PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

The Designer's Response from the Owner's Side

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The designer's response from the owner's side

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(*a*) Technological limitations are unlikely to restrict marine developments.
(*b*) Shipowner's technical staffs will promote progress and will watch closely proposed legislation affecting design and operation.
(*c*) The dialogue with legislating authorities must be on a proper technological basis with the financial consequences fully appreciated.
(*d*) Much existing legislation could well be revised, e.g. load lines.
(*e*) Future research might include:

The sea	wave spectra and ship motions.
The ship	materials, corrosion and navigation.
Environment	dredging, undersea studies, port development.
Economic	insurance, cost benefits of new transport systems.

(*f*) Against the increasing cost of new transport systems, policy decisions will require careful evaluation, and the relationships with legislatory bodies will need attention to avoid unfair restrictions.

1. Introduction

Let it be admitted that to predict the course of ship technology in the 1980s with any certainty is too difficult for a shipowner designer, if the pace of technological development in the 1960s and 1970s is any guide. It was advance in technology that allowed the increase in tanker size to pass from 100000 tons deadweight in the 1960s to over 200000 tons in 1970; but it was also lack of technological knowledge that led to certain quite important findings on structural weakness; and failings in operational abilities that led to some noteworthy disasters. In 1960 the average intercontinental container ship carried *ca.* 400 6 m (20ft) containers, but in 1970 ships built for such trades carried up to 1500 6 m (20ft) containers. Ships are now entering service carrying over 2000 containers. Here technology met the demand set by commercial requirements, although pressing to the limits of knowledge at the time. In 1960 the *Methane Pioneer* had just entered service, the first important liquid natural gas carrier, but in 1970 there were eleven in service with several very much larger designs in the offing costing up to £30 M each, the development of which involves new kinds of technical expertise. Clearly any extrapolation into the 1980s from such a background must be fraught with assumption, but some lessons seem clear: the demands of trade can be harsh on our technological resources; international competition for economic transportation ensures a continuing spur to these demands; but in the main ship technology has been able to keep pace with such demand.

Indeed it may be for consideration whether technology is at all a major stumbling block in the development of shipping or whether other less concrete factors are more significant. However, there must continue to be as close a match as possible between commercial requirements and the technological means to achieve them. This is where the designer who has access to the inner thinking of the commercial world has an advantage and can even influence development; but at the same time, he becomes sensitive to the increasing number of regulatory factors that tend to limit what would otherwise be more progressive technological development.

2. Sources of constraints

Designers and operators have never been without factors that limit preferred activity. From the very multiplicity of contacts that must be consulted, obeyed or cajoled, there is bred a versatility of approach and outlook. It may be helpful to note for example the number of bodies with which a shipowners' technical staffs become directly involved (see figure 1).

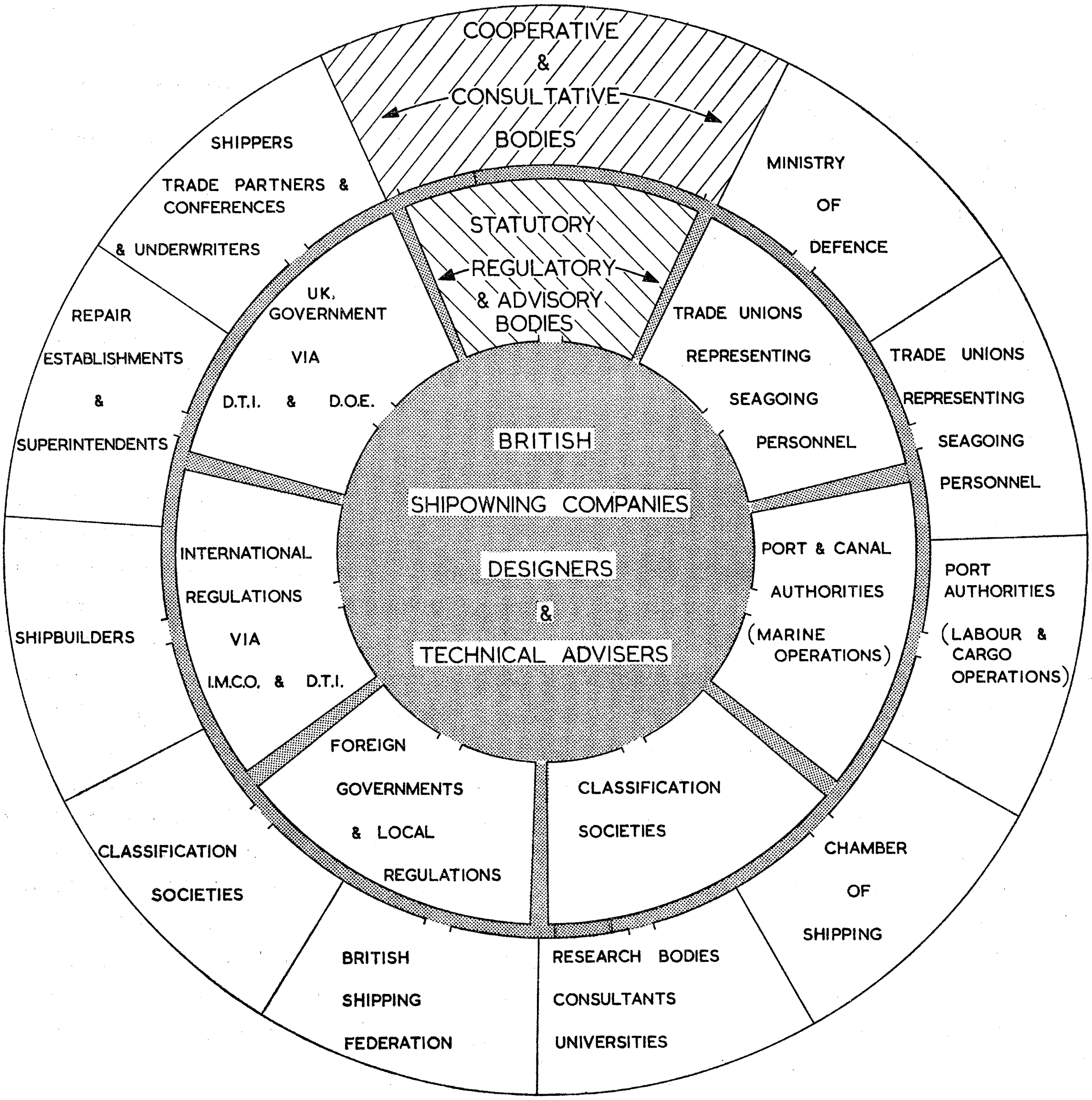

Figure 1

Whereas limitations have in the past been mainly physical or technical and reasonably easily comprehended (e.g. port imposed limitations on draught, or structurally imposed limitations on highly stressed hull members) there are now the more esoteric constraints of environmental considerations e.g. reduction in pollution and noise, or sociological considerations such as adequate technical qualification of operators or adequate facilities for seagoing personnel.

It is, therefore, necessary that all such limitations must be defined in such a way that the designer can with confidence take necessary decisions in the full realization that virtually

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irrevocable projects have to be committed involving quite vast sums of money. It will be obvious that when ships cost £30 M each even in the 1970s, there are going to be, in the 1980s some basic decisions required which, if unjustly influenced by ill-conceived regulations, could irretrievably alter an operator's economic prospects. We have seen in 1972 the impact of international requirements regarding the limiting size of cargo compartments in tankers for the supposed reduction of pollution after damage whereby ship cost is increased by 3 to 5%. How much greater might be the effect in the 1980s of similarly applied legislation to ships which being larger may be of even greater interest to the legislator.

It is the removal, if possible, of doubt or uncertainty that will be needed when the enormous sums of money likely to be involved are envisaged. As an example of the simple physical aspect, much conventional ship design and operation in the past was based on the availability of the Suez Canal, i.e. length of voyage, bunkering policies, draught and ship dimensions. When the use of Suez was denied to operators, with an unclear picture of any future opening, a leading shipowner quite justifiably announced that his company could live with the Canal open; it could likewise adjust and learn to live with the Canal closed; but what was very difficult was to live in the situation where it was not known if the Canal would be open or closed.

Or consider the Panama Canal, whose locks already are restrictive to the design of large ships. (The present generation of large round-the-world container ships are in fact governed, solely and most uneconomically, by the lock dimensions.) Will there in the 1980s be any chance that a new canal will be proposed or even started? Or could there be a period of debilitating uncertainty caused either by economics or politics, that would leave shipowners guessing as to the availability of a new and larger canal system and so perhaps distort the rational progress of marine transportation. It is much less easy to make the detour round Cape Horn than it has been round the Cape of Good Hope.

There is also the difficulty that the introduction of certain new legislation might tend to be retrospective and this can be to the disadvantage of operators committed to new projects. Shipowners would at least ask that regulations for new ships should, as regards timing, be applied on a world-wide basis and so prevent more conscientious governments acting in advance of those less responsible.

So that there is here as a basic premise, the suggestion that any constraint will have to be evaluated if such progress is to be expected and it ought, therefore, to be reasonably capable of evaluation.

3. Shipowner approach to technology

Does a shipowner need to be interested in technology? Does he need to have his own designers or does he need a technical staff at all? Some shipowners get by apparently successfully with a near negative reply to such questions. But can it be right that capital assets of such value and complexity as are found in a shipowning company, entrusted to the elements for their livelihood, should be expected to yield a return without being intelligently tended?

And where does the impetus for development come from? The writer suggests it is from the same source today as it was over 100 years ago when such men as Alfred Holt harmonized commercial acumen with technical curiosity. So today, although few commercial minds can be expected to embrace much of today's technology, at least there can be an understanding approach that finds its evidence in the presence of technologically minded and technically trained personnel in the employ of forward thinking shipowners.

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It can be quite possible to make an adequate living by keeping a step behind the leaders. By learning from the observation of others, by being content to eschew the role of pioneers, by obtaining ships from shipyards which have built the pioneer's vessels, a comparatively safe and profitable path may be trodden, and indeed it has been said (Hearth 1970) that it is usually more rewarding to concentrate on the mastery of the minor technological advances rather than to pioneer. Even maritime nations, let alone companies, can show such tendencies. Nevertheless there will always be some brave spirits in the shipping world who will encourage a designer team in the belief that by blending the expertise of technologically minded persons, they will ensure that the worlds advancing economic demands are met by equally advanced solutions (Alexander 1970). It is then such shipowners and designers who will tend and indeed, can be expected, to query and to evaluate the various constraints that become imposed on operation and design, and against these to exploit developments in technology as they become apparent. It is doubtful whether the container ship would have had such an early development if only the shipbuilders' initiative was relied on; or the Lash type ship, or the liquid natural gas (l.n.g.) carrier. It appears to be the variation in the demands on and in the duties of marine vehicles that constitutes the significant difference with other land or airborne vehicles. In those the uniform nature of freight, whether passengers or regularized cargo, makes it possible for the manufacturer to take most of the responsibility for design, development and technological evaluation. Nevertheless there must be an amicable liaison between the appropriate technical staffs of shipowner and shipbuilder, as indeed with the other bodies shown in figure 1 to yield sensible and economic fruits from technological development.

Neither will the shipowner readily let others speak for his interests in the international council halls of those who seek to advise him on safety, on pollution or relations generally. He will again want the right technically-oriented minds to be exercised on his behalf with a proper comprehension of his economic livelihood, and he will expect to establish intelligent and responsive rapport with the legislator.

In the technological 1980s it will be more important than ever that equally qualified minds meet at international level, particularly because of the growing importance of regulatory bodies such as I.M.C.O. Those who have seen the complexities of the technical arguments carried on under the aegis of that organization will appreciate the need, and also the importance of the national bodies who interpret and implement international requirements, being in sympathy with the shipowner's outlook. The same argument applies right down through all grades of surveying staff because at the practical day-to-day level it cannot give satisfaction to any surveyor to know that he may, in the ultimate, be helping to put his country's shipowners out of business or to reduce the level of activity and employment in his own home port. And yet such can be the end result of an understandable pride in the exercise of technological expertise, applied in an unwise or overzealous way. Hence the need for a close, friendly and productive interchange of views between shipowners' technical advisers and the statutory and classification bodies.

It may be suggested again (Geddes 1971) that cost effective considerations should in future be applied with even more point, to the increasing mass of impending legislation that is likely to descend on the shipowner. In the same way that the designer must be prepared to justify his decisions on the dimensions of his ship or the materials in terms of cost benefit to the owner, so should the legislator be prepared at least to attempt to qualify his arguments financially.

Against this background, it is suggested that shipowners will still further close their ranks in future, with national associations being even better supported by technical teams speaking with a united voice, and who are all the while deeply conscious of the immense value of the transportation systems they are dealing with. It is worth remembering that the value of the U.K. merchant fleet is many times greater than the value of B.O.A.C. and B.E.A. fleets combined, and in addition there is the value of the merchant marine to the nation's trade. A single large tanker or container ship is more than the equivalent in terms of money of the Forth and Severn bridges combined.

And lastly there will be a greater appreciation by shipowners of the value of technical research and development in the next decade. By that time it may be somewhat clearer who should fund and undertake research as between shipbuilder and shipowner or operator, an area of activity that is somewhat blurred at the moment. Perhaps, however, it will continue to be at least in part a joint exercise because no ship, however novel in concept, is likely to be type-tested as say Concorde is, before being sold in quantity.

Service experience with the operator may, therefore, still need to be coincident with further development by the manufacturer.

Altogether, the response of the shipowners' designers will tend to be more a corporate one in the face of such regulatory factors as can be seen or sensed at present. Although there will be this greater alinement of thought between the technical people in the different maritime nations, there must always be prevented a kind of technically promoted emulation that may emerge – a trend to produce needlessly complex arguments either in favour of change in regulations or against it.

A consideration of some factors bearing on the shipowner and designer, together with his possible response now follow under the headings, technical, economic, sociological and environmental.

4. Some technical considerations

Other papers at this meeting will cover in much more detail the technical implications affecting both ships and shipbuilding, but the shipowner probably thinks of technicalities more often from the operational point of view. Of course, all the other problems, whether sociological environmental or economic almost invariably end up by requiring technical solutions.

Clearly there is no inherent mystique in ship technology. Almost any country in the world is able now to build adequate ships and operate them, and few countries would feel it necessary to bring in foreign nationals either to build, except maybe initially, or to sail their ships in the way that some countries do for aircraft operation. Nevertheless the development of technology is not easy because of the cost and the fact that only certain leading Maritime countries can be expected to take a lead in it. There never has been the finance available for technical development that there has been for aircraft. As mentioned earlier there has not so far been a prototype merchant ship, fully tested both in the building and in operation before it is sold in quantity. It must be admitted, however, that recently a large Japanese container ship made a dummy trans-Pacific voyage before entering European service, and a Japanese ethylene tanker has been built as an experimental vessel before building large-sized l.n.g. ships. Ships are becoming more expensive (an l.n.g. ship in the 100000 m^3 capacity range is roughly equivalent to two very large crude oil carriers – v.l.c.c.), so there is even less likelihood of the full prototype approach. This must lead to more extensive laboratory and model testing, together with a continuing dependence on the actual ship as the laboratory or test bed, making the separation of design and development as between manufacturer and user less feasible.

(a) *Size and speed*

These are the two parameters that from time immemorial have fascinated designers, and both have direct effects on the cost, but not necessarily on the economics of ships. It takes no great knowledge to be aware that the recent increases in both size and speed have been dramatic. Taylor (1972) suggests that in marine as in air transport size is more important than speed, and we have seen this to be true in the main types of ship, although perhaps only when the cost of the hull is relatively modest in relation to the machinery and where the value of the cargo is not high. In the only type of ship where this has not been so in recent years, namely the cargo liner, speeds crept up continually, perhaps with only a dim comprehension of the reason why this was happening. But for the modern l.n.g. ships where the cost of the hull is twice as high in relation to the machinery as in a v.l.c.c., it is suggested we may see speeds rising again. However, although high speeds can be achieved relatively easily with more powerful machinery, we are apparently still in danger of producing in our present state of knowledge, propeller-induced vibration troubles. There will almost certainly be, in the 1980s, some reasonably documented and internationally agreed guidance on acceptable limits of vibration discomfort – and also probably on noise levels both from vibration and other sources.

As for size, the main problems may tend to be structural, to be solved more readily by the shipbuilder, but it is believed that, in general, theory and experimentation will keep pace with commercial practice. Conn (1970) highlights many of the fields of structural design that remain to be examined and for very large ships it must be asked whether present theory is adequate. When ships become virtually floating islands of great depth, can they be treated with conventional wave bending theory any longer? And do we fully understand the buckling of plates in the light of all that has happened, for example, on bridges on land; and what about thermal stress on ships? But since this paper is intended to refer particularly to legislative aspects of the future, the writer would suggest that some of the basic tenets will need re-examining by the 1980s. For example, presently agreed international regulations demand that a ship be limited in draught at certain times of year and in certain arbitrarily chosen areas of the oceans. The reasons are greater safety, strength, freeboard and stability after damage in the supposedly more adverse weather in these areas.

But internationally agreed regulations on the required range of stability, both static and dynamic, take adequate care of any stability deficiencies. The safety of hatches and deck openings can nowadays be assured with adequate closing devices. And as regards strength, ships are about to be designed using statistical and probability theories, incorporating a knowledge of sea states, and for example, fatigue life of highly stressed structural details measured in terms of years of life and stress reversals. If then a large tanker, say, is to have successful life of x reversals in y years, what can be the relevance of the arbitrary reduction of say 56 cm in a draught of 22.5 m for example, at certain times of year. There are obvious consequences. A very small extra draught in a very large tanker will, by altering the carrying capacity by as much as 10000 tons, stand to alter the economics of the system. Again as regards freeboard and any possible increase in safety ensuing from the reduction of 'winter' draughts, does it make sense that a 290 m container ship designed by probability theory and with a freeboard of 13 m or more must obtain the additional freeboard of 33 cm at certain times of year? Truly, international bodies have here scope for their talents.

For the ship operator, increasing beam will be no problem so long as Panama or other physical limit need not be reckoned with, and likewise with length as long as the cost benefits are apparent. But draught is more and more a problem, particularly as its increase is such a convenient way of improving a ship's profitability, and yet we are approaching or have reached the limit of navigational depths in most of the world's ports and waterways. By the 1980s these limits will have been pushed to extremes and no doubt there will be by then, agreement on acceptable margins of navigational acceptability e.g. safe depth of water under keel or maximum speed related to size and depth of water under keel. There may well have to be new attacks on the dredging of critical channels.

The I.M.C.O. requirements for increased subdivision of tankers introduced to minimize the consequences of accidental rupture and spillage are fresh in our minds, but this may not be the end of such matters. Far be it for a shipowner who has seen the cost of ships increase by 3 to 5 % thereby, to suggest that further imposts of this type might be proposed, but it is clearly going to be necessary for I.M.C.O. to accept closely argued challenges in future to the theory behind any legislation relating, for example, to damage and flooding, where the basic premises are at the moment rather empirical.

And lastly there is always the vexed subject of a sensible system of tonnage measurement where shipowners, while desirous of seeing developed an equitable system, will be vigilant in their own interests as to any proposals. On this subject as on others, it is regrettably possible to find individual Governments interpreting international agreements in a manner less severe than is found in other countries.

(*b*) *The sea itself*

It is often said that the ship's problems stem largely from its having to work at the interface of two fluids, the sea and the atmosphere, affected by all their action and interactions. Other means of transport do not suffer from such acute interface effects, being either mainly landborne or mainly airborne. Yet how little is known about the sea and the ship's response to it. How big are waves, or how big can they be, and how often can a ship encounter wave systems of known energy content on any particular trade route? Where do we find an explanation of the behaviour of a ship in any given wave system and do we know which of the ship's parameters are the significant ones in helping a ship to behave best in relation to speed, course keeping, comfort and safety? We have a long way to go, probably into the 1980s, before we know enough to speak intelligently on such subjects. Meantime there is a danger that we shall have rules imposed upon us regarding safety margins, whether governing freeboard and possible flooding, or ship motions and cargo securing, or wave loading on the hull and basic strength, before the appropriate knowledge is acquired and correct theory developed.

Then there is the undersea habitat. The idea of the cargo submarine has been probed a little and laid aside for the moment, but it may yet have a place in marine transportation. Indeed is not the v.l.c.c. reaching the stage of being a semi-submersible to which conventional theories may no longer fully apply? When does a ship cease to be a 'surface' vessel, if we are now speaking of ships of perhaps 26.5 m draught which can by no means be said to 'ride' any normal waves. In which case do all our traditional concepts of freeboard and flooding not require a new approach, as well as the basic principles of navigation and manoeuvring?

(*c*) *The materials*

It continues to look as if steel is to hold its own in ship construction. Aluminium or other lighter materials do not at present seem likely to displace it even in the 1980s, particularly as new steels are still being developed the better to resist brittle fracture and to provide higher strength and ductility at a reasonable price. Still other steels are being developed with new alloying elements to refine the grain structure and so provide better fatigue life, and as the importance of the l.n.g. ship looms up we see the interest in cryogenic materials such as nickel steels in an endeavour to reduce the enormous cost of such ships.

It is in the other subsidiary materials that changes may occur by the 1980s, e.g. fire resistant materials both for protection of load bearing members and fire partitions, as well as for decorative items in accommodation. Clearly this is a subject that attracts much interest, but it must be studied against cost effectiveness and also on the relatively new concept of probability of accident. We should see improvements in methods of making materials more fire resistant. Then there are the cold insulation materials including perlite and balsa wood that can be used in such quantities in l.n.g. or l.p.g. carriers, not forgetting the humbler timbers and plywoods. May the legislators use diligence in the cost effective approach in their deliberations on materials as they try to make them safer or stronger or more hygenic.

And lastly, paint and the underwater areas. Noah's ark was pitched within and without and his ship was at least in partly fresh water. Conservation of the structure in marine surroundings has been a continuing exercise ever since. Is there to be help for ship operators in determining corrosion margins scientifically, or in producing protection systems that will reduce the tremendous bill at present involved in combating corrosion in a marine environment? It is open for suggestion that a v.l.c.c.'s cargo tank structure should from now on be more carefully designed, if not to prevent or reduce corrosion, then at least to make it possible to carry out the necessary internal surveys of the very large areas in an economic manner. It would almost appear today that the system of surveying the large areas of steelwork inside such tanks to satisfy classification or statutory requirements has hardly been thought out. Should we not be seeing a simple built-in system of access to such tanks, or a better hatch opening system with some mechanically extending-arm device capable of being inserted through it into the tanks.

Regarding the external aspects, might it be suggested that the drydocking of very large ships will become something of an expensive and slightly hazardous luxury. If regulations are to require examination of underwater surfaces at regular intervals or if owners wish to reassure themselves on bottom conditions, there could well be an increase in the activities that can be carried out by underwater divers, whether in examining or in actual repair work, and so the avoidance of the high expense both of deviating to a drydock and of hiring it. Perhaps we shall then look at present day conventional large dry docks much as we now look at the old slipways onto which the smaller ships of the day were hauled.

(*d*) *Navigation*

When in deep water the ship of the 1980s will almost certainly navigate by artificial satellite and by computer, as some already do today, or by inertial navigation such as only military vessels use at present. But in restricted waterways there will still be found the greater problems, especially with increasing size of ship. The service speed hardly matters in this context, since actual speeds will be low at such times – but it should not be forgotten, that the profitability of a fast ship of 25–30 knots (12–15 m/s) suffers unduly for every hour at which it has to run at reduced speed. Hence there will be a continual urge to maintain speed on such ships for as long as possible – with concomitant risks. At the other end of the speed scale it is not infrequently that a tanker unloading jetty or dolphin is knocked about by a v.l.c.c. as it ties up, because the momentum of a 250000 tons deadweight v.l.c.c. approaching a jetty at 1 knot (0.5 m/s) is the same as for a large cargo liner approaching at a rather crazy full speed of 15 knots (8 m/s). Hence even at the lowest speeds there is the need for care and navigational skill.

Regrettably statistics show that the incidence of casualities due to faulty navigation, although infrequent, is generally increasing. At the same time the nature of the cargoes being carried is becoming more hazardous. Clearly there is likely to be much interest on the part of legislators in the subject.

Nevertheless British flag ships with such characteristics have a record to be proud of, and it might well be argued that what they can do other nationalities ought to be able to do also, lest there be a slide towards acceptance of some lower standard of navigational capability.

However, in the more scientific 1980s there will clearly be technical assistance with which to meet the possible imposition of fresh regulation. Paffett (1971) gives a useful summary of the needs: to acquire the right information; to take the right decision; and to perform the right manoeuvre. In each of these there is wide scope for technological development, whether in electronic devices for detecting obstacles and integrated navigation systems with ergonomically designed bridge control rooms; or the acceptance of traffic separation schemes and routing systems which of necessity involve some measure of outside control over the ships (a sensitive point indeed); or in improving the manoeuvrability of ships by better rudder and propeller design and the use of new propulsive devices. Few would deny that compared with movement in the air (where it must be immediately conceded that the vexed subject of 'control' is complete – or is supposed to be) the degree of freedom left to a ship's Master is high and the general level of technical expertise is rather low. We still have fog sound signals of at least 1.6 km range in estuaries in the middle of large conurbations, that have the habit of sounding in the night hours when it is illegal to sound a mere motor car horn, and possibly when no ships whatsoever are moving anyway. Yet having said all, we come back to the conclusion that it is the men that count most – in spite of the most complex technical assistance we can give them, their abilities, training and discipline. Meanwhile, the writer supports the view that technology in navigational matters might be directed firstly towards helping to reduce human error.

(*e*) *Safety of life at sea*

Fire is a rather sensitive subject considering that the element is as old as time itself, but understandably so when casualties due to fire are analysed. In one U.K. Company with a fleet of 70 ships, fire easily features most often in the lists with as many as 190 in a 20 year period, of which 24 were serious. And as this is written the *Queen Elizabeth* burns to her doom in Hong Kong harbour. It is scarcely surprising that international deliberations have been from time to time preoccupied by the consideration of fire protection in ships, but here again a rigorous examination of the probability of fire occurring in any particular area must be balanced against the demands of legislation. As regards such international agreement on fire, or other subjects, it would be helpful if the designer could have some sort of assurance on the timing and indeed on the likelihood of ratification by his own country's legislature of any particular regulation. It is unhappy to have to spend quite large sums as has recently been done, on the introduction of structural fire safety features in rather elderly passenger ships on the basis that they were no more than 'recommendations' pending the passing of formal legislation. If legislation is not to be mandatory, a recommendation should only be made where the benefit is clear and logical.

Life saving gear regulations represent another aspect that some designers would say needs examining in the long term. It is clear that many people doubt the value of lifeboats as against inflatable liferafts, particularly on the smaller ships such as oil rig supply vessels, where present regulations are too rigorous and where indeed it is believed that the requirement for lifeboats is undesirable altogether because of the harsh nature of the service. There must, therefore, be a continuing interchange of opinion between the law maker and the practitioner with a reasonably flexible attitude towards new marine developments.

5. Economic approach

Other speakers have referred to the broader application of economic principles, but it is salutory to remind ourselves that it is only quite recently that ship operators have brought themselves to discuss openly their comparisons of costs and expenditures (see, for example, Mactier 1968). It is not without significance that the really rapid developments in the present marine revolution appear to have begun about the same period.

If one looks at the technical side alone, the designer has had to alter some of his basic ideas. Already the familiar concept of 'full and down' being the profitable way to sail a dry cargo ship is disproved. It becomes clear that a ship designer may appear to waste valuable space in a particular design, but it may provide a far more economic proposition in that the cargo is more easily stowed, whether break bulk, containers or roll-on roll-off, with the overall profitability ensured by the faster turn-round and greater utilization of the vehicle. And a larger ship of higher cost but at reduced draught may indeed be preferable regarding pay load or freight costs to a smaller ship sailing down to her marks.

It will always be beneficial to review the main items of expenditure and of income and concentrate on the significant ones. For too long, for example, many shipowners have endeavoured to satisfy sundry smaller shippers in uneconomic ports in the belief that their custom was necessary, when it would have been better to omit such ports and leave the cargo to operators running a cheaper type of ship; or alternatively, to secure a better freight rate which is fairly easily proven as the surest way of increasing profitability.

Nowadays, the designer who after all provides the link between the economic environment and the practice of economic calculations, is becoming accustomed to evaluate for himself the merit of adopting any particular design or installation with such helpful guidance as that of Goss (1968) and Buxton (1971). Alongside this the importance of reliability must be realized, together with the overriding need to reduce capital outlay, and a truth stated by Thwaites (1959) then comes to mind, that the achievement of the ultimate in technical perfection is seldom economic – only nowadays we must reasonably expect to prove it fairly quickly in figures. For example, for very large ships providing hopefully large returns, it is not difficult to show what a day's running will earn – or what a day lost by avoidable delay will lose, and this can be balanced against the cost of drydocking or of taking a ship out of service for repair. It then becomes apparent that the whole concept of conventional drydocking and repair by a piecemeal approach may need altering. Ships may not quite become disposable, but if a large tanker suffers corrosion underdeck and requires replacement of material, it may well be for consideration whether the pre-fabrication of a whole deck area before the ship reaches the repair port, with immediate cutting out and replacement of very large panels on arrival, might be preferable to retaining a valuable ship in port for the few days longer that would be required by more conventional repair procedures.

One concern in these days and which may be examined by the 1980s, is the very large proportion of total disbursements represented by the insuring of the ship itself. It hardly seems right that such a large outlay should be almost beyond the power of the designer to control or the operator to influence. It is no real comparison to suggest that the rate is similar to that imposed on modern aircraft, since these are standard machines of but few types, and with generally standardized safety equipment operating in largely controlled conditions. Human error is likely to be the main cause of accident. In ships, there are very big differences between ships, between owner's choice of equipment and in the way they are navigated and operated. Hence in addition to ever present human error there are the differences in the ships' capability of operating successfully.

Since the writer has a background of self insured ships, it may be that he is influenced by this, and he would admit that it is quite difficult for an owner to gauge the capital investment in safety items that is justified by the financial saving due to self-insurance. But the fact remains that for ships insured on the market, the value of the ship is the major parameter in calculating premiums. Therefore, if an owner expends more on safety features than his competitor does he will at present merely be increasing his premium instead of reducing it.

Is there no way of producing a more selective approach, particularly for a new class of risk? Is it right for example that a container ship that is built to a two-compartment standard of subdivision should be regarded as a similar risk to one that will sink if more than one compartment is flooded, remembering that the legislators have not decreed that such ships should merit any particular consideration on these lines. Or is it right that an owner who is prepared to invest in an additional degree of fire fighting capability on a new type of ship should have only the same consideration as an operator who cuts down to the bare minimum. If safety regulations cannot keep up-to-date with new ship types and their risks, the conscientious owner will be at a continuing disadvantage unless underwriters are prepared to bring such features, and many others, such as navigational aspects, into their valuations.

It may be in the efficient operation of the ship, whether in navigating or in tending the machinery that the quickest way of influencing insurance costs may lie. It is well said that the best insurance is a loyal, responsible, reliable and efficient body of men whether operating on board or servicing on shore.

Space does not allow further expansion on the constraints of government economic action, or on the economic effect of international regulations. Suffice to remind ourselves that ships are seldom now individual units. They more usually form the links in transportation systems whether of oil, containers, or liquid natural gas, into which ship's design and cost must be married and so form only a part of the overall economic calculation.

6. Sociological aspects

The designer can never retreat wholly into pure technicalities. Again referring to figure 1, there are people to be considered at every step, whose services, needs and failings rightly claim consideration.

No matter how carefully a ship is designed, it will not be possible to prevent someone at some stage doing something that will imperil the structure. The time has gone when a ship could be loaded with almost infinite choice as to which cargo compartments were full and which empty. To produce efficient design and economic use of material, it is necessary to stipulate how the ship should be loaded with its cargo, until we reach the present state where almost any modern large ship can readily be permanently damaged by malpractice. Hence the need for intelligent operation based on clear instructions. Likewise with the sea loading, where in the modern large ship it is becoming increasingly difficult for the officer of the watch, standing in a warm bridge control room, to gauge the state of the sea and know what is happening at the forward extremity of his ship in heavy weather. For the faster ships, particularly, it is quite easy to maintain such a speed and course that damage is sustained without the officer of the watch knowing it.

Enough has been said in recent times, following some well publicized incidents, on the dangers of faulty navigation. And no ship operator could deny that errors of judgement occur due to lack of experience or fatigue or other explicable cause even without including carelessness. In port the incidental damage inflicted by the unskilful handling of cargo, or by impatient handling of cargo into or out of badly designed cargo spaces, can be expensive. Even in the maintenance of the ships or port installations, there can be unnecessary and expensive errors due to uncoordinated activities, or to equipment of such poor design initially, that undue labour and effort is needed to rectify them. What can the designer do? I believe he must live close to the practicalities of the service; secure adequate feedback from the seagoing personnel or from the shore maintenance departments; be aware of modern practices and materials; allow for and anticipate the errors of the operator ashore or afloat; and remember the cost effective aspect of all works committed. Anything he can do to assist the work of the ship's crew must be studied.

So one reverts to the consideration of the control areas. Mariners are allowed to be remarkably individual in their views on bridge layout compared with the aircraft crew or the landborne vehicle operator. A day must surely be coming when there will be greater uniformity of thought on ergonomics as it affects the mariner – probably it will be international in character, and at the same time it must be remembered that not only are the control systems and the communication methods becoming more complex, but there are changes in the systems of manning ships: smaller crews, new grades of seafarers and new crew systems, new responsibilities on board and changing ideas on job satisfaction.

It is not only the working areas on board that need the designer's specific attention. The problem of living away from wives and families, the need for adequate ventilation and air-conditioning and sound-proofing, the determination of space, neither too little nor too wasteful, some sense of decor and aesthetics that will satisfy at least a majority of those who will inhabit the areas, all demand attention. The writer's company has devoted no little money to the achievement of a high standard of accommodation, but he would like to be assured more definitely that it matters to or is appreciated by the crew. Or is it the case that men having decided to go to sea will always, to some extent, be prepared to endure something less than first class hotel standards. If so perhaps it is as well since in the same large company nowadays it is quite possible to have very high class accommodation in large container ships, but at the other end of the fleet we may find a group of oil rig supply ships where the crew have to endure vastly greater discomfort in a harsh service with nothing like such comfortable accommodation.

Then some of the legislation regarding accommodation is getting outdated. Is it really necessary, nowadays, for a ship's crew to have natural light and air to toilet spaces when any modern hotel (and officers' spaces on some ships) already have wholly inboard toilet spaces? Is it still necessary to make a vow to the authorities that the air conditioning will be running and the outside doors closed in alleged mosquito areas before useless mosquito screen doors can be omitted? Sometimes there would seem to be merit just in revising and updating the existing rules.

7. Environmental limitations

This section deals only with the technical approach to environmental aspects. The subject is otherwise too large and too poignant at this moment. Suffice to say that from the shipowners' side there is no less concern for our common heritage than from any other, and it is firmly believed that reason and mutual understanding will prevail.

(a) *Physical limits*

The most obvious environmental limitations on ship design are the physical ones affecting the dimensions or configuration of the ships. Apart from the man-made limits of canals, locks, bridges and underwater sewers or other obstructions, and accepting that length may be limited by manoeuvrability in certain estuaries, there is no indication that the size of ships will reach some recognizable maximum. It is draught alone that is now more universally limiting and is tending to control design, for example, the critical passages in the North Sea, Strait of Dover and Malacca Straits. The next average size of v.l.c.c. is generally accepted as about 310–330000 tons dwt with an arrival-in-port draught of 23.6 m, which is the recognized maximum to suit Europort. It will not be easy finding ports if draughts are to increase further, as they will, and we may yet see as Taylor (1972) suggests, new routes being developed and maybe the west coast United Kingdom deep water ports coming more into their own.

(b) *Safety*

A curious reversal has taken place. For millenia the designer's aim was to protect the ship's cargo from the elements. Within very recent years we have seen the change to preserving the ship's environment from its cargo. So it must be in our complicated industrial way of life with new kinds of dangerous cargo demanding carriage almost daily. The 'blue book' (1966) is surely one of the most common, voluminous and detailed handbooks to be found in general use throughout the whole range of marine activities and needing continual updating. Even so, some shipping companies still require their own particular handbook for additional guidance to their ship operators.

Balanced opinion must be exercised nevertheless on this vexed subject. If someone, today, were to suggest that a toxic and explosive gas should be manufactured in the middle of every town in this country and thence led under the streets to hundreds of thousands of outlets for casual use by any member of the public however incompetent, would there not be an outcry about the dangers? But is not this what we have been doing with town gas for 150 years?

Is it not then a case of (*a*) recognizing the dangers with any particular cargo, (*b*) planning and designing the correct technological equipment, (*c*) training and disciplining the individuals involved, and most importantly (*d*) contingency planning in the event of accident. Perhaps it is in the last that we have been weakest, maybe because of the relatively few accidents so far. Undoubtedly, the problem will become more acute. Typically, the advent of the liquid natural gas carrier is upon us, with the outward hazard of collision and fire, and the inward danger of rupture of the tanks or membranes and subsequent risk to the structural steel at −160 °C temperature. But with each development there is corresponding technical skill. Taylor (1972) reminds us that technical limits have not restricted the marine revolution, and it would almost seem, and perhaps it should not be surprising, that they go hand in hand.

(c) *Pollution*

The designer is as anxious as anyone else to preserve our environment in a hygienic and enjoyable condition. He is rather mystified as he instals a biologically activated sewage treatment system in his ship to obviate raw discharge into the sea and then finds his ship tied up within a stone's throw of an open city sewer discharging one thousand times more objectionably to the sea – perhaps a minor example of how the present day concept of 'system' might surely mean a systematic and consistent application of thought to the various considerations on environment.

Pollution may be either a result of thoughtless original design and concept, or of accident. The former may be exemplified by the one-time practice of cargo tank cleaning in tankers with discharge overboard, the subsequent improvement by such developments as the load-on-top principle being mainly British-promoted. Undoubtedly, new concepts will be scrutinized more closely in their design stages but there can be no denying that the end result in every case will be increased cost to the shipowner and so to the ultimate user. Even present endeavour to fulfil the D.T.I. 'M' notice (1970) on avoidance of discharge of oily water in ports and harbours from existing ships already reflects additional cost in finding road tankers to remove slops and oily bilge, not to speak of ensuing delay in the start of repair operations, for example, until such liquids can be removed. Accidental pollution can only be treated with the same logic as expressed in the preceding paragraph regarding safety.

As shipowners enter the next few years they are naturally prepared for much more intense interest in such subjects. The dialogue with the legislators and the authorities will be conducted with understanding and with all the help needed from technical advisers, but in the expectation that there will be reciprocal appreciation of the inevitable financial consequences.

(d) *Aesthetics*

A plea for the intangible and oft slighted consideration of beauty, or at least of appearance. We have spoken of preserving the beauty of sea and shore, but what of the ships themselves? The writer suggests that 'design' will, even in marine matters, spread to cover the appearance of the article as well as the structure and its operation. A few devoted spirits have campaigned for years to encourage a greater interest in the aesthetics of ships. Now that there is in many quarters a greater interest in the finer qualities of living, is it too much to hope that they may find a little more support, which indeed and for once could be more psychological and moral than financial?

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8. Summing up

(*a*) It is unlikely that technological limitations will restrict marine developments in the 1980s. Any such hindrances are more likely to come from institutional or ideological sources.

(*b*) Shipowners' technical staffs will continue to have complex relationships with many other bodies, and these staffs will be required to provide advice increasingly on the intricacies of proposed legislation. The main source of stimulus for further development is likely to come from owners willing to pioneer new systems.

(*c*) Shipowners are prepared for and understand the interest likely to come from authorities regarding many of their activities. A plea is made for a dialogue based on mutual comprehension of the problems, equal utilization of the technological background, and an awareness of the financial consequences because of the large sums involved. In so far as it is the role of government to set the stage for individual enterprise it is hoped that legislation will be correspondingly conducive to progress.

(*d*) There is scope for revision of existing legislation, e.g. regarding load lines, accommodation and tonnage.

(*e*) Some topics for future research and study might be:

(i) The sea — wave spectra, ship motions, mooring.

(ii) The ship — materials, corrosion, navigation in confined waterways, aesthetics, bridge lay-out.

(iii) Environment — dredging, undersea studies, port development, safety studies.

(iv) Economic — insurance, cost benefit studies on new transport systems.

(*f*) Provided adequate finance is available, by the 1980s ship technology will pass from being somewhat middle grade to high grade, as theory becomes updated, factual information and results from experimentation accumulate, and design techniques become more sophisticated. The very large sums involved in owning and operating ships will involve critical policy decisions, and the relationships with legislatory bodies and national authorities will need careful tending.

References

Alexander, J. L. 1970 *British shipping after the Rochdale Report*. Institute of Transport.

'Blue book' 1966 Carriage of dangerous goods in ships 1966. Department of Trade and Industry.

Buxton, I. L. 1971 *Engineering economics and ship design*. British Ship Research Association. Report.

Conn, J. F. C. 1970 Mammoth ships. *Trans. IESS* **113**, 263.

Department of Trade and Industry Merchant Shipping Notice No. M. 589 *Discharge of oil into United Kingdom territorial waters*, September 1970.

Geddes F. I. 1971 *The Naval architect*. July 1971. p. 38.

Goss, R. O. 1968 *Studies in maritime economics*. Cambridge University Press.

Hearth, J. D. M. 1970 *Forecasting the demand for shipping and meeting the demand*, Symposium on Ship Technology in Transition. N.E. Coast Institute of Engineers and Shipbuilders.

Mactier, Sir Stewart 1968 The economics of ship operation. 1st Blackadder Lecture 1967. *Trans. N.E. Coast Inst. of Engineers and Shipbuilders* **83**, 9.

Paffett, J. A. H. 1971 Technology and safe navigation. *Trans. IESS* **115**, 2.

Taylor, R. J. F. 1972 The shipping revolution and trying to learn from it. 40th Andrew Laing Lecture 1971. *Trans. N.E. Coast Inst. of Engineers and Shipbuilders* **88**, 83.

Thwaites, R. M. 1959 The economics of ship time. *Trans. N.E. Coast Inst. of Engineers and Shipbuilders* **75**, 125.