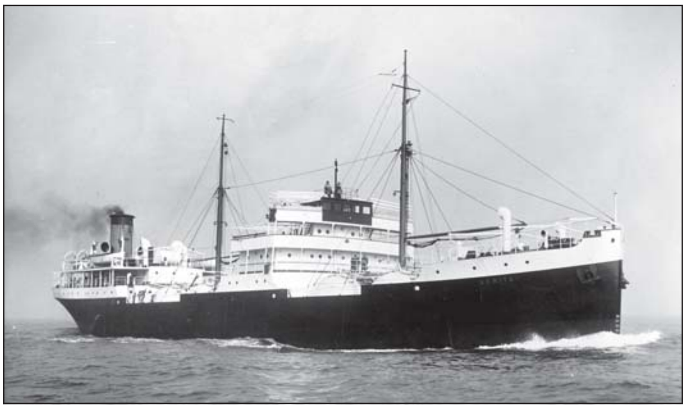

BULK LIQUEFIED GAS BY SEA: THE EARLY YEARS

by Robin Gray

Much has been written about the carriage of the first cargoes of liquefied natural gas (LNG) onboard the Methane Pioneer in 1959. But what of liquefied petroleum gas (LPG), a gas ship cargo which predates LNG? When were the pioneering LPG cargoes carried and how did this important seaborne trade develop?

In this tribute to the first gas carriers, Robin Gray, former SIGTTO General Manager, sheds light on the early days of the less well-known part of the gas shipping industry and on the role played by one particular shipyard in the North East of England.

SIGTTO

The Society of International Gas Tanker and Terminal Operators Ltd

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FIRST DECK
20000 A/B
AT SIDE
2ND DECK
gas
BERGE NICE

In his book "Oil Tanker Cargoes", published in 1954, John Lamb, the then technical director of Shell Tankers, described ships able to carry butane and propane gas in Chapter 17. He stated that the Shell oil tanker *Megara* was the first ship to carry LPG in bulk. *Megara* may have been the first ship to physically transport LPG but she was not the first *able* to do so.

The Dutch-flag *Megara* was built by the Le Trait shipyard at Rouen in France for Petroleum Maatschappij "le Coruna", part of the Shell Group's Anglo Saxon Petroleum, in 1928 as an oil tanker.

However, the 7,931 gross ton (gt) ship did not become a gas carrier until 1934 when she was specially converted to enable the carriage of LPG, as well as oil, by the Werkspoor yard in the Netherlands.

The conversion work entailed the installation of 20 cylindrical pressure vessel tanks totalling 1,305 m^3 for the transport of butane and four tanks totalling 158 m^3 for propane. Each butane tank had a capacity of approximately 65 m^3 while the propane tanks, at about 40 m^3 each, had smaller diameters to compensate for the much higher vapour pressure of propane.

All the cylindrical gas tanks, which were positioned vertically, were fitted in several of the ship's centre tank spaces. When engaged in the carriage of gas, the butane tanks were filled to 95 per cent of the cylinder's capacity while the propane tanks were filled to 91 per cent. This provided *Megara* with the ability to carry up to a maximum of 780 tonnes of LPG cargo.

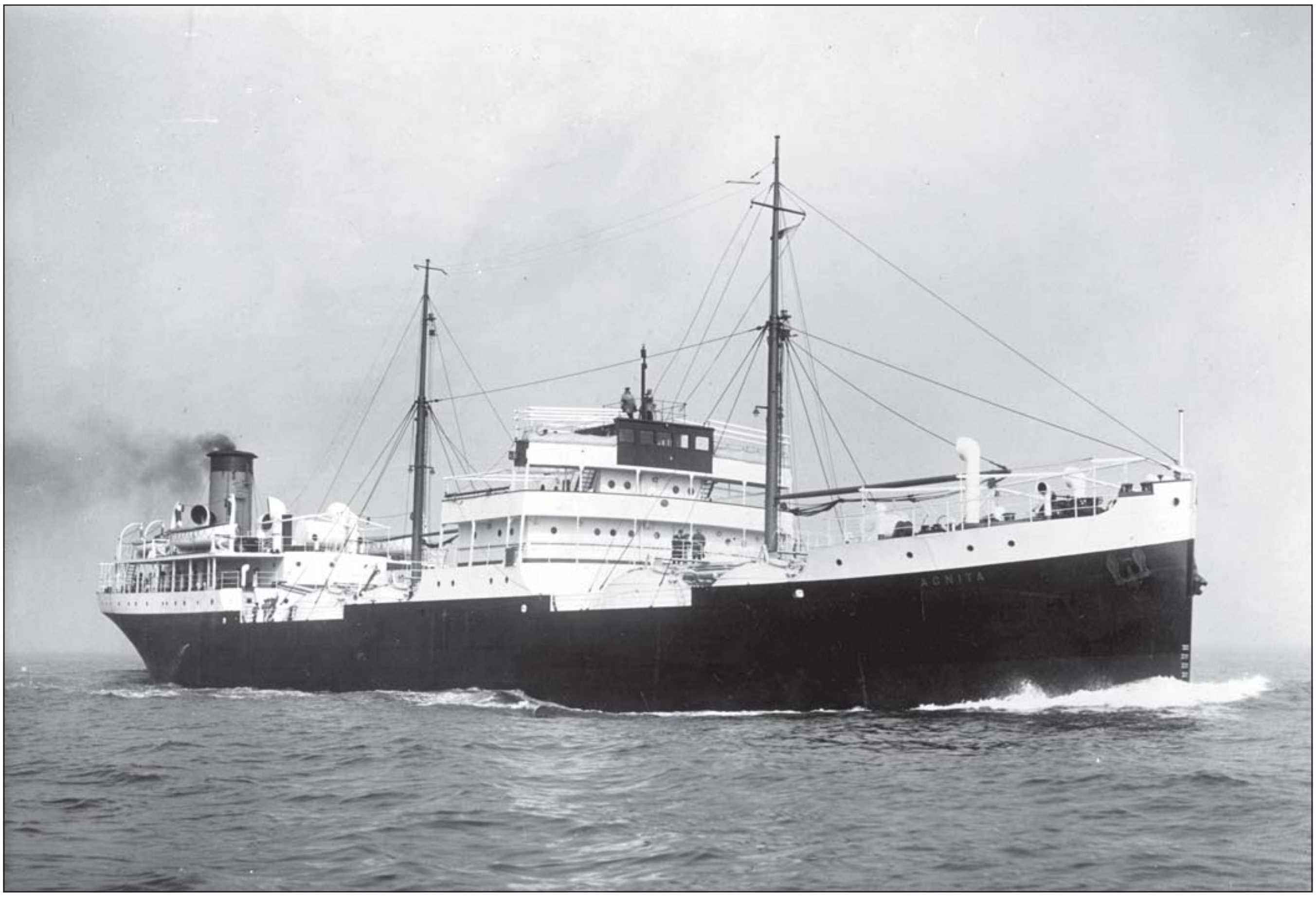
Purpose-built Agnita

The cylindrical LPG tanks for *Megara* were built by Werkspoor to a design by R & W Hawthorn Leslie, a shipyard located at Hebburn on the south bank of the River Tyne. Shipbuilding had come to Hebburn in 1853 when Andrew Leslie, the son of a dispossessed Shetland crofter, arrived on Tyneside from Aberdeen to take advantage of new opportunities and launch his enterprising project.

The UK yard's LPG tank design was chosen for *Megara* because Hawthorn Leslie had designed and constructed the first purpose-built gas carrier a few years earlier. This was the 3,552 gt *Agnita,* delivered in 1931, also to Anglo Saxon Petroleum. *Agnita* was a unique vessel in that she was designed to carry three different types of cargo - gas oil, sulphuric acid and LPG.

For the carriage of oil *Agnita* was provided with six sets of cargo tanks divided by a centreline, longitudinal bulkhead. For the carriage of LPG and acid, the ship had 12 large cylindrical pressure vessel tanks. Built to a 4.14 bar gauge working pressure, each was 5.26 metres in diameter and 9.91 metres high, providing *Agnita* with a total pressure vessel capacity of 2,100 m^3.

Agnita's cylindrical tanks were built of 24 mm thick boiler plate in the engineering works of R & W Hawthorn Leslie. The tanks had butt straps inside and out, with the close-butted pressure vessel shell plates being double row-riveted on each side. The hemispherical ends were



Agnita - the first purpose-built gas carrier, showing the domed heads of the cylindrical cargo tanks protruding above deck constructed in petals with double riveted overlap joints. In addition, end capping plates of 3.60 metres in diameter were double-riveted outside the petal plates.

In installing the cylindrical cargo tanks onboard ship, each was supported on substantial angle bar sections, radiused and riveted back to back to the longitudinal and transverse ship girders, with a short section riveted through the pressure vessel bottom petal plates serving as a holddown bracket. The top of the hemispherical end of each tank protruded 1.83 metres above *Agnita's* upper deck.

Victim of war

Because of her unique cargo-carrying capabilities and her distinctive appearance, with the domed cylinder heads visible above the main deck, *Agnita* became quite well known in shipping circles following her delivery in March 1931. The ship construction project had presented considerable challenges for both the tank manufacturer and the shipbuilder.

Later in 1931 the ship was provided with two additional cylindrical tanks for the carriage of propane. Located in the forward oil tanks, the new cylinders had a working pressure of 13.8 bar gauge and a total capacity of 100 m^3.

The author contacted Shell Transport and Trading in 1965, enquiring about *Agnita*. Shell advised that records for the tanker had been lost, probably during World War II, but she had carried five LPG cargoes, most likely from the Caribbean to Malta.

Agnita had emerged unscathed after a tangle with a Heinkel bomber while running up the Channel to Rotterdam in December 1939, thus becoming the first tanker to be attacked from the air in World War II. However, the ship was not so fortunate on March 22, 1941, when she was sunk in the mid-Atlantic near the Equator, by the surface raider *Kormoran* while enroute from Freetown to Caripito in Venezuela. Anglo Saxon Petroleum lost 10 tankers in 1941.

Special cargo secrets

The author has a copy of a Lloyd's Register of Shipping internal note dated May 17, 1935 and headed "Motor vessels *Megara* and *Agnita*" which concerns their published class notation. The note reads:

> *"The owners desire to avoid any reference in the Register Book to the fact that these two vessels have been specially constructed for the carriage of sulphuric acid and high-pressure petroleum products. They state that they have spent a great deal of money in constructing these vessels for a special trade and it is essential in their interests not to advertise their special features. They, therefore, ask that the notation in the Register Book be limited to "Carrying Petroleum in Bulk" and point out that, in making this request, the vessels are not insured in the open market and in consequence no outside interests will be adversely affected by the record being made as suggested. In these circumstances no objection is seen to omitting from the records in the Register Book the purpose for which the cylindrical tanks are to be used …… These tanks occupy a large proportion of the volume of the ordinary oil compartments ……. Some reference to the cylindrical tanks should be made."*

As a result, the notation "100A1 Carrying Petroleum in Bulk" and "Fitted with Cylindrical Tanks" was agreed by Lloyd's Register and Anglo Saxon Petroleum for the two vessels.

Carefully to carry

In his "Oil Tanker Cargoes" book John Lamb describes the operating procedures to be followed when carrying cargoes of butane, i.e.:

> *"Prior to loading, all containers and lines are completely filled with water. This should be done during the ballast voyage when well clear of land in order to prevent sediment entering the containers which might choke the test and pressure gauge valves … The tanks are topped up through the sounding opening"* (this opening was at the top dead centre of *Agnita's* tanks) *"by a hose connected to the wash deck line. By opening the appropriate valve, the vapour line and all its branches can be filled simultaneously with water …. thus …. eliminating the possibility of any air being present in the system which could form an explosive mixture with butane or propane.*
>
> *"When the system is completely filled with water the sounding openings in the tanks are then closed and the containers and pipelines tested on each occasion by restarting the ship's pumps until the vapour relief valves on the masts lift and water is ejected at the tops of the vapour lines. All pipelines and joints should then be inspected for leakages.*
>
> *"Butane and propane can then be loaded in various ways. One method is by 'gassing' the containers … by admitting a small quantity of liquid butane. The butane entering the containers through the top vapour line gasifies and ejects the water via the 150 mm loading line led down to 150 mm above the bottom of the container and overboard through a length of flexible hose coupled to the outboard loading line connection. The discharge of water overboard is continued until a rushing sound is heard in the loading line which indicates that butane vapour has entered this line. The loading line control valve is then closed and the balance of water remaining in the containers drained off through the bottom 50 mm drain line.*
>
> *"The test valve is then opened and at first water only*

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will be ejected. When gas only emerges, this indicates that all water has been ejected. For measuring the quantity of 'oil' and observing the liquid level when filling or emptying the butane containers, an internal pipe extends into the container to a predetermined fixed level. For butane this level is fixed at 95% full, so that when loaded to this level 5% of the total volume of the container is available for expansion of the liquid butane … vapour will emerge from this pipe until liquid has reached the lower end of it, when liquid will emerge showing that the tank is 95% full. The expansion coefficient of liquid propane is higher than that of liquid butane and, consequently, in propane containers the internal ullage pipe extends to the '91%' line, allowing for an ullage of 9% of the total capacity of the container.

"The discharge of LPG is affected by pumping sea water into the bottom of the containers and displacing the LPG through the 100 mm gas line from the top of the tanks."

Post-war developments

The interfacing of LPG with salt water described in the previous paragraph is practised today in underground salt caverns used for LPG storage. Such facilities include the caverns operated by Warren Petroleum at Mont Belvieu, Texas and those on Teesside in the UK.

The author had the privilege of meeting Rex Phelps of Warren Petroleum during a visit to the USA in 1964 at which time he was shown models of the huge salt storage facilities then being planned for Mont Belvieu.

Rex Phelps had also been closely involved in the development of the fully pressurised gas carrier *Natalie O Warren* on behalf of Warren Petroleum in 1947. *Natalie O Warren* was a converted cargo ship and the first vessel able to carry propane in large volumes. The 68 vertical, cylindrical tanks, positioned in the ship's five holds, were able to withstand working pressures of up to 17.6 bar g and provided a total capacity of 6,050 m^3. The ship was used to carry propane from Houston to New York.

While *Natalie O Warren* was the first ship to carry LPG in bulk in the immediate post-Second World War years, she did not remain the only one for long. Again, owners initially turned to the conversion of existing ships because the work could be carried out more quickly and at less cost than the construction of a new, purpose-built gas carrier. Also, the trade in LPG was at a comparatively early stage of its evolution and conversions represented less of a commercial risk should the market fail to develop as envisaged.

Major conversions

The oil and gas majors Esso and Shell modified a number of their tankers in the immediate post-War years to provide them with the ability to carry LPG. Esso fitted some pressure vessel tanks for propane onboard the T2 tanker *Esso Sao Paulo,* while on Teesside in the UK Smith's Dock built *Genota* (later renamed *Shell Manaure*) for Shell in 1951, installing 34 pressure vessels tanks with a total gas capacity of 950 m^3. The same yard converted *Rebecca*, also in 1951, by providing 10 pressure vessel tanks totalling 245m^3 in capacity. In 1960 Smith's Dock converted the 7,900 dwt oil tanker *Gyrotoma* (later renamed *Shell Murachi*) for the carriage of up to 1,643 m^3 of propane in 22 pressure vessel tanks.

In the 1950s the seaborne movement of LPG developed slowly. Some notable trades were the carriage of LPG from the US to Italy in large horizontal pressure vessel tanks strapped onto oceangoing barges and the transport of LPG and ammonia on the Mississippi River in tank barges towed by tug boats.

Hebburn yard returns to gas

By the early 1960s, when the author was working at Hawthorn Leslie and the size of crude oil carriers was beginning to exceed the 50,000 dwt maximum capacity of the yard, management looked at gas carriers once again. In April 1961 the yard purchased plans and a specification prepared by J J Henry Inc, the New York naval architecture firm that had carried out the design work for the *Methane Pioneer* conversion, in order to tender for two 7,500 dwt fully refrigerated LPG carriers for the British Coal Board for service between the US Gulf and the UK.

In the event the Coal Board did not go ahead with the order because the project was competing with a British Gas Council scheme to import LNG from Algeria. Hawthorn Leslie continued with the development of a slightly modified fully refrigerated LPG carrier design for approval in principle by Lloyd's Register of Shipping and the US Coast Guard by the end of 1961.

As this precedent-setting LPG carrier project progressed, Hawthorn Leslie had to deal with several issues that were new to shipyards. The major issues, which are described below, can be itemised as follows:

(a) construction rules and patents;

(b) liability Insurance;

(c) cargo tank and secondary barrier steel; and

(d) tank insulation.

Rules and patents

Because fully refrigerated gas carrier design development was only in its early stages at this time, the various classification societies had no firm rules for the construction of such ships. Their requirements were "tentative" or "provisional" in nature. Classification societies, as well as shipyard designers, were operating under frustrating conditions because many features of fully refrigerated gas carrier designs were protected by patents.

Most of the patented designs were based on a double-hull tanker configuration but Hawthorn Leslie was able

to design out this liability by developing a single-hull design in which the side shell and containment space boundary were constructed using cargo tank quality steel and welding procedures.

Amusingly, the yard was pursued by an Italian patentee in 1967 who had interpreted the ghostline depicting the offset bulb frame to stiffen the single-skin side shell as depicting a "double-hulled tanker".

Having taken the morning of our meeting to establish that this sole point was the cause of our alleged infringement, we broke for lunch and provided the visiting Italian delegation with high-class Italian cuisine in Newcastle's new Ristoranti Roma. After lunch we opened the classification society's stamped midship section to reveal that we had not built a double-hull tanker! Others had more of a struggle to stave off the claims of this early designer.

Liability insurance

As shipbuilders entering a new technical trade, involving hazardous and difficult-to-handle cargoes, we requested liability insurance from Lloyd's underwriters in case our gas carrier failed to carry gas. We estimated the cost of converting our purpose-built gas carrier into a dry cargo vessel and a distressed sale price to establish a reasonable limit of liability.

Subsequently, we heard that the cargo tank membrane of a pilot project LPG carrier had been so badly corroded through maloperation of her inert gas generator on the first voyage that she was converted to a dry cargo vessel. This sensible contractual precaution benefited us in an unexpected way. Insurance was granted for our ship on the condition that *"Owners operate the gas cargo handling system strictly in accordance with the shipbuilders' Operating Manual throughout the guarantee period"*.

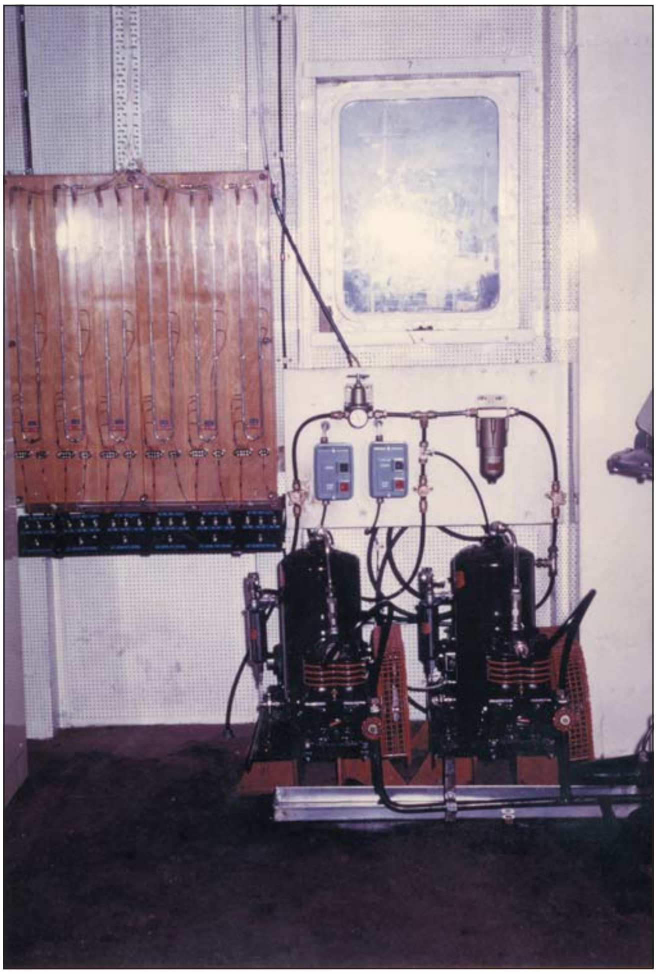
Cargo familiarity

This requirement did not conform with accepted practice, as shipbuilders generally know, or are required to know, remarkably little about the nature of the cargoes carried by the ships they build. The details of cargo handling had traditionally been considered the exclusive province of the shipowner.

It thus became essential that Hawthorn Leslie consider all the operating procedures and the components of the cargo-handling system from first principles and acquire a basic working knowledge of the physical and chemical characteristics of the commercial gas cargoes to be carried. The McGraw-Hill handbook *"Butane-Propane Gases"* and our good friends at ICI Teesside, recognising their potential interest in competently designed ships for their export cargoes, provided this basic knowledge.

However, we failed to adequately recognise the liability from subcontracted items which may result in the inability to carry gas or cause costly delays in ship completion and system testing. Tank cargo liquid level gauging, overfill shutdown trips, low pressure gauges and alarm pressure switches all had to be replaced on Hawthorn Leslie's first fully refrigerated LPG carrier.

We made good use of the inherent pressure accuracy of the U-tube manometer, with platinum contacts fused through the glass and mercury for electrical switches for low and high pressures in the intrinsically safe electrical alarm systems.



Mercury-filled U-tube manometers with electric contacts at tank high and low level alarm settings

The cargo tank overfill switches were standard stall-speed alarm switches from the Aerocommander light aircraft of the type used by the chairman of the company that owned the ship.

All these ingenious provisions were replaced at the guarantee drydocking.

We developed our own cargo-handling system design team to specify and manage the complete cargo system for our second and subsequent gas carriers.

Cargo tank steel

Hawthorn Leslie was fortunate to find a locally produced modified carbon steel suitable for use with cargoes at carriage temperatures of -50°C to replace the 3 per cent nickel steel plate which had been specified by J J Henry Inc. Such nickel steels were not then made in the UK. The modified carbon steel used on this and subsequent fully refrigerated ships built at the yard was known as Arctic D steel.

Our shipyard was fully aware of the problems experienced by two shipyards which had called in welding teams from Chicago Bridge & Iron Inc to meet the stringent low-temperature welding quality control standards. It took us three years and 150 weld procedure tests to qualify all position manual welding procedures and another year to qualify submerged arc twin fillet welding of stiffeners and submerged arc, butt welding of plate panels for our production lines. Low-temperature cargo piping, in 3 per cent nickel steel, was easily welded with consumables used for the fabrication of 9 per cent nickel steel.

Tank insulation

Perlite powder insulation had been specified for the complete filling of the void spaces between the cargo tank and its secondary barrier. Our reservations on the practicality of this material for the service life of the ship were determined when we saw that perlite, floating on water in a large glass container, became perlite sludge when the container was inverted!

Various alternatives were considered. The shipyard obtained quotations for four million ping-pong balls; for glassfibre slabs to fill the void spaces; and for factory-made polyurethane slabs pinned onto the cargo tank. We concluded that polyurethane was the most practical solution and developed shipyard application procedures with an expert local insulation contractor.

For another design project, for an ethylene gas carrier, we had specified a 'proven' proprietary polyurethane

The test tank used to demonstrate viability of polyurethane foam insulation and secondary barrier system at -104°C on Emiliano Zapata

for –104°C service for application to the ship's inner hull with an epikote resin sealed glassfibre secondary barrier. This foam developed random through-cracking under test when the secondary barrier was cooled to –104°C.

Newcastle University undertook a three-dimensional stress analysis to confirm that cracking must be expected based on the 'proven' foam's mechanical properties! We had to rapidly develop a modular polyurethane system with deliberate Z cracks for stress relief of the foam applied by our local contractor using an ICI polyurethane formulation for deep-freeze applications. No random cracks occurred under test and we were just in time for the shipbuilding programme.

Conversion project

In 1963 Hawthorn Leslie converted a 1956-built coaster to enable the carriage of LPG and chemical gases for Stephenson Clarke, the company that managed *Methane Pioneer* during the time when the historic trial cargoes of LNG were transported from Lake Charles in the US to Canvey Island in the UK.

The LPG carrier conversion project proved to be an excellent small contract for our shipyard, especially in helping us to develop our understanding of gas cargo operating procedures and pump and compressor performance calculations. The semi-refrigerated gas carrier was the first such ship in the UK to be equipped with a reliquefaction plant.

Cargo was carried in two large horizontal, cylindrical tanks, each 16.3 metres long and 6.0 metres in diameter, providing a total capacity of 734 m^3, at a maximum pressure of 7 bar g and with a minimum service temperature of -10°C. A memorable moment was lifting the tank pressure relief valves at 4:00 AM to sound off the largest organ pipe ever heard on the River Tyne. Blowdown seemed to take forever!

The first cargo carried by the converted ship, which was renamed *Abbas*, was isobutylene. A sample was taken upon completion of cargo loading by opening the 50 mm tank bottom drain line, after water had been purged to form a sheet of ice over the tank canopy and a golf ball size sample of polymer hung off the valve flange.

Just as the loading operation was being completed, the ship's master, fresh from a voyage on *Methane Pioneer*, was suddenly convinced that our system, of pressurising one tank to press cargo liquid into the deck-mounted cargo pump with vapour from the adjacent tank, would not work due to rapid condensation of the overpressure.

As a result, we used the cargo compressors to provide a 2 bar overpressure in one tank and closed all valves. Three days later, after fog delays on passage, we were relieved to find the 2 bar overpressure was still holding on arrival at the port of discharge. It was our first experience of gas carrier folklore!

The Danish contribution

This is an appropriate point at which to acknowledge the pioneering contribution of the Tholstrup brothers towards the development of transporting liquefied gases by sea in the early 1950s.

Their innovation was the so-called "semi-refrigerated" gas carrier. Such ships were able to refrigerate their gas cargoes to reduce their carriage pressure. Because the cargoes did not have to be fully pressurised to liquefy them, the shells of the pressure vessel tanks on a semi-refrigerated tanker did not have to be as thick as those of the tanks on a fully pressurised ship.

The Tholstrup brothers put their first gas tanker, the 127 m^3 *Kosangas*, into service as early as 1951. This was a converted ship fitted with a pressure vessel for the carriage of gas in the fully pressurised mode. By 1960 they had built up a fleet of 10 fully pressurised gas carriers, with an average capacity of 500 m^3 per ship and the primary focus of operations in Northern Europe.

Then, between 1961 and 1963 the Tholstrups added six semi-refrigerated gas carriers to their operation. These were larger ships, with an average capacity of 912 m^3 and improved cargo-handling flexibility. By this time the Tholstrup brothers had experience of handling 16 different liquefied gas cargoes, including a range of chemical gases.

Integrated gas distribution

The Tholstrups provided a fully integrated bottled gas distribution service for domestic and commercial customers, backing up their ships with bottling plants, bulk storage facilities and a gas bottle pick-up and delivery service. The hulls of the company ships sported a distinctive, bright yellow colour, as those of the successor company Lauritzen Kosan still do, while the company's gas road vehicles were distinguished by the slogan "KOSANGAS – The housewives' burning desire" painted across them in bright blue.

For deliveries of limited quantities to remote island communities, the company's smaller, 175 m^3 gas carriers were used to refill domestic LPG bottles directly onboard ship.

As part of the Tholstrups' network of gas distribution activities and full customer service package, company engineers also tested new domestic and commercial appliances at the in-house research station.

I met one of the Tholstrup brothers in 1962 in Copenhagen. He was busy developing his Danish blue cheese spread for sale in a tube! They were innovative people and, besides being masters of their gas market niche, always seeking to promote technological advances!

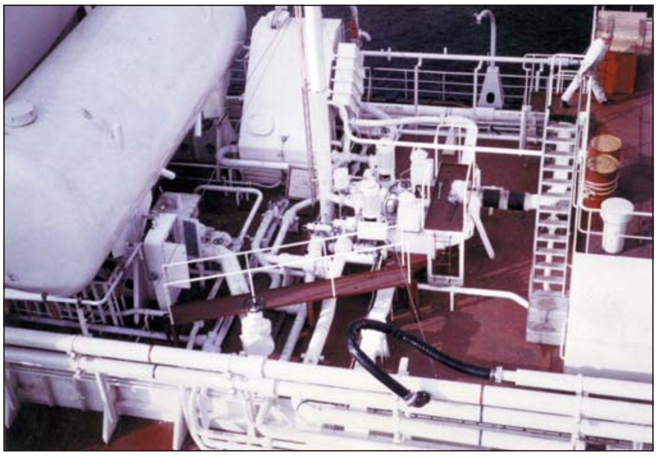
New departure with Clerk Maxwell

The first fully refrigerated gas carrier to be ordered at Hawthorn Leslie, and the first such ship to be built in the UK, was the 11,750 m^3 *Clerk Maxwell*, a ship contracted in 1965 by Ocean Gas Transport Ltd, a joint venture between Houlder Brothers and Gazocean. The order marked the realisation of our fully refrigerated gas carrier design project commenced four years earlier.

We had built many ships for Houlder Brothers in the past, although this particular newbuilding was to take us into new territory. The French company Technigaz, the technical affiliate of Gazocean, brought its experience of gas carrier technology to bear in its appraisal of our design and cargo equipment selection.

The basic ship became more complex when it was decided to provide the ability to carry butadiene cargoes. This necessitated the use of nitrogen as inert gas, indirect reliquefaction and chemical seals on cargo tank pressure instruments.

A storage tank for 36 tonnes of liquid nitrogen was mounted on deck at the front of the accommodation. This tank clunked from side to side inside its vacuum-insulated enclosure during the crash stop and full astern trials when the completed ship underwent sea trials in 1966. The experience prompted the installation of 100 mm of insulation on deck with an overside chute port and starboard to protect the hull structure!



Liquid nitrogen storage tank and steam vaporiser on Clerk Maxwell, with aft end of reliquefaction house at right

Propane loading problems

The gas trials on *Clerk Maxwell* were dogged by propane hydrate blockages. The blockages were attributed to the fact that the trial propane cargo had been loaded from an underground salt cavity storage facility without methanol dosing having been carried out. The blockages occurred first in the refrig-drier which was used to remove water vapour from the cargo tanks before inerting, and then later during tank cooldown at the loading port.

When the watch was changed at the terminal, as preparations were made to load the gas cargo onboard *Clerk Maxwell*, the loading pump was restarted without reference to the ship after a four-hour stoppage to purge the cooldown spray lines with methanol. A quantity of propane liquid in the 1,500-metre long loading line had vaporised during the stop period and the pressure surge on refilling the line liquid full exceeded the test pressure of the liquid filter of 38 bar g, with consequent leakage through all the joints and liquid relief valves.

This potential hazard, equivalent to the rapid shutdown of cargo transfer operations through the quick closure of power-operated valves, was only properly addressed by *"Recommendations for Linked Ship-Shore ESD"* Philips published by SIGTTO in 1987, some 21 years following the incident described.

More valuable lessons

In addition, the reliquefaction compressor lubricating oil was contaminated during this first loading operation, causing seizure of the compressors. Compressed butane vapour condensed in the cold discharge line into cold oil separators when the reliquefaction plant was first started up. These oil separators had float-operated drain valves to return separated oil from the discharge gases to the compressor oil sumps. Liquefied butane was returned initially in sufficient quantity to vaporise in the compressor bearings to expel the lubricant!

This was a problem which was experienced throughout the 1960s and was only satisfactorily solved when specialised oils were developed and operating procedures established to control gas contamination of the compressor lubricating oil to tolerable levels.

We had also experienced equipment problems due to galling and seizure of stainless steel components, as well as deepwell pump shaft bearing failures during those early days with *Clerk Maxwell*.

Liquid crossover on Clerk Maxwell, with liquid filter on left

I will never forget a Sunday visit to the Chantiers du Havre repair yard by Rene Boudet, the much-revered founder and chairman of Gazocean. Surveying the cargo deepwell pumps, reliquefaction compressors and cargo line valves in pieces on the upper deck of *Clerk Maxwell*, he put his arm round me and said "I don't know who is going to pay for all this damaged equipment but I do admire and thank you for staying with us to sort it out."

This very human action ensured maximum effort from all his team, outsiders like myself included. John Houlder, chairman of Houlder Brothers, commanded a similar loyal response with his innovative thinking and 100 per cent back-up in awkward situations. But that is another story!

Pemex followup

Thanks to a sterling currency loan by a London banker, Hawthorn Leslie received an order for a sister ship to *Clerk Maxwell* from Petroleos Mexicanos (Pemex) in mid-1966. We repeated the hull, cargo tanks and propulsion machinery but the cargo-handling system on the Mexican ship, which was to be christened *Mariano Escobedo*, was much simplified. Simplicity is good engineering; it lowers initial capital and maintenance costs and simplifies operations.

Butadiene was not a specified cargo on the Pemex newbuilding, so an oil-burning inert gas generator replaced the liquid nitrogen tank and vaporiser.Simple tests had demonstrated that liquefied propane, with at least 3 bar g saturated vapour pressure, will flash through a 3 mm orifice to a fine aerosol to generate a directional flow of cold vapour to precool the cargo tanks. A single spray line each side of the centreline bulkhead to give a flow of cold vapour across the top of the tanks enabled a satisfactory cooldown.

U-tube manometers enabled accurate cargo tank pressures to be read at each tank hatch and a low-pressure transmitter allowed tank pressure changes to be monitored in the cargo control room.

Float-operated tape gauges were used to determine tank liquid levels as well as for high and low liquid level alarms. These level alarms were tested on every voyage.A float overfill level switch, based on aircraft fuel tank technology, was fitted in each tank, port and starboard.

Local gas trials

Pemex had also ordered a 3,500 m^3 non-propelled, oceangoing LPG barge from Hawthorn Leslie at about the same time.

The demonstration of successful inerting, gas purging and precooling of at least one cargo tank at a safe berth on the River Tyne was commercially essential before these Pemex vessels entered service across the Atlantic in Mexican coastal service.

The Pemex contract for the LPG barge, which was named *Petroquimico I*, called for its handover before delivery of *Mariano Escobedo*. After a short trial of the vessel's cargo features on the Tyne, we towed the barge to Felixstowe for the gas trials. There we loaded a full cargo of propane from Philips Petroleum's new gas jetty and fully refrigerated propane storage into one of the barge's tanks up to overfill and automatic shutdown level.

The deepwell pumps were to be used to transfer the cargo from tank to tank and then for the discharge of the propane back to the shore tank. At least, that was the plan. Unfortunately, we could not get started because the heat from the summer sun, shining down on the 500-metre liquid export line, was generating propane vapour at a higher rate than we could reliquefy it!

After two hours we returned to our hotel for an early night and returned at 0400 hours the next morning.

had vented the liquid in the line to reduce the liquid temperature and, with a little assistance from the fourth compressor (the vent mast for those unfamiliar with LPG carrier language), we loaded the cargo and completed the trials.

Ethylene is different

Pemex had also ordered the 3,344 m^3 ethylene carrier *Emiliano Zapata* from Hawthorn Leslie. Upon completion of the ship, we were fortunate to be able to arrange the delivery of a supply of this liquefied gas cargo by insulated road tanker from ICI's nearby Teesside petrochemical complex. This enabled short gas trials to be conducted at the Tyne Tanker Cleaning Berth.

A few parts per million of ethylene gas in air are used in commercial horticulture to ripen tomatoes. Ethylene in excess of this small dose kills vegetation. This fact is used when underground ethylene pipelines are overflown by air to check for leakage!

We were fortunate that the local press were not aware of this property of the cargo when we conducted our short ethylene gas trials. We were aware of the hazards and ensured that no ethylene was vented. The quarter tank volume of nitrogen-ethylene mixture from

The short ethylene purge and tank cooldown trials on Emiliano Zapata

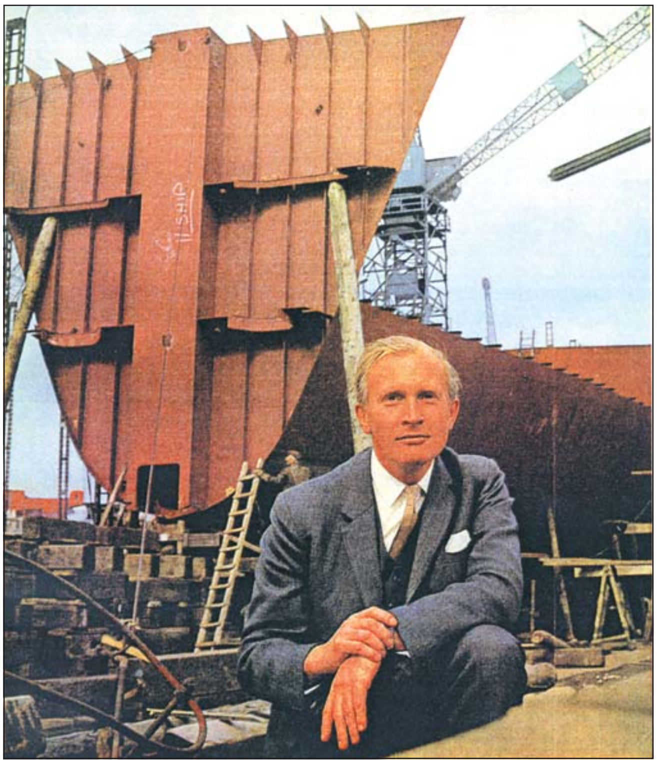
the gas purge of the trial tank was contained in the adjacent cargo tank.

These short gas trials on all our gas carriers enabled us to confirm the performance calculations we had estimated for both the time and quantity of liquid cargo needed to purge and cool down the tanks, and the stratification achieved in purging the relatively light ammonia vapour with relatively heavy propane vapour.

Oh, for the simplicity of designing and operating a gas carrier for just one cargo - LNG - on a liner trade between nominated export and import terminals with custom-designed jetty facilities!

Officer training

If we were to achieve a guarantee operating period free of guarantee claims on the shipbuilder, it was obviously essential that the Pemex officers were familiarised with the liquefied gas cargoes and operation and maintenance of all the cargo-handling equipment on their vessels.



Robin Gray in 1970 as Emiliano Zapata takes shape in the background; he won a NatWest Bank Young Exporter award that year for gas carrier sales to Mexico

Pemex operated a modest fleet of oil tankers and readily agreed to pay for training of their gas carrier personnel. We rewrote the cargo operating manual prepared for *Clerk Maxwell* to make it more concise. We also provided some worked examples to illustrate how we calculated time to inert; time to gas purge; time to cool down the tanks and establish a liquid reading on the float gauge; time to load using full reliquefaction capacity, etc, etc.

The Pemex officers attended instruction courses at Newcastle University's Chemical Engineering Department to understand the physical characteristics of ammonia and commercial propane-butane mixtures and appropriate cargo reliquefaction and R22 unit operating conditions.

They also visited the reliquefaction plant makers for instruction in the operation and maintenance of the compressors and protection instruments.

To Pemex must go great credit; they were fully committed to the safe and reliable operation of the ships we had built. We had no major guarantee claims on their three gas carriers and developed lifelong friendships with the Mexican officers.

Bibby and Wiltshire

The yard ensured continued involvement with this ship type when an established shipowner, already operating a fleet of smaller capacity gas carriers, ordered a fully refrigerated gas ship. At 15,500 m^3, this was to be the largest size LPG carrier in the company's fleet. Also, because a long-term charter had been negotiated, substantial bank finance was forthcoming.

However, when the charterer defaulted halfway through construction of the ship, Hawthorn Leslie sought out a new owner for the vessel.

At this juncture, it can be pointed out that few LPG carriers operate in the trade for which they were originally ordered. Such ships need to be flexible in their operation, e.g. they need to be able to change cargoes, say, from LPG to ammonia and back again to LPG. They should also be able to discharge fully refrigerated propane through a cargo heater into semi-refrigerated shore storage or into rail tank cars.

All such operations were commonly encountered during the course of normal LPG carrier operations. Because these features were fitted onboard our latest newbuilding, we felt confident that alternative ownership arrangements could be found.

Bibby Brothers of Liverpool were keen to enter the gas shipping business. After discussions, the company agreed to finance the construction of the ship, which was christened *Wiltshire*. It was Hawthorn Leslie's fourth purpose-built gas carrier and was constructed without any difficulties or delays.

Wiltshire proved to be the yard's most profitable contract, a reward for its established lead technology. Bibby arranged a long-term charter to ICI Australia for the ship at a good rate, so both parties were satisfied.

Faraday features

The Hawthorn Leslie yard at Hebburn next built two fully refrigerated gas carriers that were twice the size of *Wiltshire*, the sisterships *Faraday* and *Lincolnshire*, the latter ship also being constructed for Bibby Brothers.

The 31,300 m^3 LPG carrier *Faraday* was ordered by Ocean Gas Transport Ltd in 1969 and incorporated many novel features at the request of her owners. The cargo-handling system was operated locally on deck, at each of three cargo tank hatches and in the cargo compressor room on deck aft and 1 metre clear of the aft accommodation house front.

The cargo supervision room was a corner of the wheelhouse, an arrangement which enabled the officer of the watch to monitor cargo tank pressures and reliquefaction plant alarms at sea.

Cargo line ball valves were arranged so that the position of their operating handles, open or shut, could

Deck storage tanks at forward end of Faraday

be checked from the wheelhouse with binoculars.Six red traffic lights were mounted on the accommodation house front so that, if the alarm klaxon sounded over the cargo deck, the cargo officer could see if attention was required in either the wheelhouse, the cargo compressor room, the R22 compressor room or at No 1, No 2 or No 3 tank hatch.

The electric motors for all compressors and the R22 reliquefaction system were mounted at upper deck level on a flat within the engine room for supervision by the engineer officer on watch. The cargo compressors were driven by shafts extended from the engine room, across the 1 metre open cofferdam into the compressor house.

Fire protection tests

A high expansion (hi-ex) foam system discharged through the house ventilation ducts provided fire protection for the compressor house. A swimming pool was fitted on the upper deck just forward of No 3 tank hatch and this receptacle was used to receive the hi-ex foam during its performance test. So voracious was its output that, following the test, a 500-metre slick of foam was observed proceeding sedately down river to the sea!

The "traffic lights" just below the wheelhouse on Faraday; the compressor house ventilation ducting is shown below and the swimming pool in left foreground

A similar story was told about the hi-ex foam demonstration by the Glamorgan Fire Brigade. In this exercise the hose-drying tower was used to demonstrate the height of foam which could be supported by its cellular structure. Unfortunately, a lower window in the tower had been left open so that the foam never appeared at the top of the tower but, instead, covered the VIP car park and all the cars therein. The fire brigade had to respond with the well-rehearsed drill of blowing away the foam with water spray!

Cooldown tanks

Three large, horizontal pressure vessels were fitted on deck on *Faraday* and *Lincolnshire* forward of No1 cargo tank hatch. These tanks contained sufficient ammonia and propane to enable either commissioning and cooldown of all cargo tanks or a change of cargo in a three-day operation.