The Petroleum Handbook

been invested in organic petroleum-based chemical plants in the UK and the European Economic Community countries. The heavy investment involved in establishing manufacturing capacity on a worthwhile scale, means that petroleum chemical production is very much the preserve of large concerns – primarily major chemical companies and oil companies. On an investment basis oil companies and their subsidiaries account for only about one-third of petroleum chemical capacity in the world outside North America and the Sino-Soviet spheres. Thus the manufacture of chemicals from petroleum is by no means the private preserve of the oil companies.

It seems certain that world demand for organic chemicals will continue to grow rapidly for many years, and that by far the greater part of this new demand will have to be satisfied by petroleum raw materials. In the areas outside North America and the Sino-Soviet spheres for example, it is estimated that total output of petroleum-based organic chemicals will rather more than double during the next five years. This should create few major raw material problems, since at present chemicals manufacture accounts for little more than 2 % of world consumption of crude oil and natural gas.

Transport

Many main producing areas of crude oil and natural gas are remote from the main consuming areas of the world. The efficient movement of oil over great distances is therefore an integral part of the oil business. Oil and oil products are transported in bulk mainly by tankers and pipelines.

Tankers

Water transport is normally much cheaper than other means, and tankers are used whenever possible. The growth of world tanker tonnage since World War II has been enormous, corresponding with the increased demand for oil, and is expected to continue steadily in the future. Fig. 3 shows the growth not only in tonnage but also in size, an important development in recent years permitting considerable economies in freighting costs.

As stated earlier, oil is much the largest single commodity in international seaborne trade. In 1964, the total was approximately 800 million tons, and iron ore came second and well below with 160 million tons. It is estimated that on any day an average of more than 30 million tons of oil cargoes are at sea valued at well over £200 million.

The pattern of this seaborne trade has changed in two ways since pre-war days. Firstly, the change from refining near source to refining near point of consumption has resulted in a preponderance of crude over refined products in the cargoes. Secondly, the development of production in the Middle East and the changed role of the USA from a net exporter to a net importer has entirely changed the quantity and direction of oil movement as shown in Figs 4 and 5. The pre-war flow of exports (mainly products) to Europe from the USA and the Caribbean has been largely, though not entirely replaced by an enormous increase in the flow of exports (mainly crude oil) from the Middle East to Europe.

Pipelines

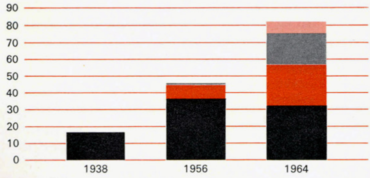
Pipelines provide the only form of long distance continuous transport for oil and gas. Their main uses are to gather crude oil from producing points and transport it to shipping or refining centres, and to carry refined products and natural gas to consumers.

The economics of pipelines are such that unit costs fall as throughputs and capacities increase. At present the practicable limit for pipe diameters is 42 in., corresponding to a throughput of 40–50 million tons/year, but the future may bring still larger sizes.

Extensive networks of pipelines have existed for many years in North America and the Middle East, whilst in recent years their development in Europe and other areas has been rapid and is expected to continue. For certain landlocked oilfields (Canada, the Middle East, North Africa) pipelines furnish the only access to the sea; similarly large inland refineries are unthinkable without pipelines from the coast.

Other means

Apart from this international bulk transport of crude and refined products on a large scale, the delivery of oil products to the consumer entails the smaller scale use of bulk transport by road, rail and water within the consuming area, for which special facilities and equipment have to be provided. Here too there has been an enormous increase in the amount of material transported and great developments in equipment.



Tankers dwt	1938	1956	1964
	million	deadweight	tons
Over 70 000	—	—	6·3
45 – 70 000	—	0·4	18·2
24 – 40 000	—	8·3	25·4
Up to 25 000	16·6	35·8	31·4
	16·6	44·5	81·3

Fig. 3 Growth of world tanker tonnage

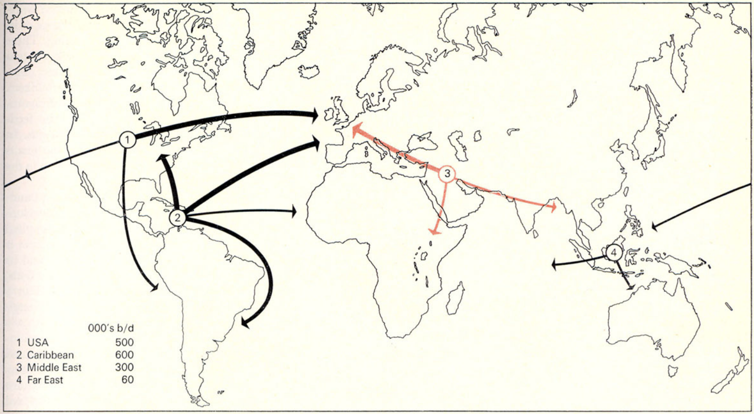


Fig. 4 International movements from major oil producing centres, 1938

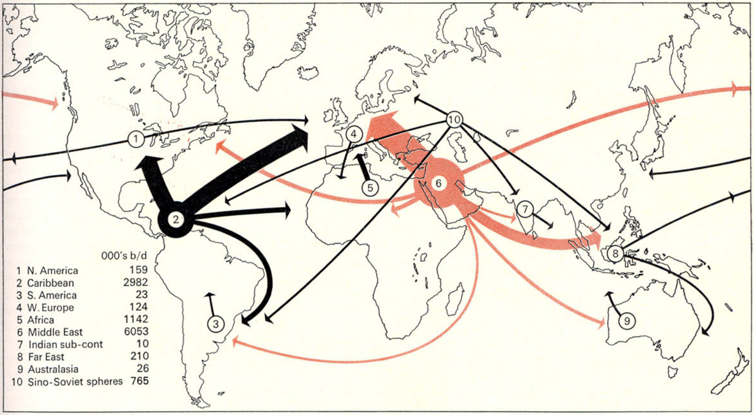


Fig. 5 International movements from major oil producing centres, 1963

Marketing

Marketing – the selling and delivery of oil products and chemicals to the customer – is the ultimate link in the long chain of oil operations which starts with exploration. Moreover, it earns the revenue that finances all other phases of the business and provides a surplus for further investment.

Marketing in the petroleum industry is not merely selling what is produced; it is more concerned with satisfying the customers' needs. It thus has a dual responsibility; to the customer in finding out and satisfying his needs, to the industry in informing the manufacturing side of what the customer requires or is likely to require and of ensuring long-term and profitable outlets for its products.

interests in oilfields in twenty countries. Oil available from production and supply contracts totalled over 3 million barrels/day.

Nearly one-sixth of the world's tanker tonnage is managed or chartered by Group companies – the largest maritime enterprise in the world, comprising about 470 vessels totalling 13 million tons deadweight. Group companies also own or participate in 35 800 miles of pipelines handling crude oil, oil products or natural gas.

There are some seventy-seven refineries operated, under construction or projected by Group companies in forty-four countries and 3·4 million barrels/day of crude oil were refined by Group companies in 1964.

Group companies market in almost every country and supply nearly one seventh of the world's consumption of oil products outside the Sino-Soviet spheres. The USA is the largest single outlet for oil products although Group sales in Europe as a whole are higher than in the USA and Canada combined. In Europe, Group companies hold the largest share of the market – about 21 %. Group companies are the principal suppliers of aviation fuels to the world's airlines, and leading suppliers of fuels and lubricants for shipping.

Group companies have an important share of world gas reserves and have taken a prominent pioneering part in the growing natural gas business. BPM has a half share in the company that discovered in the Netherlands, one of the largest gas fields in the world and other Group companies are developing local markets for natural gas in Germany, Nigeria, East Pakistan and New Zealand. Group companies also have a 40 % interest in Conch International Methane Limited who hold valuable patents for transporting refrigerated natural gas by sea.

Group companies' interests in chemical manufacture taken together are larger than those of any other oil group and, on the basis of sales proceeds, they rank twelfth among the major chemical producers in the world. Manufacture of chemicals by Group companies is carried out in eleven countries.

Group companies carry out research in connection with all spheres of their activities, employing some 7000 people in twenty-seven research establishments.

The rapid expansion in world-wide consumption of oil products and chemicals calls for ever-increasing capital expenditure by Group companies to ensure that products are available when and where required in the quantities and qualities needed. It is expected that by 1970 the world will be consuming at least a further 11 million barrels/day of petroleum products in addition to the 29 million barrels a day consumed in 1964. Tables 9 and 10 give some idea of the expansion that has taken place within the Group to meet growing demands in the past. With their world-wide sources of supply, intensive and widespread search for new sources, and forward-looking programmes of research, Group companies are well equipped to continue to meet growing demands and to maintain their place in the forefront of the oil and chemical industries.

Table 10 Tanker tonnage

Thousands dwt

End of year	World	Group owned/ managed	Group chartered	Group total
1907	962	142	15	157
1914	2338	265	45	310
1938	16600	1410	529	1939
1956	44377	3021	5610	8631
1963	74982	4182	7517	11699

Tankers

History and development

When the economic history of the twentieth century comes to be written, the amazing developments in the transport of oil by sea will form an interesting chapter. We who are living during the course of these changes cannot see the whole picture, and he would be a bold man who would say that the limits of progress have been reached; but a brief survey of developments up to the present day will give a sufficient indication of the revolutionary changes which have taken and are taking place.

When oil first entered into international trade about one hundred years ago its transport by sea was, like that of most other cargoes, effected in specially made containers. At first wooden barrels were used, but these were subsequently replaced by large iron tanks fitted into the hull of the ship. As the economies of bulk transport became evident, the idea was conceived of using the hull of the vessel itself as the oil container. This necessitated the use of iron ships, instead of the wooden vessels previously employed, and constituted the main principle in the development of the tanker as we know it today.

Probably the first ocean-going vessel constructed on these lines was the ss *Glückauf* built in 1885, with a gross tonnage* of 2307 tons. The use of steam machinery and coal-fired boilers in a vessel engaged in oil transport was still in its infancy and was attended by grave risks in view of the highly inflammable nature of the cargo; but such risks are the lot of the pioneer, and subsequent experience showed that running them was well worth-while.

The next landmark was the passage of the Suez Canal by a fully laden tanker, the first Shell tanker, ss *Murex*, of 5010 dwt, built in 1892 at West Hartlepool. After lengthy negotiations with the Canal authorities she undertook her maiden voyage from Batum on the Black Sea to the Far East. The passage through the Suez Canal was completed without incident, despite fears that she might prove a danger to other shipping using the Canal. From this small beginning some seventy years ago, the annual quantity of oil moving through the Canal has continually increased and reached 138 million tons in 1963.

In the early years of the present century the pattern of the oil trade underwent an important change owing to the opening up of the Sumatra and Borneo oilfields. Whereas previously oil was carried only from west to east and dry cargo on the return voyage, the new requirement for oil movements from the East Indies to Europe made it possible to employ vessels exclusively for the carriage of petroleum. This resulted in a change of tanker design and encouraged

* References are made in this chapter to gross and deadweight tonnages. Gross tonnage, broadly speaking, represents the total capacity of all enclosed spaces in the ship, measured in 'tons' of 100 ft^3. Deadweight tonnage (dwt) represents the weight of the cargo, stores, bunkers and water which the ship can lift, expressed in tons of 2240 lb. It is customary when referring to merchant shipping generally to express tonnage figures in terms of gross tons, but statistics relating only to tankers are more often quoted in deadweight tons which is the measurement used in this chapter except where otherwise stated. With a normal tanker of average size, the gross tonnage is usually about two-thirds of the deadweight tonnage.

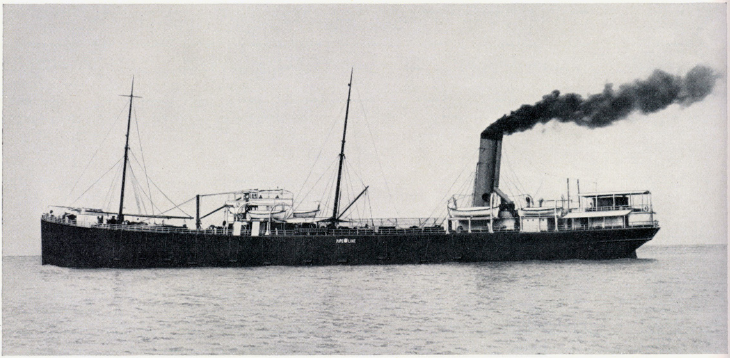


Fig. 211 Shell steam tanker *Volute*, 5670 dwt, built in 1893, a sister ship of ss *Murex*

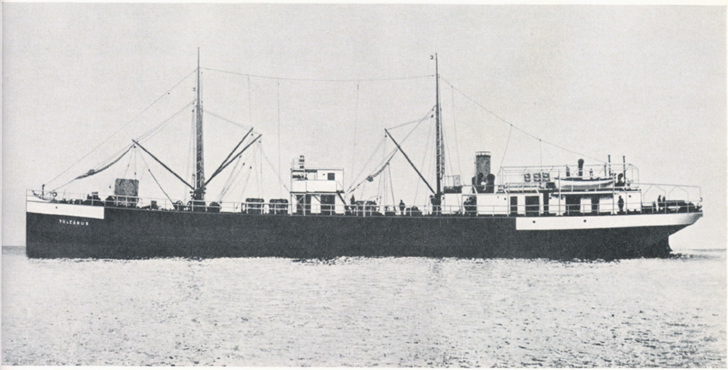


Fig. 212 Shell motor tanker *Vulcanus*, 1215 dwt, built in 1910

some increase in size. At the beginning of the century the total tanker tonnage was half a million tons with an average of 5000 dwt per tanker; by 1914 the total tonnage had increased to 2 million dwt with an average of something over 6000 tons per tanker.

During this period preceding World War I a further development, in which the Royal Dutch/Shell Group played an important part, was the construction of the first ocean-going motor vessel of any kind, the Shell tanker *Vulcanus*, built in 1910. Although only a small vessel of 1215 dwt, she amply proved the advantages of motor propulsion and was the forerunner of a very large number of motor tankers which today represent half the vessels in the world tanker fleet.

The years between the wars were characterized by a policy of consolidation and gradual development in size, speed and technical improvements. The size of the standard tanker rose to 10 000 dwt and later to 12 000 dwt with a speed of 11 knots. Half-hearted attempts were made to push the maximum size up to more than 20 000 dwt but very few large vessels were built. By 1939 the world tanker fleet had grown to more than 1500 vessels totalling 16½ million dwt, of which over 1½ million dwt were owned by Group companies.

The vital need for oil during World War II gave a tremendous impetus to tanker building. The lead was taken by the USA which, having developed a standard tanker of 16 600 dwt with a speed of 14½ knots, proceeded to turn out such vessels in very large numbers. During the years 1942–5 nearly five hundred of these ships, known as T2, were built. Thus, despite heavy war losses, the world tanker fleet by the end of the war had risen to a total of 24 million dwt.

Thereafter began one of the most spectacular advances of shipping history. A number of influences were at work. The growth of the Middle East as a producing centre, the new policy of building refineries in the consuming areas instead of near the oilfields, the enormously increased demand for oil in the industrialized regions and the growing realization of the economies to be secured from the use of larger vessels, all combined to establish a revolution in outlook. Gradually at first, and then at a quickened tempo, tanker owners began to build bigger ships. From 24 000 dwt, claims were made for the world's largest tanker by successive stages at 32 000 dwt, 45 000 dwt, 84 000 dwt and 132 000 dwt; and even larger tankers were planned and ordered. The era of the mammoth tanker had arrived. The output of the world's shipyards increased by leaps and bounds; in 1964 over 8 million dwt of tankers were delivered. By the end of that year, out of a total tanker tonnage of nearly 82 million dwt (more than a third of all merchant shipping throughout the world) about 25 million dwt represented ships larger than 45 000 dwt. In the upper ranges, tankers of more than 70 000 dwt totalled 6 million dwt, with another 8 million dwt of this size group on order. The effect of this growth in tanker size on the shape of the world fleet is illustrated in Table 21.

Table 21 World tanker fleet (2000 dwt and over)

Year	Percentage of total carrying capacity: Up to 25 000 dwt	25 to 45 000 dwt	45 to 70 000 dwt	Over 70 000 dwt
1951	93	7	—	—
1956	78	21	1	—
1961	50	37	11	2
1966 (estimated)	30	29	28	13

Group companies, keeping pace with world expansion, owned or managed at the end of 1964 a fleet of 171 vessels aggregating 4·1 million dwt, and had a further 8·8 million dwt on charter. The total operated fleet represented nearly

16% of all world tanker tonnage. Vessels still to be built for Group ownership at the same date amounted to over 1 300 000 dwt for delivery in the years 1965–7, and included two ships of over 110 000 dwt each. Early in 1965 further orders placed by the Group included four crude carriers of about 165 000 dwt each, the dimensions of which exceeded those of any merchant ship afloat or on order throughout the world at that time.

Classes of tanker

In the drive for ever larger tankers, owners could not, of course, ignore the limitations imposed by port and drydock facilities or by the maximum permitted draft for Suez Canal transit. The tendency in recent years has been to concentrate on three main classes of ocean tanker in conformity with the emerging pattern of trade and the port facilities available.

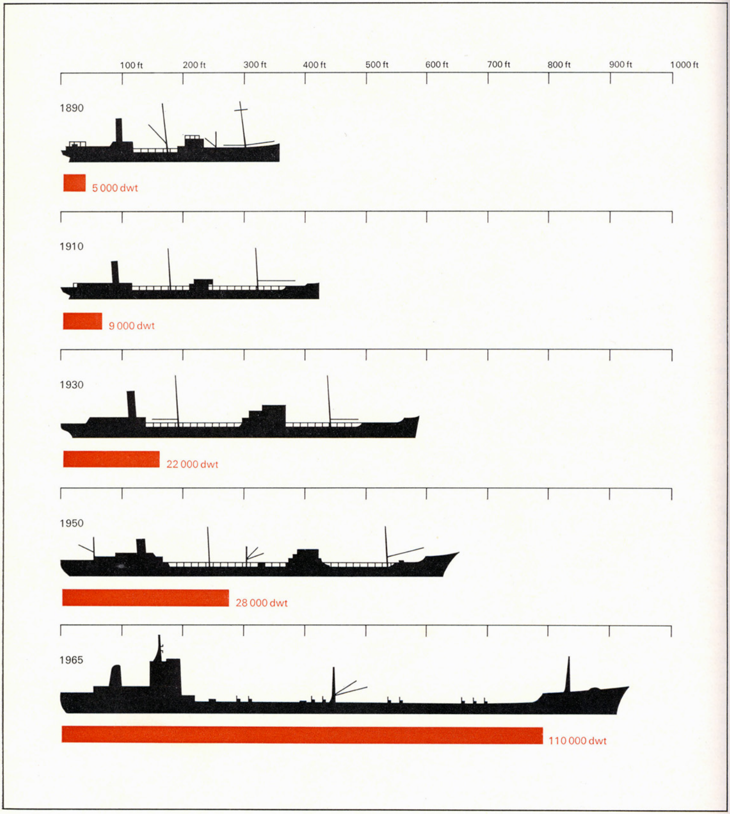


Fig. 213 Development in size, capacity and characteristic appearance of the ocean tanker

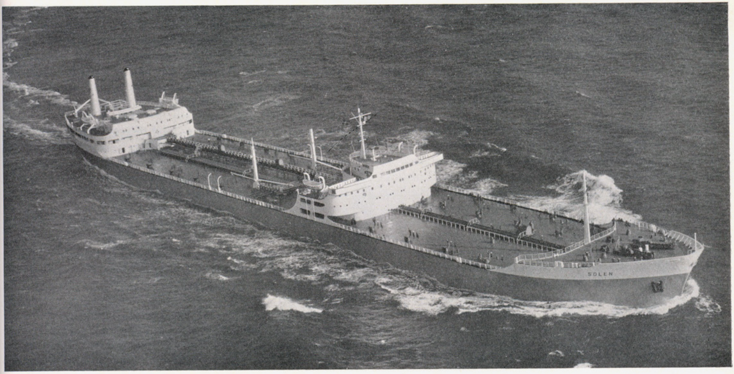


Fig. 214 ss *Solen*, 67 848 dwt, built in 1961

Firstly, the general-purpose ship of 15 000–25 000 dwt and 14–15 knots, which can be accommodated at most oil ports and carries all the more important types of oil cargo, mainly refined products. Secondly, for the ferrying of crude oil in large quantities from oilfields to distant refineries, the 'work-horses' of up to about 70 000 tons and 16 knots; at present the majority of these are around 30 000–40 000 dwt but as the new, larger ships come into service, the average size will move towards the upper ranges. Thirdly, the crude carriers of over 70 000 dwt which cannot pass through the Suez Canal on full draft and can enter only a limited number of loading and discharging ports. These ships tend to be employed regularly on the same run and may be described as the 'liners' of the oil trade.

The tanker market differentiates between two types of trade, referred to respectively as 'white' and 'black', or 'clean' and 'dirty'. This has no reference to the cleanliness of the ships – the Master of a tanker trading dirty would justifiably resent any suggestion that his ship was not spick and span – but merely indicates the type of oil cargo which she is carrying. Clean cargoes, which are mainly carried in general-purpose tankers, consist of the highly refined products such as aviation and motor gasoline; dirty cargoes include crude oil, fuel oil and diesel fuels. Dirty tankers are usually fitted with heating coils in the cargo tanks in order to maintain a sufficiently high temperature to keep the oil in a fluid state for easy discharge. Formerly it was the practice to commit a products tanker to clean oil trading for a number of years and then transfer her to the black oil trade because the steel cargo tanks were more vulnerable to corrosion by clean oils than by black oils. Great progress has since been made in corrosion control by tank painting and other techniques in place of, or supplementary to, cathodic protection and it is no longer necessary to transfer from clean to black solely for corrosion prevention. Transfers from one class of trade to the other may sometimes be necessary for operational reasons, but a switch from black to clean is avoided as far as possible because of the expense and delay involved in tank cleaning, without which the highly refined cargoes would be ruined by residues left from the previous black oil cargo. Moreover, only a limited number of ships are suitable for white oil trading.

These classifications are extremely important for the tanker-operating companies. Having made a close estimate of the requirements of their trade for as far ahead as is deemed necessary, they endeavour to have available a fleet which is closely matched to those requirements, both in total quantity and in classes of tonnage. As an illustration of the respective proportions of each type which may be employed, Fig. 215 shows how the carrying capacity of the Royal Dutch/Shell ocean-going fleet was composed and utilized in 1965.

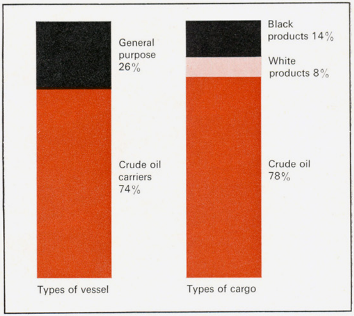


Fig. 215 Composition of the Royal Dutch/Shell fleet, 1965

Specialized tankers

In addition to the main classes of ocean tanker, comprising well over 90% of the total tanker tonnage operating commercially, there is a segment consisting chiefly of ships employed in localized or coastal trades but also including a number of vessels designed for the carriage of particular cargoes.

Bitumen, for example, is solid or nearly solid at normal temperatures and must be carried in ships capable of keeping the cargo at a high temperature during the voyage to ensure that it can be pumped easily on discharge. Lubricating oil, of which there are many grades, requires handling with the greatest care to keep it free from contamination, and if carried in a general-purpose tanker for one voyage only this necessitates expensive tank cleaning before loading and, in some cases, after discharge, and ships may therefore be restricted to this type of cargo for long periods. The transport of chemicals demands a high degree of purity which may call for specially protected tanks and, with a large number of comparatively small parcels of different grades, completely segregated pipelines and pumps.

The size and number of liquefied petroleum gas (LPG) carriers, chiefly for the transport of propane and butane, have increased over the past few years, mainly because of development in the use of 'cooling' techniques. Previously, the only method used to liquefy the gas, and thus to reduce its volume to manageable proportions for transport by sea, was to compress it into cylindrical containers (often described as 'bottles') in ships specially constructed for the purpose. Most of the vessels engaging in this type of transportation are small, seldom greater than about 3000 tons gas carrying capacity.

A more recent method of transporting LPG is to maintain it at ambient atmospheric pressure by reducing its temperature. Commercial butane liquefies at +6°F (−14·5°C), and commercial propane at −55°F (−48·4°C), both at ambient pressure. There are now a number of LPG carriers in service which carry liquefied gas at low temperatures in insulated tanks. Generally, the gas is cooled in shore refrigeration plants but some ships of this type have plant to cool the cargo as it is loaded (a slow process, however) and most have plant capable of reliquefying the 'boil-off'. For the transport of large quantities over long distances, refrigeration is more economical than pressurization because of the weight of steel saved and the relatively lower cost of the cargo tanks per gas volume. For middle distances and comparatively small quantities, techniques utilizing a combination of both pressure and cooling are often adopted, while for very small quantities the original pressurized method is the most economical.

An important development in marine transportation is the carriage of liquefied natural gas (LNG). Natural gas can be liquefied only by an extreme reduction in temperature, i.e. down to −258°F (−161°C). The very difficult technical problems involved in the ocean transport of a liquid at such a low temperature have been overcome in recent years and the validity of the techniques was established by the prototype vessel ss *Methane Pioneer* in 1959–60, carrying 2000 tons of LNG. Following upon this initial success, the ss *Methane Princess* and the ss *Methane Progress*, each of 12 000 tons capacity, came into service in 1964 as the world's first commercial natural gas carriers. Due to the low specific gravity of the liquefied gas, i.e. 0·42 or roughly half that of crude oil, and also due to the need for completely separate ballast spaces, these vessels have dimensions comparable to those of a crude oil tanker of 28 000 dwt. With a speed of $17\frac{1}{4}$ knots, they were planned to make about thirty round voyages a year each between Arzew on the North African coast and Canvey Island in the UK, with a combined

Fig. 216 ss *Methane Princess*, built in 1964, designed to carry refrigerated LNG

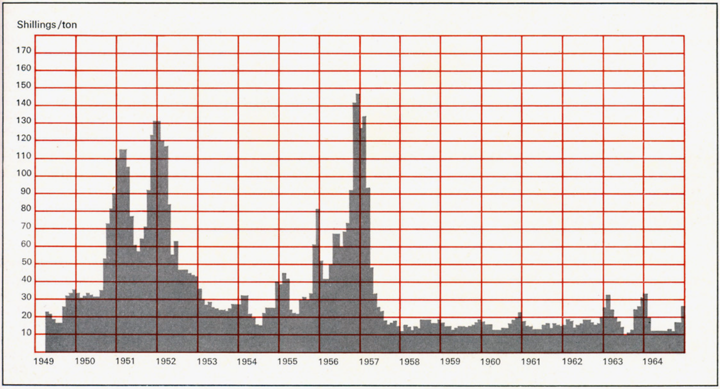


Fig. 217 Tanker single voyage freight rates, 1949-64

annual delivery of 700 000 tons of liquefied gas – some 10% of Britain's gas consumption. Owned respectively by Conch Methane Tankers Ltd, and Methane Tanker Finance Ltd, the ships are operated by Shell Tankers (UK) Ltd, under the British flag. (The handling of LNG is further described under Natural gas, p. 70.)

Organization of the world's tanker fleets

Nearly two-thirds of the world's tanker tonnage operates under the flags of five countries. Before World War II the British and Commomwealth flag fleets were larger than those registered under any other flag, but the severe losses sustained by British owners during the war, coupled with the very large quantity of wartime tanker tonnage constructed in the USA, brought the latter country into top place by 1945. Subsequently, there were large transfers of American tonnage to other flags with the result that by 1965 the USA had dropped to fourth place with 11% of the world total. Norway and Britain held second and third places respectively with 15% and 14%. Japan, with virtually no tanker tonnage after World War II, had risen to fifth place with 5 million tons or 6%, and was still rapidly increasing her tanker fleet. The really striking change of recent years, however, has been the emergence of Liberian flag, from nothing at all in 1945 to first place with 15½ million dwt in 1965, representing 19% of the total. The practice of registering ships under so-called flags of convenience, such as Liberian, which is due to the taxation advantages enjoyed by the owners of ships so registered, has been the subject of much controversy in shipping circles.

Apart from considerations of flag, the three main classes of owner are: the oil companies, who run their ships as part of a fully integrated industry; independent owners without any other stake in the oil industry; and Governments which, in addition to requiring tankers for use as fleet oilers, in some cases desire, for reasons of internal policy, to control the commercial transport of the oil which they import or to engage in international trade with national flag ships.

Before World War II more than 50% of the total world tanker tonnage was owned by the oil companies, but the rapid post-war expansion in the demand for oil, with its consequent heavy burden of capital expenditure in all segments of the industry, made a reduction in this proportion almost inevitable. Many independent shipowners were quick to foresee the new situation and, with complete confidence in the future, took steps to increase their share of the tanker trade. As a result, in 1965 commercial oil companies owned about 34% of the total fleet, independents 57% and Governments 9%.

The role of the independent owner is a vital one. In making their long-term plans for the provision of tonnage, the oil companies, after taking account of their own ships, proceed to charter from the independents the balance of their requirements up to perhaps 90% of the whole, this chartering being done on a period basis for five, seven or even ten or more years. By leaving the remaining, say 10%, unchartered, the oil companies give themselves room for manoeuvre in circumstances of fluctuating demand, and as the actual deficit of tonnage becomes apparent in a short-term review, they secure it, again from the independent owner, by chartering ships for single or consecutive voyages. This system provides the flexibility essential to an industry which is particularly susceptible to seasonal fluctuations and other factors causing rapid swings in demand.

For all that, the system has its demerits, since the law of supply and demand falls upon a comparatively small amount of marginal tonnage with the result that tanker freight rates for these ships are subject to violent changes [Fig. 217]. In 1951–2 and again in 1956, when world requirements tended to outstrip tanker availability, rates rose to very high levels; on each occasion large new building programmes, which in the aggregate proved larger than necessary, were put in hand during the time of shortage, with a resulting surplus of tanker tonnage in the following years, and a consequent slump in rates. No valid solution has yet been offered which will ensure a measure of equilibrium between the demand for tankers and their availability, although in 1963 a number of independent owners pinned their hopes to the Tanker Recovery Scheme, launched by the International Tanker Owners Association. The aim of this scheme was to counteract the continuously depressing effects on tanker freights of a surplus of tonnage, by paying cash allowances out of members' contributions as an inducement to lay-up or scrap eligible tonnage. At the time of writing there was some doubt whether the scheme had attracted sufficient support to ensure its success. Despite the problems of the tanker market, however, the success of the oil companies' operating machinery is evident by the fact that under normal conditions oil consumers all over the world can obtain their supplies as and when required.

This demands frequent and careful reviews of the ever-growing tanker requirements. The oil companies are obviously in a better position than the independent owners to undertake such reviews and thus implement them by placing orders for new ships or by contracting to charter vessels of the size and type required, which independent owners undertake to build or may already have available or on order. The independent owner who elects to build without a charter-party in his pocket is, of course, running the risk that when his ship is ready she may not be able to find employment; but on the other hand there is always the possibility that delivery of the ship may coincide with a tonnage shortage and correspondingly high freight rates.

Obsolescence must naturally be considered in these reviews. For some years after World War II tankers were scrapped, on the average, after a life of about thirty years, but with changed conditions resulting from the rapid expansion in tanker size, most forward estimates regard twenty years as the useful life. As a ship gets older her repair bills tend to become extremely heavy, and a very careful comparative study of costs and potential earnings has to be made as each four-year special survey becomes due. When tanker freights are low it may be cheaper to lay up a vessel than to run her at a loss; or there may be for the independent shipowner the possible alternative of conversion from an oil carrier to a carrier of dry cargo in bulk, depending upon the state of the tramp market. In recent years some two hundred tankers have been converted to dry cargo carrying at an average age of fifteen years per ship, and many others have been temporarily employed in the grain trade when unable to obtain an oil cargo.

Economics of tanker operation

It goes without saying that the relationship between costs and earnings is a matter of prime importance to any shipowner. The vagaries of the tanker freight market, on which earnings depend, have been touched upon in the preceding section. The factors affecting tanker freighting costs are complex, covering as they do the original purchase price of the ship, its size, speed, mode of propulsion, type of fuel, pumping capacity and manning scale. The general rule is that a large ship freights more cheaply than a small one, since building and operating costs do not rise proportionately with increase in size, but the descending curve of freighting costs tends to flatten out when the very large tonnage ranges are reached.

Building costs can vary considerably, not only as regards the cost per deadweight ton for various sizes of ship but also according to the state of the market at the time an order is placed. In the middle 1950s there was not sufficient shipbuilding capacity to meet the great surge in demand for new ships, and owners placing orders at that time had sometimes to wait several years before the ship could be delivered – a seller's market in which prices were high. Ten years later

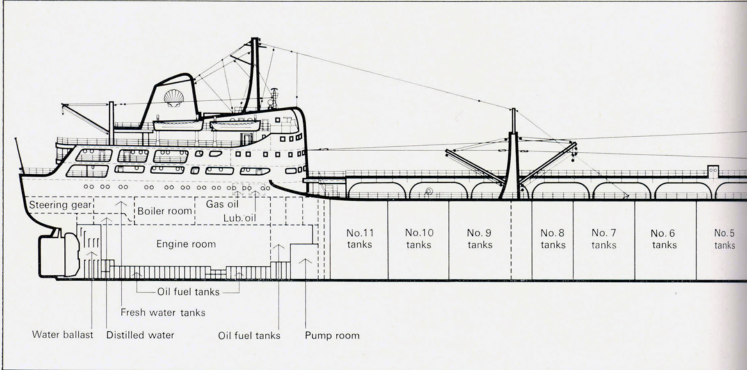
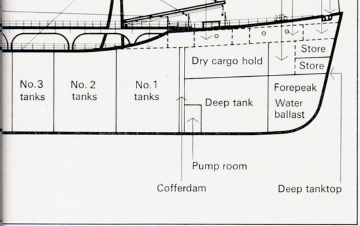


Fig. 218 Profile of a modern 22 000 dwt general-purpose motor tanker

shipbuilding capacity had increased to such an extent that theoretically one-tenth of the entire world merchant fleet could have been replaced every year; consequently competition became fierce and prices slumped. As an illustration of extremes in price fluctuation (a small ship in a dear market and a large ship in a cheap market), the cost of building an 18 000 dwt tanker in a European shipyard in 1956 was over £75/dwt, whereas a 65 000 dwt tanker building in Japan in 1964 cost less than £37/dwt. But even in 1964, the small ship would probably have cost well over £60/dwt.

Whether motor ships are more economical than steam-propelled ships is a question to which there is not at present any final answer; the contest between the two modes of propulsion has continued unabated during the post-war years. Whereas in 1947 only 32% of world tanker tonnage consisted of motor vessels, the proportion had risen to 46% by 1955. With the coming of the large crude carrier, however, the tendency was to change over to steam-propelled ships and relatively few large tankers on order in the middle 1950s were designed as motor ships. Since that time the pendulum has swung again and spectacular development in the 'large bore' diesel field has once more challenged the turbine. For powers up to approximately 25 000 shp either steam or diesel engines are available with the latter claiming more attractive fuel rates. Linked closely with this question is that of the type of fuel consumed. Diesel fuel, formerly the normal fuel for motor vessels, is considerably more expensive than fuel oil, but in recent years marine diesel engines have been able to burn the cheaper oil, largely as a result of the development of improved lubricants.

The pumping capacity of a tanker contributes largely towards the speed of her turnround in port. Having regard to the fact that the daily operating cost of a general-purpose tanker is about £1000 and of the largest crude carrier over £2000, it is clear that all unnecessary port delays must be avoided and the ship must proceed as quickly as possible on the next voyage to help earn her keep. In very general terms,



it can be said that tanker owners have tended to give their ships discharge capabilities roughly equivalent to 10% per hour of the cargo capacity; however, this is by no means a rigid criterion as the equipment of individual ships, as well as the shore receiving facilities, must be related to the economics of the particular trade.

The problem of unremunerative ballast-runs is one which must be faced by every tanker operator. Oil companies with a world-wide trade are sometimes able to reduce the loss of earning time by programming their ships on triangular voyages. Thus, a tanker may carry crude oil from Venezuela to a port in north-west Europe, followed by fuel oil from the United Kingdom to the Canary Isles. This represents a considerable saving in ballast time compared with the employment of two tankers, one on each of the voyages mentioned. With the same object in view, there has in recent years been an expansion in both the number and the size of dual-purpose vessels, designed to carry oil on one leg of a voyage and iron ore on another.

From time to time oil companies have had to consider the relative cost of pipelines and tankers. Over the same distance, tankers can generally be operated more cheaply than a pipeline, but where the pipeline runs more or less as the crow flies while the tanker voyage describes an arc, the pipeline may well be cheaper. A classic example is the line running from the Saudi Arabian oilfields to the Eastern Mediterranean over 1000 miles of country. This can reduce the tanker round voyage by 6000 miles, and also save the expensive Suez Canal dues. However, political problems, and the fact that a pipeline has no alternative uses such as are available to a tanker, can have an important bearing on the issue.

Tanker design and equipment

From the earliest days the propelling machinery of a tanker has nearly always been situated at the after end, as this location avoids the need for an oil-tight propeller shaft tunnel running through the cargo space and thus simplifies design and assists in reducing the initial building cost.

For many years this characteristic made the tanker's silhouette instantly recognizable. Gradually, however, dry cargo shipowners followed suit and silhouettes became remarkably similar; only such features as size, freeboard or decks cluttered with cargo derricks or cranes led a trained eye to differentiate between the two types of ship. By the middle 1950s development had gone a stage further, with the removal of the navigating bridge and accommodation, traditionally maintained amidships, to a position at the after end above the machinery space. Again, this was primarily on grounds of achieving economies in building costs, but with the advent of improvements in navigational aids, cargo handling and mooring arrangements, it was seen as a logical stage in the development of automation and remote control.

Early experience gained with all-aft ships in the smaller general purpose class showed such arrangements to be satisfactory, and larger ships quickly followed the same pattern. All-aft arrangements are now common in all classes of cargo ships and tankers alike, and there are already such tankers of over 100 000 dwt in service.

As can be seen from Fig. 218, the cargo tanks are isolated from the machinery space by a virtually empty space called the pump room. A similar empty space, which traverses the

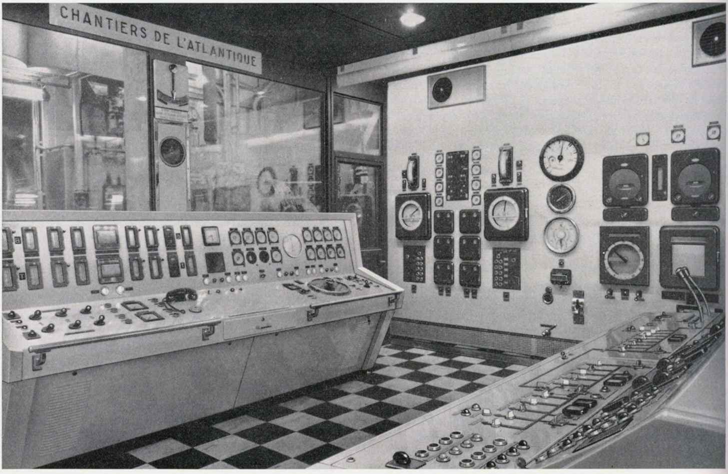


Fig. 219 Engine control centre on Société Maritime Shell's ss *Sivella*, 79 327 dwt, built in 1963

whole breadth of the vessel, and which is termed a cofferdam, may isolate the cargo space from the fore part of the ship, if a permanent ballast tank is not fitted in this position.

The cargo space is sub-divided transversely, and a further sub-division is provided by two longitudinal bulkheads between the forward cofferdam and the pump room. In the particular case illustrated in the diagram, this results in thirty-three separate compartments.

On this ship, in common with most modern tankers, not all of the space is utilized for cargo carrying. Four wing tanks, isolated from the cargo system, are used solely for clean sea-water ballast. As they do not contribute to the cargo-carrying capacity, they are generally exempt from tonnage charges. By reducing the need for carrying ballast in empty cargo tanks, they form a most useful adjunct to the measures employed in combating oil pollution of the sea. Permanent ballast tanks also assist in minimizing delays and reducing turn round times at loading and discharging ports, since the ship can start loading cargo as soon as she moors, or can sail immediately the cargo discharge is completed. In the larger ships currently entering service, empty ballast tanks amidships materially assist in reducing the sagging stresses in large loaded tankers.

A general-purpose tanker such as that shown in the diagram is designed to carry several different grades of cargo. A complex system of cargo pipelines, located at the bottom of the ship, permits a number of grades to be stowed and correctly segregated, and to be loaded or discharged simultaneously without contamination. Loading and discharging are effected from manifolds, generally placed amidships, by means of which shore flexibles can be connected to the ship's pipeline system. The flow of oil into or out of each cargo tank is controlled by valves mounted in the pipeline. The remainder of the pipeline valves and the cargo pumps are usually situated in the cargo pump room, and where this is located adjacent to the engine room the cargo pump prime movers are normally found there. Gas-tight seals are fitted to the pump drive shafts at the engine room/pump room bulkhead.

Larger tankers are basically constructed and equipped in the same way. When only homogeneous cargoes such as crude oil are carried, however, present practice is to simplify the design still further by the introduction of fewer, but much longer cargo tanks. No stability difficulties have been encountered on such ships, and the problem of oil surging in long tanks has been satisfactorily resolved. Cargo-handling methods have also advanced and cargo pipelines are tending to be used to a lesser extent on crude carriers, free-flow systems being adopted in their place. Here openings in the steel walls at the bottom of the tanks take the place of the conventional pipeline valves, and cargo flows from tank to tank through these openings, controlled, again from the deck above, by sluice valves. Droplines from the midships loading connexion permit cargo to flow both forward and aft when loading. When discharging, the cargo flow is directed to the after end, where large pumps situated in the pump room take suction from the aftermost tank and discharge the cargo ashore through the midships manifold. With such systems, high capacity pumps are capable of very fast pumping speeds, and 120 000 tonners are able to discharge a full cargo in under 10 hours.

Centralized cargo control systems are being increasingly adopted with automatic operaiton of valves and pumps linked with or controlled by remote reading ullage gauges at the cargo control centre. Controls of main engine and certain principal auxiliary machinery, together with comprehensive instrumentation and safety monitoring equipment, are being progressively concentrated in a control centre to enable the entire watch-keeping operation to be undertaken from one point. Electronics figure largely in these developments, and also in improved communication and navigational systems. Data loggers to monitor machinery performance automatically, telex over radio to transmit communications between ship and shore anywhere in the world, facsimile recorders for the reception of weather charts, and radar sets incorporating automatic plotting arrangements and great circle course computers; these are among the electronic aids which assist the navigator in the task of guiding the tanker smoothly, speedily and safely across the sea.

Safety measures have progressed in recent years with the introduction of considerably improved gas-freeing systems and fire-fighting methods. Mooring and unmooring operations are now performed more smoothly and more quickly by the installation of automatic tensioning winches.

Despite the reduced manning resulting from these and other innovations, the crew will always play a most essential part in tanker operation. Since the ship, apart from repair periods, spends a very short time in port, and returns to the home port are irregular, every effort is made to provide the staff and crew with compensating amenities by way of accommodation and 'off-time' activities. The modern tanker has a separate cabin for each member of its complement and many owners permit the officers to take their wives away with them indefinitely or for trips in home waters according to their rank. Spacious and comfortably furnished smoke and recreation rooms are available for both officers and crew and all the accommodation is air-conditioned. A swimming pool is provided and facilities are installed for film shows. The leave arrangements are generous and every endeavour is made to grant leave at reasonably short intervals and on the date it becomes due.

Single buoy mooring

A recent Shell development, single buoy mooring, is designed to overcome the difficulty of inadequate facilities for large tankers. A large buoy is securely and permanently anchored to the sea bed at a convenient distance offshore to give sufficient depth of water and swinging area, and is linked by submarine pipelines to the shore installation. Floating hoses provide a connexion between the buoy and the tanker's manifolds. The moored tanker can swing freely through 360° as wind and tide dictate, thus minimizing mooring forces.

Single buoy mooring is not intended to supersede normal berthing facilities but only to provide an attractive solution to the problem of large tankers requiring accommodation in difficult locations. The system has been operating successfully in the open sea since 1960 and has weathered many a storm without serious damage.

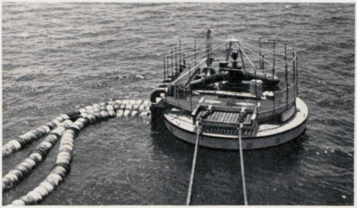
Fig. 220 (above) shows such a buoy with the ship's hawsers (centre) and the floating hose pipes (left) connected to the buoy's pipelines and (below) a tanker attached to the buoy, with the floating hoses ready to be pulled aboard for attachment to the ship's manifolds.

Anti-pollution of the seas

The serious results of pollution of the seas by oil caused much concern in post-war years and attempts were made to deal with the problem by inter-governmental conferences in 1954 and again in 1962, although without any great success.

Although tankers were not wholly responsible for this pollution, it was clear that the practice of discharging crude oil tank washings and dirty ballast into the sea was contributing very largely to it; in fact, it was estimated that by the early 1960s a million tons of crude oil was being dumped into the sea by tankers every year. Shell's marine experts had given much thought to the problem and by 1962 they had developed a method, known as the 'load-on-top' system, of collecting the tank washings into one of the ship's tanks, allowing the water to separate from the oil, then discharging the water overboard, leaving the oil residues and a very small amount of water in the tank. The next crude oil cargo was loaded on top of the residues.

The efficacy of the load-on-top system having been proved, it was later adopted by other oil companies and by the end of 1964 was in operation for some 60% of international crude oil movements. Although not providing an answer to the problem of persistent oil already in the sea, it is hoped that universal adoption of the system will eventually lead to the removal of the menace of oil pollution.



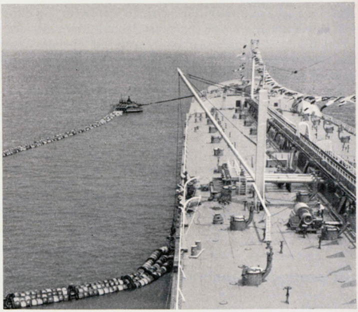


Fig. 220 Single buoy mooring

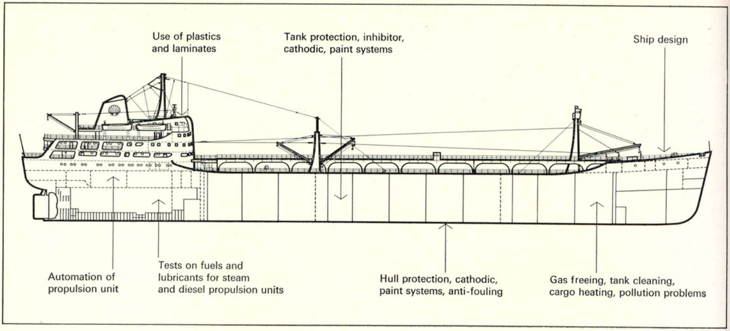


Fig. 250 Research problems connected with the tanker

paint systems and by inhibitors; transport by tanker of liquified petroleum gas; all these are typical examples of marine research [Fig. 250].

Research is also being carried out to solve problems emanating from the increased use of pipelines for the transport of crude oil and products.

This type of research is carried out in most laboratories, depending upon the nature and location of the particular problem, and not in a central specialized laboratory, but central co-ordination ensures effective utilization of research facilities.

Fundamental research

There was a time when it was the practice for industry to 'obtain from books' the basic knowledge necessary for the solution of its problems, and the establishment of this knowledge was almost exclusively the province of the universities. However this is no longer the case; the increasing complexity of the problems in the oil and other industries has created so great a need for basic knowledge that it can no longer be satisfied by the universities. Therefore a certain part of the Group's research effort is concerned with fundamental research. This comprises research in practically every department of chemistry, organic, inorganic, analytical, physical and colloid; in many departments of physics, such as the structure of liquids and solids, spectroscopy, physical measuring methods, thermodynamics, physical technology, rheology, geophysics and optics; in mathematics, for example in mathematical statistics and numerical analysis; and in biology, including microbiology and biochemistry [Fig. 251].

Problems that can be solved only by long-term efforts, and for which a specialized knowledge of mathematics and theoretical methods is necessary, are becoming of increasing importance. In order to master the very extensive calculations which are often necessary, use is made of modern computers, without which many fields of investigation would remain inaccessible [Fig. 252].

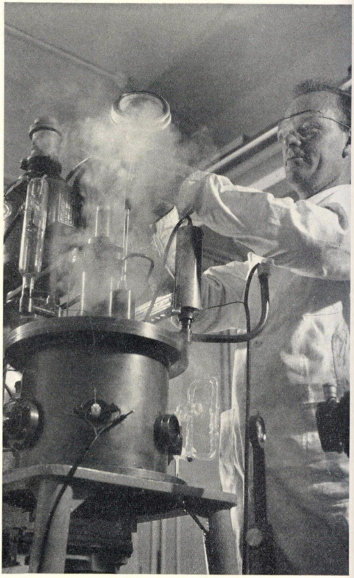


Fig. 251 The rotating cryostat used to isolate organic free radicals for further study