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"RECENT SHIPBUILDING DEVELOPMENTS"

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Whether they are concerned with shipbuilding or equipment, engineers should be fully aware of the fact that the ships they deal with are intended to be used in trading. The technical Departments are called upon to solve problems which are set to them within a group of commercial interests rather than actually set the problems. They are responsible for the improvements in sea transport but do not create them. In this field as in others, it can be easily seen that there are no problems facing technicians to which a solution cannot be found. A particularly striking case is that of super-tankers. Within the course of a few years, Shipyards have been equipped with entirely new means of working, both in the field of research and in that of production, in order to satisfy the demand for tankers ranging between 200,000 and 1,000,000 tdw.

1. GENERAL

1.1 Development of the world merchant fleet

Since the beginning of 1970, the world fleet has exceeded 15,829,000 gross register tons and reached 227,490,000 grt on the 1st July 1970, and the order books in January 1971 total a third of the latter value. The tonnage of ships in service has doubled since 1957; as to order books, they have been multiplied fourfold in less than seven years, starting from 27,000,000 tdw in October 1963 to reach 114,000,000 tdw in October 1970. We wish to insist on these figures as they clearly show the expansion of the merchant fleet over the last ten years and the intensive activity in the area of shipbuilding, whereas the attention of the public in several countries has been drawn to the crises that industry has had to overcome in that period ; shipyards closing down or amalgamating under difficult circumstances, investment and credit problems, ruthless international competition concerning prices, withdrawal of navigation lines showing a deficit, social problems regarding re-employment of the staff, creation of international shipping companies. The cause of the difficulties facing shipbuilders and, to a lesser degree, shipowners may be largely looked for in the expansion of the shipping industry; adjustment to these trying circumstances could only be harsh.

1.2 Specialization and giantism

Shipbuilding is at the disposal of shipowners who, in turn, are dependent upon economic factors governing sea-borne trade. The progress of merchant ships is characterized by two trends: a trend towards giantism and one towards specialization. Actually these trends are tightly inter-independent, the determining one being specialization.

Roughly, the procedure is as follows: when a given trade increases on a given line beyond a certain proportion, a specialised vessel is created, better fitted to the trade and line: size, speed, carrying capacity, handling equipment .... The first ship, or ships, put into service will prove to be more profit-making than the competitors, thence the other owners will have to follow suit.

Should the trade under consideration go on increasing, then the owners will proceed with the "specialized vessel" solution, at the same time increasing the carrying capacity. This goes to explain giantism. Instances of this are easy to find: oil-tankers, bulk-carriers, L PG carriers. Although we still speak of general cargo ships of 15,000 tdw - even in the case of recently ordered ships which are more or less of the same size as those built between the two World Wars - on the contrary, a few years' existence has been enough when it concerns container-ships to start giantism. +

The Owners' answer to demand in sea-transport is therefore the specialized vessel; it is their solution for offering the best services at the lowest costs. By doing so however they are taking a risk, that of seeing the traffic diverted along a different direction from the one expected or else decreasing. Furthermore there are freight crises. In such case, the heavily specialized vessell will lose a huge proportion of its commercial value with respect to a more conventional type of ship which corresponds to a smaller investment and fits more readily to traffic changes. One thus witnesses a resurgence of the ancient fears of shipowners who, whilst having their ships built with a durability of twenty years, reckon that specialized vessel would increase in value if assigned to a trade other than initially intended. In this respect, one must consider that one result of excessive specialization is the success of the bulk-carrier/oil-tanker combination in all its varieties: ore-oil, ore-bulk-oil, oil-coal-ore carriers. Of course things are not so simple and one must also consider these multi-purpose ships as a tentative solution to the return trip on ballast for bulk-carriers.

Refrigerated vessels capable of carrying bananas at +12° C as well as refrigerated cargo at -25° C are the outcome of similar reflections regarding the uncertainties of some refrigerated transports.

What should be kept in mind of all the above, is that specialization which has become vital to shipowners, is not a recent necessity. At all times, when ordering their ships, owners have always kept in mind - as early as the call for tenders - the type of trade for which their ships was intended and fitted them accordingly: hatchways of adequate length to receive steel products, strengthened bottoms or decks for heavy packages, lifting machinery, refrigerated capacities .... +

1.3 Standardization

It is with some amount of fear that most Owners launch into an all-out specialization, but no other choice is open to them; furthermore this solicitude to have ships well fitted to their requirements explains why - in our days of planning and mass-production - we have not reached the point where ships are standardized. Several shipyards aim at offering their customers ships to be picked out of a catalogue, over a wide range of sizes and performance. As a matter of fact, selling standard ships affords an enormous advantage to shipyards as regards preliminary studies, supplies, rationalization of building methods, risks in the field of research and development. It must be admitted this goal has been rarely reached and, very often, imperfectly so, not because shipowners are not aware of the advantages of such a solution, but because they only rarely find what suits their immediate needs. Investment costs are heavy, progress is fast and one cannot run the risk of having ships which will be out-dated within a few years. That is why, generally speaking, the series are quite small - five to ten units. It may be noted that, in the quite particular case of economical "replacement" ships intended to replace Liberty-ships built during World-War II, several large shipyards have attempted to offer standard vessels resulting from elaborate studies both in the technical field and in the field of commercial operation. However, a few hundred orders for such vessels do not seem to have corresponded to the Builders' hopes.

1.4 Specific development

To sum up, one may say that shipbuilding is a field of activity closely dependent upon another field subject to sharp fluctuations. The market expansion noted over the last few years has made shipbuilders aware of the modern means of production now put at their disposal, both for studies and production. Shipbuilders have started using these means, but adaption will not be easy because shipbuilding is and will remain for some time to come, doomed to deal only with ships retaining their own individuality with respect to other ships.

2. TRENDS IN THE DESIGNING OF SOME TYPES OF SHIPS

2.0 Under the heading "non-military ships", can be set not only ships strictly speaking, but also "craft" self-propelled or not, such as drilling platforms, dredgers, submarines.

Consequently, four large categories of ships can be differentiated which correspond to:

- Passenger-ships
- Cargo-ships
- Fishing vessels
- Craft the essential mission of which being not the carriage.

I shall deal withthe first two categories only, so that this lecture shall remain within reasonable limits of time.

2.1 Passenger ships

When passenger-ships are mentioned, it supposes that reference is made to all the difficulties encountered by Naval Architects. The construction of a passenger-ship put any kind of problems, the resolution of which requires more care and contributes to the progress of the world shipbuilding.

The passenger-ships of international lines considered as a means of transport have been in fact losing their prevailing position for a rather long time, in favour of aircraft. Since they are no longer an economical necessity, they ceased being the essential concern of shipowners and shipbuilders.

Attempts are made to prolong the operation of passenger-ships thanks to the development of cruising traffic. For the time being no conclusion can be drawn. It concerns a series of experiments made by Shipping companies of varied countries. Nevertheless it may be noted that the few passenger-ships under construction have been designed having in mind their possible use for cruising traffic: single class, large public rooms are the essential characteristics of them.

As far as hull is concerned, it can be noted that the determination of a sufficient strength of the steel structure to main longitudinal loads does no longer put any problem for passenger-ships. The main difficulties are due to the large increase in superstructures (resistance to racking) and to the determination for these superstructures of a minimal weight: appropriate structural arrangements, the use of high tensile steels, or light alloys for superstructures allow to solve these problems.

On the contrary, there is a great deal to say about car-ferries. Begun some 15 years ago with a small number of ships covering the traditional sea routes between European nations in the form of "ferry-boats" or "mail-boats", the fleet of car-ferries has witnessed a very fast development, first along the well-established sea-routes, then by creating new ones.

The transport of trains has remained at a standstill, whereas mail boats have become "car-ferries", this being a repercussion on the shipping world of the well-known phenomenon of the invasion of motor cars.

In the vast majority of cases, these ships are built for short crossings, from a few hours to a full day. They have a capacity of 100 to 150 private cars and 800 to 1,000 passengers. There is no slowing down in the demand for car ferries, and this ensures a fair amount of work to shipyards specializing in this type of ships. One may however note a trend towards an increase in capacity in view to using these ships on increasingly longer trips. These ships may develop into ocean-going ships, for cruises for instance, including motor-car trips in the countries visited. For a European, going to the United States to spend his holidays with his car does not sound a reasonable perspective, but one is compelled to note that the leisure industry will not shrink from a fresh idea.

What are the main features of building car ferries?

- length between 80 to 125 m (262.5 and 410 ft), the longest reach 140 m (460 ft.).
- rather broad: the length to breadth ratio (L/B) varies between 6.1 and 6.5.
- small draught, although one meets 4 metre (13 ft) + draughts on ships 110 m (360 ft.) in length. In most cases, these draughts are connected to the vertical position of the car deck for reasons concerning the ramp or docking along the quay. Trim conditions too are to be complied with during docking and unloading.

- they are fast ships, with a speed between 18 and 23 knots. The medium-speed (500 rpm) diesel engine is often selected due to the small clearances of the engine room, with or without a variable pitch propeller.

The structure of car ferries put specific problems which join with some of the problems put by conventional passenger-ships (among which it is necessary to mention more particularly the vibration risk most probable due to the reduced draft. It is necessary to mention essentially:

- Calculation of the car deck: the structure should withstand moving loads to be determined.
- The resistance to racking of transverse bulkheads and superstructures: this being the more difficult to obtain as the load decks are to be cleared at sides as far as possible and that, consequently, the web plates of web frames should be as small as possible.
- Structural discontinuities: rear door, movable or fixed ramps, bow door.

Other types of passenger-ships will be dealt with very briefly:

.<u>Hydrofoils</u>: Some of which now provide coast-to-coast connections with a capacity of over 100 passengers. They can no longer be considered just as harbour craft or inland water navigation craft, since they are designed to withstand waves of up to 2.5 m (7.2 ft).

.<u>Aircushion vehicles</u>: although at least in their present stage, these vehicles come under aeronautical techniques, they are subject to maritime regulations. They are already being used throughout the world, with the + British Hovercraft Corporation SRN4, and the SEDAM N.300 whose weight when loaded is 30 tons. SEDAM will urge on the production of their N.500 (weight when fully loaded 200 tons) which will link continental France to Corsica.

2.2 General cargo ships

One may believe that the conventional cargo vessel concept covers ships of a conventional design not fitted for progress, whereas all the other types of ships are being modified and improved. We would rather say that progress with cargo vessels has been slow but steady over the last 30 years and affects operation rather than general particulars: deadweight and performance have remained of the same order of magnitude.

I would suggest that we restrict our examination of modern cargo ships to two types which - at this point in time when specialization is establishing itself in the field of shipping - precisely constitute a complement to specialized transports:

.one is the replacement of Liberty-ships, vessels economical both for building and operation;

.the other is the fast cargo-liner which, to Owners' mind, opens the way to container-ships or completes them.

(a) Replacement of Liberty-ships

The Liberty-ships, built in thousands by U.S. Yards, and the less known "Victory", "Empire", "Park" ships built in smaller numbers, have largely contributed to the revival of sea-borne trade after the second World-War. Some structural weaknesses have been corrected in the earlier stages, but they were after all permissible, considering that the ships were to have a short life; disregarding these inconveniences, Owners and Charterers have pleasant recollections of these ships. Post-war freight rates may to some extent be concerned with these flattering appreciations, but it is beyond doubt that facilities offered by Liberty-ships as regards hold capacity and low operation and maintenance costs have made them a major commercial success. +

The death knell tolled for Liberty-ships. Statistics show that 480 were operated at the end of 1968 (including the other series built during World War II). They are generally operated under Liberian or Panamanian flag, and they still yield a good profit to the Owners. The risks however are increasing together with the maintenance costs, and one may think that, within a few years, they will have completely disappeared from international lines.

That exceptional success gave rise, in 1965, in some large shipyards to the notion - still a deep-seated one, although it never opened on spectacular success - of a serial ship. After very accurate marketing and economic assessments, they designed a so-called "economic" ship: cheap to build and operate per ton capacity, and they put her on the market.

The design concerned, at least in the case of certain Japanese shipbuilders, very costly ships; depreciation of the expenses incurred and of the competitive price of the mass-produced ships was to be covered by a minimum amount of owners' orders calculated by the marketing.

By the end of 1969, somewhat less than 250 of these standard cargo ships has been ordered. Three types have pulled ahead of the bunch: the Freedom type, the SD 14 type and the German Liberty. It looks that the demand from the Owners has fallen short of the shipyards' expectations which had evaluated it at some 800 units. This is an additional proof of the necessity which befalls owners, who have to face an increasingly harsher competition, to choose the ship best fitted to the trade they are considering. Offers of these standard vessels, although quite interesting, did not provide the profit-making capacity expected. Shipbuilders have realised and they are now offering variants of their economic vessel: bulk-carriers, partial containerization, timber-carriers, refrigerating spaces. +

(b) <u>Cargo-liner</u>

One should beware of adopting the present tendency which consists in presenting cargo-liner as the "indispensable complement" to container-ships. This is a sort of empirical explanation, but it is not a satisfactory one, because this fast ship, which ensures regular rotations on regular lines, is still the essential backbone of sea-borne trade. The general cargo ships of all types at present stand for 40 per cent of the existing world tonnage. Of course when it comes to new-buildings or ordered ships, the ratio drops to 10 per cent; and it is beyond doubt that these new ships will be the complement to container-ships. In so far as the latter are subject to a strict time-table, with a certain number of calls at selected ports, it will be necessary to run "broom" ships to collect the freight at other ports, with a loose time-table but capable nevertheless of ensuring a regular trade.

At present, these ships are fast ones, with a speed range between 19 to 23 knots. At such speeds, the ship's lines are an essential factor, and they may not be sacrificed to other economic considerations. - Two important problems are set to the Naval Architect when looking for a compromise between the lines of the under-water body and those above the waterline:

- on the one hand, the adaption of the lines selected on account of their hydrodynamic performance and of the lines which, cargo-wise, will show maximum "containerability". In the midship area, one should endeavour to obtain prismatic holds. Some designs provide a hard chine adaption between the boot topping and the sides in such a way that the latter is vertical and thus ensures maximum container capacity;

- on the other hand, the centre of buoyancy is thrown back well aft of the midsection, so that the distribution of volume available for the cargo is to be calculated so that positive trim conditions are set up for a homogeneous loading. Several of these modern vessels show this defect of + having to ballast in order to comply with correct trim conditions.

- In order to reserve the most useful spaces to the cargo, the engine room has had to be installed aft.

Improvements in handling and stowage conditions constitute an important factor for an economic operation: shorter turn round in harbours, better use of the hold capacity, reduced danger of damage to cargo when handled.

The owners will thence spare no effort in this direction; but it is beyond doubt that their efforts would have been fruitless if they had not been assisted by a similtaneous action in rationalizing and mechanizing the preparation of cargo loadings in warehouses and on quay. "Carry anything, anywhere": this traditional saying for cargo vessels may be quite good in the commercial field, but is certainly not a token of economic success.

The first leading unit was the pallett which has soon been followed, but not eliminated, by the container. The latter led to an increase in the number of hatches and of their unit size and the first one led to the necessity of having doors on shell-plating in tweendecks, as well as flush deck hatchcovers (pontoon type).

There are important innovations in handling appliances: conventional rigging are more and more seldom and, on specialized ships, the capaicty of hoisting appliances can reach 150 to 200 t.

The power available at the propeller shaft currently reaches 18,000/20,000 hp. It is supplied by low-speed or medium-speed diesel engines, the latter becoming ever more popular specially with automated installations (due to the fact that noise levels produced by these engines are still very high and tiring for the crew on watch), also providing an appreciable gain in capacity and doing away with an air casing. +

2.3 Container ships

In fact, one can range in that category not only cellular container-ships, but also roll-on/roll-off and barge carriers. These ships proceed from the same principle, since they have been designed to transport "loading units" (containers, platforms, lorries, private cars, or barges).

Of course the most spectacular expansion has been noted in the case of cellular container ships. Early 1970, there were already 157 new-buildings or ships on order of that type since 1967, capable of carrying 400 to 2,000 20-ft. containers.

This represents about 180,000 containers. It is expected that the expansion of that kind of ships will proceed at the same pace and that about one hundred units of this type will be ordered within the four or five next years.

These ships are costly to operate, thence they are fast. The earlier ships of this type were designed for a normal service speed of 21 knots; later the speed went up to 23 knots, then 26 knots. A speed of 30 knots is being considered. Most owners insist on having single-shaft ships: this has been possible with some difficulty, however, concerning the adaption of the screw up to 32,000 bhp. Brake horse powers involved in the latest container ships that have been ordered are of magnitude of 90,000 and have made it mandatory to use twin-shaft screws. It is not unreasonable that, for vessels with a capability of 33 knots with a 120,000 hp, the use of nuclear energy should be considered.

They are deep ships with a double-hull. It can be noted that these ships have a reduced deadweight and that the loading is well distributed: thence, still water bending moments remain low, the severest loading conditions are those met with when ballasting and lead to hogging. Despite these advantages, the section modulus at deck is difficult to achieve, as the upper plate of the equivalent beam has to be realized by the sheerstrake and a very narrow stringer plate, the remainder of the deck being open. It is often necessary in that area to provide a box structure with largely adequate strength. High tensile steel is widely used for the deck and sheerstrake.

The hatch-covers - which are generally of the pontoon type and flush deck - extend over 85 to 90 percent of the ship's breadth and over 75 to 80 percent of her length. In order to reduce the size of the covers, there are one or two lines of side coamings and transverse boxes at either end of the holds.

Therefore, for these open ships, the hull torsional strength under the effect of waves is to be taken into consideration, and the additional longitudinal stresses thus created are far from being negligible. Several theoritical and experimental studies were undertaken regarding the midship section torsional centre, the distribution of stresses and their variation along the length of the ship. They vanish at the midsection and tend towards their maximum value at the aft end of the cargo area. The transverse beams at the hold ends are also subject to considerable reactions and their scantlings are to be carefully determined as well as the connection with the side coamings.

I think it interesting to inform you that BUREAU VERITAS have set forth an electronic computation method locating with precision the ship's torsional centre and giving additional stresses due to torsion, which must be added to stresses due to longitudinal bending moments. It would appear unthinkable to determine scantlings of such ships without applying this programme. We can take account of the influence of the double-hull, intermediate platform and transverse beams between two hatches.

We were able to verify and complete both our hypothesis and results through model tests carried out in our Laboratories and strain gauges measurements fairly complied with theoritical results.

We go on improving this programme not only by comparison with the results obtained by the finite element method (ELFI), but also by measurements carried out at sea on container-ships. Presently, such + measurements are carried out on a 26,500 g.t. container-ship, of 32,500 shp, during international voyages.

We dealt also with less important matters such as calculations of container guides, of hatchcovers, structure reinforcements in way of heavy concentrated loads arising from container corners; we published, at the beginning of 1968, amendments to our Regulations dealing exclusively with container-ships.

Among the essential problems I mentioned regarding car-ferries, some of which also concern roll-on/roll-off ships. One can realize that it will be the case for the resistance to racking, due to large and clear tweendecks, without transverse bulkheads, the adoption of suitable aft body capable of ensuring a sufficient fixation for the ends of ramps and, at last, for reinforcements around the openings of large dimensions made in the shellplating.

2.4 Tankers

Tankers that are currently submitted to BUREAU VERITAS for approval reach on the average 210,000 to 270,000 tdw. The first design for a 210,000 tdw tanker was submitted to us in 1965. What was then our position? We did know that at least a structural problem could no longer be solved by extrapolation: it concerns the shearing stresses. We were duly aware of it and that inadmissible stress would appear involving buckling of bulkheads or fractures of shellplating. We did contemplate such an eventuality and required a suitable rigidity of transverse bulkheads and more particularly that of swash bulkheads which thus constituted a suitable bearing between the main beam flanges.

Should we want to sum up the researches we carried out for the last three years on the scantlings of large tankers, we can say that we endeavoured first of all to find or to improve appropriate computation methods.

The intensive use of computers allowed us to constitute a series of programmes dealing satisfactorily with the scantlings of cargo spaces. +

After some years of application, we published an amendment to our Regulations, in which appear our assumptions for these various electronic computations, and the permissible level of stresses. This amendment was published in the course of 1969. I am entitled to say that BUREAU VERITAS was one of the first Societies to adopt that kind of publication which states frankly the methods of direct computation chosen by the Society, including the assumptions made on the structure idealization, on the loading conditions and the permissible stresses.

When I deal with our research works, I shall revert to the computation programmes that we are formulating and on the experiments we are carrying out with a view to going closely into our surveys on the structure for cargo-range of oil-tankers.

We have also to solve the problems set by the structure of the fore and aft parts. Giantism of compartments led us to reconsider the fairly simple scantling methods of their structure. Sea effects and vibration phenomena can be determining in such parts, though it is right to say that these methods have given satisfactory results up to now and no important damage occurs on the largest ships. We have some examples of upper decks distorted in way of the foundation of windlasses and indent suffered by the upper part plating of stem due to sea impacts.

What about "super-tankers" to be built? Presently, the tonnage variation ranges from 250,000 to 270,000 tdw. By a slight increase in main dimensions, while using the same general arrangement, a 350,000 tdw tanker can be reached. We already studied some projects of 400,000 and 550,000 tdw tankers. We endeavour to think out the new problems set by that kind of ships.

On board these large ships, we suppose that some scantling methods successfully applied for 250,000 tdw ships shall have to be reconsidered,more particularly those concerning longitudinal elements. Moreover the liquid motions inside tanks can lead to dangerous dynamic phenomena of the internal structure. It is why we attach a great importance to model tank tests we are at present carrying out; these model-tanks are submitted + to any type of motions and accelerations encountered aboard a ship (rolling, pitching, heaving).

The transfer functions between ship's motions and waves' characteristics, being computed by means of our electronic computation programme, we shall then be in a position - owing to the motion parameters thus determined for 500,000 tdw ships - to calculate the dynamic effects of liquid cargoes.

The first 500,000 tdw ships who will be built - it seems useless to remind that they are ordered in Japan - will be quite similar to those of 250,000 tdw asfar as general arrangement and structural scheme are concerned. One may hope that this further doubling of tonnage does not lead to the same troubles as those suffered when tonnage increased from 100,000 to 200,000 tdw. In fact, Builders together with Classification Societies have realized the importance of the problems put by such extrapolations: powerful computation means are at their disposal which will thoroughly analyse stresses whatever may be the sizes of structural elements, provided that loading assumptions should be very precise. It appears thence quite necessary to have a thorough knowledge of loads: sea-effects, dynamic stresses due to liquid motions, vibrations due to ship's motions or induced by propulsive plant. The specialized Departments of Yards and Classification Societies aim consequently at such a knowledge. In addition to the above-mentioned model-tests, BUREAU VERITAS has undertaken a series of long-lasting experiments "Europe-Persian Gulf" East-and West bound*. We much rely on the analysis of the measurements to establish correlation between ship's movements and dynamic stresses.

Reverting to 500,000 tdw tankers, I shall mention the question of the limitation of unit tank capacity, which might be brought forward, in a rather near future, by I M C O. This question is being debated for more than two years, within the measures to be taken internationally for the protection against pollution. Classification Societies have been consulted. In the present state of debates, a maximum value of 30,000 to 50,000 cubic metres should be put forward for tank capacity. Such a limitation - if it cannot be considered as a fundamental + modification of the ship's design, should lead however for a 500,000 tdw vessel, to such an increase in the number of tank-ranges as this type of ships could no longer be operated with a suitable rentability.

In this respect, it is worth mentioning that double hull tankers would be more available if such regulations should come into force. From a technical point of view, this solution can be justified. As far as safety is concerned, the double hull is interesting in case of

* on a 250,000 tdw ship

collision or grounding. In operation, precautions are to be taken so that no explosive atmosphere should exist inside double-hull compartments.

To conclude about tankers, I shall say that I do not believe that the problem set by the construction of new super-tankers (from 500,000 tdw to 1,000,000 tdw) should be the problem of Naval Architects. Shipyards and Classification Societies have, in their respective field of activity, duly realized the problems put by these ships and have acquired means to solve them.

The determining factors will be political, for instance due to I M C O decision, or of economical order. I think that, should the tonnage requirement goes on increasing so largely as in the present time, it will prove necessary to disregard any question of price, or even of ship's rentability. Under those conditions, the most efficient position enabling the Builders to comply with that demand will be to increase the ship's size as much as their means of production should allow them to do so (for instance, breadth of building docks).

2.5 Bulk-carriers

For the last decade, the unit increasing in that kind of ships has been similar to that of any type of specialized transport. If the largest units or order exceeded 150,000 tdw, they were however rather few and shipowners' request was still very important for + bulk-carriers from 20,000 to 30,000 tdw. Following the great success of combined carriers with all its varied types (ore-oil, ore-bulk-oil, ore-coal-oil carriers), it has to be noted that giantism phenomenon has appeared for that kind of ships since the end of 1969 and mainly in 1970 (numerous orders of ore-oil-carriers of about 250,000 tdw).

Thanks to this fairly weak increase, the questions put by the calculation of scantlings of bulk- and combined-carriers - although relatively more difficult to study than those of tankers - have been approached in better conditions, by means of a reasoned extrapolation of rather simplified scantling methods, untill methods of analysis of the structure by direct electronic computation had been elaborated. Because, as I already told it, the structure of a bulk-carrier is fairly intricate, if it is wanted to take into due consideration all the structural elements: grillage of double-bottom, torsional rigity of lower and upper wing tanks.

Loadings are also very intricate and severe. Several loading factors were badly known as, for instance, the pressure exerted by ore on transverse bulkhead platings, on slopped longitudinal bulkhead platings, or the dynamic effects due to liquid motions in the long-sized wing-tanks.

We have now computation methods to check all the structural elements of an ore hold. A ELFE programme allows a three dimensional analysis of all the main elements: bottom-plating and primary longitudinal girders, side-plating and longitudinal bulkheads, deck and upper wing-tanks, transverse rings and transverse bulkheads.

The last "improvement" - brought at the beginning of 1971 - to the aforesaid programme allows to represent graphically by "plotter" the variations of the deflection for all the calculated girders.

Another problem that we are carefully studying concerns the dynamic effects of liquid motions in large axial holds. +

After having theoritically approached this question, we carried out a model experiment with various types of transverse screens constituting swash bulkheads. These experiments are a part of a large campaign of experiments on tank-models for which the various motion and acceleration parameters are transposed in Laboratory. This campaign will go on all the 1971 year round.

We shall also take advantage of this campaign to go more closely into the question of scantling methods for covers of O.O. and O.B.O. Our present regulations are severe, as we consider that a suitable tightness and a sufficient rigidity are essential conditions for that kind of ships, when they carry crude. Owing to our experiments, we shall be able to verify our assumptions.

3. HULL SCANTLING

3.1 General

Determining the scantlings of a hull consists in calculating the secondary dimensions of the various members (plate thickness, modulus of inertia of stiffeners, weld throat size, ...).

The main dimensions of hull and of its constituents are the subject of design, the study of which is irrelevant here and now.

The problem of scantlings is met:

- either when checking a complete design: all the main and secondary dimensions are known in that case;
- or when preparing a design: then a selection must be made for inter-dependent elements, normally leading to a trial and error calculation.

3.2 Practical conditions for determining hull scantlings

Means of transportation other than sea-borne (motor-car, lorry, locomotive, train, aircraft) are mass-produced after one or several prototypes have first required complete calculations by the most up-to-date + methods and mock-up testing for doubtful points, then called for exhaustive testing after building together with numerous measurements and adjustments. This lengthy and costly procedure is justified by the number of the mass-produced units.

In the case of a ship, true mass production is an exception and there never is a prototype similar to the one mentioned above. In that respect, the ship is like a highway structure, such as dams and bridges (although bridges over motorways are standardized) or buildings in general.

The ship is subject to wave, a very powerful and most varied phonomenon, which until recently challenged analysis, and the wavelength of which is of the same scale as large and medium ships over the full length of the ship, the waves produce a maximum bending moment of the same order of magnitude as the maximum permissible still water bending moment; simultaneously, local stresses induced by wave have a marked effect on the scantlings of several members of the hull.

There is nothing of a similar nature for the other means of transport, including the aircraft.

In Civil Engineering, here is a problem of soils and foundations, made more complicate in certain countries by earthquakes; in the case of tall buildings, the problem is that of the wind.

There again resemblance is to be sought for with Civil Engineering rather than with the other means of transport.

Since the day aviation was born, weight has been a vital factor for the aircraft, whereas this has never been the case with ships. This has compelled aircraft manufacturers to undertake most extensive studies, research and testing for each of their prototypes; as a practical result:

(a) Aeronautical research is in the van with respect to shipbuilding research;

(b) The number of aircraft manufacturers has always remained rather limited and in far smaller quantities throughout the world than the number of shipyards. +

Competition, both price-wise and delivery date-wise, is thence far more severe till now for ships than for aircraft.

Because of this two-aspect competition, neither time nor the budget granted will generally allow complex scantlings methods for a given ship: the methods at the disposal of those interested should be straightforward, extremely fast and cheap to solve scantlings problems both at the design stage and when the drawings come up for approval by the Classification Societies.

Nevertheless, these scantlings methods must remain safe.

3.3 An increasingly complex problem

Due to the appearance of new types of specialized vessels or to the very fast increase in the size of some ships, mostly tankers, ore- and bulk-carriers, the experience gained with existing ships running for several years is no longer directly applicable for an increasingly large number of vessels in the design stage.

Furthermore, competition for price and weight induces a reduction in the value of the safety factor. Competition between Classification Societies pushes in the same direction.

As a result of increasing dimensions and decreasing safety factors, some phenomena which had rarely been taken into consideration in the past, now frequently affect scantlings: effect of shear stresses, distortions of the ship's cross sections, buckling, plastic analysis.

Regarding buckling for instance, the use of high tensile steel has made things more difficult. It is used to gain weight when this is economical because, where capacity of resistance to stresses is the same, it is less thick than usual hull steel. But it results in a greater tendency to buckling. +

3.4 Improvements which have brought about the present progress of scantlings methods

Several current improvements in many fields contribute to the present progress in scantlings methods, but one may say that progress started off with the following two improvements.

- possibility of computing wave action connected with pitching and heaving, the approximation being satisfactory for the application of the results;

- new, large capacity methods for automatic computation of hyperstatic structures consisting of straight beam nets or stiffened plates.

These new methods, and particularly the finite element method, have already been frequently used in the aircraft industry for the study of prototypes. Their use in shipbuilding is a timely application which has allowed the application of improvements made in the determination of stresses.

3.5 Progress in scantlings methods is of an international character and covers several fields of activity

The progress in scantlings methods thus started off is at present encouraged by the development, in quite a number of countries, of research affecting fields of activity directly connected with, or fundamentally associated with, shipbuilding such as oceanography or strength of materials.

On the other hand, there exist in these countries organisations of a varied nature which carry out or support research; Universities, Research Institutes, Naval Authorities, Classification Societies, ... with the assistance of a number of shipyards and owners when it comes to carrying out measurements on board the actual ships. The research is often enough partly taken over by the State, in proportion to the importance the latter attaches to its shipbuilding industry and its merchant fleet. +

On the other hand, means of information exist on an international scale, among them being:

- technical articles published in specialized magazines
- reports read before technical associations, followed by discussions
- the works of I.S.S.C. (International Ship Structure Congress) which since 1961 holds a meeting every three years. Each of its numerous Committees, with precise terms of reference concerning a particular field in the study of ship hulls, has to record all the results published in its field of activity between two meetings. Furthermore, it also has to inform, as far as possible, of research work in progress, or intended, in order to avoid redundancy.

- Working Parties within I.A.C.S. (International Association of Classification Societies) are intended to concentrate the results of the experience gained by, and research work made by, its member Societies towards Regulations as consistent as possible.

The development of research, the circulation of the results obtained overcome but partially only the heavy handicap of shipbuilders and shipowners with respect to air transport and aero-nautical builders who are now their direct competitors in ever more numerous fields and who have the double advantage of working on prototypes and mass production.

This should constitute an incitement to extend ship research and to develop an international co-operation.

3.6 Contribution of sea experiments

Of necessity, the use for strength calculations of methods which give a better representation of the distribution of stresses in the structure must, to attain its full value, be accompanied by a search for a better definition of the forces acting on the structure under normal conditions of operation. This means a better estimate of wave action on marine structures. +

Access to such an estimate must be made along two complementary roads:

- the study of the sea and of its possible representations by mathematical formulae or tables of data, to make calculations possible;
- the development of calculational methods to furnish from a representation of the sea, the hydrodynamic forces and moments acting on a structure.

The first road is for the meteorologists to follow, once the naval architect has defined the conditions in which he must obtain the description of the sea to be able to carry out his calculations.

The second road is the domain of the naval architect.

The practical use, in shipbuilding, of methods combining evaluation of sea action and strength calculation can only be achieved, with all the safety required, after comparison with experimental results and, eventually, modifications to these methods which the comparison may show necessary.

Motions and, to some extent, bending moments and shearing forces may be measured in model experiments, either in simple waves or in complex waves.

On the contrary, the study of stresses in a given structural element is not possible on a model.

Measurements on real ships are the only one which allow for a complete comparison between calculational and experimental results:

- static measurements yield a verification of the structural calculation method;
- dynamic measurements are a validity test for the combination sea representation/dynamic calculation of the structure. Accumulation of satisfactory results of such comparison must lead to the double conclusion that the representations selected and the calculational method adopted are acceptable. +

It is on these bases that the measurement programmes set up by BUREAU VERITAS in the last years have been defined. To each series of measurements corresponds a series of calculations, employing the computer programmes developed at BUREAU VERITAS several years ago.

The evaluation of the cyclic stresses to which a structure is submitted gives the possibility to develop a method for the study of the fatigue accumulated during the life of the structure.

As far as the study of the sea is concerned, BUREAU VERITAS is fortunate to have the collaboration of a French specialized office - the French Meteorological Office. Such a co-operation is indispensable for:

- obtaining information on seas encountered during measurements ("hindcast", during trials or long voyages);

. establishing a statistic of sea representations, for important ocean areas, so that long term statistical evaluations may be made for given effects (stresses, bending moments, accelerations, ...).

For these two tasks, the French Meteorological Office plays vis-a-vis to BUREAU VERITAS, the role of data acquisition centre for data that it is necessary to gather around the world.

I believe that the orientation thus taken by BUREAU VERITAS will soon give very interesting results.

In the years to come, many shipowners will appreciate to their full value the advantages of an organized system for the navigation on the main sea routes: there is no doubt that proven dynamic calculations combined with a reasonably sure weather forecasting will allow for adequate recommendations to be given to captains in order to reduce sea action and hull fatigue.

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4. CONCLUSION

The present tonnage requirement is so important as a decrease in shipbuilding price is hardly thinkable. Nevertheless it is necessary to note that the very low value of freight rates played an important part in the development of merchant fleet. It is to be feared, consequently, that, in a rather near future, this unbridled increase in freight rates shall have consequential effects on tonnage requirement.

Besides, it is highly improbable that technical arrangements of the ships presently delivered (automation, increase in deadweight, for isntance) can appreciably influence the operation costs. It appears that a major factor to reduce prices is to be sought for in the organization of shipyards, both as regards studies and production.

As far as production is concerned, it will be endeavoured on the one hand, to build series of standard ships and, on the second hand, to automate as far as possible the production lines. That is all the more necessary as in quite a large number of shipyard, the biggest risk is the shortage of labour.

As for studies, shipyards will dispose of very powerful means by hull scantlings computation methods. These methods require much work and Design Departments of large shipyards, Research Institutes and Classification Societies are spending much time in that respect. It would be much beneficial that an international co-operation should become more and more efficient between these organisations.

Contrary to an aircraft design which is slowly and steadily elaborated thanks to a prototype, a ship design is made to measure, quite often in applying methods used in "high-class dressmaking" and, too often, hurriedly. It would be much advisable that hull scantlings computation methods should originate in an "idealized prototype" for a given type of ship. That requires much work. One can hope that co-operation in this field + should go on developing internationally and more particularly that between Classification Societies. Competition that aircraft is making to ship, in more and more numerous fields, must certainly incite us to act in that way.

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