The shipbuilding industry in Europe has a turn-over of £1000 million per annum, and if the market was thoroughly searched out, rising to double that figure by the 1980s. Some £30 million/year capital investment rising to £50 million would appear to be justified for new plant and technical developments associated with its introduction. This is roughly the scale of investment which has already been taking place in Japan, and should surely be forthcoming in Europe if it is intended that shipbuilding should continue. Such investments would seem to be rather more useful, to the trade and economy of the world, and probably more certain in its return than the rather larger sums now being invested in supporting supersonic aircraft design and production facilities. For Concorde, some £800 million is being spent on development and initial tooling for a production of some 250 aircraft worth perhaps £5000 million with spares over 10 years, split between two countries. For the Rolls-Royce RB 211 engine some £250 million is being contributed by the Government for an order of 550 engines. Some of this may possibly be recovered if there is a profit on spares. For specialized ship production in Europe, £400 million invested over ten years could certainly give the best possible production facilities for say 4000 ships valued at £10000 million over 10 years, providing work in 6–8 countries. This would include the using of 20 million tons of steel and the manufacture of 37500 MW (50 million horsepower) of main engines. To grasp this potentially great opportunity and to realize its full economic benefit to Europe will require a greater degree of concentration and organization within the shipbuilding industry and a greater degree of coordination and recognition of common interest with the shipping industry, than is apparent at the present time.

It is interesting to speculate whether the trend in shipping to international groupings and to integration into wider transport systems, will now extend horizontally and vertically to give a European grouping, including the building as well as operation of ships, in which the overall profit is the most important criterion, not that on any segment. If this close working could be brought about, it would be to the great benefit of the maritime industries of these countries, and the economy and trade of the world.

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