PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
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# Shipyards of the Future: Possibilities and Prospects

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# Shipyards of the future: possibilities and prospects

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Some comments are made on the effect of world trends, economic and social influence on future trade and investment patterns, and the growing influence of the emergent nations. The attractions of shipbuilding as an employer of large numbers, embodying a high level of technology and its national value are reviewed. Developments in transport systems and the future of ships as the main form of bulk transport are discussed, together with some of the considerations and restrictions which may affect ship design in the future.

The trend towards specialized ship types is reviewed.

The siting and design of future shipyards is discussed in the light of advances in technology. Consideration will be given to the changes in trade patterns and transport systems and their influence on shipyards. Mention will be made of the social and economic facets involved in the choice of the site and the design of the shipyard.

## 1. World trends

Before commenting on the future development of new shipyards, it is necessary to consider the nature of shipbuilding, what stimulates its growth and where it thrives. Shipbuilding is a capital goods industry to international transport; as such it is subject to a magnification of its changing patterns, booms and slumps.

To consider shipyards of the future, some assessment is necessary of world transportation trends, and predictions of the influence these trends will have on the siting and design of future shipyards and the type of ships that will be built.

The starting point should be to question whether the present aims and structure of society will continue in the 1980s. Will free enterprise and profit continue to be the main motivating force or will other social considerations modify the drive. Will nations still measure their wealth primarily in terms of living standards and material consumption, or will the quality of life in terms of improved social and environmental conditions be increasingly important. A move towards an economy based on the conservation of resources will be regarded as a necessity, and it is to be expected that the technical modifications will result from social reaction to the pollution and misuse of exhaustible supplies that is now being recognized in our consumptive age in the form of international legislation.

While society may be expected to change rapidly locally, it is probable that the general pattern of global change will be steadier and more predictable. Mankind will continue to demand a higher standard of living and nations will continue to be motivated mainly by economic considerations. In the wealthier nations however, this attitude may be tempered with an increasing awareness of their social and ecological responsibilities, which will result in more complex and safer ships, particularly those vessels carrying bulk cargoes which are dangerous, or have ecological disadvantages if discharged unintentionally.

One of the major influences in future world trends will be the growing strength of the emergent nations. Motivated by their desire to acquire the same wealth and standard of living as the richer nations, a rapid expansion of industrialization is to be expected. Their resources,

† The views expressed in this paper are those of the author and are not necessarily those of the company or industry in which he is employed.

together with industrialization will probably still attract foreign investment and stimulate trade. Governments generally can be expected to encourage expansion and so act as an accelerating force to the growth of world trade.

In many countries, shipbuilding could be a useful industry on which to build industrial expansion. Conventional shipbuilding is basically labour intensive and can offer work to relatively large numbers; alternatively, technology and automation can be utilized to reduce the quantity of labour needed. Workers can be trained to perform the basic or specialized shipbuilding functions. Shipbuilding is primarily an assembly industry, depending on large numbers of other specialized companies to supply the basic parts. In the initial stages of development, packages of equipment could be imported from existing shipbuilding countries but support companies would be expected to grow in time, in developing nations to supply the local shipbuilding industry.

The level of applied technology required in shipbuilding and its support companies is moderately high and forms a good starting point for the development of national technology. Probably in the early stages, technical and managerial expertise will be acquired from established shipbuilding countries.

Ships have their national value. From the economic point of view they offer a lead into growth industry and provide a major way of earning foreign currency. They also give a degree of independence from international pressures.

## 2. Transport systems

Over the next decade, transport systems can be expected to continue to develop and new methods to emerge. Future developments will probably be in integrated transport systems covering all movements from supplier to consumer. Methods of packaging and methods of transport will need to be considered together to minimize the total transport cost. One obvious example of this approach is the use of containers which are suitable for road, rail and sea transport. Although they do not make the best use of a ship's cargo carrying capability, the economics of the overall transport system are improved by the faster cargo handling and high throughput.

The choice of transport system will depend on a number of factors, but one of the main ones will be the geographical locations of the supplier and consumer. This can have considerable influence, as the transport system chosen for one route may not be the best for another. For example, Russia uses pipelines to move crude oil to eastern Europe, but Great Britain relies on ocean going tankers for its supplies. To understand the role of ships in future transport systems one must consider the various methods of transport available. These can be basically broken down into land, sea and air methods.

Recent years have seen an increasing use of pipelines for transporting fluids mainly overland. They have the advantages of high throughput coupled with an ability to take the shortest route between supplier and consumer. However, because of the high capital investment involved, there must be an assured market. Sovereignty problems where pipelines cross national frontiers, and the vulnerability of pipelines to malicious damage have to be considered. As yet, their use for underwater routes has been limited by the technical difficulties of laying and maintaining them and by the problems of pollution.

Submarines have been considered for routes under the northern ice-cap and may have a role to play as oceanology develops and man attempts to exploit the sea bed. They have been



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considered for carriage of bulk cargoes but at present, do not appear to be an economic proposition. They would probably need to be quite large and nuclear propelled so the capital investment in building and running such vessels would be high. Empty and partially full holds would need to be pressurized and the process time involved would increase considerably the time in port with consequent drop in utilization. Because of their diameter and normal operating depth, it is probable that large submarines carrying bulk cargo would need to surface when reaching the continental shelf. This would seriously impair their operating and economic efficiency. One of the interesting developments of the 1960s has been the hovercraft. These craft are now operating competitively on short haul routes. They are also being increasingly used in the more inaccessible parts of the world where their amphibious nature is most suitable. Hovercraft are probably most suited to passenger carrying and containerized or 'roll-on/roll-off' cargoes. Their limited payload makes them unsuitable however, for the heavier or more voluminous bulk cargoes.

As yet, the hovercraft has not been used on medium and longhaul routes in exposed waters. One of the difficulties is that should a hovercraft break down in mid ocean, it must have survival capabilities. This in effect means giving it sufficient structural strength to withstand floating in a rough sea. At present the weight penalties these safety considerations would impose are severe. Hovercraft are also subject to high accelerations as they traverse the waves, which may be unacceptable to passengers for long periods and may limit their use for fragile cargoes.

A steady increase in air freight for high value and high priority cargoes is to be expected. It is probable that a larger part of perishable goods will be carried by air. Aircraft are not expected to make inroads into bulk cargo fields, however, due to their low payload capability. The high capital and operating costs of aircraft make it important that they achieve a high utilization rate. The cyclic pattern of world trade could therefore also be a constraint on air freight.

It is worth noting that there has been renewed interest in airships for passenger carrying, high value cargoes and containers. With a speed of about 200 km/h they are between the ship and aircraft.

Within the foreseeable future, ships seem to provide the most economical method of transportation for the major portion of the world trade. For bulk transport of oil, ore etc., longhaul shipment of containers and cars, movement of low value cargoes and non-perishable goods, ships are likely to remain the first choice. Only a relatively limited proportion of world trade by volume will be likely to be moved by other methods.

With a move to consider ships as part of integrated transport systems, ships are likely to become more specialized, being designed to carry a specific cargo as part of an overall transport system.

## 3. Ship types of the future

One of the major factors in the design of future ships to function as part of an integrated transport system will be to try to minimize the cargo handling time. The minimization of time in port and consequent higher utilization of the ship has a considerable influence on its viability. There is a general trend towards larger ships, mainly due to the reduction in freight cost per tonne and the reduction in operating costs. However, the trend tends to become asymptotic as size increases, and normally other factors such as depth of water, size of market, repair facilities etc., become of increasing influence.

The speed of ships can also be expected to grow, particularly in ships designed to carry high value cargoes. The cost of fuel as a percentage of the total operating costs has been less important in recent years. It should be said that it is difficult to predict what specialized ship types will appear in the future, as the demand for specialized transport tends to arise relatively quickly.

One of the major influences on shipbuilding has been the expansion of the world tanker fleet and the increasing size of individual vessels. Tankers of 250000 tonnes dwt are becoming commonplace and plans are already in hand for building vessels of double this size. It seems technically feasible to build tankers of up to one million tonnes deadweight but their economic justification has still to be settled.

It is more probable that the economic penalties of depth restrictions, dry docking and shore facilities may limit the size to between 400000 and 600000 tonnes dwt.

There has also been a substantial increase in the number and size of bulk carriers and as the general trend towards collected cargo and bulk carriage continues, the demand can be expected to increase. These ships are tending to become more specialized and are normally designed to carry a specific cargo or limited range of cargoes. The oil-bulk-ore carrier (o.b.o.) is a typical example of present trends. With large bulk carriers and tankers the main problem for the shipbuilder is the structural design and economic manufacture.

There is also a growing market for chemical and petroleum product carriers. These carriers are often designed to carry more than one chemical at the same time and to be capable of carrying a range of chemicals. In some cases, chemicals such as liquid phosphorus or sulphur need to be carried in heated containment. These ships have a high engineering content and are bringing shipbuilders into contact with the problems of chemical engineering and the special materials required to contain the chemicals.

The continuing demand by the richer nations for energy has led to an increasing demand for liquefied gas carriers. These ships are designed to carry either liquefied natural gas or liquefied petroleum gas or other similar hydrocarbon and chemical products. Because of the low boiling points of these products, it is necessary to transport them either under pressure or at sub-ambient temperatures, or a combination of both. The main problems for the shipbuilder are in the structure of the containments and their insulation from the ships hull.

One example of the speed with which new transport methods can arise is the containership. When containerships were first introduced it was decided in the interest of speed, to convert existing freighters. Since then, container ships have continued to develop and are one of the major shipping revolutions of our age. It is interesting to note that containers reflect the general trend towards bulk carriage.

Other ships are being developed to apply the same principle of packaging commodities. The Lash type of ship works on the principle of loading rectangular barges into a mother ship. These barges are in effect, large floating containers.

Another development is the 'roll-on/roll-off' ships (ro-ro) where cargo is loaded onto the ship on the lorry trailer on which it was brought to the dock. Ramps extend down from the dockside to doors in the ships side and the trailers can be driven on board.

The importance of the motor car as a major export/import has led to the development of specialized car delivery vessels. These are either similar to the ro-ro ships described above or have lifts down to the cargo holds.

There is a continuous development in the smaller types of ship such as fishing vessels, ferries and coasters. Again the trend is towards specialization. Although the trend towards specialized ship types means that there are more basic types of ship than in the past, it has eased the task for the shipbuilder by allowing him to standardize his product for a specific trade rather than have to build each ship as a compromise suitable for many types of cargo.

## 4. The siting of future shipyards

As world economic trends and social factors have a significant influence on world trade, they affect shipping and shipbuilding. Such factors also influence the siting of new shipyards and the viability of existing shipyards. It has been a feature of recent investment in shipyards, that a large proportion has been associated with labour saving modernization in existing shipyards, particularly in western Europe. Japan on the other hand, has not been content with merely modernizing its existing yards but has also engaged in massive investment in new shipyards. Plans have been announced for five new shipyards to be completed by 1975 and it has been suggested that six more are expected to be built by 1980.

Perhaps more significantly, there are indications of a pattern of overseas investment by existing major shipbuilding countries in nations with little or no experience of shipbuilding. With labour costs rising rapidly in the richer nations of the West and Japan, the alliance of their technology with low cost labour in developing nations is attractive to the respective Governments.

Many factors influence the choice of site for a new shipyard. In some cases, there may be a government requirement for shipbuilding industry, but in the first instance most cases will have to be assessed on the availability of capital investment, a willing low cost labour force, a suitable deep water site, the availability of steel supplies at viable prices, the availability of electrical power and good communications. Other points to consider will be whether the supporting industries making sub-contracted parts exist or can be developed locally or whether the shipyard will have to rely on imported items. The choice will also be influenced by the knowledge of a large or growing national shipping fleet, or the expectation of an international competitive product to provide sufficient orders to ensure a continuing base workload.

Governments of developed nations can, by the use of subsidies and the availability of cheap credit, or alternatively, by the erection of trade tariffs and other restrictions, significantly impair the ability of emergent nations to compete in shipbuilding.

Given that an expanding world requirement exists for ships which are liable to become larger and more specialized, the question arises how is the United Kingdom placed to retain or increase the present percentage of this market. As the British shipbuilding industry is presently constituted, bearing in mind the size of capital investment required to create an industry capable of international survival and expansion, it is impossible to forecast anything other than a declining share of the expanding market. There has not existed during the last decade a climate which would encourage sufficient investment in the shipbuilding industry to enable it to compete internationally.

During this period, shipbuilding industries elsewhere have enjoyed a high degree of protection or subsidy (or both) leading, for example, to the massive investments made in Japan, where in almost any single year the amount of the capital spending has exceeded the United Kingdom's total investment over the entire decade.

Here in the U.K. a low level of investment, coupled in recent years with an unprecedented rate of cost inflation, has impeded the industry from matching the inevitable wage claims with a comparable increase in productivity. There has thus been created an inward winding failure spiral of losses due to inadequate investment which in turn discourage further investment, even at the previous modest level.

Although there may be individual companies capable of resisting this trend, it is an inescapable conclusion that, for the industry as a whole, the required level of investment can only be achieved with the assistance of government.

Successive administrations have adopted a series of ad hoc expedients in the absence of a continuous long term national shipbuilding policy. Recent events have shown that the economic and social cost of failure can exceed the size of the investment by which that failure could have been averted. Taking into account the large work force involved directly and also indirectly in shipbuilding activities, it is self evident that a long term policy, specifically designed for shipbuilding, must now be formulated. Such a policy should start from the proposition that in the context of British shipbuilding, the present fiscal and grant policies have no obvious relevance. Accelerated depreciation allowances, for instance, however welcome to industry at large, provide no incentive if profits are insufficient to obtain advantage from them.

In such circumstances, the present taxation measures in relation to capital investment merely make the strong stronger, without ensuring that the weak have the opportunity to become stronger. Similarly, such grants towards capital expenditure as are still available – depending as they do on an increased level of employment – are unlikely to confer very much advantage on the British shipbuilding industry. Indeed, even if such grants were more readily available, the financing of the balance of the expenditure required would present insuperable difficulties unless there were associated measures which allowed the industry to envisage a profitable long term future.

It is not by any means suggested that the British shipbuilding industry should be the object of perpetual subsidy simply to enable it to function as an extension of some social security system. However, the industry has the right to expect that the Government, in the national interest, will formulate long term policies which will enable the industry to meet international competition on level terms. There are clearly a number of means by which it would be open to Government to achieve this end. In so far as these involved the direct investment of public monies in any particular concern, it would have to be evident that a suitable return could be expected as much in a monetary as in a social sense.

The unions would also be required to cooperate in the event of government policy for the industry. The problem here is one of restrictive practices between and within unions associated with a past history of militant protectionism which has become increasingly counter-productive to the protection sought and the security needed by the work force represented by the unions.

Japan is a splendid example of output related to investment which reduces the manhour content while increasing the labour force requirement. The spiral there is an expanding one, giving more security to the work force and better incentive to management. It is no secret that successive Japanese governments have encouraged shipbuilding and certainly created a climate for massive and sustained investment.

## 5. Shipyard layout and design

The problems of siting a new shipyard have been discussed. Problems of layout occur in a new yard, or when an older yard is modernized. Numerous factors must be taken into account in solving layout problems, some of which are mentioned below. For convenience three stages in the layout design process are identified, but it should be emphasized that the process is iterative.

The first stage is to determine what ship types are to be built, what size or sizes and how many per annum. The basis for these decisions will be market research. Once the objective has been defined, it yields the overall requirements from the production system. Estimates of, for example, annual steel throughput can be made.

The second stage depends on local conditions. Labour availability and costs are taken into account to decide the ratio of labour to capital. The intended production rate is also considered in this respect. Decisions on whether to make or buy various items, whether to sub-contract parts, and on necessary stock levels, are made. From this stage, the basic layout emerges.

At the third stage, the detailed design of the shipyard is completed in conjunction with ship designs, so as to achieve optimum production. For example, parts of the ship may be standardized, allowing repetitive functions to be performed on a flow-line basis. The future must see an increasing awareness of the need to consider the shipyard as a system, with various aspects of the process as sub-systems. Not only hardware, such as steel production, engineering and outfitting, but management structure, materials handling and information, all of which can be considered as the software of shipbuilding.

For the 1980s it is possible to pick out stage two as being of major importance. Technology is capable of meeting future requirements; the question is at what stage will new methods be introduced into the shipbuilding process? This is asked against the background of rising labour costs and increasing demand for more sophisticated ships. Design for production must also be refined. Powerful new design techniques are being developed for the ship designer in the future, especially in the field of ship structures. He must use his increased knowledge to design structures which are cheaper to build, balancing this against increased steelweight. It will be essential for him to be aware of value engineering, and of the latest production techniques, some of them from other industries.

It is easiest to discuss what possibilities and prospects the 1980s hold for techniques in shipbuilding by considering various aspects separately, though in practice an integrated approach is essential. To date, most attention has been paid to the steel production aspect and it is unlikely that any material will be seriously challenging steel as a major shipbuilding material. In the preparation of steel, present techniques will probably continue into the 1980s. There will be improvement but major changes are not likely. The associated present manning levels are low and other areas will yield greater savings.

In the field of cutting, numerical control techniques for gantry burning machines will probably carry shipbuilding into the 1980s but the actual cutting methods may change.

Possible alternatives to present day oxy-gas cutting are:

- (i) Plasma–arc: this method is potentially much faster but as yet cannot combine adequate finish with speed. (Finish and accurate edge preparation are essential for shipbuilding).
- (ii) Laser: very much in the future but a possibility.
- (iii) Mechanical: limited to straight work, but this is a fair proportion of the cutting required.

Main developments will be in the unit assembly areas. A major consideration at present is that overhead welding is more expensive than downhand if the quality is to be maintained. In addition, the mechanization of much sub-assembly work, e.g., in panel lines, puts a greater load on the work areas which follow.

Welding down is preferred and overhead welding can be eliminated from all but final assembly by using rotating jigs, though these are expensive, having to turn units of several hundreds of tonnes. Attention will be focused on improving welding techniques or using other joining methods. However, there is no alternative method at present likely to be used.

The other major area of production is that of outfitting. Improvements in outfitting technique have come about more recently, but will be of increasing importance in the future. Outfitting of ships is becoming more complex, in view of the increasing specialization of types, and also more bound by international and governmental regulations. The work is by its nature, labour-intensive and requires a skilled specialized work force.

By the 1980s present 'advanced outfitting' techniques will be further improved and in general use. There will also be more integration of the outfit work of ships with the steelwork, requiring an advanced outfitting concept at the design stage. This will not be easy to achieve until design techniques are revised, as discussed under the general heading of 'communications'.

Materials handling pervades the shipbuilding industry. It is increasingly an essential aspect of layout design, rather than ancillary to steel or outfit production. It has been estimated that 60% of shipyard labour costs may be taken up in material handling. As ship size and steel throughput increase, and as outfit becomes more complex, the problems increase. The problems of moving 60 tonne units in early pre-fabricating days were more easily solved, than those in moving blocks approaching 1000 tonnes. As size and complexity increase, a more sophisticated approach is required.

At the other end of the shipbuilding cycle, the repetitive handling operations are being increasingly automated and integrated with the productive operation. For example, the treatment line, with conveyors, shot-blast etc., form a coherent system.

## 6. Communications

In its broadest sense, this heading covers many management functions and general dissemination of information. It is the oil to lubricate the shipbuilding machine.

In this important field, the computer has played a significant part to date, and as automation is more extensively applied to the shipbuilding process, will be of increasing importance. The basic problem in shipbuilding is to ensure that information arrives at the right place and time. Because of the complexity of ships, the number of people involved and the physical size of the facility, the problem is a difficult one. As more costly machinery comes into use, the solution of this communications problem will be crucial.

The larger number of parts involved in the making of a ship, and the many processes, make the computer with its ability to handle large quantities of data, the obvious tool.

Apart from the financial and administrative aspects of the industry, the computer has already been applied to design calculations and stock control. In addition, lines fairing techniques and the preparation of numerical control techniques to plate cutting have eliminated the mould loft, whether working on full scale or tenth scale.

The techniques described will be developed, but in the 1980s the significant development will be in eliminating bottlenecks in producing drawings. To produce the drawings required showing details of small areas, construction details for units, and erection sketches including elements of outfitting by traditional drawing office techniques, will impose a heavy workload and be increasingly expensive. By the 1980s the draughtsman will have exchanged his pencil and paper for a light pen and an interactive graphical display. Drawings will be produced using the computer via a microplotter. Draughtsmen will still be the essential link in the information flow, but they will be using more sophisticated tools to give them information more accurately and quickly.

The information flow and software systems are as important as the hardware in a shipyard and this will apply increasingly, as shipbuilding moves into the 1980s.

## 7. General conclusions

Ships will continue to be the means of transporting the bulk of world trade which will continue to expand. Specialization in ship types and shipyards for the construction of series designs will continue. Shipbuilding in developing nations will be expected to expand but the balance between the numbers employed and the capital invested will, for obvious reasons, be significantly different from that in Japan and Europe.

Japan will still dominate the shipbuilding world and unless the Government evolves policies designed to reverse the present trend, the U.K. tonnage output will decline as a percentage of world requirement.



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