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Very Large Crude Carriers (VLCCs) and Rules of the Road for the Prevention of Collisions

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Well written but what

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Research Paper

VERY LARGE CRUDE CARRIERS (VLCCs) and RULES OF THE ROAD FOR THE PREVENTION OF COLLISIONS

by

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Abstract of

VERY LARGE CRUDE CARRIERS (VLCCs)
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FOR THE PREVENTION OF COLLISIONS

A discussion of tanker ship development from the World War II T-2 to the million ton "Delta Ship" concept and an analysis of present and proposed Rules of the Road as they apply to VLCCs. The advantages of size, design characteristics, crew size and automation, propulsion systems and shiphandling characteristics are discussed in general comparitive terms. Projections show tremendous increase not only in the size of tank ships, but also in the size of the world's tanker fleet - approaching 5,000 vessels in the next ten years or so. The increasing size of crude oil carriers and their immense pollution potential has prompted special accomodation in the Rules of the Road in order to reduce the risk of collision. The 1972 IMCO revision, to the Rules of the Road incorporated VLCC definition and accorded these vessels privilege in specific terms. Aspects of these new Rules are discussed and some of the weaknesses are pointed out.

PREFACE

About five years ago while my ship was undergoing repairs in a Japanese shipyard, I had the opportunity to follow final phases of construction of the 213,000 dwt tanker, "Energy Evolution". Since then, as tanker sizes have progressively increased, I have taken a sailor's interest in observing their growth and operational sophistications. I was amazed when I was told that "Energy Evolution" was designed to operate with a crew of just 35. By comparison, my ship, a World War II destroyer, had a crew of 275. It was intriguing to me how so few men could operate such a large ship - and do so safely. But so far my skepticism has had no grounds. The sensation of size that one gets aboard one of these huge ships simply cannot be described, and the only one I've been on is smallish compared to the 500,000 tonners being built now.

Related to size, is the ominous pollution threat of the VLCC. The "Torrey Canyon" grounding in 1967 resulted in release of some 36 million gallons of crude oil into the approaches to the English Channel and dressed the nearby shores of France and England with a gooey and pungent "chocolate mousse" emulsion that took almost three years to dissipate and return the coast to some degree of pre-pollution normalcy. Compared to the most popular size VLCC ordered in 1973, the Torrey Canyon was only about one-third the size, thus the potential hazards from such accidents is of vital concern to the Coastal Zone.

Besides the danger of grounding, tankers are vulnerable to collision from which some oil pollution is almost always evident. Fire and explosion constitute other hazards to tankers, and are perhaps more feared by the crews, but viligence towards them is more sentinel and results in less incidental pollution than the hazards of collision or grounding. There has been considerable progress in reducing the fire/explosion risk much of it in the form of mandatory regulation, but also voluntary because of the tremendous investment represented by the VLCC. The "eggs-in-one-basket" concept has stimulated shipowners into designing into the VLCC advanced technologies which if used properly can enhance vessel safety physically and operationally. Numerous governmental and inparticularly the Inter-Governmental Maritime Consultive Organization (IMCO) have taken active roles in the reduction of risks from collision or groundings by introducing sea traffic separation schemes and changes to the Rules of the Road.

In constructing this paper, one of the problems that confronted me was that I didn't have the opportunity to refresh my memory by first hand experience on board a VLCC either in service or under construction, and I had to rely on my somewhat vague recollections of a VLCC tour taken in 1969. The hoped for discussions with shipyard personnel and/or ship's officers would have been extremely helpful had they taken place.

The main problem in researching the subject was not in finding rules and regulations on the subject of shipbuilding or ship operations, but in putting together "the nature of the beast". By far, the vast majority of my material was derived from articles in periodical magazines, as many as five or six on the same subject from which I was able to piece together a reasonably accurate explanation or description. Lacking a technical background, I had some heavy steaming through such material as "Principles of Naval Architecture" for example.

I have been fortunate in gaining timely assistance from several individuals who have helped me considerably in piecing together this paper. I am grateful to Commander William E. Turcotte, USN, holder of the Land Chair of Merchant Marine Affairs at the Naval War College, for his advise and background material, to Professor B. Vincent Davis, Director of the Patterson School of Diplomacy at the University of Kentucky, for his timely assist in providing me material on oil transport, and to Miss Doris Baginski of the Naval War College Mahan Library staff for her assistance in digging out research material.

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INTRODUCTION

Background. I think most people will agree that the economy of the world today is essentially an "oil economy". Without crude petroleum, what would our lives be like? If, for example, all the oil wells in the Middle East had suddenly gone dry in the 1930s, would we ever have experienced World War II? One can only speculate on what today might be like without petroleum in significant quantities. We in the United States are reminded of our heavy reliance on petroleum and its by products by the recent artificial shortage of fuels which many of us have experienced only as a minor annoyance occasioned by the appearance of "sorry no gas" signs at the corner service station or as a sharp fluxuation in the price paid for home heating oil. Elsewhere in the world the reliance on petroleum is just as heavy in industrialized nations. In fact, the United States is far more fortunate than most because we have less total reliance on oil imports than do many others. In Japan, the consumption of petroleum and petroleum products has trebled in the last ten years and is expected to increase again by a factor of four by 1990.[1] The Japanese rely almost totally on oil imports to meet their rapidly increasing needs, with almost 90 per cent of that total imported from the Middle East. Similarly, Europe's oil consumption has trebled since founding of the EEC skills in ample supply. Thus with the increased demand of tanker capacity, and the application of the assumption that a single large ship can operate just as efficiently and at significantly less total operating cost per cargo-ton mile than two or three smaller ships of the same type, the ways were greased for the supertanker.

Record Size Ships. Since 1956, the distinction of world's largest ship has been claimed by tankers, one of them holding the honor for only seven days. The following table shows the spectacular growth in ship size:

Table 1

Name	Tons (DWT)	Year	Where Built
SINCLAIR PETROLORE	56,089	1956	Japan
UNIVERSE LEADER	85,515	1957	Japan
UNIVERSE APOLLO	104,520	1959	Japan
MANHATTAN	108,590	1962	USA
NISSHO MARU	130,250	1962	Japan
IDEMITSU MARU	206,000	1966	Japan
UNIVERSE IRELAND	326,000	1968	Japan
NISSEKI MARU	372,400	1971	Japan
GLOBTIK TOKYO	483,644	1973	Japan

Source: Lloyd's Register of Ships, 1973-74

Clearly the Japanese are the leader in building ships of great size with the one exception, Manhattan, built in the USA as a token effort, holding the world's largest ship record for only seven days. Currently the French are building two 500,000 dwt tankers and Aristotle Onassis has announced plans to build a one million ton tanker. It is difficult to forsee a technical structural limit on the size of ships - the present limits appear to be economic and navigational. Economically limiting because of cost vs loss risk and navigationally limiting because of the ships draught considerations and lack of port facilities.

Advantages of Size. There are numerous advantages to the VLCC. First, although the total initial investment is greater, it takes less labor, less steel and shipyard effort to build a single tank ship to carry 300,000 tons of crude oil than it does to build six 50,000 ton capacity tankers or three 100,000 tonners. The savings in steel is also a major concern and results from the fact that the skin of any container increases only as the square of its dimensions, whereas the volume enclosed increases as the cube using the formula $V=a^3$. Lower operating costs are realized providing the VLCC operates in a steady trade in goods easy to load and discharge in large volume - this suits the VLCC perfectly. In economic terms the VLCC represents economy of scale, which can be seen in Table 2 below, with comparative fuel consumption rates of

Table 2

DW Tonnage	Consumption Per Day (Tons)	DW Tons Carried Per Day Per Ton of Fuel Used.
17,000	45	350
48,000	90	533
131,000	143	912
206,000	166*	1022*
326,000	198*	1225*

Source: Phillips-Birt in The Future of Ships. *Extrapolated some representative size tankers between 1945 and 1970.

Essential to the profitability of operating the VLCC must be the opportunity to persistantly operate with high load ratios. The long-term certainty that the VLCC will have a load ratio of 50 per cent - fully loaded one way and empty, or in ballast the other - is an important reason for increasing size. In 1967, with the closure of the Suez Canal, this wisdom began to pay off with some 155 tankers operating the routes between the Persian Gulf and the U. S. and Europe that could not pass through the Canal fully loaded, and whose size made the 60 day round trip competitive with the Suez route used by smaller tankers.

As with every business, economic disaster would befall the owners and operators of VLCCs if there is not reasonable certainty of their being able to maintain adequate and profitable load ratios during their lifetimes. According to a recent article appearing in Marine Engineering/Log,[3] tankers represent 69 per cent of the shipbuilding orders for 1973 with the most "popular size" VLCC on order at 380,000 dwt. It would appear quite safe to assume that with the oil economy such as the world has today, and with oil consuming nations both increasing in number and total demand, favorable load ratios for VLCCs can be anticipated for many years ahead.

How Big Is Big? The point at which the size of tankers will begin to show decline in the saving of transport costs per ton mile of cargo is uncertain. A crucial situation will be reached when the size of the ship is more than can be propelled by a single engine and propeller because (1) there will be a loss of propulsion efficiency with twin screws and (2) construction will become more complicated and expensive thereby offsetting economy of size. To answer the question, how big is big, we can use some simple comparisons to attempt an answer. Appendix I shows comparative growth in deadweight capacity of tank ships with the areas of the squares being roughly proportional to deadweight tonnage. Comparative lengths of the ships are indicated by the heavy horizontal lines. The proportions shown are supported by a simple mathematical computation where a cube, measuring in any units, for example - 20 x 3 x 2 - will have a volume of 120 units. Take another cube; to double the volume to 240 units, all one needs to do is increase the measurements to 24 x 4 x 2½ units. In other words, to double the displacement of the dwt of a ship, an increase of approximately one fifth in length, one third in beam and one fourth in draught, or any combination thereof will suffice.

<u>The Million Ton Ship</u>. As mentioned earlier, plans are being made for the construction of a million dwt tanker - an Ultra Large Crude Carrier (ULCC). It is projected that the vessel will measure approximately 2,000 feet in length, will have a beam of 300 feet, and a draught of 100 feet, probably more. There is no question

that a prestige will attach itself to the country, the shipyard and the owner that launches the first million tonner - a prestige similar to that enjoyed by the U. S. from putting the first man on the moon. Recently, two Japanese shipbuilding companies made public their plans to construct drydock facilities capable of handling a million ton vessel, and another group, headed by Aristotle Onassis, has discussed a somewhat revolutionary million ton ULCC they might construct.

Earlier I noted that the larger a tanker gets, the cheaper the per barrel transportation cost becomes. But there is a curious phenomena, laying somewhere between the 483,644 dwt "Globtik Tokyo" Class ULCC and the one million ton tanker, which reverses the economies of scale. Naval architects are not sure about the actual size at which such a reversal takes place, but most of them with experience in VLCC/ULCC design and construction agree that at some point approaching a million tons, the cost per dwt will escalate rapidly.[4] This increased cost per dwt will be emphasized in the early efforts at the million ton ship. The "Globtik Tokyo" was contracted for at slightly under $49 million.[5] The cost for a million ton ship (1973 dollars in a Japanese shipyard) has been estimated as high as $130 million.[6]

Andrew Spyrou, Technical Director of the Onassis group, points out that Onassis' decision in 1953 to build a 47,000 dwt tanker, which began the era of giant tankers, was thought by many people to be impractical. Spyrou's credo for tanker construction is: "An owner should select a design keeping in mind that optimum deadweight to give minimum building cost is of lesser importance than the selection of the optimum deadweight to give minimum operating cost."[7] This philosophy, combined with some creative solutions to emerging international tanker regulations, has led to design of the "Delta System Ship."

The Delta Ship. The Onassis' Delta Ship advances modular design and in doing so sidesteps many of the problems seen in the building and operation of a million ton tanker. The Delta "mothership" would be used for clean ballast only, would carry all main propulsion fuel, accomodate the main propulsion system, crew, and equipment to process the contaminated ballast from four detachable modules or caissons. The four caissons would carry petroleum only and each would be equipped with its own pumping facilities to handle cargo and ballast.

Distributing eargo in four 250,000 dwt detachable caissons has a number of advantages. Existing pump technology and systems can be applied to them, and construction carried out in a drydock in series, or production line method. Since the total ship is not intended to enter port and since individual caisson draught would be considerably less than the complete Delta ship, port depths become less a factor.

It is conceivable that the Delta ship could carry four totally different products on the same voyage, particularly in view of the fact that there are very few (if any) oil dumps or refineries that could accomodate one million tons of crude oil at one time. Ecologists should have no more arguement with the Delta configuration because it is essentially four, 250,000 dwt tankers arranged in close order. A grounding or a collision would represent no more danger than a similar mishap to a present-day 250,000 tonner. Following cargo discharges, ballasted caissons would be towed back to the mothership where they would be fitted in place. Final ballasting for voyage would trim the Delta ship so she actually "rides" on the caissons.

Even with these innovative concepts, there are numerous problems to be solved before construction could be attempted. Mooring lines and winches of adequate size and power have yet to be developed. Directional and course stability problems require considerable research in hull configuration and rudder design to make such a large vessel responsive to small rudder angles. The vessel's anticipated sluggishness and unpredictable response, plus man's traditional tendency to oversteer (when a ship is steered manually) can cause excessive fuel consumption over and above the expected norm of 500 tons a day for a 14 knot cruising speed.[8] Then there is the problem of routine hull maintenance and/or emergency repairs, because of virtually non-existing drydocking facilities. It is hard to imagine how cumbersome a million ton ship would be. A Norwegian study points out that few tugs exist today that could manage a million tons even under the calmest of seas. There will not be much flexibility in routing such a large ship either. She would probably ply between a very few ports and as a result insurance rates might be higher. One Japanese firm noted that the bigger tankers become, the more risk increases, consequently higher insurance rates are applied.

As for crew, operating companies would want to ensure comfort and relaxation of the highest quality to make berth aboard the million ton ship a coveted one. Since the ship would seldom enter any port, there would likely be a swimming pool, gym, sauna, bowling alley, etc. Since the ship doesn't go where man wants to go, a helo pad would be a requirement for crew rotation and shuttling them to land. Quarters would be plush, with three bedroom apartments possibly available for the ship's officers and their families should they choose to take them to sea. There is little doubt that the million ton tanker would be a very comfortable ship.

There are many obstacles to overcome, but these are the same obstacles that confronted the 250,000 ton tanker. The only possible answer to the question of how soon construction of the million ton tanker may begin is - sooner than you might think.

Design Characteristics of Operating VLCCs. The "eggs-in-one-basket" philosophy has led to special care in construction and manning considerations for VLCCs. The recently completed and now operational, 483,644 dwt Globtik Tokyo, provides some advanced design concepts in vessel safety that reduce the range of hazards and extent of pollution in event of an accident. Her hull strength (longitudinal and transverse) form, superstructure, piping systems and propulsion systems are all specially designed to minimize the cost of maintenance and guarantee seaworthiness. All plates used in deck and hull construction are of one inch mild steel. Because of Globtik Tokyo's greater depth compared to her length, HT steel was not used. After completion of the ship, static stress measurements were made at more than 100 points to ascertain vessel safety and the reliability of design calculations concerning bending stress in still and rough water. The stress analysis confirmed that the bending stress of the ship in a variety of sea conditions would be highly satisfactory.

The programmed occupancy ratio of 50 per cent (fully loaded one way and empty or in ballast the other) has had an effect on hull design for the VLCCs to improve shiphandling. A very pronounced type of bulbous bow, appropriately called a "ram" bow, has gained most favor and may extend 20-40 feet ahead of the stem just below the waterline. The original design concept of the bulbous bow is to reduce the bow wave system, however because the VLCCs are so wide of beam, the bulb had little effect in cancelling the surface bow wave resistance. Instead, it was discovered that the bulb tended to reduce drag along the keel. Tank tests have shown that certain designs of bulbous bows may reduce water resistance by as much as 25 per cent.[9] This is an important factor in VLCC operating efficiency.

Globtik Tokyo's designers incorporated design concepts in the hull that provided a "honeycomb" strength, cost effectiveness and an element of pollution control. The ship is designed with three longitudinal cargo tank systems divided by oiltight bulkheads. Because the designers placed limits on tank capacity, the outboard tanks instead of having wash type bulkheads, are provided with oiltight bulkheads. Thus the outboard cargo tanks are compartmentalized so that a rupture in the skin of the ship would effect only the tank(s) or space where the opening occurred. By comparison, the double bottom design offers greater pollution protection from a hull rupture, but such a design also increases the cost of construction significantly.

Mobil Shipping Company Ltd. has incorporated the double bottom design into its tanker fleet with the 212,000 dwt tanker "Mobil Pegasus". This new design is intended to reduce port turnaround times since loading and ballasting can be carried out at the same time. It also guards against spillage of oil in event of a grounding - a further step in Mobil's "Clean Seas Program" begun in 1965, which is intended, by application of various measures to prevent pollution and increase safety at sea.[10] The Mobil Pegasus has a ten foot high space that separates the underside of the cargo tanks from the bottom of the hull and extends the length of the cargo section of the ship. A central tunnel in the double bottom includes all the suction piping and valves for cargo discharge. The location of the piping and valves has the advantages of allowing complete cargo discharge without crew "mucking".[11] It also protects the piping system from corrosion by alternate immersion in oil and seawater. The double bottom includes flooding alarms and a gas detection system. Mobil claims the double bottom design provides greater transverse strength which could alleviate one of the principal strength problems facing builders of VLCCs. Some of the design detail of Mobil Pegasus is shown in Appendix II.

Built In Safety and Anti-Pollution Devices/Methods.

On Globtik Tokyo as well as on almost all cargo carriers being built today the superstructure and engineering spaces are located aft. The accomodations and ship's control spaces when located over the engineering space are separated from the propulsion spaces below by a one meter deep "dead space" in consideration of rules governing explosion protection. Special care is also taken in dampening to prevent vibrations from machinery and screw beat.

An inert gas system has been designed and installed aboard Globtik Tokyo for tank explosion prevention. This system sends inert stack gas into the cargo oil tanks when empty as well as when unloading crude oil in order to reduce the oxygen content in the tanks which minimizes the risk of explosion. For an explosion to take place, the oxygen content must exceed 11 per cent by volume, and hydrocarbons between 2-10 per cent. A particularly dangerous period occurs during the unloading phase of crude oil where air will enter the tanks as the cargo is discharged thus creating an explosion danger by increasing the O_2 ratio.[12] By adding a mixture of CO_2 and Sulphur Dioxide to the stack exhaust and passing it through seawater "scrubbers" that cool the gas and clean most of the SO_2 from it, then blowing the gas into the tanks, the oil vapor/oxygen mixture is greatly diluted and the danger of explosion is significantly reduced. Several companies have marketed inert gas systems of this type that can be retrofitted on older design tankers - and while the equipment is expensive, and heavy (50 tons or more) it can be installed while the ship is underway with a minimum of outside assistance. The installation saves money in the long run through reduced insurance rates and potential ship repair/replacement costs, not to mention increased crew and vessel safety. To date however, there are no rules safeguarding tankers from empty tank explosions - primarily because there has never been a totally accepted reason

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Again, using the Globtik Tokyo as an example, cargo oil piping incorporates many new devices to shorten the cargo handling time, but also to reduce the chance of accidental oil spills. At the unloading port, wing tanks are unloaded first then filled with seawater ballast through a separate pumping system. The ability to load ballast while discharging the oil cargo allows the tanker to leave port as soon as unloading is completed. At the loading port, the ship can take on cargo while discharging the ballast water. Oil/water separators are used to reduce the oil water mixture and prevent oily discharges above minimum pollution standards established by IMCO.[13]

Some time ago, major oil companies adopted the "load-on-top" (LOT) method of reducing or preventing oil pollution. This procedure is used by an estimated 80 per cent of all oil tankers in operation today. It consists basically of collecting all oil, contaminated ballast and tank washings is a slop tank. After the oil and water are separated the relatively clean water is pumped overboard until the oil water interface is reached. The next oil cargo is loaded on top of the oily sludge in the tank bottom. To be effective, the LOT method requires that any oil which remains in the piping system or as clingage[14] in the tanks which are to be washed, and which otherwise might be discharged into the sea, shall be collected and processed, transferred to a common holding tank and stripped so that the amount actually dumped overboard is a very small percentage of the residue left aboard. Providing the method is in the hands of "good" operators more than 99 per cent of the oil previously dumped at sea, can be reprocessed.

Tank cleaning on Globtik Tokyo is accomplished by stationary type units installed in each of her 21 cargo tanks. The cleaning water is transferred by the cargo oil pumps under pressure to the tank cleaning piping system. The water is removed from the tanks after cleaning by eductors or self stripping devices. Each tank has several openings for sludge removal which is transferred to slop tanks for oil/water separation.

Fire prevention has advanced further than most other safety measures with fire resistant and/or retardent materials, smoke detectors, automatic smothering devices using foam and CO_2, purple K and so on. When the liner United States was completed a number of years ago, it was said that the only two things onboard that would burn were the piano and the butcher's chopping block. With the relatively small crews on board the VLCCs, the importance of building ships that are designed not to catch fire or at least will retard the growth of a fire giving the crew enough time to put it out, is an extremely important step.

Crew Size and Automation. Traditional concepts of seafaring have been associated with the discomfort of cramped quarters and a lack of anything but the minimum of privacy for anyone. Not so today, accomodations aboard VLCCs are plush and creature comforts extensive. They have to be. The largest VLCC may have a crew of perhaps 35 (Globtik Tokyo has a compliment of 39) which might include four each deck and engineer officers and perhaps eight each of crew for deck and engineering. Total watchstanders underway will rarely exceed three or four men. Increasingly, enginerooms and boiler rooms will be unmanned for much of the time with the entire plant monitored from a remote console. The old chores of maintenance at sea are all but eliminated with innovative new paints and anti-corrosive coatings and what maintenance is performed is usually deferred to time in port or annual upkeep periods. The ship has become a huge and sparsely inhabited island. The VLCCs are indeed a dilema to the seaman, as Ralph Hewins wrote in an article appearing in the London Times, "As tankers get bigger and crew size decreases, the problem of lonliness mounts. The officers and men tend to lose touch with reality - sometimes suffering the agonizing biological fears of the prisoner of war - and a general melancholy sets in, which occasionally lands the victim of these unnatural surroundings in a straight jacket.....One might envision as the approaching ideal, after studying the mass of electronic navigational equipment available today, ships exceeding 500,000 tons under the control of one man lolling before a bridge console pressing a button from time to time. Then there will be the last button which, unpressed and by some super-sensitive means, will transmit the warning (to whom is uncertain; perhaps the owners a few thousand miles away ashore) that the man has died at his station or gone mad; while the ship steams on, directed by its computer mind, automatically steered, course automatically plotting itself, automatically warned of collision, making its own pre-planned changes of course, fully programmed to meet all emergencies.[15]

Use of Computers in Ship's Control. The trend towards automation by use of compact solid-state computers in ship's control systems has been gaining momentum over the last few years. Several U. S. ships have been computerized and one, the 38,000 ton, 641 foot, M/V "Sugar Islander", has been certified by the U. S. Coast Guard to operate with an unmanned engineroom.[16] The engineering crew of the Sugar Islander has been reduced to six men, a Chief Engineer and two other officers, two qualified enginemen and a wiper. Of course being a diesel ship, her enginthat automatically shuts down operation in a programmed sequence when abnormal conditions occur such as low water in the boiler, fan failures, gas/air heater failures, etc. The engineering plant is however designed to use the most modern and compact equipment having long life and low maintenance characteristics without which automated control systems would be fraught with difficulties.

Anti-Collision Devices and Automated Navigation Systems. To paraphrase one of the oldest sayings of sailors, "a collison at sea can ruin your entire day," in fact, it could ruin your entire company where a VLCC becomes involved. A rupture in only one tank on an average size VLCC could dump as much as 50,000 tons of oil into the sea. (Torrey Canyon lost over 100,000 tons of crude) Probable lawsuits that could result from such an accident could add up to a tremendous amount of money. It makes good sense therefore for a ship owner to utilize the most advanced ship's guidance and anti-collision devices available.

Essentially a collision avoidance system is no more than a computerized radar which correlates data from as many as 64 separate "contacts" or other ships within a given range, displays this information to the deck watch officer, and provides warning of those ships which will approach within a given distance or which have no appreciable bearing drift. There are a number of such systems on the market in a variety of sophistications.[17]

find their way into predominance. Their reasons were quite simply the higher costs of maintenance for steam plants compared to gas turbines and the assumption that nuclear power had too far to go to be economically acceptable and operationally reliable.

Nuclear power propulsion systems may not be so far off as Ohashi and Komoto seem to think. The reason is evident, the high price of fuel oil. Another is the rising cost of VLCCs - approaching $100 million each. At these prices the estimated $25 million cost for a high performance 120,000 shp nuclear power plant becomes less significant.[21] There is the added return of higher speed from nuclear power that will enable a VLCC to make more trips per year than the conventionally powered VLCC. Such an investment could result in a tremendous payoff for the shipping company that goes nuclear.

<u>VLCC Shiphandling Characteristics.</u> In 1957 it was said by a leading naval architect that "a supertanker can be as dangerous at sea as an express train without brakes".[22] This may be overstating the case as it is today, but it is clear that the increased size of ships is producing a new set of maritime problems.

Mid sized VLCCs of 200,000 dwt will run on for 10 miles or more after stopping the engines if no further action is taken. In part, the very existance of VLCCs is due to the economical low power propulsion systems installed per ton of ship that still provides an adequate speed. This fact, together with single screw design, severely limits maneuverability. The free running distance may be reduced by reversing engines to a distance of about 2.5 mi for a 200,000 dwt tanker (5000 nautical yards) assuming the ship was proceeding at full speed before reversing engines.[23] As a rule of thumb, astern horsepower is about one-third of the ahead hp due to propeller and steam turbine designs. The use of water brakes, such as flapped rudders whose side plates are hinged on the leading edge, which may be opened to about 35 degrees on each side of the centerline to receive the braking action of the propeller slip-stream, water parachutes, drogue anchors and other types of brake flaps have all been tried at one time or another but with no real solution to the problem of absorbing the tremendous stresses involved. The magnitude of the control problem can be appreciated by comparison of the liner United States and a typical sized VLCC five times the weight of the liner but with only one-eighteenth of the power per ton installed!

The most important factor in connection with collision and groundings - two of the most common casualties that can occur to a ship - is the "crash stop" or, "emergency stop" ability. Unfortunately, the ability of the VLCCs to come to an emergency stop as compared to smaller vessels, has decreased as size has increased. While there has been an enormous increase in the size of tankers their speed has remained rather constant at 14 to 17 knots or, about the same as the World War II T-2 tankers. The fully loaded cruising speed of the 483,644 dwt Globtik Tokyo for example is 14.68 knots.[24] Since the energy to be absorbed in stopping a ship is directly proportional to her displacement, the distance and time required to bring her to an emergency stop from full ahead has increased tremendously. This can be seen vividly by comparing a 17,000 dwt T-2 tanker, which can come to an emergency stop within a half a mile in five minutes, with the stopping distance for a 200,000 dwt VLCC which requires approximately 2.5 miles and takes 21 minutes. By extrapolation, for the 500,000 dwt VLCC, the straight line stopping distance for an emergency stop would be about 4.5 to 5 miles and would take nearly 30 minutes. During the period of backing full, the ship's master is unable to steer her or regulate the speed. In yet another awesome fact, the engines on Globtik Tokyo were stopped and not put astern during sea trials. It took the vessel in excess of one hour to run her way off and come to a complete stop. To add to these phenomena is the factor that as speed of the VLCC decreases its maneuverability drops off sharply. At half speed for example the VLCC is virtually unmaneuverable. What all this means is that the crews who navigate these ships must exercise a much higher degree of viligence, and be able to anticipate their next maneuver.

The inability of the VLCC to stop within a reasonably short than the forward light. Owing to the design of VLCCs, the after light is carried on the radar mast above the after superstructure. This means that there may be a distance of from 700 to 900 feet or more horizontally between the two lights. It is not so surprising that an observer on another vessel could mistake the lights for two vessels instead of a single ship 1,000 feet or more in length. This did in fact happen in a collision in Tokyo Bay between the 1,135 foot Universe Daphne and a small merchant freighter because the master of the smaller vessel believed the Universe Daphne to be two separate vessels. To solve this midship lighting problem for the VLCCs, the U. S. delegation to the 1972 IMCO Rules of the Road Conference suggested that a Rule similar to Rule 9 of the U. S. Great Lakes Rules which requires the long Great Lakes ore carriers to show a white light every 100 feet along the main deck, be adopted. This Rule has been in effect on the Great Lakes since 1895, and since that time, there have been no collisions caused by an ore carrier being mistaken for two vessels. However helpful this U. S. suggestion might appear, I can see a problem with it because the Great Lakes ore carriers are designed with their pilot houses and conning stations in the fore part of the ship whereas the VLCCs invariably have their pilot houses and conning stations aft. The lumination from the numerous lights along the hull of the VLCC, even when shielded from direct view of the crew, would no doubt cause a deterioration of night vision for the bridge watch that would defeat the purpose of such lighting. I don't believe that lights every 100 feet are necessary, and would suggest use of blue lights every 200 feet or perhaps a different mastheat/rangelight arrangement that might include three lights, ie., two range lights on the same horizontal plane aft separated by at least 15 feet. Meanwhile, in waiting for the new Rules to be ratified and placed in effect (no earlier than 1976) some VLCC masters are following the practice of sailing ships which, when underway in congested waters will reflect floodlights off their sails. The VLCCs (noted in Japanese waters) are illuminating the superstructure and midships sections of their vessels with lights not specifically provided for in the present Rules. The result is that there is a rapid trend towards distinctive lights on ships outside the Rules which does not solve any problem except perhaps for the VLCC.

To give an example of how confusing and traumatic lights at sea can be, I was once in a formation of 20 Navy ships in the Western Mediterranean, steaming at darken ship (no lights showing) with two aircraft carriers and two cruisers in the center of the formation about which sixteen destroyers were arranged in a double circular screen. Sometime during the night the formation entered into a meeting situation with a well lighted merchant vessel. The formation remained darkened until the merchantman had penetrated the screen of destroyers. The Officer in Tactical Command had given a signal for all ships to maneuver independently to avoid shipping but as the situation deteriorated someone must have alerted the Admiral to the potentially dangerous situation and he ordered the formation to light ship. The merchantman became confused and disoriented and immediately changed course - right into the path of one of the carriers and a collision occurred.[1] Thus there is the arguement of no lights, too many lights or, a lack of good judgement. Perhaps there was a little of each. I have mentioned this incident only because it points out the fact that lights at sea can reveal, confuse and/or conceal and there must be a single prescribed rule for lights for all to follow.

What is Safe Speed? In Part I, the so-called emergency-stop characteristic of VLCCs was discussed. One of the most important ramifications of the inability to stop within a reasonably short distance is that most of the very large tankers, the VLCCs and the ULCCs. cannot operate today within the restrictions established by the present Rules of the Road.

Rule 16 of the present Rules states:

> "Every vessel, ..., shall, in fog, mist, falling snow, heavy rainstorms or any other conditions similarly restricting visibility, go at a moderate speed, having careful regard to the existing circumstances and conditions."

The admiralty courts have almost always held that "moderate speed" is the speed at which a vessel can stop within one-half the distance of visibility. Since a VLCC cannot be maneuvered readily when moving much below half speed, and not at all (for all means and purposes) below five knots, and cannot be stopped in less than two or three miles, the inability of such ships to comply with this rule is apparent. To comply would mean that the largest VLCC would have to come to a complete stop whenever the visibility decreased to less than five miles! There is no easy solution to this perplexity for to change or relax the Rule would be chaotic for the majority of merchant vessels.

Traffic Separation Schemes. In 1966, the total volume of seaborne oil moved by 3,654 ocean tankers was 935 million tons.[2] By 1983, the total volume of oil moved by sea is forecast to be 3,350 million tons by 4,400 tankers, and by the turn of the century, a volume of 13,400 million tons is projected.[3] These are clear indicators of the magnitude of the navigational problem for the future and the need for traffic control or, separation, to minimize the collision risk between ships plying the same shipping routes.

A further need for ship routing has evolved from the exploitation of offshore petroleum and natural gas discoveries. With several hundred mobile and stationary drilling rigs on the open sea, each valued from 5 - 50 million dollars, located all over the world, the dilineation of "fairways" for ships has become a necessity. In 1964, Great Britain passed a law making it illegal for ships to approach within 500 meters of any drilling rig, principally to prevent wake damage and the possibility of a blowout. Gary Knight points out that the existing system of voluntary shipping safety fairways utilized by the U. S. in the Gulf of Mexico has not been particularly effective and that it may be necessary to assert some limited proprietary rights in areas of the high seas to protect the international communities interest in safe navigation by designating certain corridors as mandatory routes for shipping.[4]

A significant accomplishment of the 1972 IMCO Rules of the Road revision has been the consolidation of a variety of traffic separation schemes into a well defined set of mandatory regulations which will apply to only traffic control schemes approved by IMCO. The traffic schemes have been listed in an IMCO publication[5] which includes a list of advisories for operating in and around sea lanes and traffic separation schemes. Because of the significance of this Rule I think it is appropriate to quote and comment upon it. The proposed Rule states:

Rule 10

Traffic Separation Schemes

(a) This rule applies to traffic separation schemes adopted by the organization.

(b) A vessel using a traffic separation scheme shall:

(i) Proceed in the appropriate traffic lane in the general direction of traffic flow for that lane;

(ii) So far as practicable keep clear of a traffic separation line or separation zone;

(iii) Normally join or leave a traffic lane at the termination of the lane, but when joining or leaving from the side shall do so at as small an angle to the general direction of traffic flow as practicable.

(c) A vessel shall so far as practicable avoid crossing a traffic lane, but if obliged to do so shall cross as nearly as practicable at right angles to the general direction of traffic flow.

(d) Inshore traffic zones shall not normally be used by through traffic which can safely use the appropriate traffic lane within the adjacent traffic separation scheme.

(e) A vessel, other than a crossing vessel, shall not normally enter a separation zone or cross a separation line except:

(i) In cases of emergency to avoid immediate danger;

(ii) To engage in fishing within a separation zone.

(f) A vessel navigating in areas near the termination of traffic separation schemes shall do so with particular caution.

(g) A vessel shall, so far as practicable, avoid anchoring in a traffic separation scheme or in areas near its termination.

(h) A vessel not using a traffic separation scheme shall avoid it by as wide a margin as is practicable.

(i) A vessel engaged in fishing shall not impede the passage of any vessel following a traffic lane.

might involve major damage and pollution from a fully loaded VLCC. The Japanese ports - all of them - are among the most congested in the world, as anyone who has ever transited the Inland Sea or steamed up Tokyo Bay will readily agree. In 1973 Japan enacted a Maritime Traffic Safety Law which establishes special rules for vessel movements under the control of the Maritime Safety Agency (MSA).[6]

Two types of vessels are subject to the rules and regulations set forth under the new law (1) ships over 200 meters in length (640 feet) and (2) ships laden with dangerous cargos such as liquid natural gas or explosives or certain chemicals. Essentially the rules are divided into three sections which are:

(a) the display of underway signals by day and night,

(b) the filing of a plan of intended movement over prescribed routes established by the MSA,

(c) compliance with the advisory instructions issued by MSA control offices.

The underway signals are the same as those mentioned in the foregoing under Rule 28 for vessels "constrained by draught". The difference is that vessels over 200 meters which must carry the special signal may be highly maneuverable and not constrained by draught. This conflicts with the IMCO Rule change. Vessels carrying dangerous cargos are required to fly the Bravo flag by

(j) A vessel of less than 20 meters in length, or a sailing vessel, shall not impede the safe passage of a power driven vessel following a traffic lane.

The importance of traffic separation and traffic lanes is emphasized by the VLCC which cannot maneuver smartly and must look seven or eight miles ahead and think a half hour ahead to keep out of trouble. One of the busiest waterways in the world, the English Channel, has a voluntary traffic separation scheme which many think should become mandatory. An IMCO publication, "Ships' Routeing and Traffic Separation Schemes" describes the English Channel System as follows:

> "The separation of traffic in the area is achieved by its division by natural obstacles situated along the middle parts of the Strait.
>
> Traffic lanes of the scheme are areas between the obstacles mentioned above and boundaries of the inshore traffic zone defined below.
>
> It is recommended that the north-east bound ships should use the passage near the French coast, whilst ships moving in the opposite direction should navigate in the passage between Sandettie-Varne Banks and the English coast...
>
> The arrows printed on the chart to indicate tracks are intended to give the general direction of traffic flow only; ships need not set their courses strictly along the arrows."

Appendix IV provides a general idea of the overall traffic control scheme which IMCO has approved.

Japanese Maritime Safety Law of 1973. Nations such as Japan that are so dependent on waterborne commerce cannot risk the high cost of maritime accidents, particularly those which significantly, however traffic density has. There are a number of reasons for this, greater concentration of ship movements on a limited number of trade routes, increased vessel size which limits the ports in which the larger vessels can be accomodated and the increased time a ship spends at sea. In the case of the VLCC, approximately 80 per cent of her time is spent in transit. Along with this increase in traffic density, the hazards of collision have also increased from an average of less than 100 per year in the ten year period 1950 - 1960 to an average of over 150 per year in the ten years from 1960 - 1970.[7] Yet when this somewhat alarming statistic is compared to other marine hazards such as groundings or fires and explosions, it ranks a far third with percentages of 44, 15 and 12 respectively.[8] In other words, in an average year, using the 1960-1970 figures, we can expect 66 vessels to run aground, about 23 that will be victims of fire and/or explosions and 18 in collisions. Since it usually takes two ships to make a collision, this means an average of only 9 such accidents where accidental pollution might result. Further, the percentage of collisions occuring on the open sea is just 9 per cent of the total for all collisions and herein lies the most significant reason for the establishment of traffic separation schemes. The higher incidence (91 per cent) of collisions within the coastal zones subjects the area to greater incidental pollution, real and potential. With regard to the greatest pollution threat - tankers, 25 per cent of collisions at sea involve tanker types due largely to the increased time this type spends at sea compared to other type vessels. In other words, the risk of collision for a tanker is about one in four in any given year. As the tanker fleet increases in numbers over the next decade, as many predict it will, the risk of collision most likely will increase too as will the incidence of accidental oil spills.

The 1972 IMCO revision to the Rules of the Road might seem to go overboard with regard to the prevention of collision, but in view of the location such accidents mostly occur, the emphasis seems to be justified. The imposition of mandatory sea lanes and traffic separation schemes would be a step in the right direction towards minimizing the number one hazard to ships, that of running aground. If such a Rule was in effect in 1967, the Torrey Canyon disaster might not of occurred. The most unfortunate result of groundings is that almost always they occur within the coastal zone and result in almost one-half of the accidental oil pollution occurring there. Being the most productive area of the ocean in terms of total dollar value, the coastal zone would really be hard hit where one of today's "popular size" (380,000 dwt) VLCCs were to duplicate the Torrey Canyon accident. The magnitude of such a disaster would be difficult to comprehend and almost impossible to project where the vessel concerned might be a VLCC day (a bright red flag) and by night to display a flashing red light, flashing 120 times per minute, in addition to regular running lights.

Ships must file a movement plan by noon preceeding their day of transit in any of the prescribed traffic lanes by notifying the appropriate MSA Office and provide: (1) the name and gross tonnage of the ship (2) length and draught (3) international call sign and methods of communication to be used (4) destination and (5) estimated times of transit. In addition, ships carrying dangerous cargo must report the type of cargo aboard.

Ships intending to transit one of the prescribed channels must comply with four basic instructions: (1) establish and maintain contact with the appropriate MSA Office at least three hours prior to arrival (2) change their time of arrival if so instructed by the MSA Office (3) proceed at an assigned speed and (4) make no transit in poor visibility.

Its too early to evaluate the Japanese scheme as to its effectiveness and there have been problems with VLCCs and crossing traffic. It is noted that other such schemes, such as that in effect in the Dover Straits has tended to reduce collision incidence and inprove traffic flow.

Collisions Versus Other Hazards. Over the years since World War II, the total number of seagoing vessels has not increased of 500,000 dwt or more. The Torrey Canyon lost her entire cargo of 36 million gallons of crude oil to the sea off Land's End whereas if we were to project the 153 million gallons that a VLCC the size of the Globtik Tokyo will carry, dump that into the English Channel, the result would probably be more enduring and quite catastrophic.

Multiple Use Conflicts Facing the VLCC. The accidents that have been referred to in the preceeding are examples of the growing problem of multiple-use conflicts in the coastal areas as well as in the open ocean areas of the world. These examples represent problems that specifically involve ocean transport and which represent conflicts with the potential for creating damage for third parties. It is not my intention to enter a lengthy discussion of use conflicts here, but indeed the VLCC introduces a great many new conflicts as well as the more common. Competition with others for use of the oceans for the same purpose and competition with others for use of the same ocean space but for different purposes such as deep water oil exploration and exploitation, fishing and recreation are only a few conflict areas. The traditional concept of freedom of the seas - for a vessel to sail or steam, wherever and whenever it chooses - seems to be gaining obsolescence and in need of reassessment.

vessels the plan becomes only partially successful. This is not to imply that mandatory traffic schemes are the ultimate solution to the problem of collision, but they do represent a giant step in the right direction towards solving multiple use conflicts. If for example, the imposition of mandatory traffic separation and sea lane routings were to reduce the incidence of major collisions by perhaps 50 per cent, which is a realistic albeit conservative goal, the savings to the shipping industry and third parties would be astronomical. Sea Lane advisories to avoid shoals, deep water drilling rigs, storms, etc, such as the U. S. Navy's Optimum Track Routing System is suggested. Also, it might be useful to incorporate route plans, such as the Navy's Movement Report System under some form of international control which could negate a route that was considered too hazardous.

In conclusion, it is extremely important that nations be provided some form of protection in the control of shipping within their coastal zones. The Traffic Separation Scheme proposed in the 1972 Rules revision provides a vehicle by which this control can be exercised but only if such a Rule is made mandatory. The question arises then, do coastal states have this right? It may become an irrelevant question overtaken by events should the upcoming Law of the Sea Conference adopt a change to the 3 mile territorial waters limit, increasing the limit to 12 miles or more. Only time will tell.

18. "On Export Freedom's Bridge - A Computerized Man-Machine Combination", Marine Engineering/Log, November 1973, p. 25.

19. "Optimum Propulsion Installations for Four Different Types of Ships", Shipping World and Shipbuilder, July 1973, p. 805.

20. Ibid.

21. "Speculation on the Million Ton Ship", Surveyor, February 1973, p. 12.

22. Phillips-Birt, "The Future of Ships", p. 76.

23. Ibid.

24. "The ULCC: Lowering the Cost From Well to Refinery", Marine Engineering/Log, July 1973, p. 30.

Part II

1. Collision between the U. S. Aircraft Carrier Franklin D. Roosevelt and a French Merchant Ship occuring in 1961.

2. Beattie, "Safer Saner Seaways", p. 38.

3. Ibid.

4. Knight, "Legal Problems of Offshore Deep Draft Port Facilities", p. 117.

5. Ships' Routeing and Traffic Separation Schemes. To be listed in this publication, schemes must have adequate control facilities, navigational aids, and a means of enforcement.

6. Saunders, "The Japanese Maritime Safety Law: A workable Compromise", p. 105.

7. Frankel, "Approaches to the Creation of Systems for Reducing Risks", p. 54.

8. Ibid.

SUMMARIZATION

PART III

After proceeding at some length to describe the nature of the VLCC and attempt to impress upon the reader the emmense proportions and inherent limitations of these monsters of the sea, I can only hope that an appreciation has been gained with which one can realize the potential hazards involved without closer regulation. As I started research for this paper, I had in the back of my mind thought of just how does one stop a 500,000 dwt tanker plodding along at 15 knots if an emergency situation arose. The answer is quite obvious, you can't. The 1972 Rules revision by IMCO takes this situation into consideration only by continuing use of the old Rule concerning safe speed, however the vagueness of what speed is a safe speed for a VLCC still prevails. It would appear that decision will have to be deferred to await an admiralty court decision to set a precept.

By far the most useful and most significant change to the Rules of the Road is the introduction of Rule 10 concerning Traffic Separation Schemes and IMCO's influence over high density traffic areas such as the Straits of Dover, Gibraltar, the Dardanelles/Bosporous and a half-dozen others which are, or should be, under IMCOs approval authority. Once established, and approved by IMCO, it is my belief that the traffic separation scheme should become a mandatory scheme, for without mandatory compliance by all

Notes

Part I

1. Miller, "Indonesia's Archipelago Doctrine and Japan's Jugular", p. 27.

2. B. J. Abrahamsson & J. L. Steckler, "Strategic Aspects of Sea-Borne Oil", p. 7.

3. "Orderbook Hits 100 Million GT, An All-time Shipbuilding Record", Marine Engineering/Log, Yearbook Issue, June 1973, p. 123.

4. "Speculation on the Million Ton Ship", Surveyor, February 1973, p. 12.

5. Ibid.

6. Ibid.

7. Ibid. P. 13.

8. "A Million Ton Ship on the Horizon?", Marine Engineering/Log, April 1973, p. 86.

9. Phillips-Birt, "The Future of Ships", p. 42.

10. "Mobil Pegasus, Japanese Built Tanker With A Double Bottom", Shipping World and Shipbuilder, March 1970, p. 400.

11. Ibid. p. 401.

12. "Explosions in Tankers", Shipping World and Shipbuilder, March 1970, pp. 421-424.

13. "Oil Pollution", Marine Engineering/Log, June 1973, pp. 25-29.

14. "Marine Pollution", Shipping World and Shipbuilder, April 1973, p. 435.

15. Phillips-Birt, "The Future of Ships", p. 78-79.

16. "First U. S.- Flag Ship Certified for Unattended Engineroom", Marine Engineering/Log, November 1973, p. 36

17. Among some of the most popular collision avoidance systems on the market are: Automated Marine international, ITT-Decca Marine, Raytheon, Marine Digital Systems, Kockums, Nordata, Sperry and several others.

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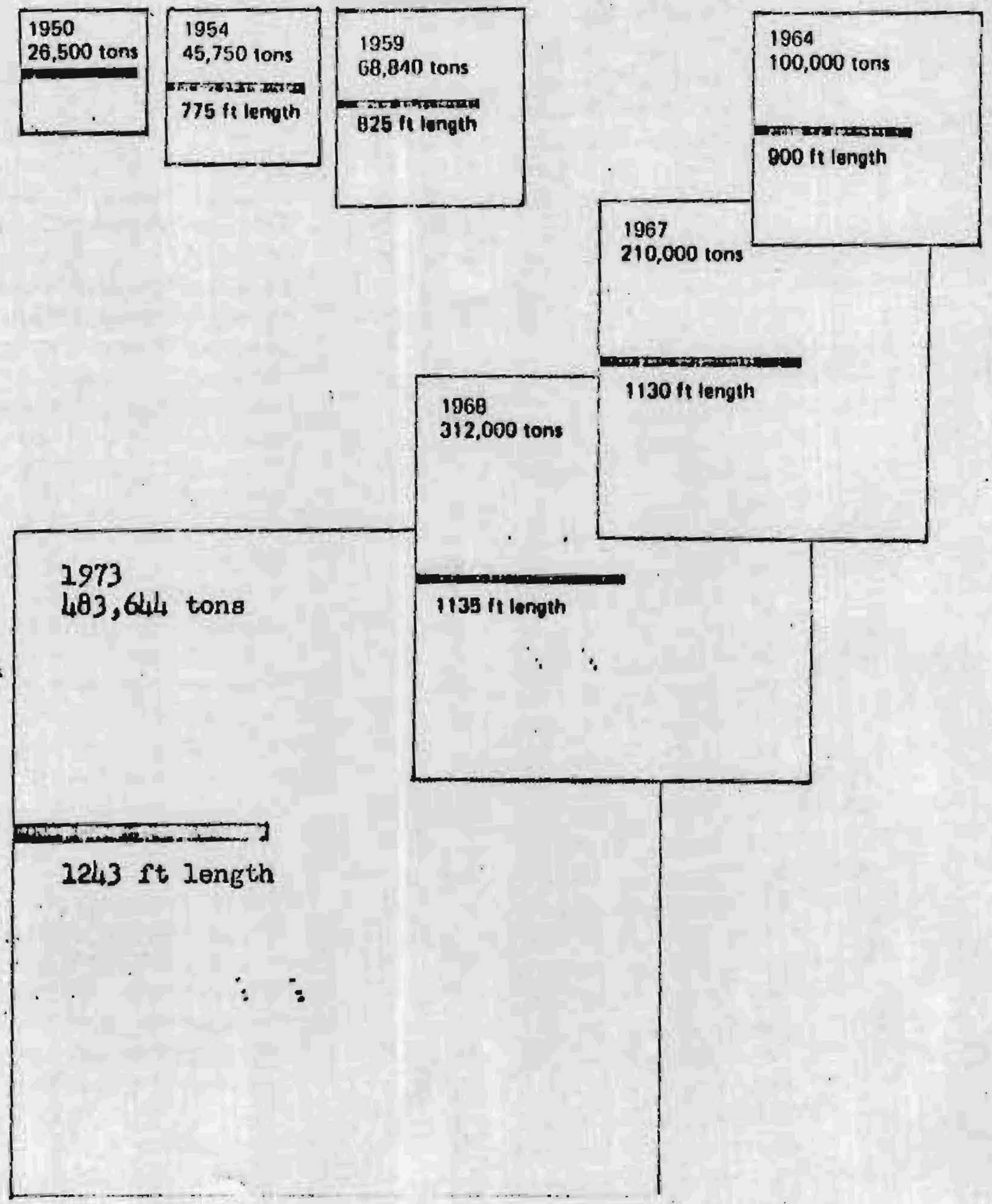
APPENDIX I

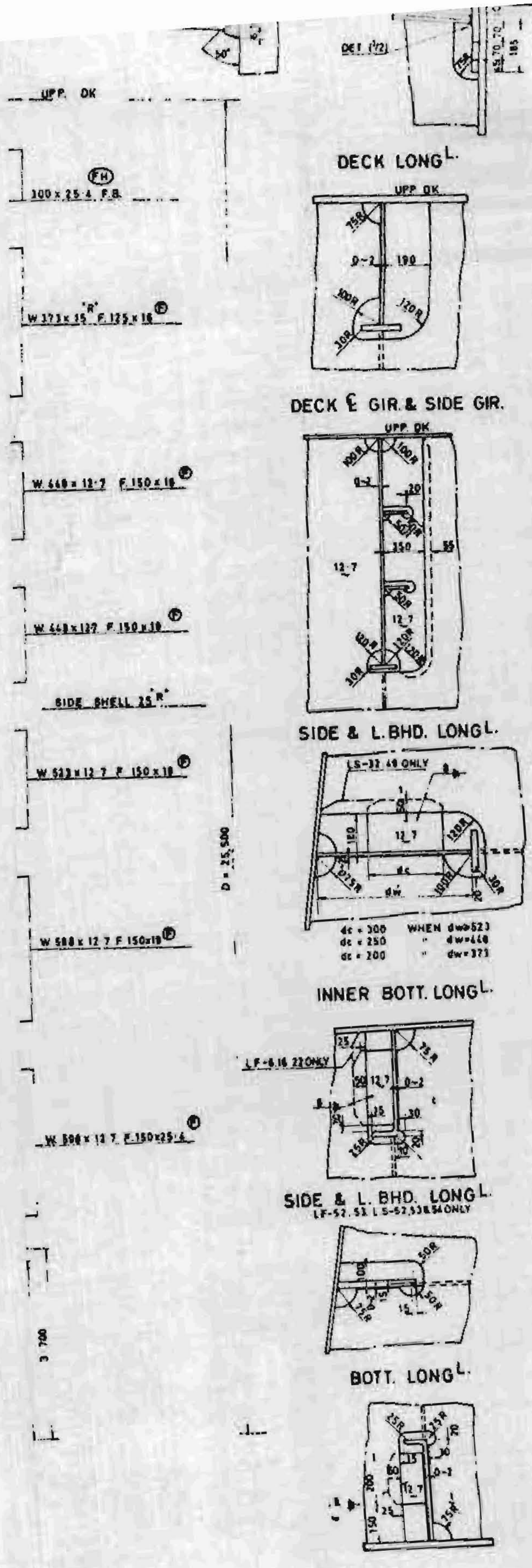
APPENDIX I

COMPARATIVE GROWTH IN DEADWEIGHT CAPACITY OF TANKER SHIPS



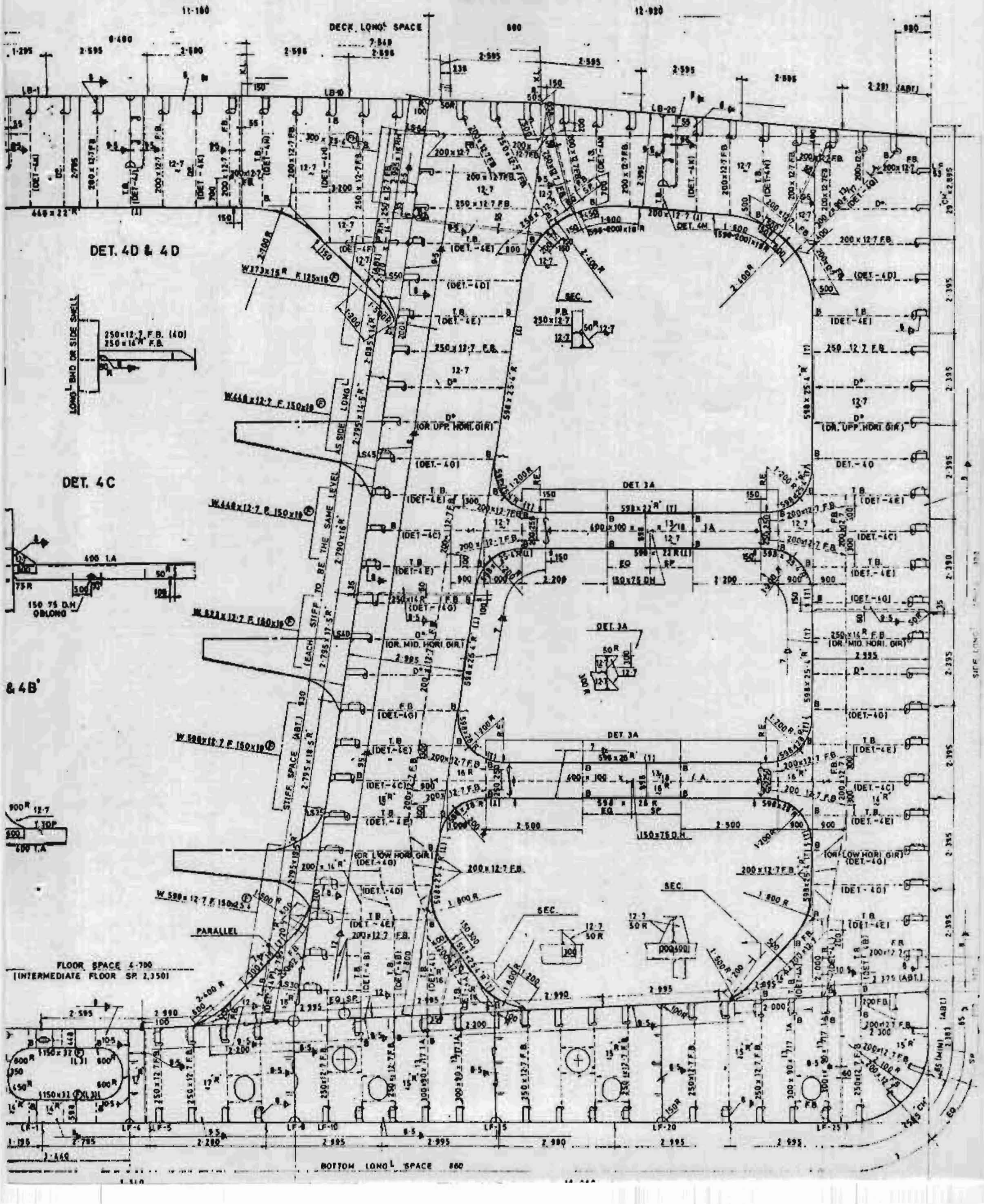
Note: The areas of the squares are proportional to deadweight tonnage. Lengths are indicated by the dark horizontal lines. Capacity increases as the cube of the length, hence, increases in vessel length are less spectacular than deadweight tonnage.

APPENDIX II

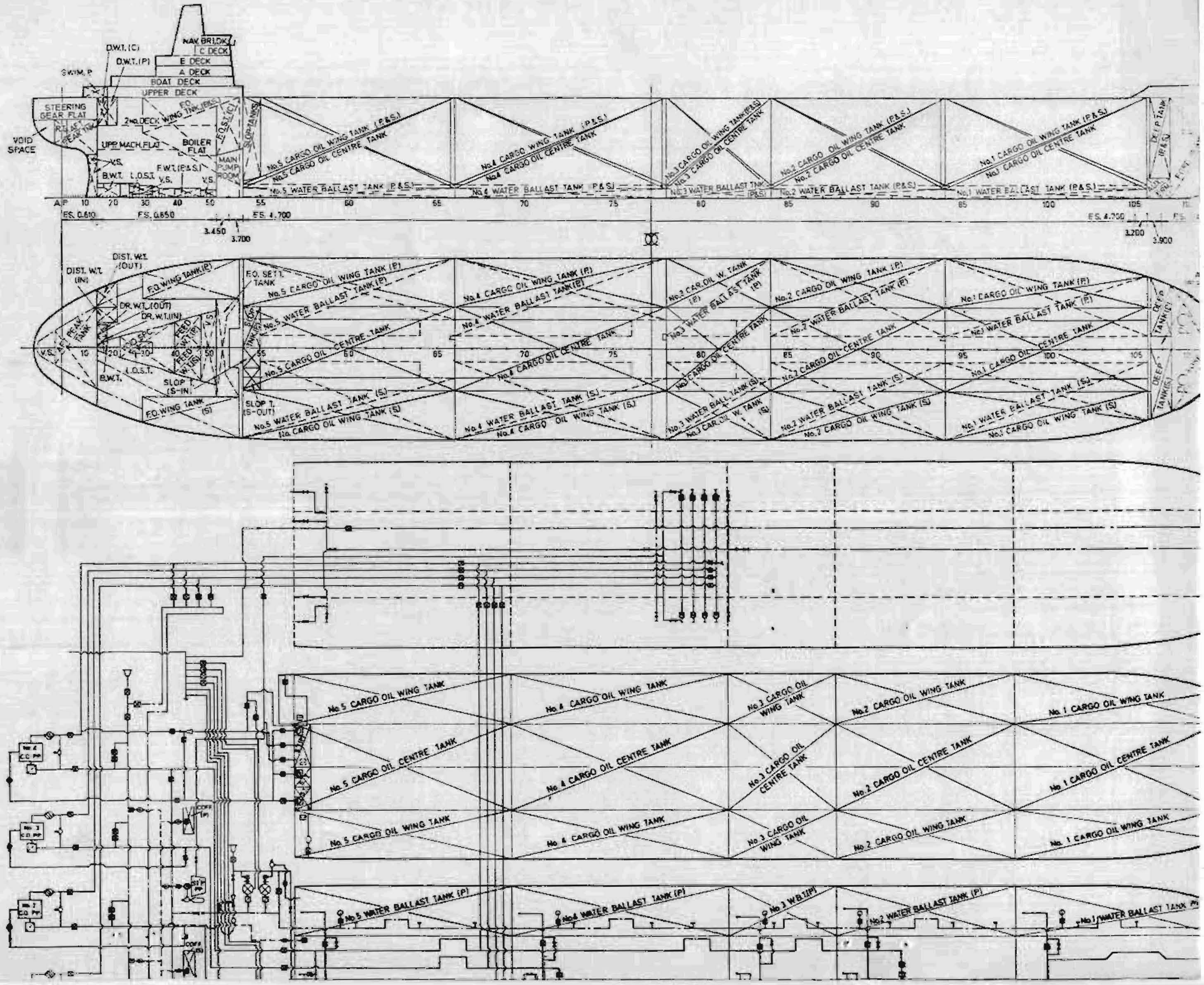


'Mobil Pegasus'

APPENDIX II
DESIGN DETAIL OF THE MOBIL PEGASUS



DECK LONGL SPACE 800
DET. 4D & 4D
DET. 4C
& 4B'
DET. 3A
FLOOR SPACE 4.700
(INTERMEDIATE FLOOR SP. 2,350)
PARALLEL
BOTTOM LONGL SPACE 860
SIDE LONGL
(EACH STIFF TO BE THE SAME LEVEL AS SIDE LONGL)
STIFF SPACE (ABT) 930
(OR. UPP. HORI. GIR)
(OR. MID. HORI. GIR)
(OR. LOW HORI. GIR)
LONGL BHD OR SIDE SHELL
150 75 D.H OBLONG


NAV BRIDK
C DECK
E DECK
A DECK
BOAT DECK
UPPER DECK
D.W.T. (C)
D.W.T. (P)
SWIM. P
STEERING GEAR FLAT
VOID SPACE
2nd DECK
F.O. WING TNK (P&S)
F.O.S.T. (C)
SLOP TANKS
UPP. MACH. FLAT
BOILER FLAT
MAIN PUMP ROOM
V.S.
B.W.T.
L.O.S.T.
F.W.T. (P&S)
No.5 CARGO OIL WING TANK (P&S)
No.5 CARGO OIL CENTRE TANK
No.5 WATER BALLAST TANK (P&S)
No.4 CARGO WING TANK (P&S)
No.4 CARGO OIL CENTRE TANK
No.4 WATER BALLAST TANK (P&S)
No.3 CARGO OIL WING TANK (P&S)
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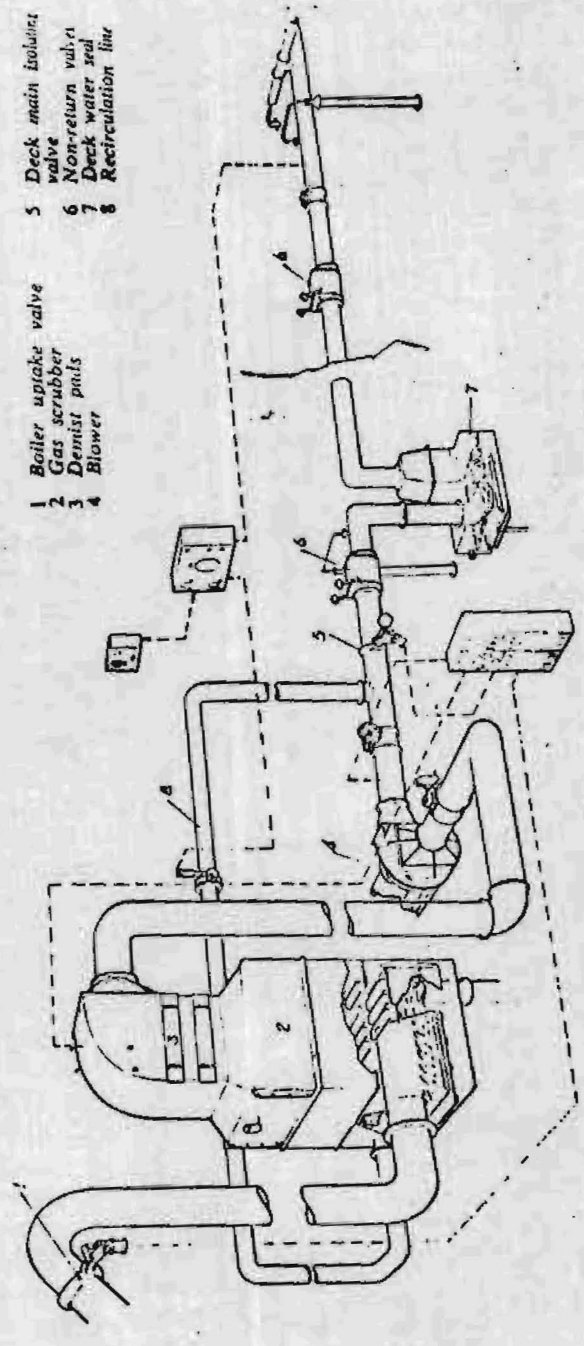
No.2 CARGO OIL CENTRE TANK
No.2 WATER BALLAST TANK (P&S)
No.1 CARGO OIL WING TANK (P&S)
No.1 CARGO OIL CENTRE TANK
No.1 WATER BALLAST TANK (P&S)
DEEP TANK (P&S)
A.P.
F.S. 0.610
F.S. 0.650
F.S. 4.700
3.450
3.700
3.200
3.900
DIST. W.T. (IN)
DIST. W.T. (OUT)
AFT PEAK TANK
DR. W.T. (OUT)
DR. W.T. (IN)
FEED W.T. (P)
FEED W.T. (S)
F.O. WING TANK (P)
F.O. WING TANK (S)
F.O. SETT. TANK
SLOP T. (S-IN)
SLOP T. (S-OUT)
SLOP TNK (P)
No.5 CARGO OIL WING TANK (P)
No.5 WATER BALLAST TANK (P)
No.5 CARGO OIL CENTRE TANK
No.5 WATER BALLAST TANK (S)
No.5 CARGO OIL WING TANK (S)
No.4 CARGO OIL WING TANK (P)
No.4 WATER BALLAST TANK (P)
No.4 CARGO OIL CENTRE TANK
No.4 WATER BALLAST TANK (S)
No.4 CARGO OIL WING TANK (S)
No.3 CAR. OIL W. TANK (P)
No.3 WATER BALLAST TANK (P)
No.3 CARGO OIL CENTRE TANK
No.3 WATER BALL. TANK (S)
No.3 CAR. OIL W. TANK (S)
No.2 CARGO OIL WING TANK (P)
No.2 WATER BALLAST TANK (P)
No.2 CARGO OIL CENTRE TANK
No.2 WATER BALLAST TANK (S)
No.2 CARGO OIL WING TANK (S)
No.1 CARGO OIL WING TANK (P)
No.1 WATER BALLAST TANK (P)
No.1 CARGO OIL CENTRE TANK
No.1 WATER BALLAST TANK (S)
No.1 CARGO OIL WING TANK (S)
DEEP TANK (C)
DEEP TANK (S)
No.5 CARGO OIL WING TANK
No.4 CARGO OIL WING TANK
No.3 CARGO OIL WING TANK
No.2 CARGO OIL WING TANK
No.1 CARGO OIL WING TANK
No.5 CARGO OIL CENTRE TANK
No.4 CARGO OIL CENTRE TANK
No.3 CARGO OIL CENTRE TANK
No.2 CARGO OIL CENTRE TANK
No.1 CARGO OIL CENTRE TANK
No.5 WATER BALLAST TANK (P)
No.4 WATER BALLAST TANK (P)
No.3 W.B.T. (P)
No.2 WATER BALLAST TANK (P)
No.1 WATER BALLAST TANK (P)
No.4 C.O. PP
No.3 C.O. PP
No.2 C.O. PP

APPENDIX III

APPENDIX III

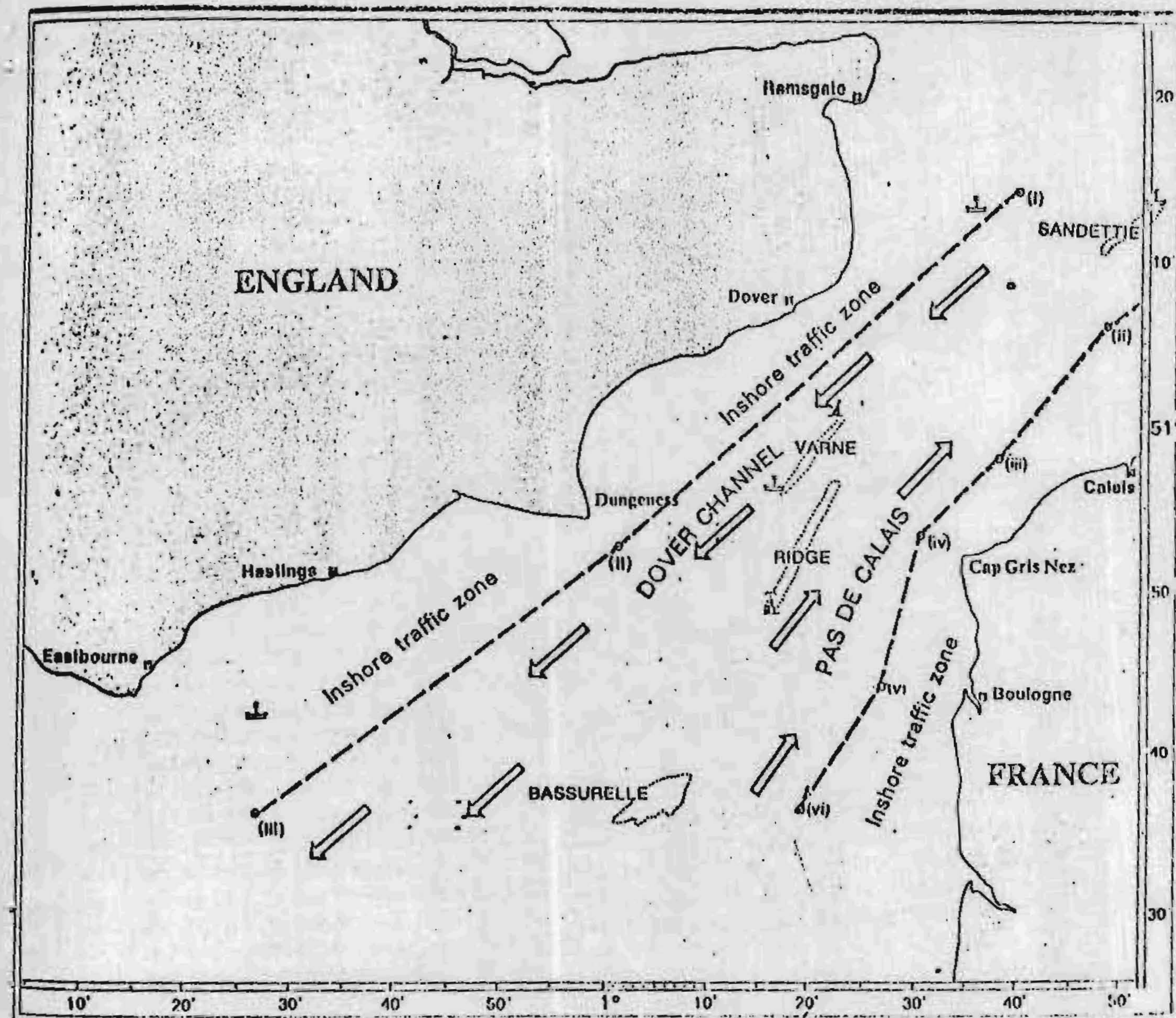


Airscrew-Axia inert gas system

APPENDIX IV

APPENDIX IV

TRAFFIC CONTROL SCHEME FOR DOVER STRAITS



APPENDIX V

APPENDIX V

GLOSSARY OF TERMS

Cargo Tonnage

Classified as either "weight" or "measurement". A "weight" ton of cargo is 2,240 pounds, and a "measurement" ton of cargo is 40 cubic feet. Freight rates on general cargo are usually quoted in dollars per ton, weight or measurement, at the ship's option. This means that the specified rate per ton will be applied either to a weight ton or to a measurement ton, whichever will result in the higher revenue, depending upon whether a weight ton of the cargo occupies more or less than 40 cubic feet.

Deadweight Tonnage

The term "Total (vessel) Deadweight" is used to express the total weight carrying capacity of a ship including cargo, fuel oil, crew, fresh water, stores, etc. "Cargo Deadweight" is used to express the cargo carrying capacity of the ship.

Displacement, Light

The weight, in tons of 2,240 pounds, of a vessel excluding cargo, passengers, fuel, water, stores, dunnage, and other items necessary for use on a voyage.

Displacement, Loaded

The weight, in tons of 2,240 pounds, of a vessel including cargo, passengers, fuel, water, stores, dunnage, and other items necessary for use on a voyage which brings a vessel down to her maximum permissible draft.

Dunnage

Wood boards of various sizes used to shore up cargo in transit.

Essential Trade Route (Area)

A route between ports in a U. S. coastal area or areas and a specific foreign coastal area or areas which has been determined by the Maritime Administration to be essential for the promotion development, expansion, and maintenance of the foreign commerce of the U. S.

Gross Tonnage

The entire internal cubic capacity of a ship expressed in tons of 100 cubic feet to the ton, except for certain spaces such as inner bottom peak tanks, peak and other tanks for water ballast open forecastle bridge and poop, shelter deck spaces, excess of hatchways, certain light and air spaces, domes and skylights, wheelhouse, galley, cabins for passengers, and certain other spaces.

Liquid Cargo

Bulk - Commodities in liquid form transported in tankers or in deep tanks of dry cargo ships.

Ships, Types of

Bulk Carriers - Ships carrying dry bulk cargoes such as wheat or coal - as distinguished from tankers, another form of bulk carrier.

Tanker Ship - A ship designed to carry liquid cargoes in bulk quantities, especially petroleum.

Trade Route (Area)

A trade route (area) is a specifically designated channel through which the commerce of the U. S. flows between a particular U. S. coastal area or areas and a specific foreign coastal area or areas.

Ullage

The usual way of measuring the amount of oil in the cargo tanks of oil tankers is to measure the distance from the top of the hatch, or from the top of the inspection cover in the hatch, down to the surface of the oil. This distance is called ullage and the corresponding capacity tables are known as ullage tables.

Weights and Conversion Factors

@ 1 Ft^3 = 7.48 gallons
* 1 Bbl = 42 gal. or 5.61 Ft^3

Quantity	Water		Oil		
	Salt	Fresh	Fuel	Diesel	Gasoline
Ft^3 per ton (2240 lb)	35	36	38	41.5	50
Gallons per ton @	-	269.28	284.24	310.42	374.00
Barrels per ton *	-	-	6.768	7.391	8.905
Pounds per gallon	-	-	7.881	7.216	5.989
Pounds per cubic foot	64	62.222	58.947	53.976	44.800
Pounds per barrel	-	-	331	303	251.5

in 1957, and almost all the oil is imported with about 50 per cent of it coming from the Middle East.[2] The United States too has placed increasing demands on imports and since 1968 has consumed more petroleum than she has produced. Much of the imported oil comes from the Middle East. Thus with the Middle East a focal point of oil production, and its customers located at the far corners of the world, the requirement for transporting oil over long distances becomes very obvious. owing to its physical characteristics (lighter than water) and the universal thirst for oil, there is great advantage in being able to transport it in great bulk by sea. The tanker ship has, and is providing this advantage.

Tanker Developments. It is primarily the emmense and ever-increasing demand for oil that has influenced the size of tankers, however world events such as the Suez Crisis of 1956, the emergence of Japan as an industrial giant and the founding of the EEC in 1957 have had their profound influences as well. The threat of a closed Suez created a sharp increase in the demand for tanker capacity by the Europeans and in the U. S. This demand proved a very timely circumstance for the Japanese shipbuilding industry, for they already had plans to build for themselves extraordinarily large oil carriers. The shipyards of Japan provided an exception to the upward spiraling costs of labor and materials in shipbuilding and even more importantly had both the capacity and the technical eering plant is less complicated than the steam turbine plants typical of the VLCC.

The advantages of computerized ship control systems permit greater safety in operation in propulsion and guidance. It can result in improved fuel consumption rates and a reduction in the total number of personnel needed to operate the ship. There are disadvantages too, primarily the reliability of the computer system itself and its maintainability. Some minor problems with electronic interference have also been noted.

A typical digital computerized shipboard control system may consist of a small computer, more probably two, costing as little as $10,000 each. The main computer components feed operator consoles for main propulsion, auxiliary machinery and perhaps one for cargo control. Display panels may be either digital or CRT types. A main propulsion console would be located on the bridge and under normal steaming conditions control would be exercised by the deck watch officer and the entire engineering system monitored by a single engineer on watch. The computer does the rest, monitors all temperature guages and pressure guages, all liquid level indicators and automatically regulates numerous boiler and auxiliary machinery functions, including printouts of bell and engine/boiler performance logs - traditionally done by watch personnel to ensure every engineering plant function was regularly checked. Such an automated system also includes a safety feature

Inertial navigation systems, Loran A and Loran C, Depth recorder navigation, and computerized DR systems are only a few devices available to render the sextant obsolete. Many of the VLCCs incorporate all of these systems, or at least a combination of three or four that compliment one another to ensure exact position fixing so essential for efficient operations and the avoidance of disasters such as Torrey Canyon. Current efforts are to marry the collision avoidance system computers to accomodate the navigation systems thereby consolidating computers and reducing costs.[18]

VLCC Propulsion Systems. Of VLCCs above 200,000 dwt built during 1970, 68 were steam turbine and only two were slow speed diesel powered, and during 1971, these figures were 63 and 5 respectively. During 1972, 69 VLCCs delivered had steam turbine systems and 10 were slow speed diesel, and during 1973, steam turbines outnumbered diesels by 72 to 10.[19] As can been seen from these figures, the steam turbine systems predominate the VLCC fleet. In an article appearing in a recent issue of Shipping World and Shipbuilder, Ohashi and Komoto[20] drew some comparisons between the two systems in discussing the future of gas turbine engines. It was their opinion that steam turbines will maintain their predominance in the VLCC market for the time being but that medium speed diesels would replace slow speed diesels and gas turbines gradually enter and distance creates a unique set of circumstances with respect to regulations set forth in the International Rules of the Road. Clearly the VLCCs are "outside the law" so to speak - at least in terms of their maneuverability and size.

Part II of this paper will discuss the current rules and their relationship to the VLCC and what is being done, or should be done to remedy the problem.

VLCCs AND RULES OF THE ROAD

PART II

Introduction. In Part I it was intended to create a basic understanding of the intracacies of the VLCC in terms of cost, their many advantages as well as their limitations, for it is these limitations that are so important in discussion of rules governing ships at sea. I hope it is obvious from the foregoing discussion that VLCCs have a tremendous pollution potential in event of a major accident such as collision or grounding. I hope it is also evident from the foregoing that shipowners and operators are acutely aware of the considerable investment they have in each VLCC and consequently have gone to extensive efforts to protect this investment by hiring the best possible crews, by installing complex collision prevention systems and devices to protect their ship and cargo and hence to help control pollution. Still, the beast is vulnerable by its size and limited maneuverability. Not only are they vulnerable unto themselves but to others of their class and particularly to smaller, faster ships and vice versa. It brings to my mind the destroyer - aircraft carrier relationship and my own somewhat facetious rule of thumb that if you are on a destroyer at sea and can visually sight an aircraft carrier, you are too close. But then I'm somewhat biased about that, I've been involved in two destroyer-aircraft carrier collisions. Be this as it may, it does not solve the problems confronting VLCCs on the high seas and preventing collisions, rules alone cannot do this. To this end however, there are Rules to prevent collisions at sea that have existed for many years. The presently effective Rules (1960) have recently been revised because of the spectacular increase in the size and more limited maneuverability of ships.

Accomodating the VLCC in New Rules of the Road. Late in 1972 delegates from 46 nations met at the Inter-Governmental Maritime Consultive Organization (IMCO) building in London to revise the 1960 International Rules of the Road for the Prevention of Collisions. One of the most significant changes that was adopted was that which provides definition to the VLCC and accords such vessels with specific "privilege".

The matter of privilege is new with regard to the existing Rules, although it has been implied. For example, ships not under command (breakdown) and ships engaged in special operations that restrict their maneuverability such as replenishment and refueling at sea and the launching and recovery of aircraft, have been entitled to show distinctive signals. Although the signal displays have not carried with them a specific obligation for another ship (which might have the right of way) to remain clear, admiralty courts have traditionally respected such signals to imply privilege and a responsibility for the other vessel to give way.

A brief explanation is in order here, under the Rules, the privileged vessel is that which in a crossing situation, holds the other vessel off its port side. It is the responsibility of the other vessel (the burdened vessel) to give way to the privileged vessel and the responsibility of the privileged vessel to maintain her course and speed. In effect the IMCO revision gives privilege to the VLCC (and other vessels under certain circumstances) due to limited maneuverability. The revised Rule governing responsibilities between vessels states:

> "Any vessel other than a vessel not under command or a vessel restricted in her ability to maneuver shall, if the circumstances of the case admit, avoid impeding the safe passage of a vessel constrained by her draught, exhibiting the signals of Rule 28".

In clarification, Rule 28 calls for display of three vertically arranged, all-around red lights (by night) where they can be best seen and by day, a black cylinder of not less than two feet in diameter and a length of not less than 3.5 feet where it can be best seen.

Also included in the revised Rules is a somewhat ambiguous definition intended to apply to VLCCs. The Rule adopted states:

"Rule 3 (h)

> The term, "vessel constrained by her draught" means a power driven vessel which because of her draught in relation to the available depth of the water is severely restricted in her ability to deviate from the course she is following."

Unfortunately the wording "vessel constrained by her draught" could be applied to a vessel with a five foot draught having difficulty steering in six feet of water. Such a vessel could show three vertical red lights and expect privilege where not other vessel would impede her passage.

Another aspect of this new Rule which questions its wording is that no shipping company or prudent ship's master will allow his ship to be loaded to the point where they are unable to steer her. The ship may need tugs to assist her in shallow harbors and approaches when using slow speeds, but it is very unlikely that the VLCCs will be incapable of maneuvering on the high seas because of their draught in relation to the depth of the water. The more significan problem of the VLCC is slowing, or stopping, and not so much steering as pointed out in Part I.

The reasoning behind the wording and the degree of privilege accorded to the VLCC under the new Rules is made clearer by reviewing Rule 25 (Narrow Channel Rule) from the currently effective Rules. This Rule (25(c) states:

> "In a narrow channel a powerdriven vessel of less than 65 feet in length shall not hamper the safe passage of a vessel which can navigate only inside the channel."

This Rules means that a vessel over 65 feet in length, ie., a 70 foot fishing vessel, can require a VLCC to give way in a crossing situation, according to the letter of the law, if the fishing vessel is the privileged vessel. Placing this situation in perspective such as the narrows of the Straits of Malacca and Singapore where the navigable channel is no more than 1.5 miles in width, such a Rule represents a serious problem for the VLCC if such vessels are not accorded special privilege.

One can assume that the Rule governing responsibilities between ships is straightforward enough to preclude problems such as that mentioned above, however the terms "constrained by her draught" and "available depth of water" are subject to open interpretation. Hopefully the admiralty courts will not conclude that this is a matter of steering ability but will interpret the wording to mean that a very large vessel in a narrow channel or in an approved shipping lane, in congested waters, is not obliged to alter course and that other vessels should give way. Only the practice of mariners and eventual rulings of the admiralty courts will determine whether or not the new Rules will accomplish their purpose.

Rules Concerning Additional Lights for VLCCs. Another area of the IMCO Rules revision concerns Rules which prescribe lights for vessels underway and at anchor (excluding the special lights mentioned above). Rule 2 prescribes that when underway, a light shall be carried in the fore part of the vessel and a second light (both white lights) shall be carried abaft the forward light. The after light shall be carried at least 15 feet higher