JOINT MEETING

of

THE INSTITUTE OF MARINE ENGINEERS

and

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

Human Problems in Marine Engineering

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In this paper the author is occupied not so much with engines as with the impact of engines upon engineers. Accordingly the paper comprises items known both to the reader and to the author; items known only to the author; and items understood by neither.

Although not so designated, the paper consists of two sections. In the first section, examples illustrative of the more important steps in a century of engine evolution pass in review. Some points are then more closely considered and the deductions epitomized. Factors in the decline of sail contemporaneously with the advance of steam are mentioned and the limitations of propulsion systems receive attention.

In the second half of the paper, a number of miscellaneous matters which the author groups together and calls current problems are delineated and evaluated. This part is a picture of certain aspects of marine engineering life as seen by a man located at the nerve centre of the world's greatest shipyard, who has himself been responsible for the designs of well over one thousand marine machinery installations, many of them of advanced type and of high power, running into millions of shaft horse power.

Who hath put all things in subjection under his feet . . . and whatsoever traverseth the paths of the seas.

—Familiar words from the Septuagint.

INTRODUCTION

Many times over the years the author has been invited to deliver lectures and to read papers before engineering institutions, the theme always being a technical one bearing upon the design of machinery—more especially, perhaps, heavy oil engines.

This having been so, it seems not inappropriate that, for a change, he should have accepted—albeit with extreme diffidence—the Institute's invitation to make comment upon the human side of marine engineering, any reference to technical matters being secondary and incidental.

Some Preliminary Notions

As the author sees the matter, the lives of the present generation of people are cast in the middle of a great period of intense activity, a species of activity which seems to be akin to what biologists call a mutation, something which produces a deep and permanent change but is not in itself continuous.

The general effects of this mutation upon mankind at large are of no moment to the present paper. But one of its particular effects has been profound in its importance and in its potentiality.

Looking back over the ages and visualizing all the contrivances by which man has navigated the near and the distant seas—contrivances which have included the currach and the coracle with their hand paddles, the unireme and the bireme with their oar banks, the long-ship with its oars and sails, the more primitive windjammer, and eventually the most highly evolved type of sailing ship—and it becomes clear that progress with all these varied forms could necessarily achieve only limited ultimate results because all the "propulsion" methods, alike in kind, were centred upon human muscles and sinews.

Then, not much more than a century ago, came the power operated ship. This was a technical break-through of unprecedented importance, one which was destined completely to change the whole maritime outlook, raising the ceiling of endeavour and achievement to indefinite heights.

This technical break-through, in itself, was the first—and the more significant—stage in the emancipation of the seagoing man from slave-like drudgery. But, as implied, it was only a partial emancipation; the coal burning steamer needed firemen and trimmers for the arduous muscular work of its stokeholds. As an example of what this could mean: in a high powered Atlantic liner 1,000 tons of coal per day had to be manually lifted from the stokehold floor and thrown into the boiler furnaces. This fuel previously had had to be brought down from the bunkers and wheeled to convenient points on the stokehold floor. The furnaces had to be cleaned every watch; the ashes, amounting to as much as, say, 150 tons per day, had to be raked out of the ashpits and wheeled to the ash ejectors, or the ash expellers—as may be—there to be discharged.

Eventually, some forty years ago, and within the space of little over a decade, the establishing of the Diesel engine for marine propulsion and the wide application of fuel oil burning equipment to steam boilers, brought about complete and final emancipation from animal-like toil on board ship. The cumulative effect of all the important technical advances:

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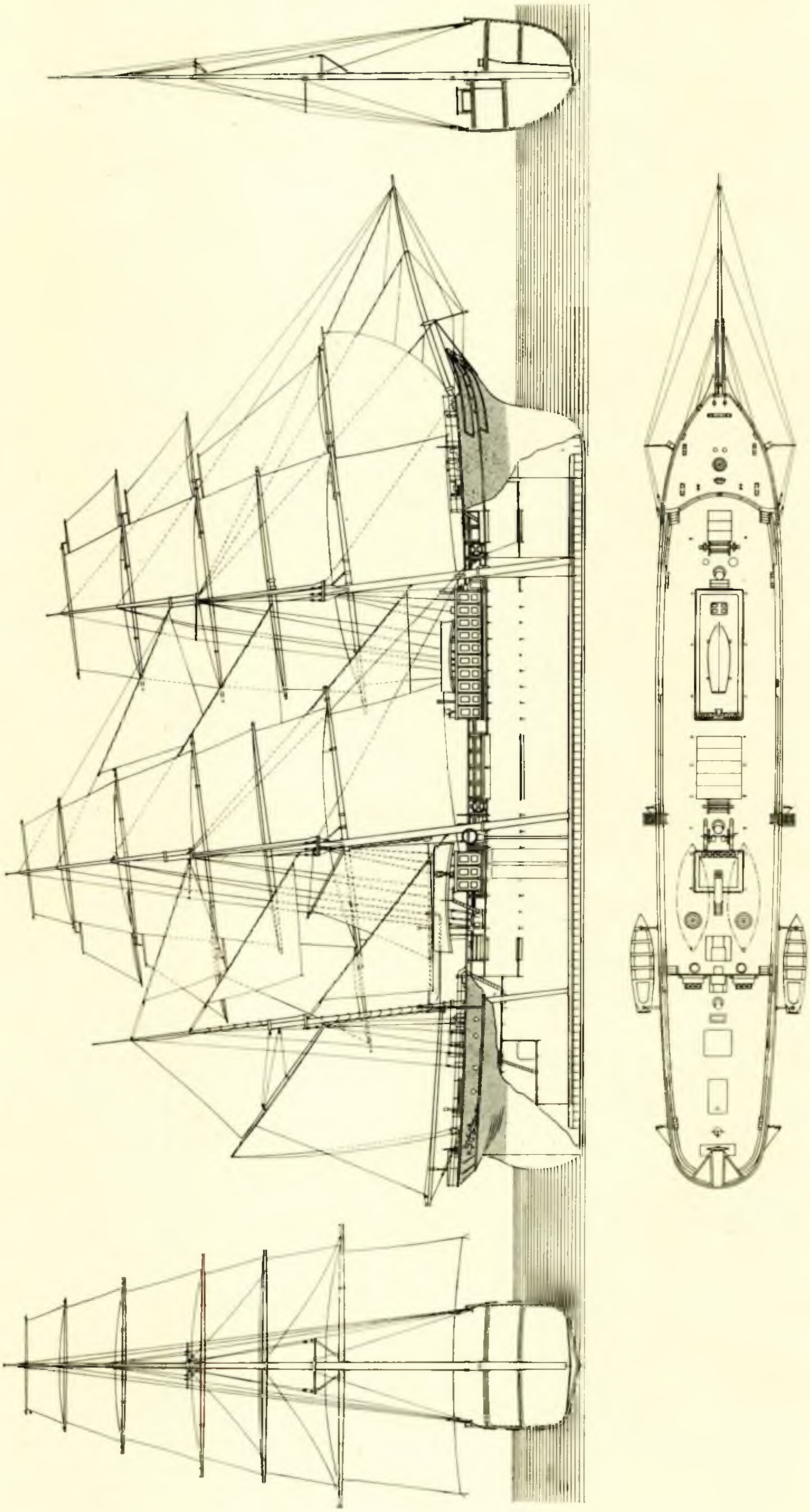


FIG. 1—*Iron barque* Broughton *(1868)*

the elimination of coal, the advent of the steam turbine, the development of the heavy oil engine, the greater use of power operated deck machinery, the increasing use of electricity for auxiliaries, the installation of refrigerating machinery: these and other things led to higher requirements of skill and knowledge, with advantageous effect upon the eventual status of the engineer.

Thenceforward the marine engineer could justly expect to be accepted as a technologist, with unalloyed interest in, and growing scientific knowledge of, the more advanced types of prime mover which were coming into vogue. The motto of the Institute, so apt at the time of its foundation, could thereafter have embraced a third distinctive term and have become *Nec remis, nec velis, nec palis,* i.e. without oars, without sails, without shovels!

RETROSPECTION

In the post-renaissance period of, say, four hundred years, with the shackles of ecclesiasticism burst and destroyed, and the cobwebs of the major superstitions cleansed from the brain of man, the steps in progress have been immeasurably great. One has only to consider the period of, say, Newton and his contemporaries, at a time when the population of England was only five millions, to realize what a great outburst of intellectual activity there was in the sixteenth and seventeenth centuries. Later, the natural philosophers were followed by the chemists, the physicists, the biologists, the geologists, and others, who, in unravelling some of the tremendous secrets of nature, transformed the life of man.

Parallel with the later phases there was the industrial application of the steam engine, leading in time to the development of other forms of heat engine and culminating in the invention of the heavy oil engine. No philosopher's stone could ever have produced the increase of wealth consequent upon these inventions.

Until the beginning of the nineteenth century, the only known means of crossing the ocean was by sailing ship. The ships were of wood; the largest did not exceed 200ft.

The Intrusion of the Steam Engine

The steam engine had not long been in use when the possibility of its application to ship propulsion occurred to many minds, with the result that, very early in the nineteenth century, navigable steamboats of small size had been built.

Soon afterwards, small low powered steamers had been applied to coastal services and, later, to cross-channel routes. The very heavy coal consumption of the simple engines installed in these ships prevented the employment of steam on anything but the shortest voyages. By 1825 a steamship 122ft. long, 27ft. beam, had made a voyage to India in 113 days. The Atlantic was successfully crossed by paddle vessel in 1838, steam alone being used. In 1843 the forerunner of the screw propelled iron mercantile steamer entered service.

To sidestep a moment: the first steamboat to be built in Belfast—in one of the yards now long defunct—was launched in 1820. It was 115ft. long, 20ft. beam, 200 tons burthen, driven by two engines of 70 h.p. In 1838 was launched the first iron steamboat; the engines developed 30 h.p. In the same year was launched the largest ship built on the Lagan up to that time, a paddle steamship 170ft. long, 750 tons, 230 h.p. Iron shipbuilding owed its origin in Belfast to the fact that the owner of the original—pre-Harland and Wolff—shipyard also owned an iron works. As he could not dispose of all his plates for boilers he started a shipyard for the building of iron hulls.

By about 1835 the marine steam engine had become a prime mover of growing significance, but fifty more years were to pass before it could be said that the steam engine was predominant. The factors in the rivalry between sail and steam were all those items which, algebraically added, ultimately determined the cost of carrying freight and passengers from one point on the earth's surface to another. Over the years there were many controversies; some centred around the effect, on progress, of Government mail subsidies; some concerned the alleged interference of the Board of Trade with matters affecting new designs; and there were others.

The year 1814 is regarded in official records as the beginning of the steamship era in British merchant tonnage, with one steamer of 69 net tons.

Hull Construction

About one hundred and twenty years ago the impracticability of being able to build a wooden ship of 300ft., especially if engine propelled, had been made clear by experience.

The chief criticism was to the effect that a wooden ship worked by paddles might well be satisfactory, but, when the power was applied by a screw propeller to the extreme end of the ship, it was difficult to combine sufficiently fine lines with the necessary rigidity to resist continuous "working" and vibration. Rigidity was of especial importance in merchant ships, which were usually run at full speed, or thereabouts. For high powers, therefore, either the screw propeller had to be abandoned or iron had to replace wood for the hull. The so-called composite system was then introduced, whereby the ship's framework was made of iron, the planking of wood. This system of construction soon gave place to the all-iron ship, with a saving of about one-third of the hull weight.

Although primarily introduced for screw propelled steamers, the all-iron construction proved equally beneficial to sailing ships. A generation later, steel began to replace iron, reducing hull weights by a further 15 per cent. Fig. 1 shows *Broughton,* built in 1868, a typical sailing ship of the period, an iron barque 165ft. length of keel and fore-rake; 27·7ft. beam; 18·3ft. depth, top of ceiling to top of beams; 603 tons gross; 580 tons net. There is no record of the crew carried, nor of the amount of kentledge.

A CENTURY OF ENGINE DEVELOPMENT

It is sufficient for the spirit and purposes of this paper if the last full century, 1859 to 1959, is spanned, retrospectively, in an endeavour to sense and to evaluate the successive steps in the logical, almost fatalistic, drive of events which were set in motion with the first revolution of a marine propeller.

The year 1859 saw the completion of *Great Eastern,* an iron leviathan 692ft. overall length, 82·7ft. beam, 30ft. draught, loaded, 18,900 tons gross, urged through the water by a combination of sails, paddle wheels and propellers, emblematic of man's conquest of material problems. It was the year of Darwin's *Origin of Species,* marking the beginning of a great intellectual upsurge which shattered the notions and myths of a myriad years. It was the year of the Lenoir gas engine, which led to the Otto cycle, and so to later internal combustion engine practice. It was the year in which, in Belfast, in what is now the world's greatest shipyard, there was built the firm's first ship.

In a shipbuilding and engineering company which has been long established the evolution of machinery can fairly clearly be traced; and so all the examples which follow are of Harland and Wolff origin. The author prefers to write from first-hand knowledge than to take examples—albeit, perhaps, better examples—from other sources at second-hand.

When the single-cylinder expansion engine had received a measure of acceptance, the three factors influencing the wider use of steam machinery were: the compound engine, the screw propeller and the iron hull. In wooden hulls the ratio of length to beam was about 7:1—sometimes less—this breadth being necessary for providing the required reaction against the overturning moment of the sails. In Fig. 1 the ratio was 6:1. Many of the earliest Harland and Wolff steamships were made with a ratio of 10:1, sometimes 11:1, thus increasing the relative pay load. This new practice in length/breadth ratio soon became general for large steamships.

By the middle of last century the struggle of steam propulsion for toleration had been won and the marine steam engine had been conceded the position of being a useful appendage to a sailing ship.

There were many distinctive types of engine in use; for example there was the side lever engine; there were trunk, diagonal, oscillating cylinder, and horizontal engines; there was also the so-called steam hammer engine. Sometimes the engines were direct coupled to paddles or screws; sometimes they were geared. The original vertical engines were engines with the cylinders at the bottom and the crankshaft above them. Gradually the steam hammer design prevailed; it was an inverted vertical engine, i.e. the crankshaft was underneath the cylinders. Each cylinder was called an engine.

The application of steam power to ships provided many new problems, which in turn were solved by new inventions. Almost all the ideas which were developed in the second half of the century had been originated in the first half. Mechanisms of all kinds were invented at a prolific rate, with the result that there is hardly any type of mechanism in use today which was not known more than a century ago.

A hundred years ago iron was replacing wood; the square boiler and the haystack boiler were yielding place to other forms; the compound engine principle was receiving recognition; the surface condenser had been invented; the pushing post, against which the forward end of the crankshaft pressed, and by which thrust reaction was obtained, had been superseded by the thrust block. The lignum vitae stern bush had just been introduced, solving what had previously been a troublesome problem. Most of the known contrivances in steam engine construction had been tried. Attempts had been made to burn oil fuel in boiler furnaces. Even the reversible and variable pitch propeller had been invented and, in at least some of its forms, bore strong likeness to designs which have been redeveloped only recently. One outstanding characteristic of marine work is that it is always the simple and commonsense design which prevails. The elaborate device either becomes simplified or it disappears.

A century ago, the national background of Britain was, in high degree, favourable to progress in the mechanical arts. There was no dearth of great men in any department of life. Strong individualists were establishing industries which grew and prospered. Fertility of body and inventiveness of mind were the characteristics of the times. There were, it is true, many grievous blemishes, too often smoke screened by the national hypocrisy. But, despite its darker side, it was a great period, a period brimming with vitality.

A Summary of Progress

A simple and reasonable picture of marine engineering progress during the century under review may, perhaps, be obtained from the following summarized notes, one ship per decade being offered as representative of the period. To further simplify comparisons, most of the examples are North Atlantic ships.

1859/60: Venetian

Four-masted iron barque (single-screw).
Working pressure = 18lb./sq. in.
I.H.P. = 450
R.P.M. = 46
Cylinder bore = 54in.
Stroke = 3ft. 3in.
Engine = two simple cylinders
Coal consumption = 4lb./i.h.p. hr.
Length overall: 290ft.
Length of keel: 272ft.
Beam: 34ft.
Depth of hold: 22·8ft.
Cargo capacity: 2,500 tons
Tonnage, gross: 1,508
Sea speed: 6 to 7 knots

1869/70: Oceanic

Four-masted iron barque (single-screw).
Working pressure = 65lb./sq. in.
I.H.P. = 2,000
Cylinder bores = 41in.; 78in.
Stroke = 5ft.
Engine = compound, tandem
Coal consumption = 3lb./i.h.p. hr.
Length: 420ft.
Beam: 41ft.
Depth of hold: 31·5ft.
Tonnage, gross: 3,800
Loaded displacement: 7,940 tons
Ship speed: 13·5 knots

1879/80: Rosetta

Three-masted iron schooner (single-screw).
Working pressure = 72lb./sq. in.
I.H.P. = 2,500
R.P.M. = 45
Cylinder bores = 54in.; 94in.
Stroke = 5ft.
Engine = compound
Coal consumption = 1·75lb./i.h.p. hr.
Length b.p.: 390ft.
Beam: 40ft.
Depth of hold: 27ft.
Tonnage, gross: 3,500
Average ship speed: 10·5 knots
Propeller: 19ft. diameter

1889/90: Teutonic

Working pressure = 180lb./sq. in.
I.H.P. (total) = 17,000
R.P.M. = 82
Cylinder bores = 43in.; 68in.; 110in.
Stroke = 5ft.
Engines (twin) = triple-expansion
Vacuum = 26in.
Machinery weight, dry = 2,410 tons
Length overall: 582ft.
Length b.p.: 565ft.
Beam: 57·5ft.
Depth: 39·3ft.
Tonnage, gross: 10,000
Service speed: 20 knots
Propellers: 19·6ft. diameter

1899/1900: Oceanic

Working pressure = 192lb./sq. in.
I.H.P. (total) = 28,000
R.P.M. = 77
Cylinder bores = 47·5in.; 79in.; 93in.; 93in.
Stroke = 6ft.
Engines (twin) = four-crank triple-expansion
Length: 685ft.
Beam: 68ft.
Depth: 49·5ft.
Tonnage, gross: 17,000
Service speed: 21 knots

Adriatic

Working pressure = 210lb./sq. in.
I.H.P. (total) = 16,000
R.P.M. = 82
Cylinder bores = 35·5in.; 51in.; 73·5in.; 104in.
Stroke = 5ft. 3in.
Engines (twin) = quadruple-expansion
Coal consumption = 291 tons per day
Length overall: 726ft.
Length b.p.: 708ft.
Beam: 75ft.
Depth: 49ft.
Tonnage, gross: 24,000
Displacement, tons: 40,750
Service speed: 17 knots
Block coefficient: 0·728

1909/10: Olympic

Working pressure = 215lb./sq. in.
I.H.P. + S.H.P. (total) = 51,000

R.P.M., engines = 77
R.P.M., turbine = 165
Cylinder bores = 54in.; 84in.; 97in.; 97in.
Stroke = 6ft. 3in.
Machinery = three-screw combination
Exhaust turbine inlet = 7in. vacuum
Condenser vacuum = 28·3in.
Length overall: 883ft.
Length b.p.: 850ft.
Beam: 92ft.
Depth: 64·5ft.
Load draught, 34·5ft.
Tonnage, gross: 46,000
Displacement, tons: 52,160
Service speed: 21·5 knots
Block coefficient: 0·685
Machinery weight, service: 9,943 tons

1919/20: Glenogle
Twin-screw Diesel engined ship.
S.H.P. = 4,500
R.P.M. = 115
Cylinders per engine = 8
Bore = 740mm. (29·13in.)
Stroke = 1,150 mm. (45·28in.)
Type = single-acting four-stroke
Fuel oil consumption = 22 tons per day
Length: 485ft.
Beam: 62ft.
Depth: 39·5ft.
Tonnage, gross: 9,500
Displacement, tons: 19,100
Service speed: 12·5 knots
Block coefficient: 0·76

1929/30: Britannic
Twin-screw Diesel engined ship.
S.H.P. total = 18,500
R.P.M. = 102
Cylinders per engine = 10
Bore = 840 mm. (33·07in.)
Stroke = 1,600 mm. (62·99in.)
Type = double-acting four-stroke
Weight one engine = 1,072 tons
Fuel oil consumption = 90 tons per day
Length overall: 712ft.
Length b.p.: 680ft.
Beam: 82ft.
Moulded depth: 43·8ft.
Tonnage, gross: 27,000
Displacement, tons: 36,800
Service speed: 17 knots
Block coefficient: 0·71

1929/30: Statendam
Twin-screw single-reduction geared turbine ship.
Working pressure = 400lb./sq. in.; 650 deg. F.
S.H.P. total = 20,000
R.P.M. = 125
Turbines = triple-expansion reaction
Gearing = single-reduction
Vacuum = 28·9in.
All-purposes fuel consumption = 0·61lb./s.h.p. hr.
Length overall: 697ft.
Length b.p.: 670ft.
Beam: 81ft.
Moulded depth: 53·5ft.
Tonnage, gross: 29,500
Service speed: 17·3 knots

1933: Capetown Castle
Twin-screw Diesel engined ship.
S.H.P. total = 32,000
S.H.P. service = 24,000
R.P.M. = 102
Cylinders per engine = 10
Bore = 660 mm. (25·98in.)
Stroke = 1,500 mm. (59·98in.)
Type = double-acting two-stroke
Length overall: 734ft.
Length b.p.: 685ft.
Beam: 82ft.
Moulded depth: 50ft.
Tonnage, gross: 27,000
Displacement, tons: 35,700
Service speed: 20 knots
Block coefficient: 0·694

1949/50: Cambria
Twin-screw Diesel engined ship.
S.H.P. total = 11,000
S.H.P. service = 9,000
R.P.M. service = 185
R.P.M. maximum = 220
Cylinders per engine = 8
Bore = 530 mm. (20·87in.)
Stroke = 1,180 mm. (46·46in.)
Type = single-acting two-stroke, trunk
Length overall: 397ft.
Length b.p.: 375ft.
Beam: 54ft.
Moulded depth: 19·5ft.
Tonnage, gross: 5,200
Displacement, tons: 4,500
Service speed: 21 knots
Block coefficient: 0·545

1949/50: Edinburgh Castle
Twin-screw double-reduction geared turbine ship.
Working pressure = 600lb./sq. in.; 850 deg. F.
S.H.P. total = 35,000
R.P.M. = 108
Turbines = triple-expansion all-reaction
Gearing = double-reduction, articulated
Vacuum = 29in. (sea 60 deg. F.)
Fuel consumption (turbines, non-bleed) = 0·435lb./s.h.p. hr.
Fuel consumption (propulsion) = 0·59lb./s.h.p. hr.
Length overall: 748ft.
Length b.p.: 700ft.
Beam: 83·5ft.
Moulded depth: 50ft.
Tonnage, gross: 28,700
Displacement, tons: 36,700
Service speed: 21 knots
Block coefficient: 0·685

1959/60: Amazon
Twin-screw Diesel engined ship.
S.H.P. total = 20,000
S.H.P. service = 17,000
R.P.M. service = 110
Cylinders per engine = 6
Bore = 750 mm. (29·53in.)
Stroke = 2,000 mm. (78·74in.)
Type = single-acting two-stroke, pressure induction
Fuel consumption, main engines = 0·34lb./s.h.p. hr.
Length overall: 579ft.
Length b.p.; 540ft.
Beam: 78ft.
Moulded depth: 41ft.
Tonnage, gross: 19,900
Displacement, tons: 23,300
Service speed: 18·5 knots
Block coefficient: 0·685

1959/60: Canberra
Twin-screw turbo-electric ship (building).
S.H.P. total = 85,000
Length overall: 817ft.

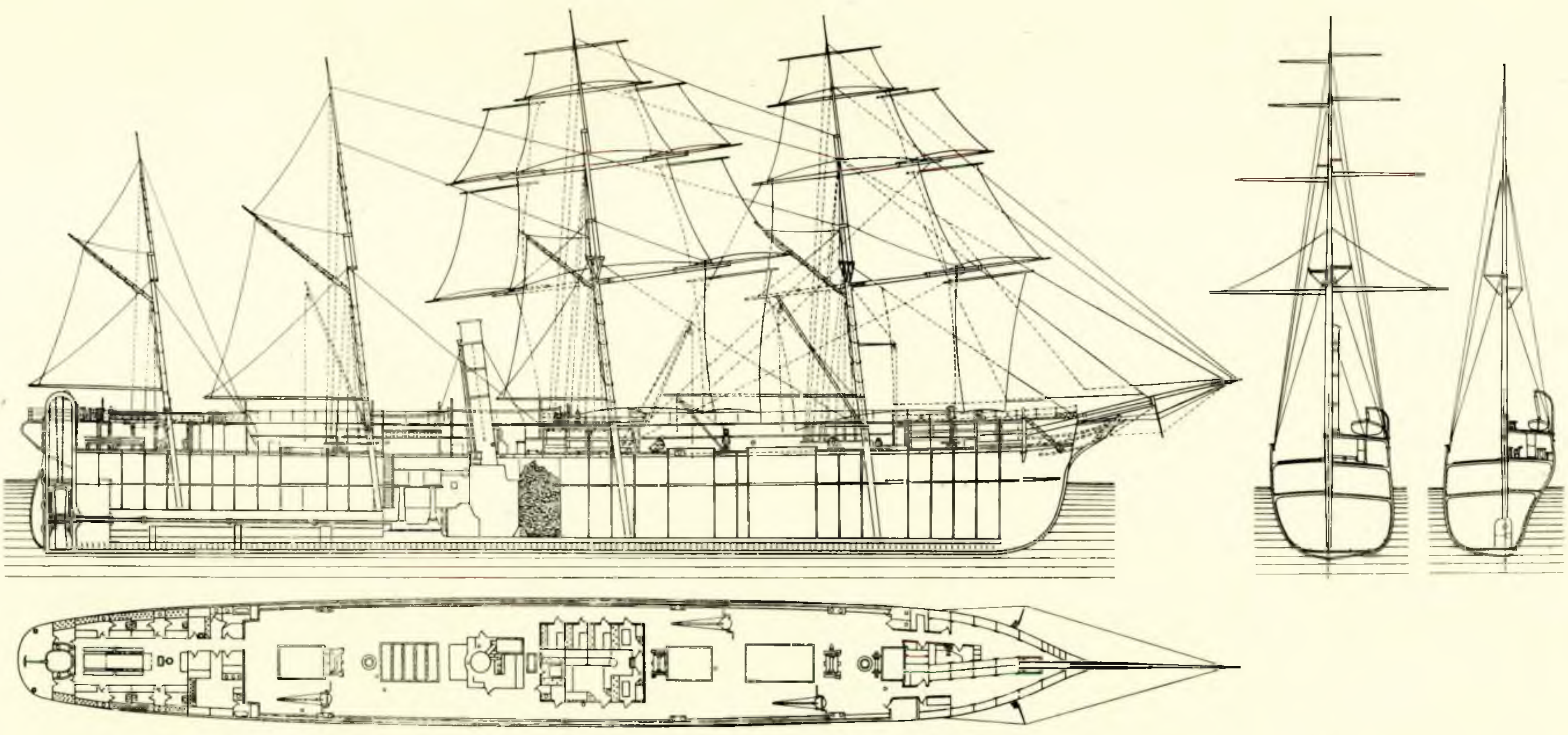


FIG. 2—*Iron barque* Venetian (*1859*)—*450 i.h.p.*

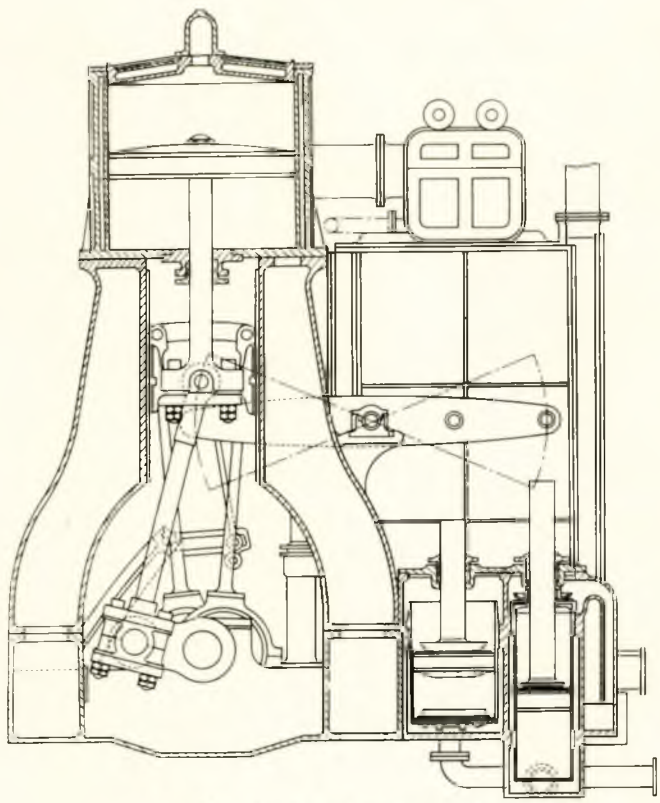


FIG. 3—*Simple expansion engine*

Some Points More Closely Considered

The ship which stands as No. 1 on the books of Harland and Wolff is *Venetian,* the first of three sister ships built for the Bibby Line. These vessels were designed for carrying goods and passengers between Liverpool and the Mediterranean. Each ship was provided with three steam winches, a capstan and self-reefing topsails. The fore and main masts were of iron and the rigging of wire. The boiler working pressure was 18lb./sq. in. Fig. 2 outlines the ship arrangement, with machinery amidships. Fig. 3 shows the engine type.

When the vessels were sailing under canvas alone, the propeller was lifted above the waterline by a deck winch; see Fig. 2. With a fair wind, the speed might well be ten or twelve knots. Under steam alone, with fully loaded ship, the speed would be about six or seven knots. The fuel consumption was 4lb. per i.h.p. hr.

The order for *Venetian* established a business connexion between the Bibby Line and the Queen's Island shipyard which was destined to last for over sixty years. Another close association was that which developed between the White Star Line and Belfast, which also lasted for sixty years.

The Oceanic Steam Navigation Company—the White Star Line—was formed in 1869 and a fleet of steamers was immediately ordered from Harland and Wolff. The first vessel was *Oceanic,* a single-screw, four-masted iron barque, 420ft. long. Fig. 4 shows the rigging arrangement. Figs. 5 and 6 show the machinery layout. The engines were constructed by Maudslay, Sons and Field. The coal consumption was 3lb. per i.h.p. hr.

Oceanic had three sisters: *Atlantic, Baltic, Republic,* identical as regards hull, with slight differences as regards machinery. On 1st April 1873, when on its nineteenth voyage out from Liverpool, *Atlantic* struck the rocks at the extreme point of Cape Prospect, at dead of night, and sank within ten minutes. Five hundred and sixty people were drowned; every woman and child perished. The manner of the loss of *Atlantic* raised a great outcry in Britain against iron steamers—not by any means for the first time; there had been other disasters.

All the propelling machinery built in the 1860's, of which the author has record, was replaced in the 1870's by compound engines and boilers of higher pressure. Coal consumption rates were reduced, in successive steps, from 4lb. to 1·75lb. per i.h.p. hr. By the middle 1880's there had emerged a definite type and style of marine engine, namely, the multi-expansion, inverted vertical, double-acting engine, together with a definite design of boiler—the Scotch boiler.

One vessel from this period was *Doric,* built in Belfast in 1883. In 1891 Rudyard Kipling was a passenger in *Doric* from Capetown to New Zealand and it is generally believed that Robert Reid, the chief engineer, was the prototype of McAndrew in " M'Andrew's Hymn", composed in 1893.

When, in 1875, *Germanic* entered the Liverpool—New York service, the new White Star fleet was complete. This fleet was so far in advance of competitors that its supremacy was unquestioned. With the passing of years, the ships of other companies gradually equalled and eventually surpassed the White Star vessels. Accordingly there came a time when it was imperative to provide larger and faster ships. *Teutonic* and *Majestic* were then ordered.

These two 20-knot liners, built in 1889-90, stood out above the background of the period. They were the first ocean going vessels, built and engined by Harland and Wolff, to have twin-screw engines; they were the longest vessels afloat. They were also the first merchant vessels to comply with British Admiralty requirements for cruisers. Each ship had

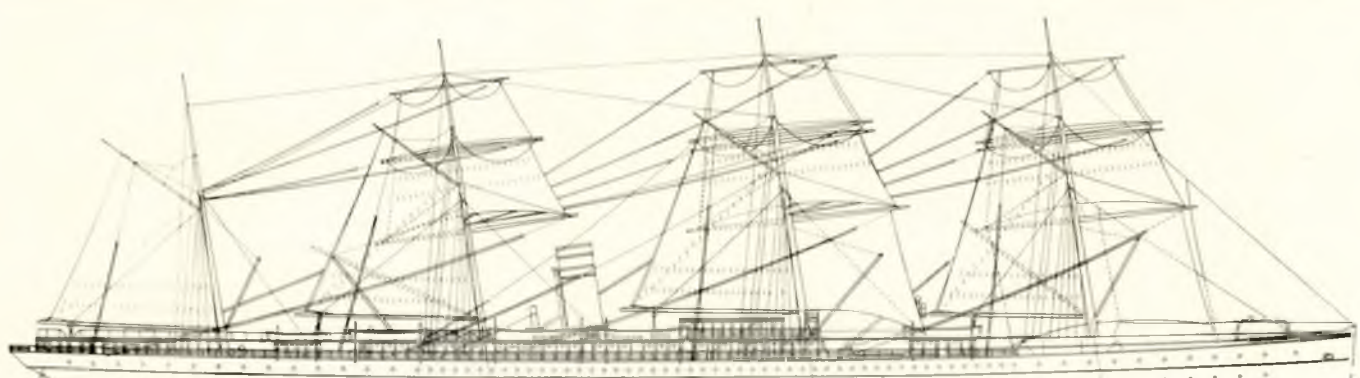


FIG. 4—*Single-screw passenger liner* Oceanic *(1870)—2,000 i.h.p.*

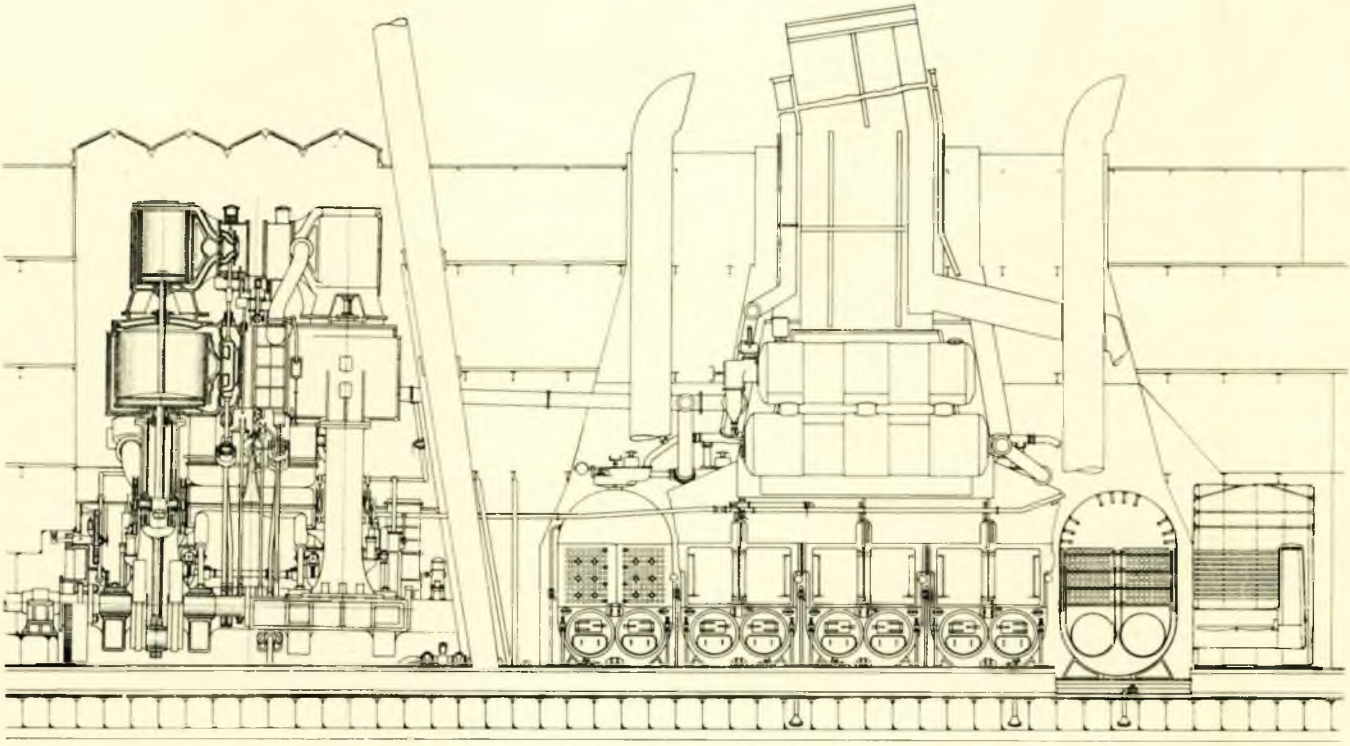


FIG. 5—*Machinery arrangement* Oceanic (*1870*)

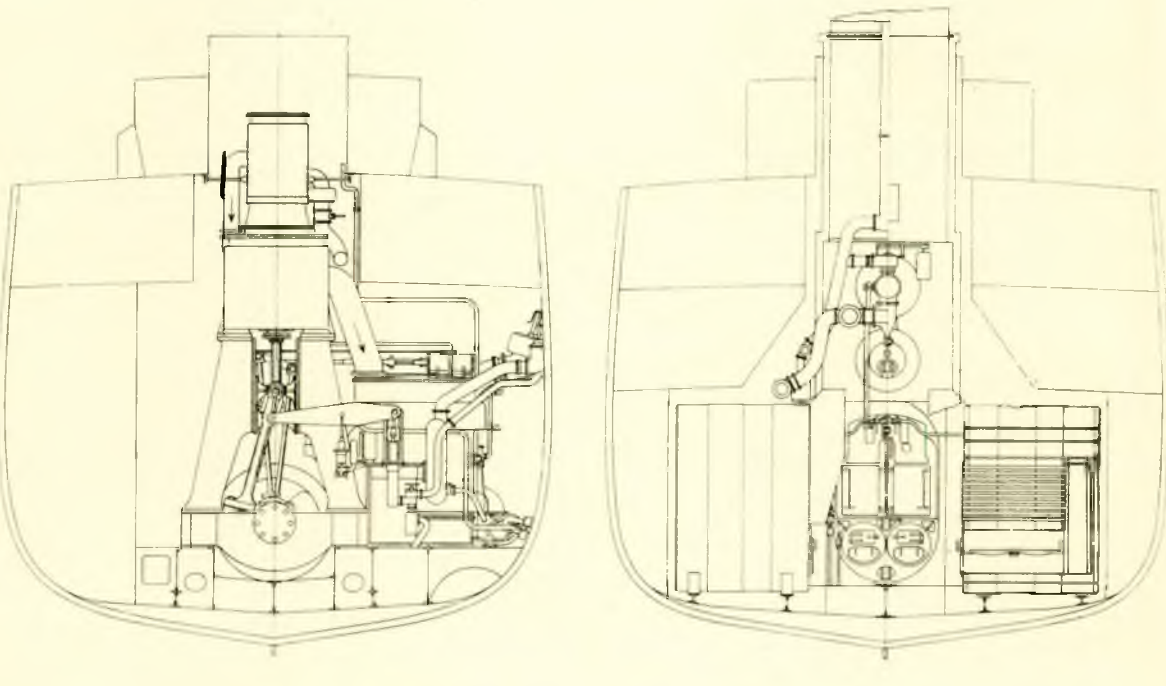


FIG. 6—*Machinery room sections in* Oceanic (*1870*)

two funnels and three masts. Sail power was retained, but there were no yards.

With the emancipation from sail of the engine propelled passenger liner—which came to pass in the 1880's—there arose problems concerning vibration. Accordingly the minds of engineers were occupied, for years, with the devising of engines which were dynamically balanced. A neat and practical method of eliminating all primary and secondary forces and all primary couples—leaving only unimportant secondary couples—was forthcoming in the Yarrow Schlick and Tweedy system. This scheme required a symmetrical arrangement of four cranks; and thus came about the four-crank triple-expansion engine, and, also, the balanced quadruple-expansion engine.

The last ship to be completed at Belfast before the century closed was the second *Oceanic,* its greatest achievement up to that time. *Oceanic* was propelled by two four-crank triple-expansion engines, conservatively rated at 28,000 i.h.p. (total) at 77 r.p.m. Each engine had two multicollar thrust blocks. The shell plates of the double-ended Scotch boilers were of special tensile steel, 1·5in. thick. Opposite furnaces were riveted to a common combustion chamber. There were two funnels of oval cross-section. It was a characteristic feature of Harland and Wolff steam machinery that most ample boiler capacity was always provided, a feature to which the regular running of their vessels could be largely attributed.

The confidence that existed between the White Star Line and Harland and Wolff must have been one of the most remarkable things in marine history. There was never a contract in the ordinary acceptance of the term; there was only a sheet of note paper on which were stated the general terms agreed upon when the first White Star liner was built.

Between the second *Oceanic* and the first World War, the firm built its greatest number of large ships, i.e. of gross tonnage 15,000 to 25,000, and over. Only twenty ocean going merchant ships were below 450ft.; the greater number were 500ft. to 650ft. and above; several were over 700ft. The largest quadruple-expansion engines were those for *Adriatic.* The opening years of the twentieth century saw the reciprocating steam engine reach the peak of its development; thereafter its eclipse was rapid.

In Belfast, steam turbines became an integral part of a propulsion system peculiarly associated, in the lay mind, with Harland and Wolff. *Laurentic,* 550ft. long, completed in 1909, was the first of the many triple-screw steamers to be built in which the wing shafts were driven by balanced four-crank triple-expansion engines and the centre shaft by a direct coupled, low pressure turbine into which the reciprocators exhausted. For the same steam consumption, and on a lower machinery weight, triple-screw machinery showed 20 per cent power increase compared with twin-screw quadruple-expansion engines.

Olympic and *Titanic* are the best remembered examples of the triple-screw arrangement. In these ships each wing engine developed 17,000 i.h.p. at 77 r.p.m. and the centre turbine 17,000 s.h.p. at 165 r.p.m. *Olympic,* completed in 1911, had a long and successful career. *Titanic* struck an iceberg on its maiden voyage, in 1912, and sank within three hours. After the loss of *Titanic,* a double skin was fitted to *Olympic.* In 1920, during rehabilitation after wartime service, the boilers of *Olympic* were converted from coal burning to oil burning. As a coal burning steamer on the North Atlantic service, average results showed: speed 21·89 knots; displacement 48,405 tons; coal burned per 24 hr., all purposes, 726 tons; fuel coefficient 19,200.

Later, when burning fuel oil, average figures were: speed 21·97 knots; displacement 49,890 tons; fuel oil burned per 24hr., all purposes, 548 tons; fuel coefficient 26,205. In 1927, when developing 58,000 i.h.p. + s.h.p., the all-purposes fuel rate was 0·97lb. per s.h.p. hr. Fig. 7 shows the machinery arrangement in the ship; Fig. 8 shows a main engine. The aftermost funnel was a dummy funnel.

Olympic and *Titanic* had a sister, originally to be called *Gigantic* but, after the loss of *Titanic,* named *Britannic.* The designed power and revolutions were the same as for *Olympic.* The crankshaft was in four pieces, journals 27-in. diameter, with 9-in. centre hole; crankpins 27·75-in. diameter, 35-in. long for h.p. and i.p., 24·5-in. long for l.p. The collective length of the nine main bearings was 26ft. 6·5in. Each thrust block had fourteen collars and three bearings; the total working thrust surface per block was 6,860 sq. in. Thrust bearings and all tunnel bearings were oil forced lubricated from a gravity system. The intermediate and propeller shafts were respectively 26·25-in. and 28·75-in. diameter, with 12-in. longitudinal hole, the hole tapering to 6in. at the cone. The low pressure reaction turbine, taking steam at about 10lb./sq. in. absolute, exhausted at 28·5in. to the port and starboard condensers simultaneously, through motor operated sluice valves. The blading varied in effective length from 16in. to 26·5in.

The total dry weight of *Britannic's* machinery, including funnels, ventilating systems inside machinery spaces, and so on, was 8,745 tons; the service weight was 10,176 tons. Each reciprocating engine, complete with condenser and all gear, weighed 991 tons; the total weight of the turbine, with all

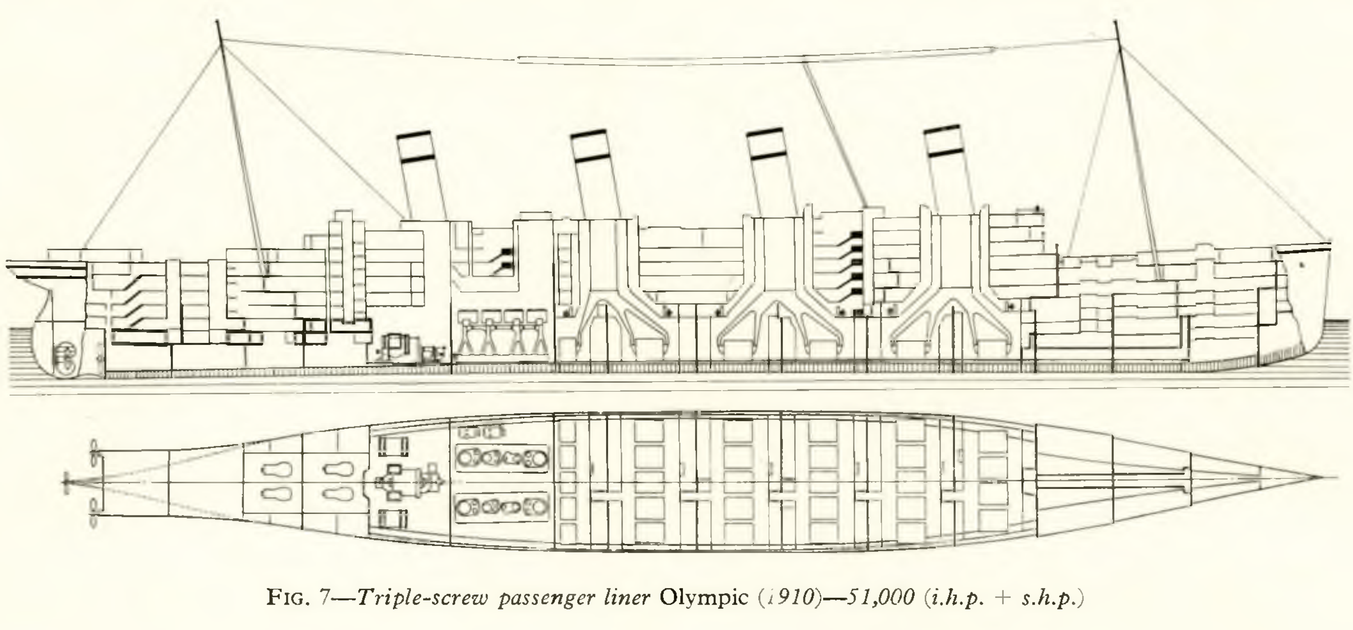


FIG. 7—*Triple-screw passenger liner* Olympic *(1910)—51,000 (i.h.p. + s.h.p.)*

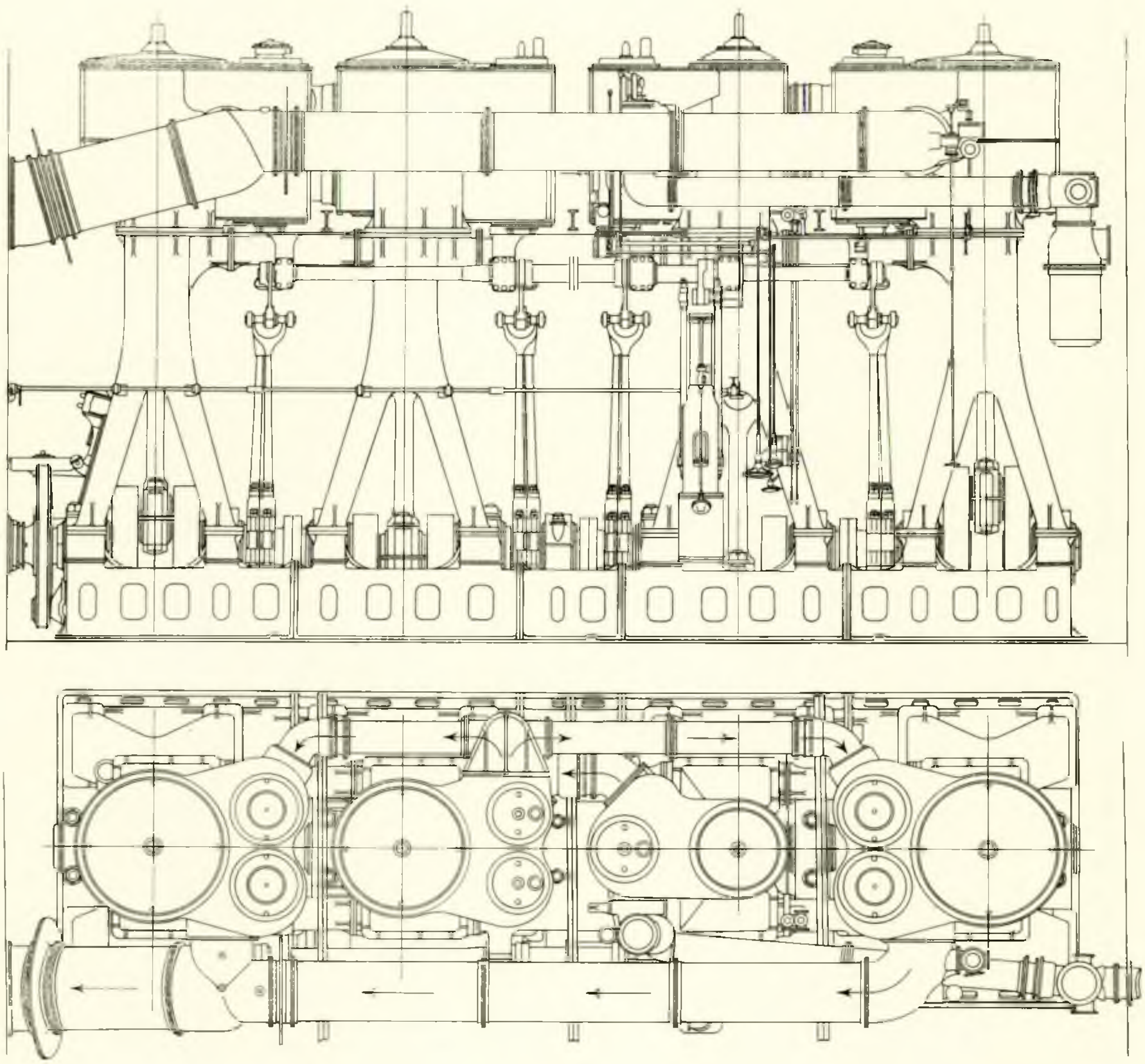


FIG. 8—*17,000-i.h.p. four-crank triple-expansion engine (1910)*

mountings, was 639 tons; the bladed rotor weighed 155 tons. Each funnel, complete, weighed 70 tons; the dry weight of the 29 boilers was 2,555 tons.

Britannic was launched in early 1914, but outbreak of war interfered with its completion. A Lough trial was held in late 1915 and the ship left Belfast. The following year it was converted to a hospital ship, and as a hospital ship it was torpedoed by the enemy. With *Britannic,* triple-screw machinery reached its highest point. *Laurentic* built in 1926, was the last of the type, and was an anachronism.

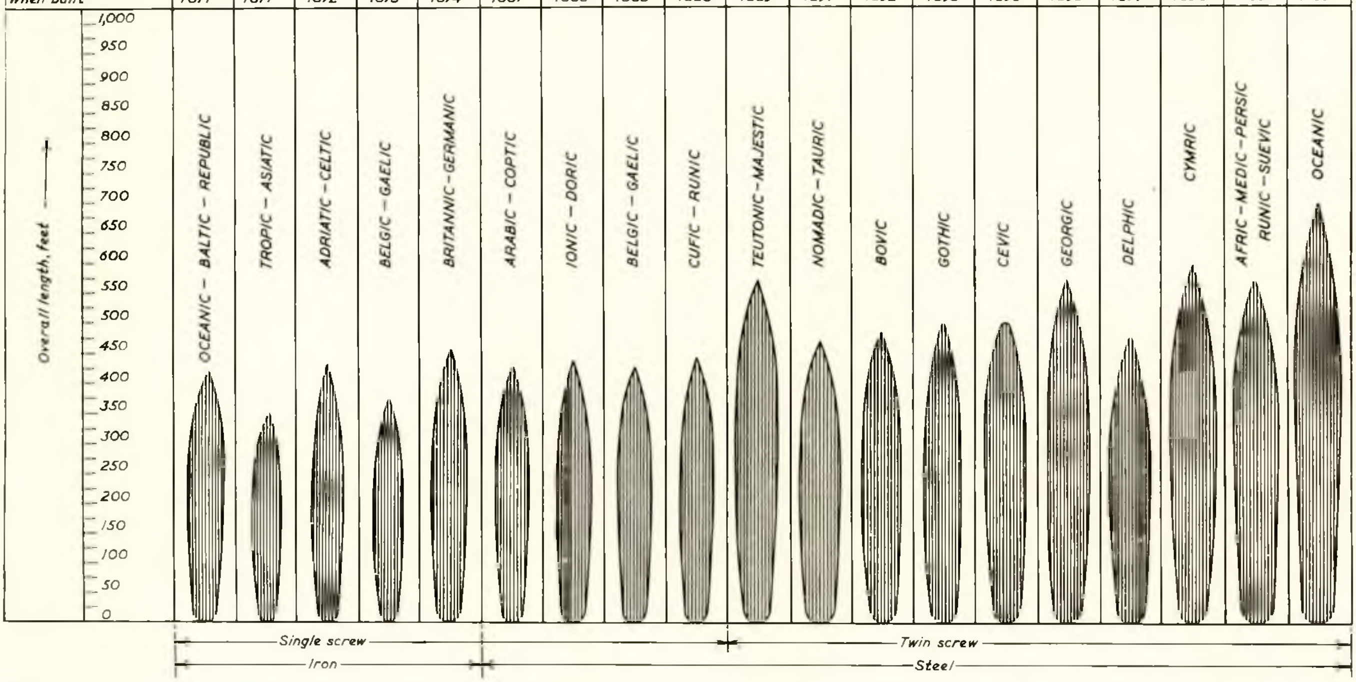
The direct driven steam turbine was not a serious competitor with the reciprocator, other than for special services; it was a compromise between a fast moving turbine and a slow turning propeller. But the successful introduction of gearing by Parsons, in 1910, whereby a high speed turbine was geared to a slow speed propeller, thus obtaining an efficient heat cycle and a high propulsive coefficient, completely changed the perspective. By the time the first World War started, the geared turbine was well established.

In the early 1920's double-reduction geared turbines were built. Although double-reduction gearing was unsuccessful in many quarters at that time, and raised such a scare that it was shunned by shipowners for many years, the fact remains that no difficulties were experienced with the double-reduction geared turbines made by Harland and Wolff.

In the decade following the first World War rapid advances were made in steam turbine propulsion, chiefly because of the shaking-up administered by the heavy oil engine. In 1920 steam turbine sets of moderate power consumed about 0·9lb. of oil fuel per s.h.p. hr., for all purposes. The Diesel engine offered an all-purposes rate of 0·43lb. per s.h.p. hr. The greater first cost of the oil engine was more than counterbalanced by the saving in fuel costs and by the greater cargo carrying capacity made possible by the substantial reduction in bunker weight. The manifest economy of the Diesel engine was the reason for many orders being placed at a time of prolonged depression.

The progress made in ten years is typified by what happened to the Holland-America liner *Statendam.* The machinery for this twin-screw steamer, designed in 1920, consisted of geared Brown-Curtis turbines of 14,500 s.h.p. total, supplied with saturated steam at 215lb./sq. in. by ten watertube boilers. Turbogenerators supplied the auxiliary power. The all-purposes oil fuel rate was expected to be 1·05lb. Before the vessel was launched in 1924 the demand for passenger ships had fallen to zero. The hull of *Statendam* lay at Belfast until 1927, when it was towed to Rotterdam for completion, all machinery units, together with the chief pipe systems, being supplied by Harland and Wolff, who also furnished the necessary plans and technical data. New twin-

Length between per^s	420'-0"	350'-0'	437'-6"	370'-0"	455'-0"	430'-0"	440'-0'	420'-0"	430'-0"	565'-0"	460'-0"	470'-0"	490'-0"	500'-0"	558'-7"	475'-9"	585'-6"	550'-2"	685'-6"
Beam	41'-0"	35'-2"	41'-0"	36'-3"	45'-2"	42'-0"	44'-2"	42'-4"	45'-2"	57'-0"	49'-1"	53'-1"	53'-2"	60'-3"	60'-3"	55'-2"	64'-3"	63'-3"	68'-6"
Depth	31'-6"	25'-6"	31'-6"	27'-6"	33'-6"	31'-6"	31'-6"	29'-6"	28'-8"	39'-4½"	30'-9"	31'-7"	33'-6"	33'-9"	36'-0"	35'-11"	37'-9"	39'-11"	44'-6"
Gross tonnage	3,807	2,130	3,888	2,652	5,004	4,368	4,748	4,271	4,640	9,984	5,749	6,583	7,755	8,301	10,077	8,273	13,096	11,948	17,274
Indicated horse power	1,990	1,500	3,500	1,800	4,900	2,000	3,280	2,800	3,050	17,500	3,500	3,700	4,400	3,700	4,500	3,000	6,800	4,800	28,000
Average speed, knots	13·5	11·5	14	11·5	15	13	13	12·5	12·5	20	13	13	13·5	13	13	11	15	13	21
When built	1871	1871	1872	1873	1874	1881	1883	1885	1888	1889	1891	1892	1893	1893	1895	1897	1898	1899	1899



Length between per^s	680'-9"	500'-3"	600'-7"	550'-3"	582'-0'	578'-3"	475'-10"	708'-5"	709'-3"	550'-0"	850'-0"	477'-0"	655'-0"	850'-0"	575'-0"	460'-0"	575'-0"	1000'-0"	680'-0"
Beam	75'-0"	63'-3"	65'-6"	59'-3"	60'-2"	59'-3"	55'-2"	75'-4"	75'-6"	67'-0"	92'-0"	62'-9"	69'-0"	93'-6"	67'-6"	58'-0"	75'-0"	120'-0"	82'-0"
Depth	44'-1"	45'-0"	47'-6"	35'-11"	38'-3"	35'-10"	35'-10"	44'-1"	52'-8"	45'-6"	Est.	34'-3"	47'-6"	64'-3"	45'-0"	33'-0"	44'-6"	67'-0"	43'-9"
Gross tonnage	20,904	12,234	15,801	11,394	13,518	12,097	8,194	23,876	24,541	14,892	45,000	10,898	18,481	48,158	16,314	9,332	18,724	—	26,943
Indicated horse power	12,600	4,400	9,800	8,436	8,000	8,513	2,170	14,000	16,000	12,000	—	4,700	8,370	50,000	8,700	3,600	13,000	275,000	23,000
Average speed. knots	17	13	16	15	15	15	10·5	16·5	17	17	21	12·5	13·5	21	15	13·25	16	30	17
When built	1901	1901	1903	1903	1903	1903	1904	1904	1907	1909	1910	1911	1913	1915	1918	1918	1927	—	1930

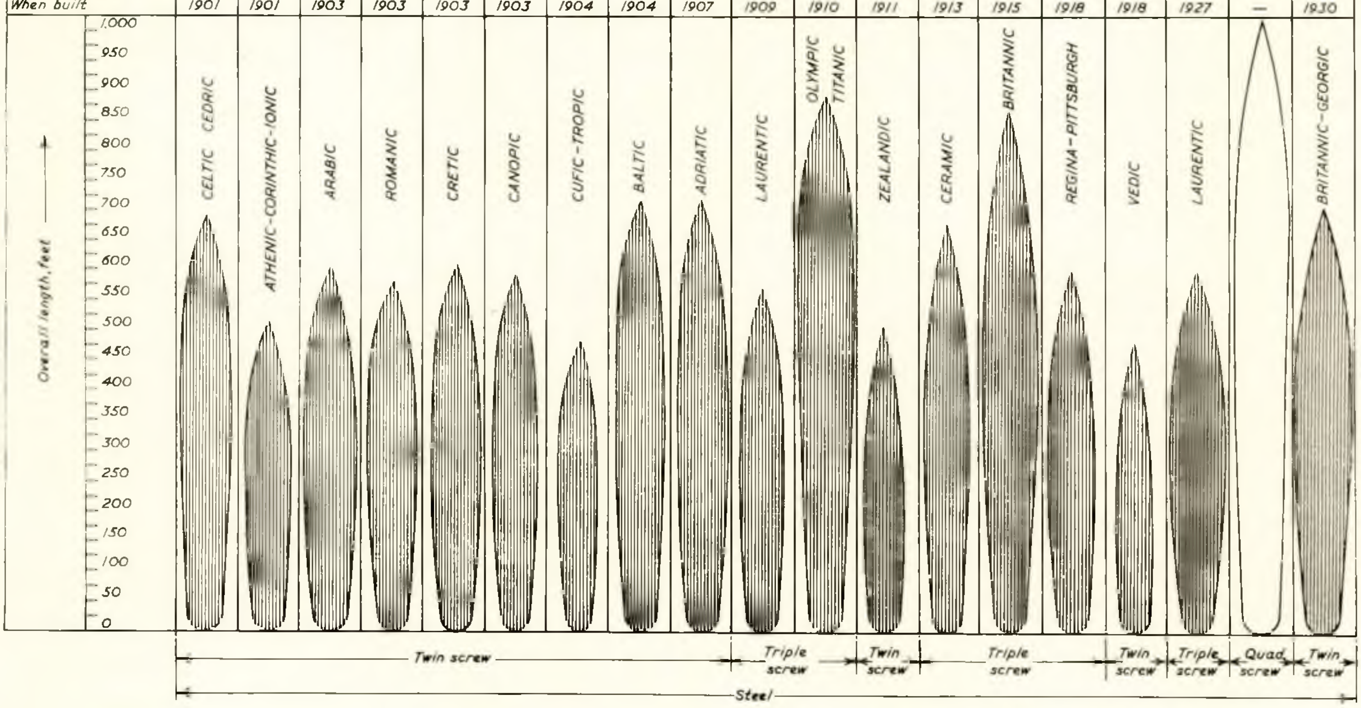


FIG. 9—*Life history of the White Star fleet*

screw machinery of 20,000 s.h.p. total was decided upon, to be accommodated between the original bulkheads. The new machinery comprised single-reduction geared turbines of Parsons' reaction design, three cylinders per set; six Babcock and Wilcox boilers generating steam at 400lb./sq. in. pressure, 650 deg. F. temperature; tubular air preheaters; regenerative feed heating; Diesel generators; and so on. Notwithstanding the more lavish hotel load, an all-purposes fuel oil consumption of 0·61lb. per s.h.p. hr. was established on the maiden voyage in 1929, when 22,000 s.h.p. was developed. At that time *Statendam* was the most economical steamer in the world.

Some of the passenger ships, steam and Diesel, built in the early 1920's proved too slow for international competition and in the 1930's they were repowered. Usually, and incidentally, the ship's bow was made finer by lengthening. Speed was not a characteristic of White Star ships.

Only two motor passenger ships were built for the White Star Line. These were the sister ships *Britannic* (1930) and *Georgic* (1932). At the time of building they were the largest and most powerful British-built and British-owned motor ships. The double-acting four-stroke engines, by which they were propelled, as well as being the most powerful were also the last of the type to be constructed. The fully built crankshafts were 635 mm. (25·0in.) diameter, 19,860 mm. (65ft. 2in.) total length. The total installation weight, dry, was 4,600 tons.

Georgic, despite having been bombed, burned and sunk, while on war service, was rehabilitated and served many years as a Government troop carrier. *Britannic* is still engaged on the North Atlantic passenger service.

In the mid-1930's the White Star Line was merged into the Cunard Line and, in due course, lost its identity. Fig. 9 outlines the life story of the White Star Line.

Of the ships listed since 1929/30 two especially notable machinery installations are those of *Capetown Castle*—comprising the most highly powered double-acting two-stroke marine Diesel engines ever built—and *Amazon*, propelled by single-acting two-stroke pressure charged engines, of aggregate output 20,000 s.h.p. Both vessels are of twin-screw type.

And so, steam turbines and heavy oil engines continue to be developed in Belfast, side by side, the one stimulating the other, always to the advantage of the shipowner. Normally, 40 to 45 per cent of the annual output of mercantile tonnage is steam turbine propelled; sometimes, however, the figure reaches 50 per cent. The remainder is Diesel engine propelled.

In Fig. 9, there is an unshaded ship of date 1929. This was a quadruple-screw motor driven passenger liner 1,000-ft. long, 120-ft. beam, 67-ft. depth, 38-ft. draught, 30-knots speed, 200,000 total s.h.p. The block coefficient was 0·61. The keel plate was laid in June 1928. A year later the economic blizzard smote shipping "hip and thigh" and the vessel was not proceeded with. Years ago the author briefly described, in words that follow, the machinery that would have been installed in this passenger liner, which was to have been named *Oceanic*.

"Fig. 10 shows the Diesel electric drive for a 1,000-ft. White Star Liner which was ordered from Harland and Wolff, Ltd., Belfast, in 1928. The propulsive power was 200,000 s.h.p. total for four screws, and there were forty-seven exhaust turbocharged four-stroke single-acting trunk engines, each having 6 cylinders 670 mm. (26·38in.) bore, 930 mm. (36·61in.) stroke, delivering 3,400 b.h.p. at 260 r.p.m. Most of the engines were arranged end-to-end, in pairs, forming twelve-cylinder units with the dynamos at the ends. The propulsion motors were 24ft. in diameter, the engine dynamos and the propulsion motors being direct current machines. The total installation weight was 17,000 tons. Unfortunately, because of increasing depression in world trade, construction had not proceeded very far when work was suspended. The White Star Line was later merged with the Cunard Line. The conventional steamers *Queen Mary* and *Queen Elizabeth* were built; and work on the great Diesel liner was not resumed. Thus was a history-making engineering achievement lost for the nation. Nowadays a much lighter, more compact and relatively less costly proposition, with alternating current and quiet running two-stroke engines, would be put forward by the author".

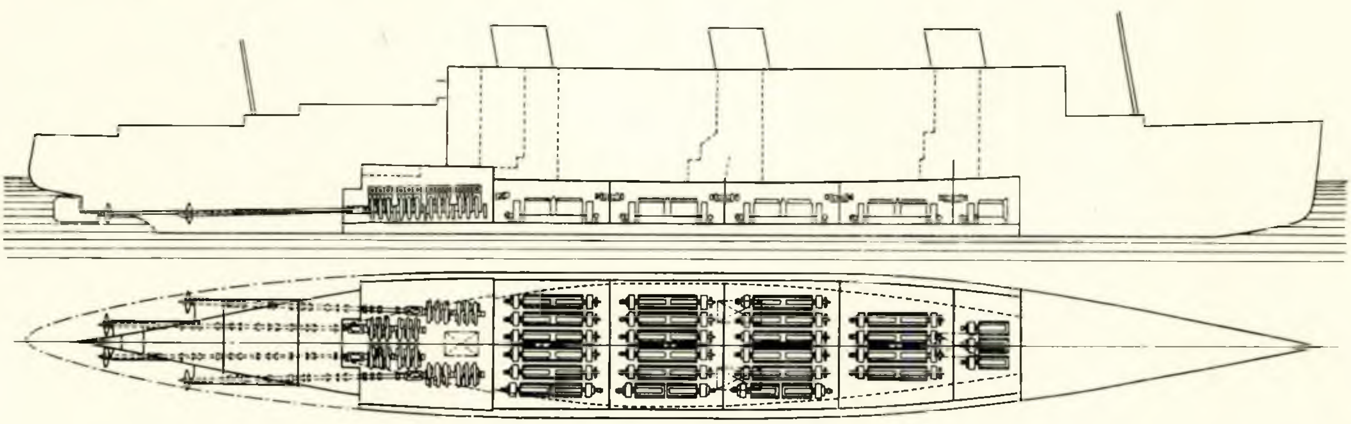


FIG. 10—*Proposed 1,000-ft. Diesel engined liner (1929)—200,000 s.h.p.*

Now there is talk of replacing the present two passenger ships. If new vessels are built it is to be hoped that the machinery designs—whatever form they may take—will indeed be worthy of the nation's engineers.

An Epitome of Progress

In a hundred years, powers which started as 400 h.p. per shaft have grown more than one hundredfold; boiler pressures have risen over fiftyfold; fuel consumptions a century ago were twelve times what they are today; and so on.

If, as an indication of performance at sea, fuel coefficient values are compared, then the results for the three vessels named *Britannic* are as under:

First *Britannic* (1874) fuel coefficient (coal) = 13,000
Second *Britannic* (1915) fuel coefficient (coal) = 18,000
(if oil) = 26,000
Third *Britannic* (1930) fuel coefficient (oil) = 67,000

For present day passenger vessels, tankers, and cargo liners, propelled by heavy oil engines, the fuel coefficient would be 90,000 to 100,000 and sometimes more.

In Fig. 11 two eight-cylinder single-acting Diesel engines are compared; the one marked A was built in 1919, the other marked B, in 1959. Engine A weighed 379 tons and delivered 2,250 b.h.p. at 115 r.p.m., i.e. 6 b.h.p. per ton. Engine B weighs 650 tons and delivers 13,500 b.h.p. at 120 r.p.m., i.e. 21 b.h.p. per ton.

The author is now prepared to offer, for serious contracts, pressure charged, single-acting, two-stroke, crosshead type engines to develop 21,000 b.h.p. at 110 r.p.m. on ten cylinders

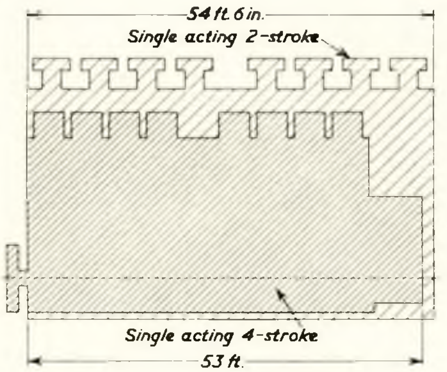


FIG. 11—*Comparison of heavy oil engines (1919:1959)*

750 mm. (29·53in.) bore, i.e. 2,100 b.h.p. per cylinder, the weight over the crankends, including blowers, thrust block, gratings, ladders, etc., being 820 tons for ten cylinders, i.e. 26 b.h.p. per ton weight. The design is characteristically sturdy and robust, both in its proportions and in its scantlings; the moderate revolutions ensure high propulsive efficiency.

The Summit of Sail

With the increasing use of screw propellers, the wooden ship quickly gave place to an all-iron construction, with the composite system as an intermediate stage. Unchallenged on the Far Eastern, Western American and Australian runs, the sailing ship reached its highest level of attainment and gracefulness in the swift sailing clippers of the period 1874-1883. That it was a very highly scientific level is clear from scrutiny of contemporary rigging arrangements.

Fig. 12 shows *Lord Dufferin,* a good class iron sailing ship built by Harland and Wolff, in 1879. This vessel was 256ft. by 38ft. by 23·3ft.; gross tonnage 1,778, net tonnage 1,696; 2,580 tons deadweight carrying capacity, on 20·8ft. draught; 158,130 cu. ft. capacity. The ratio of length of ship to beam was 6·75 : 1. The mainmast height was 178ft. above the top of the keelson, i.e. 0·70 of the ship length and 4·70 times the beam; the lowest yard arm on the main mast was 88ft. long, i.e. 2·30 times the beam. There were 31,427 sq. ft. of canvas. The masts and spars were of iron.

Between February 1877 and August 1880, Harland and Wolff built nine of their fastest sailing vessels. In 1882 their first steel sailing ship, *Garfield,* was built. At the time of launching, this three-masted vessel was the largest full-rigged ship in the world; its leading particulars were: length 299·7ft.; beam 41·2ft.; depth of hold 24·7 ft.; gross tonnage 2,347; net tonnage 2,290; main yard 97ft.

In 1885, *Queen's Island,* later called *Strathdon,* 282·7ft. long, 3,250 tons carrying capacity, 2,038 tons net, a three-masted barque, was designed for a barque rig, instead of a ship rig, because the former required fewer hands, fewer spars, less canvas and less rope. The difference in speed, especially in vessels up to 1,200 tons, was only slightly—and not always—in favour of the ship rig. Many a ship, after being reduced to a barque to save running expense, was found to sail better than before the loss of the after yards. The reason for this apparent anomaly was that a heavily rigged clipper, under all sail, tended to steer a serpentine course, and a knot or more could be lost by the drag of the hard-over rudder.

The rake of masts, in Belfast built vessels, was one inch per foot, against the more usual amount of 0·625in. It was not uncommon for the active life of a sailing ship to extend to 45 years and more; in this period its name and its nationality would, as likely as not, be changed several times. The last sailing ship to be built by Harland and Wolff was the beautiful four-masted barque *California*—the last of four sisters—delivered in 1890. It was of steel, 392·3ft. long, 45ft. beam, 26·5ft. depth of hold, gross tonnage 3,100, net tonnage 2,991. The first ship built by the firm, No. 1 on its register, in 1859, was a steamer. The last sailing ship to be delivered was No. 225, built thirty years later.

Advances in sailing ship design necessarily depended upon the availability of trustworthy experiential information regarding performance and sail spread, from ships of similar type and rig. From the reports of exemplar vessels, the effect of variations in sail area, longitudinal and vertical distributions of sail, transverse stability, and so on, would be critically examined, eventually to result in a design for a new ship of equal or superior performance. Then, as now, if great strides were attempted in a new design, away from previous conceptions of size and proportion, the arrangement of the sail power could only be experimental.

A much used rule for comparing the driving power of sails was the ratio: sail spread/displacement$^{2/3}$. The ratio varied from 70 to 110, with 80 to 85 as average. Another ratio used—if there were considerable differences in form—was: sail spread/wetted surface. For similar ships there were other criteria: e.g. area of plain sail/area of waterline section; sail spread/underdeck tonnage; area of plain sail/immersed midship section; and so on. Another rule was the expression of sail spread as a multiple of tons displacement; thus a ship of 3,000 tons displacement and 21,000 sq. ft. of plain sail would be described as having 7 sq. ft. of canvas per displacement ton. This ratio varied from 4·5 to 8, the largest ratio being for ships of least displacement; e.g. for ships below 2,000 tons, 6·5 was an average figure; for larger ships, up to 4,000 tons, the figure was 5·5 to 6. For sail spread/area of immersed midship section, the ratio varied from 22 to 35, 28 being an average value.

Plain sail, or working sail, was the amount which would ordinarily be set in a fresh breeze, say 5 or 6 Beaufort, at which wind force the pressure was assumed to be 1lb. per sq. ft. of canvas. Mast heights were determined in terms of centre-of-effort above the load line, and the beam.

Sufficient has been stated to show that the methods of successful sailing ship designers a century ago bear strong kinship with the methods of engineering designers today.

As the long struggle between sail and steam sharpened, one of the factors which weighed against sail was the size of the crew which had to be carried. By way of example: two tea clippers built in 1865, sister ships, 197·3ft. long, 33·8ft. beam, sail spread 35,000 sq. ft., would carry 1,430 tons of tea. The total complement was 32, consisting of: master, 2 mates, 24 able seamen, boatswain, sailmaker, carpenter, cook and steward. The crew worked 12 hours per day in watches.

Another clipper, built in 1860, 184ft. long, 31·3ft. beam, carried 1,000 tons of tea when fully loaded; the complement numbered 36, including 22 seamen. Another ship, also built in 1860, 168ft. long, 35ft. beam, had a total crew of 40.

The foregoing examples respectively show one man per 45 and one man per 28 deadweight tons carried. For comparison: a present day, single-screw, cargo motor ship of speed 12 knots and 8,000 tons deadweight carrying capacity will be served by a total complement of 40, i.e. one man per 200 deadweight tons. As the competition of steam increased, some of the fastest sailing ships had their existing sail plans simplified, thereby dispensing with 50 per cent of the crew. The ships became somewhat slower, but the all-round financial results were more favourable. In some ships a second reduction followed, as the ships became older. There came a time when, for emigrant carrying ships, the Board of Trade prescribed the minimum number of seamen to be borne on sailing vessels. Another rule, for steamers, based on aggregate grate area and firing rate, determined the number of firemen.

As years passed, steam appliances for working the sails and anchors, and for handling the cargo in port, attained increasing vogue. The steam was supplied from a donkey boiler on deck.

Fig. 13 shows the ebb and flow of sail and steam during the last century. Now, in a maritime country such as Denmark, the *kirkeskibe* is the chief reminder of a thousand years of sail.

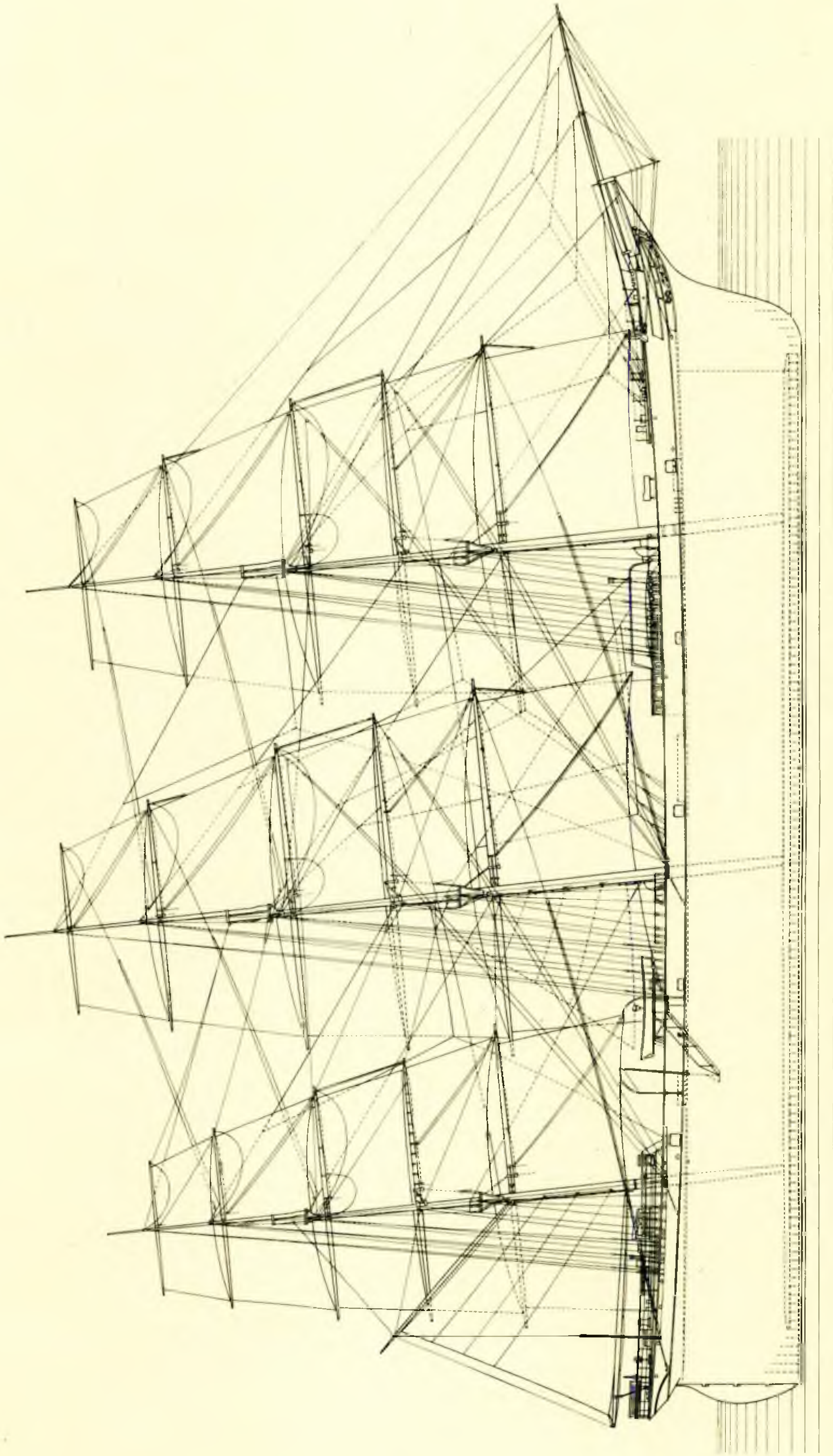


Fig. 12—*Iron ship* Lord Dufferin *(1879)*

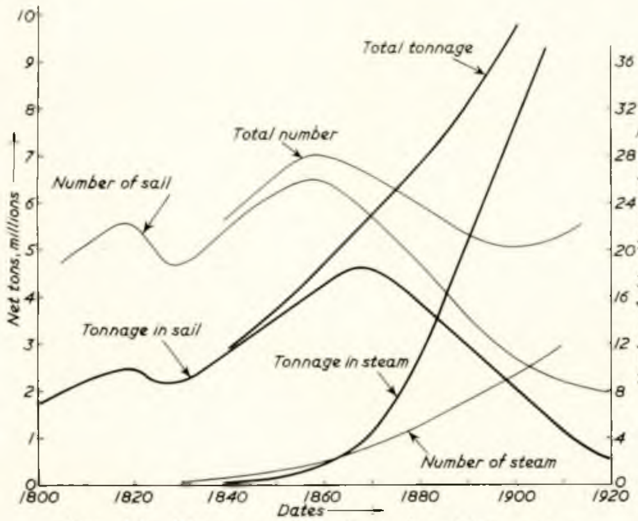


FIG. 13—*Steam versus sail during 19th century*

The Case against Coal

Reference has been made, earlier, to the impermeating significance of the abolition of coal from steamships.

Firemen were necessarily tough fellows, a proportion of them being coarse, truculent individuals who came and went; in passenger liners and good class vessels probably 50 per cent of the stokehold crew would have continuous service, if not with the same ship, then with the same company. Except for the few men needed for working a ship in port, the firemen were paid off at the end of a voyage and were without pay until they signed on again for another voyage either in the same ship or in a different ship.

On leaving port, many firemen and trimmers would be the worse for liquor; consequently, until they sobered up, difficulty was experienced in steaming the boilers, the engineers themselves having to take the shovels. Of stokehold fights and struggles many tales have been told. In one fight, in a North Atlantic liner, the senior engineer concerned—a friend of the author—had a complete finger bitten off! The aggregate actual time for lifting the coal being necessarily short, the time rate of expenditure of physical effort was undoubtedly great and beyond the capacity of many men to withstand.

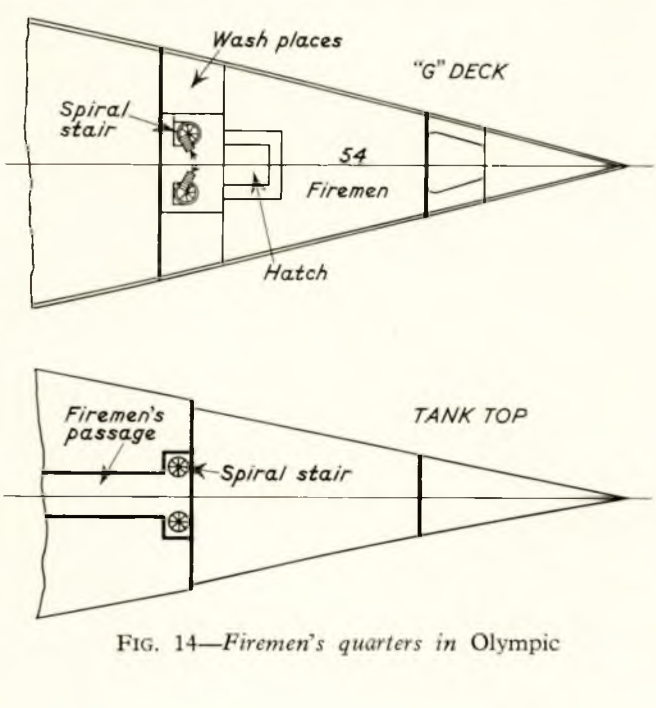


FIG. 14—*Firemen's quarters in* Olympic

Add to this the heat, the discomfort, the rolling of the ship, the ofttimes poor quarters, and it is not remarkable that few men were firemen from choice. In a large passenger ship, running to an exacting schedule, life could be harder than in a cargo carrier.

A fireman would deal with three, four, or even five furnaces, depending upon the boiler room layout. The ratio of trimmers to firemen varied. By way of example: in a certain mail ship having 9 double-ended and 2 single-ended boilers, all except the single-ended boilers were in use on the voyage, i.e. a total of 54 furnaces. The total stokehold complement numbered 72 and comprised: 6 leading firemen, 36 firemen, 6 firemen trimmers and 24 trimmers. One-third of these men would be on duty per watch of four hours, allowing for spare men. After conversion to oil burning there were 12 furnace attendants and 3 cleaners, a total of 15. On a cargo liner, with 3 double-ended and 2 single-ended boilers, i.e. a total of 24 fires, all normally in use: there were 21 firemen and 15 trimmers. After conversion to oil fuel, there were 6 furnace attendants and 3 cleaners.

A common arrangement was for firemen and trimmers to be accommodated in large rooms in the forecastle, each room berthing the complete complement for a watch.

In *Olympic,* there were 6 boiler rooms, containing, in all, 24 double-ended and 5 single-ended boilers. The total number of furnaces was 159. As a coal burner, and with full complement, there were: 15 leading firemen; 161 firemen; 48 trimmers; a total of 224. The firemen and trimmers were housed on four decks, "D", "E", "F" and "G", forward, as typified in Fig. 14. The route to and from the boiler rooms was by way of two vertical spiral stairways which intersected the decks, and a passage, as shown in Fig. 14. After conversion to oil burning, there were: 33 boiler room attendants; 12 cleaners; 9 greasers; a total of 54. That is: 170 men were eliminated. The vacated space was rearranged for third-class passengers.

Progressive Modes of Propulsion

Every method of ship propulsion has proceeded along its evolutionary path until final stability has been attained. Then, to escape from the limitations of the particular propelling agent, a completely new step—a new technical break-through—has become necessary.

The earliest forms of the marine steam engine were single-cylinder jet condensing units, consuming up to 7lb. of coal per h.p. hr. The author finds it difficult to imagine that, in those early years, there could have been men of insight clear enough and vision long enough to be able to see in those inefficient contraptions the forerunners of the great powerful machines of later days. Rather is he of opinion that the men who wrought on those simple engines, or who provided the money for the work, were enthusiasts who were simply striving to make the engines better than they were without having any sense of ultimate high destiny. In commenting thus, the author is not unmindful of the remarks attributed to Nelson and a contemporary statesman, especially as regards naval vessels.

In applying the steam engine to ships on long voyages there were many difficulties to be overcome; thus, coaling stations had to be established at suitably spaced intervals. By 1883 the steamer, with triple-expansion engines, had begun the invasion of the world's longest trade routes, but it was the end of the century before the steamer really predominated there. In 1900, a well known shipping company had 26 ships in the New Zealand trade. Of this fleet 15 were sailing ships and 11 were steamers, the aggregate net tonnage of the steamers being twice that of the sailing ships. The equivalent effective carrying power of steamships was greater than tonnage figures implied, because a steamer would make more voyages than a sailing ship in the same time.

During the twenty-five years which preceded the abandonment of sails in ships having steam engines, there were many criticisms of the dual propulsion system of sails and steam, by reason of the cost. In the late 1870's, for example, there were eminent shipowners who spoke against the use of steam in favour of sail; there were others, and engineers too, who spoke against the compound engine in favour of simple cylinder engines—always on balance sheet results. One shipowner did not expect other than very small improvements in fuel consumption in the future and looked for savings by cutting down wages!

Ultimately the limitations of sail led to its supersession by the more effective steam engine. Seventy years and more ago, naval architects had visualized a steamship 1,000-ft. long; but it was perforce a narrow ship, because of the power-weight-space limitations of the steam reciprocating engine and the multitubular boiler. Then came the steam turbine, to override the limitations of the steam engine. With it, and the watertube boiler, much greater powers at a lower fuel rate were obtainable; ships broader in the beam became practicable. Later came the heavy oil engine, with its profound effect upon ship propulsion economics.

Analysis shows that each prime mover has taken about the same period of time to evolve to a proportionately high, if not final, level. This might have significance in looking to the future of commercial nuclear propulsion. Admittedly the team work on the problem is much more extensive and intense than anything known to past experience; but, also, the problem is correspondingly more difficult. That is, the length of time needed for the establishment of atomic engines in the mercantile marine may be about the same as for the preceding prime movers. If this opinion be even roughly correct, the nuclear propulsion of competitive merchant ships is further off than many enthusiasts may imagine.

One effect of atomic propulsion may be radically to alter the form, proportions and speed of ships, because it may be easier to generate large quantities of power than to provide low powers.

In making this comment a distinction must necessarily be drawn between what is scientifically possible, with the generous backing of Government money, and what is commercially practicable. Of the possibility of being able successfully to propel a merchant ship, or a passenger liner, by power obtained from nuclear reactors there can be no doubt. But between that event and commercial success there is a deep gulf. Thus, one of the first questions a shipowner must ask is: when will nuclear fuel be available for commercial use; what will be the price to be paid for it; will supplies be assured over the years? At present nobody knows the answer to this compound question; nor is it expected that the answer will be known before the middle of the next decade.

SOME CURRENT PROBLEMS

The Sins of the Fathers

Foremost amongst the many perplexities that beset, and sometimes bewilder, marine engine builders and repairers at the present day must be reckoned the uncertain exhibitions of power by the trades unions, the frequent strikes, the exasperating demarcation disputes, and so on, in all of which—in one form or another—are entangled the interests of the shipowner. In these matters, and in others, it is easy to lose one's equilibrium and to burst into ineffectual rage. But, in the author's opinion, the inevitableness of all this was determined over a hundred years ago, when honest, God fearing, working men were transported to the penal settlements for combining together to ensure the necessities of life; when the grasping intolerance of the capitalistic employer was a thing that knew no limit. What happens in the life of the individual the author does not pretend to know, but, in the life of the nation, he is in no doubt that the sins and shortcomings of the fathers do indeed descend upon the children unto the third and fourth generation!

In an agrarian population, such as that of Ireland, memories of past tyrannies are bitter and undying. In an urban community, such as that in Britain, memories are shorter in the individual, but in the genus the memories are still there, simmering out of sight. If the trades unions, that began with a fight for the elementary decencies of life, have gone to the other extreme and have themselves become tyrants the pattern is in accord with human experience down the centuries.

At this point the question may reasonably be asked: what kind of unwholesome legacy could the twenty-first century—and later—receive from the present century? There are alternative answers. If the whole world were gradually to go "left" and the wrong men were in charge, a vast bureaucracy could conceivably emerge wherein all initiative was stifled and whereby another Dark Age would be ushered in. This is not so fanciful as it might seem; it could easily happen in half-a-dozen generations. In this connexion the mordant words of Thomas Carlyle come to mind: "There was once a man called Jean Jacques Rousseau. He wrote a book called the Social Contract. It was a theory and nothing but a theory. The French nobles laughed at the theory and their skins went to bind the second edition of the book".

There is another possibility, equally unattractive. The late Dr. Ralph Inge, of St. Paul's Cathedral, London—who used to be called the Gloomy Dean—said that the time might come when man had developed mechanisms to such a pitch that he, himself, would have no more interest and initiative left than was necessary to press a button, when all else would happen. This gibe is not now so remote from reality as when uttered.

Human life, in the author's opinion, is an unending chapter of challenge and response. If the response equals the challenge, then civilization advances; if not, then it wilts. Whether or not man has more intelligence than the lemmings only the remote future will show.

Homo Sapiens

Man—the author understands from people said to be knowledgeable on these matters—is compounded of 96 per cent emotions, passions, prejudices, irrationalities, idiosyncrasies, fancies and whims, and 4 per cent reason. According to Herbert Spencer: "opinion is ultimately determined by the feelings and not by the intellect".

Be all that as it may, experience shows that, especially in dealing with a difficult fellow, it is more important to concentrate upon his emotional reactions and to arrive at a *modus vivendi* with the 96 per cent of him, if positive results are to be achieved, than to probe for the elusive 4 per cent, only to be disappointed with the outcome.

Unlike all other sentient creatures with which he shares the earth, man is simultaneously two entirely different things; he is gregarious and he is egregious. That is, he is a herd seeking animal, a community dweller, a possessor of the hive mind; but he is also an assertive individualist, with an upthrusting ego which he is always ready to defend. It is this perpetual unresolvable conflict between the herd instinct and the ego, this opposition of powerful forces within the human personality, that presents man with his greatest problems. It is in the dexterous handling of this duality in man *en masse* that the essential task of leadership lies. It is also in the rigorous handling of this duality in himself, *solus,* that preparation for leadership in the individual begins—or should begin.

Whatever the sphere of activity, only under the direction of a first-rate man can a team of workers be employed to best advantage. A first-rate man can effectively be replaced only by a first-rate man. Half-a-dozen second raters are not the equivalent of one first-rate man. Any system of divided authority where men are co-equal in the same field of activity is usually unworkable. Two men may begin by being co-equal but they will certainly not be co-eternal, because either one will swallow up the other—after the fashion of the butler and the baker in Joseph's dream—or they will both be replaced and superseded by somebody else. Napoleon Bonaparte, who probably knew as much about human nature as most people, said that an army was safer in the hands of one bad general than two good ones.

Engines without Engineers

When the author started in engineering and when propelling machinery consisted of triple-expansion engines and Scotch boilers, there was such a continuous flow into the ranks of marine engineers that it was not uncommon to find almost everybody in possession of certificates of competency. An engine fitter, working in the erecting shop for thirty shillings a week, would—as likely as not—have a chief engineer's certificate.

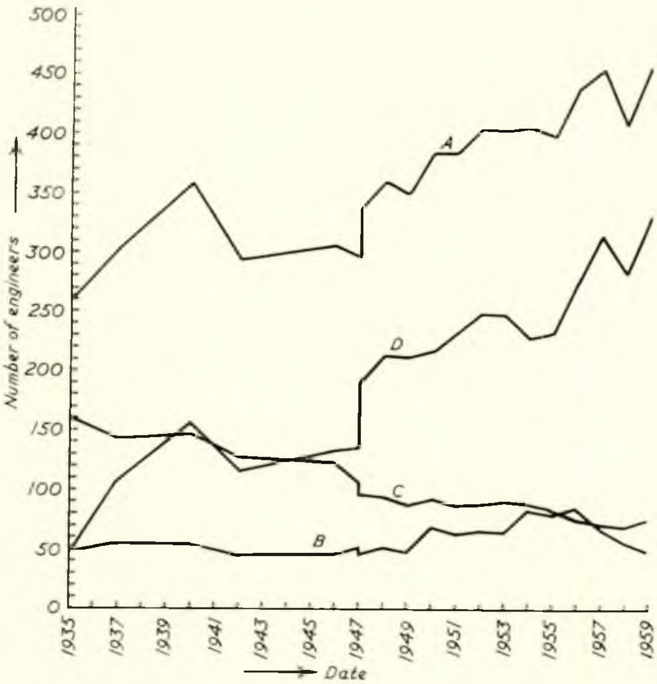


FIG. 15—*Engineers employed in liner fleet*

Now, the outlook is very different. Fig. 15 shows, at graph A, the total number of ships' engineers employed by one of the important British shipping companies during the last quarter of a century. At graphs B and C are shown the respective numbers of men with second and first class Ministry of Transport certificates. Graph D indicates the numbers of uncertificated men. Last year, apart from deaths and retirements, there were 157 resignations. Of the men concerned: 12 possessed first class certificates, i.e. Diesel, steam, or both; 21 had second class certificates, steam or Diesel; the maximum period of service had been 12 years 5 months, the minimum two weeks, the average 2 years 5 months.

When shipowners and others refer to the increasing difficulty of attracting men to a sea life it is too often taken for granted that men are less keen to go to sea now than they were a couple of generations ago. The author, however, doubts if men were ever keen to go to sea—exceptions apart—but they had to do so out of sheer economic necessity. Having served an apprenticeship in an engine shop, and the ratio of apprentices to journeymen being what it was in those days—unscrupulously large by any standard—there was little else for a vigorous young man to do but to go to sea. Later there was nothing worth while for him to do if he came ashore.

Now, qualified marine engineers tend not to remain at sea; and slight reflection upon this fact will reveal to what an extraordinary extent life has changed within living memory. Thus, in the author's childhood, there were no motor cars, no cinemas, no cameras, no gramophones, no typewriters, no electric lighting, no aeroplanes. On the farms there were men and horses; in cities there were horse drawn vehicles; towns and dwelling places were illuminated by gas. Now, most of the items named—and there are many others—absorb workers by the hundred thousand; and at many places in the complex pattern of it all there are openings for men trained as marine engineers.

If engineers are not now interested in seagoing as a career and if this outlook is likely to continue, it becomes a waste of effort to try to change the trend. The living amenities on board ship, the holiday periods, the rates of pay, the status, and so on, are such that, if men will not remain at sea, the fact must be taken as indicating a definite social change. The author and others whose life work it has been to design propelling machinery of many kinds must therefore accept the new outlook as a challenge and be actuated accordingly.

The ultimate result of present trends may well lead to complete engine room control from the ship's bridge. The men that would thereby be displaced on board ship would be employed ashore in overhauling and maintenance work. Many schemes for dividing the power of main propulsion engines have been devised in times past. In all of them the capital cost is greater, the weight is greater, the space occupied is greater and the fuel consumption is greater than for the equivalent direct coupled engines. This, in turn, necessitates greater bunkers for the same steaming radius. Nevertheless the overall balance sheet of running a ship may eventually require propelling engine subdivision. A workable alternative is to make direct coupled engines even simpler than they are now and so to improve the design that maintenance periods can profitably be extended.

Machinery room layout, subdivision of auxiliaries, pumps, etc., could be devised on the assumption of simpler schemes of overhaul in port, ensuring quicker turn-round. The increased application of automatic controls can be expected, a beginning having already been made with combustion control. In this connexion it will be recollected that, during the last war, the U.S. Maritime Commission, which was responsible for the building of many watertube boiler/geared turbine sets, arranged for their machinery rooms to be staffed by men whose only knowledge of engineering practice was that gained during the brief indoctrination course accorded them before taking up their shipboard duties.

In certain multiscrew vessels, one of which was built in Belfast, there is a master room—remote from the engine room —to which every engine control, every pressure gauge and every temperature gauge is led. The engineer in charge sits at a desk and, with all these things before him, controls the running of the machinery.

In extolling the emancipation of man from excessive physical toil on board ship, it must not be overlooked how much scope there is still for the more dexterous application of power driven overhauling equipment to existing engine rooms. The days of the sledge hammer and tup for the tightening of large nuts should be deemed to have ended. Wherever men are to be seen hauling on chains and heaving on pulley blocks, somebody is leaving a human problem untackled.

On Persons in High Places

It is not always appreciated how real can be the unspoken influence of a leader in industry. If the man at the top is a man of integrity, clear thinking, self-disciplined, industrious, faithful to his staff and modest in himself, the best of the men around him will inevitably absorb and reflect these characteristics as time passes, each proportionate to his gifts and in accordance with his perceptive faculties. The result can be a body of men of unrivalled technical and commercial strength. The converse is even more true.

Inexperienced men of subordinate rank are apt to judge their high chiefs by the knowledge, or lack of knowledge, which the said chiefs may display of their particular speciality. But this betokens a wrong conception. A high chief is not where he is because of profound expertness on some narrow sectional subject, but because of the steady confidence he commands, based on his sound judgement over many subjects, because of the wide knowledge he possesses of technical matters removed from detail, and so on.

The aim of the engineer is always to produce a silent, smooth running machine, this characteristic being a measure of its efficiency. It is the same with the human machine. If the author were as able an administrator, as sound a leader and as good an engineer as he ought to be, he should be able at all times to cope with all situations, without rufflement, without so much as raising his voice. Noisiness, certainly, is not consonant with efficiency, as witness the words of Eliphaz from long ago: "Should a wise man utter vain knowledge and fill his belly with the east wind?"

To young engineers, it is often a source of irritation that older—apparently less gifted—men can be so often right, whereas they are so often wrong. Usually the process can be summed up in the word "experience". This notion of judging by experience is most important. The explanation is that, over many years, a responsible man faces many problems and surmounts many difficulties. When, therefore, he scrutinizes a new proposal, he gives an opinion which—without his realizing it—has behind it, below the threshold of his consciousness, countless impressions of previous happenings. Judgement by experience is not to be confused with notions of intuition; experienced judgement can err, at times.

The chief temptation to which men in high places are liable to succumb is adulation. Almost without exception they are singularly susceptible to the succulence of flattery. Not to be flattered is, often, to be offended; such is the parvitude of their outlook. Bowing in the house of Rimmon can, therefore, be an unpalatable working necessity for the uninfluential underling, at least until a more congenial post is obtained elsewhere. What many a "high-up" man does not appreciate is that he, himself, may be the apparent keypoint in a great and much-ramified organization where everything awaits his decision, where everybody dances to his tune: but, take him away from the organization and he is nothing. It is unreasonable, therefore, that everybody around the adulant should have perpetually to walk with the delicacy of Agag. Stated another way: in an engineering establishment, as doubtless in other places, it is too often overlooked to what extent a man's subordinates are the strength of his position; how the most powerful man, stripped of the loyal assistance of those around him, can quickly decline into insignificance. In accepting loyalty as a right, a leader must show loyalty as an obligation. He should remember that Balaam's ass was more discerning than the prophet.

In the life of the individual it can happen that the basis of his outstanding strength is also the source of his greatest weakness. A vividly imaginative and enthusiastic man can be a great asset to a community, but those very qualities can open a yearning pit at their feet.

The chairman of one of the great British banks—an eminent financial figure who had been a cabinet minister for years—one day interrupted a conversation which concerned the author's firm to have a few words with a visiting official of his bank. This official had been brought from a distant centre. His chairman said to him: "Your record is, of course, known to us; your value is also known and our confidence is such that we are about to offer you further promotion. I have asked you specially to come here today so that I can put one question to you, namely: "Are you lucky?" What a question! Are you lucky!! If an applicant for a post were to say to the author, "In addition to my academic, technical and practical training and experience, I would like you to know that I am lucky" his answer would surely be: "Quite! but not today!!"

A Digression on Designers

The author is interested primarily in the two end links of the long chain of engineering workers, namely the machinery designer and the operating engineer. Between these two types of men—so different superficially—there are many points of affinity, for both are individualistic in character and temperament, and both spend their working lives in relative isolation from their fellows. The operating engineer has personal and inescapable responsibility for decisions which can affect safety of ship, cargo, crew and passengers; the designing engineer has heavy personal responsibility for decisions which can determine the destiny of his company. Engines are hard taskmasters. Lose or win; kill or cure; heaven or hell; the lawyer, the doctor, the cleric may receive his fees; but, when things go awry with the machine, the engineer's competence is quickly called in question.

The successful designing of machinery is at least as much an art as it is a science; and, different from what might be expected, the experienced engine designer uses a minimum of theoretical knowledge for the attainment of a maximum of practical results. As with other creative workers, he is at all times exposed to the pejorative criticisms of all comers. The critics themselves may be lacking in knowledge and talent; but these deficiencies have no deterrent effect on the critic.

Two years ago on the death of Sibelius, the great composer, an appreciation of him was given in a London newspaper, in the course of which the writer recalled sitting with Sibelius outside the latter's house in Finland. At one stage the writer interrupted the conversation of his host and, pointing to a skylark rising into the air, said: "There goes the perfect musician". "Yes" replied Sibelius, pointing to a great black, half-moulted, raucous crow: "and here comes the critic"!

The author's primary work, for many years, has been the designing of direct-coupled Diesel engines with powers per shaft of 10,000 b.h.p. and above. In this work there has been nobody with whom he could confer for an authoritative second opinion. A sobering thought? Yes! but also a stimulating one, because, without uncertainty there can be no incentive. Progress always lies where life is hard, not where it is soft.

As already implied, machinery design is apt to be regarded as an exact science, but it is far from that. It is a craft of a very high order and its basis is a wide system of experiential, scientific and semi-scientific data. No matter how capable a designer an engineer may be, he cannot escape from the inherent limitations of the things he uses. In fact, part of the art of engineering design is successfully to achieve an objective despite the limitations.

The creative powers so necessary to the successful designer seldom accompany high mathematical gifts. Conversely, a mathematician is seldom, if ever, more than a mediocre designer. In fact, he is well advised to leave the subject alone.

A master designer must be, almost in spite of himself, an iconoclast. His value and his status must ultimately be determined by his selective and heuristic skill. He, and indeed any engineer, is only safe so long as he closely abides by Newton's maxim: *Hypotheses non fingo.*

The designing of a thing which is simple can be inordinately difficult. Anybody can devise a complicated mechanism; but it takes a master of the craft to produce something which is simultaneously simple and sound. At every turn the designer has to make important decisions, always on the basis of imperfect knowledge. He is perpetually balancing a tendency to caution—leading perchance to uncompetitive costs—against a risk of cutting things too fine and running into expensive trouble. His work bears daily testimony to Samuel Butler's quip: "Life is the art of drawing sufficient conclusions from insufficient premises". The alternative is to emulate Buridan's logical donkey, which died of starvation when placed centrally between two equal bundles of hay.

It was said of Julius Caesar that he was husband to all women and wife to all men. Metaphorically—but only metaphorically!—an equivalent, versatile, willing adaptability should mark the attitude of the engine designer to his many shipowning clients.

The Marine Engineer Contra Mundum

For many years it has been said that the marine engineer does not receive a due place in the counsels of the shipowning companies. In the author's opinion he has not until recently been fitted for it. Superintendents of noted prowess as stokehold bullies, who could wring engine revolutions out of the most ferocious of firemen, were not impressive on a board room floor, under interrogation on technical matters. It was often painful for the author, in his earlier days, to have to accompany an engineer into a conference with his owners.

The engineer was never a match for the quick witted commercial men with whom he was faced; and it was frequently necessary for the author to throw a mantle over him, by intervening with a spontaneous presentation of facts and arguments which his chiefs were quick enough to appreciate. It was advocacy by a technical man, accustomed to the thrust and parry tactics of commercial managers, accustomed to meet them on level terms, that made all the difference. Now, however, there are marine engineers who are well able to rank with the highest of their fellows in a shipping company—nepotism apart—on the score of their innate gifts, their training, their administrative abilities and, if need be, their culture. The result is that here and there an engineer has been elevated—that is not the correct term, but it can be allowed to pass—to the directorate because the company's principals have come to realize to what an extent they are dependent, ultimately, upon the knowledge, the skill and the wisdom of their higher technical staffs, if their companies are to expand and prosper.

The rank and file of engineers should not feel unmoved at this, because, if the engineer at the top is "a Cock of the Right Kind"—John Bunyan's phrase—his influence should be an uplift to everybody "down the line" in the technical departments.

It is sometimes the self-assumed prerogative of non-technical men to criticize the engineer's so-called mistakes. But, surely, when able men, as zealous and as knowledgeable as any that can be found anywhere, apply themselves to the design, manufacture and running of new, advanced forms of machinery for the ultimate financial benefit of their clients, it is not to be accounted a mistake if time and money are required for partial redesigning and replacement. The author has never yet seen a so-called mistake, made by anybody, which was not perfectly obvious—afterwards. Hence the oft-quoted saying that if a man's foresight were as good as his hindsight he would be better off a damn sight!

The author is often asked by accountants, and others whose duty it is to exercise financial shrewdness, why engineers continue to develop new forms of prime mover; why they cannot remain content with things at their present level. The answer is that our dynamic world is based upon continuing progress, upon the necessary pursuance of the task of making two blades of grass grow where one grew before. From the first day that the steam engine became a substitute for human toil, material progress has been dependent upon improvements to machinery. The vast increase in international trade which has followed the widespread use of power operated ships has been an important factor in raising standards of living amongst the nations.

It is characteristic of life that "man never is, but always *to be,* blest". The consummation firmly to be desired is always just out of reach, always just round the next bend. It is, of course, this pursuit of *el dorado* that provides the mainspring for progress.

Within the last few generations engineers have conferred innumerable benefits upon mankind and if every department of human activity succeeded in keeping pace with engineering progress, the life of the average citizen would be much improved; at least that is what the author thinks. Rightly or wrongly, as he sees the matter, human beings fall into two groups. One group continually seeks stabilization; the other unceasingly reaches out to new things. What is needed is not that the engineer should stop inventing and advancing but that those responsible for our present economic, political and religious systems should keep abreast of him.

In the days of the *Pax Britannica* the country's economy bore likeness to a solid prism standing four-square on a broad base. Now—or so it seems to the author—the prism has been transmogrified into a round-bodied *tippe top* which has increasingly generated rotative momentum until it has risen from its smooth base to whirl at high revolutions on its pintle. The faster it spins the more stable is its apparent equilibrium and the more permanent-seeming its solidity. But the engineer may be forgiven for wondering where the governor may be.

A century ago, engineering achievements were identified with individual men. Now, things are different; the probing of problems has grown costly, complicated and subtle; achievement is a team effort. The change is doubtless a concomitant of rapid advancement in knowledge and the growth of great companies. But, even so, a team requires a leader; and if the team remains in being for a long time, its quality—its *timbre* as it were—will be, to an appreciable extent, a derivative of its leader.

If and when, for merchant ships, nuclear propulsion becomes an accomplished fact, it will be—nay, it *must* be—the engineer who will control and be responsible for the machinery design and arrangement; it will be the engineer who will be responsible for the execution of the work. The highly meritorious labours of the scientist will—or should—begin and end at the nuclear reactor and its ancillaries, with all their manifold and intricate problems.

Over twelve years ago the author was taken to task in a leading article which appeared in Britain's foremost engineering periodical—written by its brilliant engineer-editor—for remarks which he had made in a lecture to young men *vis-a-vis* engineers and scientists. Reading these remarks afresh, after the lapse of this long time, the author remains intransigent. The substance of the remarks is quoted below.

"There are two things which the author actively and especially dislikes. One is to be called an expert, the other to be called a scientist.

"The expert is not to be confused with the specialist. In his own sphere the specialist can be expected to be right more frequently than the ordinary man. The expert, presumably, is always right.

"In the author's opinion the engineer is not a scientist; the work and functions of the engineer and those of the scientist are widely different. As he sees the matter, engineering is a craft, for the successful exercise of which much knowledge of a technological nature is needed; it is concerned with the practical design, manufacture and operation of machines of many kinds. Practical qualifications would be superfluous if scientific knowledge made a man an engineer. The engineer calls in scientists to assist him with problems of metallurgy, physics and chemistry. But he also calls in lawyers, patent agents and so on. The grouping of engineers with scientists can and does operate to the disadvantage of the engineer; hence, once it is clear that engineers are not scientists—and conversely that scientists are certainly not engineers—many things take their proper places.

"Engineering is, first and last, a commercial business. The similarity between building and selling an engine, and making and selling a pair of shoes, may be disguised and overlaid, but, at root, the two things are the same. The engineering works, with its complicated plant, its many trades and its technical officers has, in the last analysis, kinship with the shoemaker, who, taking his raw material, fashions it into a pair of shoes and sells them over the counter. Shoes are sold on suitability, durability, price and so on; so is a power plant. The end is precisely the same; it is only the means to that end which are different. All this may be obvious, but nevertheless it is hard to get technical men to appreciate—in their bones, so to speak—the commercial aspect of their work. In design offices, men—especially those whose cast of mind tends to the academical—are apt to become so absorbed in their problems as to mistake the means for the end. In the works, men with the super-organizing complex commit the same error".

In considering the growth of industries which are based upon primary inventions it is not always easy to place true figures of merit respectively on the inventors themselves and on those men who later develop the inventions. Thus, in considering the heavy oil engine, other people besides Dr. Diesel were thinking along the same channels, seventy years or so ago, e.g. Herbert Akroyd Stuart; and readers will be familiar with the controversies that raged regarding priority of invention, the relative part played by each inventor, and so on. It is by no means clear what would have happened to his engine if Dr. Diesel had not had the tremendous advantage of working with the M.A.N. engineers in the early days of its development.

In the ordinary way of life a man may be of greater ultimate value to his generation in the stimulating directive influence upon contemporary practice and progressive development, which radiates from him, than the inventor of a new machine.

The Algebraic Sum

Although there are many facts available regarding dimensions and capabilities of steam assisted sailing ships, there are singularly few regarding the men who operated the engines.

Until 1862 the status of the engineer was no different from that of any other member of a ship's crew. In many companies it was the master who had the voice of authority in regard to boiler pressures, coal consumption, engine revolutions, and so on. The engineer-mechanics were land men, denizens of workshops; they went to sea because their engines went to sea. It was in the vocabulary of such men that names of engine details originated earlier: boss, male and female threads, dog-and-bitch key, and terms even more homely readily come to mind.

The Mercantile Marine Act of 1850 and the Merchant Shipping Act of 1854 constituted the first serious attempts to provide for the safety of life and goods at sea. Masters and mates of foreign going ships were required to qualify by examination. The Merchant Shipping Amendment Act of 1862 instituted examinations for engineers.

The syllabus for the second class certificate examination comprised seven clauses. Four of these clauses dealt with boilers and their appurtenances. Of the other three: one stipulated that the candidate must write a legible hand and understand the first five rules of arithmetic, and decimals; another, that he must be able to state how temporary or permanent repairs to machinery parts could be effected; another that he had to pass a creditable examination on the construction of paddle and screw engines, being knowledgeable on the details of the working parts.

The syllabus for the chief engineer's examination required that he could take and calculate indicator diagrams; calculate safety valve pressures and boiler strengths; test and alter slide valve settings; test the fairness of paddle and screw shafts and be able to adjust them; and state the general proportions of machinery parts. His arithmetical knowledge had to include the mensuration of surfaces and solids and the extraction of the square root.

An extra first class engineer's examination was also instituted and was intended "for such persons as wish to prove their superior qualifications".

The establishment of examinations was accompanied by the kind of hostile criticism which is inevitable with every change, with every advancement. Thus, one eminent engineer ten years later, said: "I believe the enactment that engineers should have certificates has been injurious; I mean that it has rendered steam navigation more unsafe. I believe the act was passed at the instance of the Board of Trade, simply to enlarge their region of interference. There is no handicraft skill in being a steamboat engineer". Another said: "Some of the best class of engine men were kept out because they did not pass a Board of Trade examination". And so it went on.

Such were the early days of the marine engineer. But much has happened since then, so much, in fact, that the engineer of 1959 bears no more relation to his predecessor of 1859 than the latest steam turbine installation does to the primitive steam reciprocator and haystack boiler of a hundred years ago.

As with the engineer, so with the Institute. Since it was founded seventy years ago in Stratford, Essex, it has progressed out of all recognition. As with so many of its members, it has come-up "the hard way". Now it takes a deservedly high place amongst the senior institutions of the nation. As the author sees the matter, its real work still lies ahead, especially in service to marine engineers throughout the Commonwealth. If a slight adaptation of words in *Areopagitica* be permitted: "We boast our light; but, if we look not wisely on the sun itself, it smites us into darkness. The light which we have gained was given us to discover onward things more remote from our present knowledge.... Methinks I see in my mind a noble and powerful Institute, rousing herself like a strong man after sleep. Methinks I see her as an eagle mewing her mighty youth and kindling her undazzled eyes at the full midday beam".

Discussion Held at The Society of Naval Architects and Marine Engineers, New York, on 13th November 1959

COMMANDER J. W. THORNBURY, U.S.N. (Member) said it was an unusual, but rewarding, experience to read a paper such as this. The concise history of the evolution of ship propulsion fully supplied the background for the author's remarks on the impact of engines on engineers.

The author postulated that there was less and less interest in seagoing as a career and that ultimately this might lead to minimum crew and complete engine room control from the bridge. There were fashions in engineering as in other human creations and it was presently fashionable to automatize to the maximum practicable. This, too, pointed to eventual bridge control.

While this trend was undeniable, he doubted that the ultimate fruition, except for the simplest of low-power plants, was in the immediate future. The complexity and concomitant high cost of complete automatic control would give pause to the shipowner. It was not in this area alone, however, that trouble might be foreseen, but also in the impact of the automatic engine on the engineer.

In the past each new development in engines tended to reduce the physical labour required but at the same time imposed a greater necessity for the exercise of judgement. This had led to the development of a group of men, prideful of their abilities as operating engineers. It was upon this group that reliance was now placed, and must be placed in any interim period between manual control and automatic control.

It was no exaggeration to say that this group would view with distrust and resentment this intrusion of the push-button world into the realm of the marine engineer. The historical trend to greater reliance on marine engineering knowledge, experience and judgement would have been reversed. Job satisfaction would diminish and with it the engineer's prestige and dignity. He would tacitly or openly oppose it.

A concrete example of this existed in the U.S. Navy's experience with automatic boiler controls. Almost invariably, in ship after ship, the immediate reaction of the fire room personnel was that no automatic control could tend a boiler as well as they could. This feeling, bolstered by the somewhat poor reliability of the early controls, led to little use of the controls and to continued manual control. Even today, a number of years later, automatic boiler controls for a ship which must perform rapid manœuvres were mistrusted by Navy fire room crews and were only gradually and grudgingly winning acceptance.

As in the ship built in Belfast mentioned by the author, the U.S. Navy now was providing a master room where the marine engineer might sit in air conditioned comfort, remote from the engines, and view all his dials and gauges. While undeniably more comfortable, and theoretically more efficient, it too found opposition from some operating engineers. When in the engine room the experienced marine engineer used all his senses to monitor his plant. A sound slightly off the usual pitch, a vibration felt through the shoe soles, an abnormal odour—all of these might presage trouble which the dials might not tell him about in time. Then, too, the young engineer officer-of-the-watch could not be trained properly in such an atmosphere. He needed, in the writer's opinion, to be exposed to the sights and sounds of the engineering plant—to hear the blower's whine and see the wisps of steam and to be surrounded by the power he controlled. Only in this way could he fully appreciate and develop a feeling for his plant that would enable him to evaluate intelligently what his gauges and dials told him.

The era was here now when complete bridge control was technically possible, if not economically feasible. The integration of all the controls of a complex steam plant into a simple black box, of complete reliability and controllable from the bridge, would be a tremendous and expensive engineering feat. This, however, would be a small task compared with gaining its acceptance by the marine engineer.

MR. ROBERT TAGGART (Member) said that the author's thorough review of marine engineering history and his enlightening discussion of the human factors in the design, building, and operation of ships' machinery brought to mind another attribute of the successful marine engineer—showmanship. This was not an essential trait but often a most desirable one if an engineer's thoughts and labours were to bear fruit during his lifetime. Two examples involving noted marine engineers would serve to illustrate this point.

The first of these was the attempt of John Ericsson to interest the Admiralty in his screw propeller in 1837. Ericsson had constructed a 45-ft. boat called the *Francis B. Ogden* on which his counter-rotating screws were installed. To demonstate its performance he invited aboard Sir Charles Adam, Senior Lord of the Admiralty, Sir William Symonds, Surveyor of the British Navy, Sir Edward Parry, the Commander of the Second British North Pole Expedition, Captain Beaufort, the Hydrographer of the Royal Navy, and other scientific and naval officers.

Ericsson had carefully prepared detailed plans of his mode of propulsion and spread them out on a table covered with a damask cloth for the inspection of his distinguished guests. He was quite astonished to find that the chief constructor of the British Navy gave them no more than a cursory glance. The principal point of interest on the tour of the Thames in the *Ogden* seemed to be the Seward steam engine factory with its huge array of marine engines and the Admiralty's favourite propelling apparatus, the Morgan paddle wheel. As the little steamer returned up river at ten miles an hour, propelled by its unseen and noiseless screw, Ericsson realized that his demonstration had been a failure.

What had gone wrong? With the logic of a competent engineer, Ericsson had carefully prepared an exhibition of the capabilities of his invention and clearly defined its mode of operation. Yet obviously he had not made the slightest impression on the Admiralty. He later found that his guests had come aboard with the preconceived notion that, in Sir William Symonds's words, " . . . even if the propeller had the power of propelling a vessel it would be found altogether useless in practice, because the power being supplied in the stern, it would be impossible to make the vessel steer".

Although Ericsson's preparations had been thorough, they lacked that quality of showmanship which was needed to jolt the Admiralty out of their smug satisfaction with their existing equipment. Perhaps Ericsson learned a needed lesson from this discouraging experience. At least we know that he went on to achieve great fame in the United States as a marine engineer who, in the words of John Bourne, had "the combination of that faculty of the imagination which we call invention, with the experience, the science, and the caution which are the main qualifications of successful engineers".

The second example revolved around a notable incident which occurred during the Jubilee Year of 1897 off Spithead, England. The might of Her Britannic Majesty's Royal Navy was drawn up in two formidable lines between which the Royal Yacht was to pass in review. Patrolling destroyers were set the task of preventing any of the hundreds of private yachts there for the show from trespassing in the lane between the battle cruisers. Suddenly a small, insignificant-looking steam launch wandered into the cleared area. The destroyers charged in to divert this brash intruder. With a short belch of smoke from her disproportionately large stack, the launch steamed at full speed down the lane, easily outdistancing the destroyers, much to the consternation and embarrassment of the Lords of the Admiralty.

Sir Charles Parsons had chosen this dramatic method of attracting the attention of the Admiralty to one of the most important developments in the annals of marine engineering—the steam turbine. The boat was the *Turbinia,* a 100-ft. launch with a displacement of only 44 tons. She was fitted with three direct drive Parsons turbines driving three shafts with a total of 2,000 h.p., which propelled her at a speed of 34 knots.

Sir Charles's demonstration so startled the Lords of the Admiralty that they authorized construction of the *Viper* and the *Cobra* powered in a similar manner. These two ships were the fastest in the world in their time.

Here was an extreme example of engineering showmanship as contrasted with the more prosaic approach of Ericsson. The professional engineer might find the need for such tactics distasteful; yet in our day as in the days of Ericsson and Parsons it was often necessary to resort to such measures to bring about needed improvements in the practice of providing the power for propelling ships through the water.

Rear Admiral W. D. Leggett, Jr., U.S.N. (ret.) (Member) said that the very complete history of machinery development called to mind similar developments in their Navy. One of these was covered in a report of the Secretary of the Navy to the Congress in 1851, more than 100 years ago—a report of Chief Engineer B. F. Ischerwood on the replacement of the copper boilers of the steam frigate *Mississippi* by iron boilers. With the new boilers 8lb. of water instead of 4·78 could be evaporated per lb. of coal. The steam pressure was increased substantially over the 10lb. per sq. in. permissible with the copper boilers. The smaller size and weight of the boilers permitted the carrying of more coal. Best of all, the sale of the scrap copper at 15 cents per lb. was sufficient to defray the whole cost of the changeover! This was, he thought, one of the few instances where progress was not expensive!

In 1921 he made a cruise to Peru in the protected cruiser *Columbia,* a triple-screw coal burner with double-ended Scotch boilers and four-cylinder triple-expansion steam engines. She was commissioned in 1894 at Cramps in Philadelphia. He had not been able to verify it but they all believed she made a record crossing of the Atlantic at some time. Even as an Ensign he could enjoy just watching those engines run. They were a part of a "seeing is believing" world which was being dealt its last foul blow by nuclear power.

Most of his engineering, and he believed most of the author's, had been on the Diesel engine. The American approach had been very different. In America they had pushed the development of the high performance, comparatively small type of Diesel engine to a reliability and low cost which he would not have believed possible 30 years ago. Abroad, the development had generally been along the lines which were so well presented in the paper of the slow speed, direct connected, large horse power Diesels which had also reached a high level of reliability and low cost.

At one point, however, as illustrated by Fig. 10 of the paper, they had done some very similar thinking. This figure showed a multiple engine installation connected through electric motors to propeller shafts. While he was still of the opinion that a hundred 2,000-h.p. engines connected to generators would make a less expensive and equally reliable installation, he accepted the fact that there was little likelihood of either being built. He conceded the steam turbine the large horse power ships.

Since he had just made a talk in which he attempted to demonstrate that nuclear power was advancing at a faster pace than had been realized by any previously known prime mover or fuel, he must take exception to the author's statement that "the establishment of atomic engines in the mercantile marine may be about the same as for preceding prime movers". Except for submarines, he would concede that ships were not going to be a prime target for nuclear power. Having access always to oil which had been transported only by ship, the economics of burning this oil were more favourable for ship propulsion than for power generation of any other type. On the other hand, it was possible even today to demonstrate by calculation, at least, that there were routes on which some cargoes could be handled more economically with a nuclear power plant than by any other means. The fact that in the current embryonic state of development of nuclear power even this could be done was most encouraging. Government sponsorship was still needed and central station power would provide the major impetus for development but they did not really have very far to go.

He found the philosophical opinions in the latter part of the paper very profound—which meant, of course, that he was heartily in accord with most of the opinions expressed. He thought, however, that the comments made over twelve years ago and reiterated in this paper on the subject of engineers and scientists deserved a little re-examination. He understood what he believed was the author's point; that even in engineering some practical common sense co-ordination and business logic rather than abstract scientific specialization must prevail at the head of any organization that was to produce a mechanism as complicated as a Diesel engine, for instance. They did, however, have scientists, lawyers, accountants, and many men of other seemingly narrow background heading business organizations, even engineering organizations. He would much prefer to see the engineer classed with this group rather than with the shoemaker.

The confusion stemmed from the definition of an engineer and he would like to quote a couple of paragraphs from a talk he had made to an engineering group last spring:

"Before we discuss the engineer's position in this situation, whatever it may be, it seems advisable to define just what we mean when we say 'engineer'. When I was growing up, an engineer ran the locomotive or the local power plant. Today I frequently hear the local broadcaster introduce his 'engineer' who presumably spins records and controls the volume on the radio show . . .

. . . "Engineering was a craft with thumb rules handed down from artisan to apprentice for many years. Only recently have we accumulated and classified enough knowledge to raise the engineer to the dignity of a professional. The professionals and non-professionals have both retained the title. There are jobs in operating engineering which can be filled by either. It is highly unlikely that the engineer will ever have the clean-cut, distinct, definition of the physicist".

He knew what the author meant. He agreed with him that in an engineering problem an engineer with breadth of experience could probably come closer to providing the kind of leadership that was needed in dealing with his own people and with business contacts than anyone else. But they must all keep in mind that they were highly trained members of a profession and not trade school boys from the black gang. Too many of their associates would like to think of them as just another kind of shoemaker.

MR. W. A. BAKER (Member) remarked that although by title this paper pertained only to marine engineering, there were enough references to ships and their characteristics to permit a few comments from a naval architect. To begin with, he was sorry that he could not accept the author's offer of a 21,000-b.h.p. oil engine. His personal tastes ran more towards antique wind driven craft, which, in this day when highly technical words must be employed to describe simple things, might be said to derive their propulsion from a major thermonuclear reactor—the sun. He believed the sail plan for the barque *Queen's Island* of 1885 mentioned in the paper still existed in the files of one of the shipyards on their Pacific Coast.

While the first part of the paper was simple unembroidered history, the second part was all the more interesting for being similarly unembroidered. Many simple paragraphs could well serve as subjects for further papers. The comments on designer *versus* mathematician, engineer *versus* scientist, were worthy of emphasis and expansion.

In the field of hull design, the mathematician and scientist could show that, in many cases, U-shaped forebody lines were ideal for low ship powering requirements. The designer and engineer could show that such forebody lines were also best from the point of view of the repair yards because of the periodic repairs for slamming damage. He did not ever recall seeing an analysis showing how much fuel had to be saved by a given set of lines to pay for one bottom repair job, but, in these days of superanalysis, such data must exist.

Concerning engineering experience and judgement and the young engineers' irritation with the oldsters, the young ones had in some cases legitimate gripes. On the other hand, the old timers often commented that the college graduates were younger each year and that they needed more maturing than in the past. Undoubtedly, some years of experience were necessary before a young engineer was fully useful to his employer. Considering that the average engineering graduate had had at least twelve years of experience with simple arithmetic before being employed by industry, it was discouraging to industry to find that not only did it have to train the judgement of a young engineer in his chosen field but had to cover basic arithmetic too. They appreciated that their universities must cover an immense amount of ground in a normal four-year course in the teaching of basic knowledge and modern methods, but they should expect the young engineer to be reasonably proficient with the fundamental tools of the trade.

MR. O. H. OAKLEY (Member) thought that the author's remarks regarding the accountability of the engineer were certainly apt. While the lawyer and the doctor were surely not exempt from accounting for their misdeeds, theirs was a different, generally more limited, public responsibility. Bridges, dams, ships, were all visible symbols of their progress as civilized men, and all acknowledged the handiwork of the engineer. When a bridge failed, a dam burst or a ship sank, it was generally a spectacular event and the public was shocked to see a symbol fall. The clamour for an accounting that inevitably followed could usually be counted on to flush out an engineer or two, whether responsible or not.

The design of a ship was a unique engineering effort in several ways but most notably because usually one or only a few were built to a given set of plans. Since it was manifestly impracticable to build a prototype for purposes of "debugging", as was done in the aircraft industry, the design must be "right" the first time. This tended to make the ship designer a hard-boiled conservative. In naval design, where new developments must be worked into design if the ship were not to be obsolete at launching, the opportunity to be conservative was rare indeed.

The necessity to prove and "debug" developmental items in advance of installation led the naval ship designer to attempt to predict performance by means of more complete theoretical analysis, simulator studies, and so on. These techniques inevitably demanded more sophistication in the engineer. Furthermore, these were the same techniques that were being brought to bear on many problems of the basic sciences.

As a matter of fact the engineer had always been to a degree a scientist, and today, when engineering was pressing at the very borders of science, the engineer must be more of a scientist than ever before. Admittedly, the argument was partly a matter of semantics, but the author's rigid separation of the roles of engineers and scientists seemed to him to suggest a trace of "cirrhosis of the attitude" quite foreign to his otherwise forward looking approach to engineering.

In closing, he wished to congratulate the author on a most stimulating paper. It was a unique and pleasurable experience to read a paper prepared for a technical society which required at one's elbow the Old Testament, a Latin dictionary and a copy of Bartlett's Quotations.

PROFESSOR HARRY BENFORD (Member) considered that the Society certainly owed the author a vote of gratitude for the most refreshing paper of the decade. This was an age of specialization and so many of them were so intensely devoted to their own parochial problems that escape from mass-myopia was almost impossible. The author's imaginative paper should do much to reorient their thinking and return it to proper perspective.

As an educator, he was particularly interested in his comment on the apparent incompatibility of mathematical and design capabilities. This and his views on the separation of the engineering and science professions came at a time when American engineering education was shifting in the opposite direction. The trend seemed inevitable, however. Scientists were moving ahead with unprecedented speed and were for the most part unwilling to slow down long enough to explain their work in ordinary technical terms. It fell to the engineer, then, to provide the communication with the scientist and the only way he could do this was to learn his language, which was extensively couched in advanced mathematical terms.

Another point of interest in the paper was that of automation of the engine room. Crew reduction through automation appeared to be an area of sound economic promise, particularly for American-flag ship operators with their high wages. Recent estimates indicated that it cost about $1,500,000 to provide the accommodation, galley facilities, lifeboats and other crew necessities on a large cargo ship comparable to the Mariner class. Furthermore, over the nominal 20-year life of the ship, crew wages plus subsistence costs amounted to over $12,000,000, based on current levels, and would be grossly more than that if history were any indication. Figures such as these certainly made automation most inviting.

It was his hope that this stimulating paper would receive the widest possible attention from the members of the Society.

COMMANDER H. A. JACKSON, U.S.N. (Life Member) found this paper to be one of the most interesting that had been presented for some time. It covered the history of the transition from sail to steam very nicely and incorporated all the romance of the sea. The history of the transition from oil to atoms, when recorded, might well be similar as it combined the same features. In addition to much historical data, the author included many engineering facts and an excellent insight into some of their present personnel problems.

He included two statements that were especially intriguing. In the first, he stated that mechanisms of all kinds were invented at a prolific rate with the result that there was scarcely any type of mechanism in use today that was not known more than a century ago. This statement was entirely true and one could find many applications of old time ideas or inventions that were in use today. It would be well for all in responsible design positions to search out old patents to find those items that were sound in engineering principle but which could not be developed at that time for the lack of techniques and materials that they now had. He was sure that there would be many solutions to many of their problems.

The other statement was, that one outstanding characteristic of marine work was that it was always a simple and common sense design that prevailed. The elaborate device either became simplified or it disappeared. This statement was one that they could all take to heart in these days when they seemed bound and determined to make things complicated just because they could.

They had many examples where engineering concepts, while sound in principle, had been complete failures because the designers let their imagination and desires for complication run away with them. However, this statement did not appear to be compatible with the section entitled "Engines without Engineers". It was true that it was always desirable to reduce the man power to the minimum consistent with good operation. However, it was not consistent to be placing automatic controls for all pieces of equipment at the same time as they attempted to make them simpler.

It was entirely possible to provide an automatic equipment to replace a man and then require two men to service and maintain the equipment. There was one place, however, where man was not likely to be replaced in the near future, and that was in the creative ability to carry on the development and progress so ably described in the paper.

Author's Reply to the New York Discussion

The author sincerely regretted that circumstances had precluded his being present to read the paper in person at the meeting in New York on 13th November 1959. He was grateful to his colleagues of The Institute of Marine Engineers, London, namely, Mr. R. Cook (Chairman of Council) and Mr. J. Stuart Robinson (Secretary), whose presence at the meeting had more than made amends for his own absence.

The author of any paper could only offer his own experiential views; that was axiomatic. But, if his literary craftsmanship was what it ought to be, he would know where to be provocative and where to be naïve, and, by these means, to induce the maximum number of members to offer their views, quote their experiences, and make constructive criticism. In a number of places in the paper these stratagems had been judiciously and cautiously applied; and the results appeared to have been proportionately helpful to the general exposition of the subject.

The author had naturally expected the opinions, as expressed in the respective discussions in New York and in London, to differ; but he had not expected that the differences would take the shape they had done, and this itself had been useful.

Commander J. W. Thornbury made comment upon the automatic control of machinery and cited experiences in the U.S. Navy adverse to the application of such controls. The author's reference to automatic controls had been intended to be provocative; but the trend of the comments had surprised him. It was one of the matters on which he had expected that there might be a wide divergence of views as between American and British engineers. Instead of that, there seemed to have been a substantiality of agreement.

The author was in full accord with Commander Thornbury's remarks that there were fashions in engineering as in other human creations. In shipbuilding and in marine engineering this seemed to be particularly true. Thus: somebody became enamoured of the notion of, say, a sloping soft-nosed bow in contradistinction to a vertical stem. Although the sloping bow might have been the practice of one or two isolated shipowners for many years without notice being taken, there came a point in time when the idea suddenly "caught on" and, soon, new ships which had not sloping stems and soft-nosed bows became very much the exception. Similarly, another man would conceive the idea of having a coat of arms, or other device, painted on or pinned to the bow, and this practice, also, caught on. Many other examples could have been chosen. One of the things which had not appeared to catch on in the United States, however, was the simple direct coupled Diesel engine for mercantile ship propulsion. But one day it, too, might become the fashion!

The comments of Commander Thornbury should be closely studied by every young man who intended to go to sea. The author was glad, therefore, that his comments were being printed in the Transactions of the Institute of Marine Engineers, London.

Mr. Robert Taggart drew attention to the part which successful showmanship could play in influencing acceptance of new forms of prime mover. The two contrasting examples which he so graphically described, the one a complete failure and the other a complete success, were outstanding. The author was familiar with both stories, but he might be forgiven for wondering if anything at all—not excluding the miraculous—could have made any vestige of favourable impression on the types of men with whom John Ericsson had to deal in London.

Rear Admiral W. D. Leggett took the author to task for his statement that the establishment of atomic engines in the mercantile marine might take about the same period of time as the preceding prime movers had taken. The author, of course, spoke of things as he saw them in the United Kingdom. Admiral Leggett, and not the author, must be the authority for the picture as he saw it in the United States. The author was most interested in the Admiral's statement that it was possible, even today, to demonstrate *by calculation* that there were routes on which some cargoes could be handled more economically with a nuclear powered plant than by any other means.

In his reference to engineers and scientists, Admiral Leggett admonished the author for, apparently, classing the engineer with the shoemaker rather than with the scientists, the lawyer, the accountant, and so on. This, however, had not been the author's intention. What he, the author, found so hard to drive home, especially to academically trained men, was that, although the technical work in the designing and building of turbines, boilers and Diesel engines might be absorbingly interesting to the individual, it was not the whole story, because, if an engineering product did not conform to the same simple primordial rules as those which applied, say, to the selling of shoes, then there could be no future for the engineering product concerned. Stripped of all its attractive trappings, the engineer's ultimate business in life was to produce a sound article that could be sold at a competitive price. In this he was no different from a man who made and sold umbrellas, or books, or typewriters.

The engineer might now come from the same social stratum as the lawyer and the accountant, but his activities must always take a different shape. The lawyer and the accountant were men of words; an engineer must always be a man of deeds. That being so, it was a matter for reproach that so many of the highest men of the engineering profession had literally to answer the call of the bell to somebody who, too frequently, was an exalted clerk—a so-called administrator.

Why was this? It was because the engineer had not the wisdom to acquire just that small amount of different training and experience which would bring him indubitably into the administrative class.

The Admiral referred to confusion in the definition of the term engineer. This point received attention in the author's reply to one of the other contributors. Apparently in the United States there was the same difficulty in safeguarding the status of the professional engineer as there was in Britain.

The author had been far too long in engineering to be seduced by quasi-intellectual glamour. A natural aptitude for academic study and success in examinations was not *a priori* the most suitable qualification for success in the hurly-burly of industrial life. The apparent emphasis in this clause should not be misinterpreted. In, say, the design departments of large engineering establishments there was need for every grade of technical worker, from the ingeniously practical to the clear sighted theoretical. But in this variegated human spectrum the widths of the end bands—i.e., the exclusively practical and the exclusively theoretical—were small in comparison with the broad middle band.

Many times had the author given men a start in life, or a lift in life, mainly because they had had the right temperament, the correct vision, and many times had he turned down men apparently far cleverer because they were lacking in these qualities. And time had shown that his decisions had been right decisions. If a machine failed, if a building collapsed, it could be replaced. But if the imponderable qualities of right approach, clear foresight and correct judgement collapsed and failed, the resultant loss to a company might be irretrievable.

The author found it hard to assign relative values to alternative qualifications. As already implied, there was scope in engineering for all types of men, with all grades of training. It would be unfortunate if a halo were to be allowed to gather around the head of a man simply because he had had a high place in the university or the polytechnic high school. While the author strongly held the opinion that a much higher level of technical training was needed, he was equally of opinion that the base must be broad. The practical outlook was fully as important as ever it had been. The author knew men in certain Continental firms who, in any intellectually democratic country, would rise to high positions, but who, because they lacked the formal academic training which conventionally accompanied such positions, would never rise above sergeant major level. Authoritarianism and fetishism in industry were surely as repugnant as in church and state. There was no body of men to whom omniscience was vouchsafed; accordingly the democratic team—the aggregation of individualists—was, in the author's opinion, to be upheld.

When the number of components which went to the making of the perfect engineer were counted and assessed, it was indeed fortunate that no man could do and be all the things required by the ideal. It was curious how many young men yearned to become researchers. Research work was very important, but much humbug surrounded the subject.

Mr. W. A. Baker made reference to sailing ships and indicated that the sail plan for the barque *Queen's Island,* of 1885, mentioned in the paper, still existed in the files of one of the Pacific Coast shipyards. This was indeed interesting.

In his third paragraph Mr. Baker, with subtle humour, equated, in general terms, certain shapes of forebody lines with costs of periodical repairs. The author fully agreed with the general principle behind his remark; this principle appeared again and again, in all manner of forms, in the course of the year's work. The overall picture of a ship's balance sheet was what must ultimately prevail.

In his last paragraph Mr. Baker had put his finger on another problem which, in one shape or another, must have been with human beings ever since they came down from the tree. If wisdom and the results of experience had been transmissible in the same way that bald heads and big feet were transmissible, then the human race would have forged ahead at a gratifying rate. But, in fact, each generation had, metaphorically, to knock its head against the wall to learn that the wall was hard. When Solomon was offered one gift, but one only, he had chosen wisdom. Despite the foregoing, the author would have chosen humour. He knew many successful men who went through life with little or no real wisdom; but he did not know anybody who could successfully wrestle with the daily problems of industry without a sense of humour. Solomon, having chosen wisdom, had been granted supplementary gifts. On this basis, the author would have desired perseverance, sound judgement and guts. With this undivided trinity—perseverance, humour, judgement—with guts as an additive, there was hardly any obstacle which could not be overcome. But, it might be said: what about brains? They, of course, could be useful.

When referring to the efforts of clever young men who were so often wrong, whereas older, apparently less clever men were so often right, the author had had in mind the many times when young men had endeavoured to demonstrate to him that his propositions for the future could not succeed, whereas he, acting on the basis of earlier and similar experiences, had been certain that the projected advances would be successful, as indeed they had been. The builders of mediaeval cathedrals used deliberately to introduce mistakes into their designs because to produce something that was perfect was to incur the jealousy and condign wrath of High Heaven. The author must confess that he had never felt the need to take similar precautions with Diesel engines.

Mr. O. H. Oakley correctly drew attention to the difference between the practice in the shipyard and in the aircraft industry. In the former, usually one or two, or at most a very few, vessels were built to the same set of plans. The same remark was almost equally true for main propelling machinery. The author had never known the comforts of a thoroughly tested prototype engine; his essential test bed had always been the high seas. By way of example: when the industry was emerging from the deep depression of the early 1930's, an important shipowner said that he would order two 26,000-ton passenger liners if the machinery could be direct coupled Diesel engines. The designed power, 32,000 s.h.p. on two screws, was greater than that of any installation afloat. The question put to the author was: would he be prepared to design and accept the responsibility for such powerful engines? All too soon the day of decision came. After having weighed the implications, he took his stand: yes, he would accept the responsibility. He recalled Luther's phrase: *Hier stehe ich, ich kann nicht anders, Gott helfe mir!* The contract was placed; and *three* ships were built. They had entered service respectively in 1935, 1936 and 1938, and the engines stood today as the highest powered unsupercharged marine Diesel installations that had ever been built. At the time he spoke of they did not exist even on paper. That was what responsibility could mean; no hiding behind a committee; no referring the minutes back! It was always easy to say no; always easy to take the negative way out. Any weakling could do that and give some justification for his decision. But it was not the voice of progress; it was simply a roundabout way to eventual perdition.

On many occasions the author had accepted responsibility for unusual designs, for fast running engines of very considerable power, for engines of unusually compact form, and so on, designs which had started on blank sheets of paper after orders had been accepted. Some of the most successful types had begun in this way. There had been neither time nor money for prototypes. It had meant carefully measured risk, for an error of judgement on the scale the author spoke of could bring the mightiest of firms down to the dust. But it was the *pneuma* of progress, for progress—as the author saw it—was extrapolation, the venturing forward into regions only dimly apprehended, a journey to eventual apotheosis.

Regarding engineers and scientists Mr. Oakley wrote that it was partly a matter of semantics. He chided the author for presenting a trace of what he called cirrhosis of attitude. In these ultra-scientific days, when the world seemed to be so full of highbrow specialists, it might well be asked if there was any place left in the scheme of things for the engineer. The author's assertion was: there was greater need than ever for the engineer; and his essential characteristics must continue to be what they had always been! Necessarily engineers were becoming more and more scientific, but—to the author, at least—a scientific engineer was one thing, but a scientist was quite a different thing. The author contended that it was not to the advantage of the engineer for him to be regarded as a scientist; on this point he was intransigent, because it was not simply a matter of terminology; it was the definition of an attitude to life.

If and when atomic engines became normal practice for the propulsion of mercantile ships, it must be the marine engineer who was in ultimate and sole charge of all the machinery, whatever part might be played—and it might be a very important part—by scientists and specialists.

Professor Harry Benford drew attention to the author's remarks on the apparent incompatibility of mathematical and design capabilities and on the separation of engineers and scientists at a time when American engineering education was shifting in the opposite direction. In Britain a similar shift was also apparent, but, in the author's opinion, this shift might well come under the umbrella of changes in fashion mentioned by Commander Thornbury.

Reckoned in terms of time, it was a long span from the daily use of the word *Ingenium.* in the Latin tongue, to *Engineer,* in our language. But through the centuries which had intervened between these living vocal expressions, the idea of inventiveness and the creative spirit implicit in the original word, and in others of its period, had persisted. By definition, therefore, an engineer was a creator, an implanter, a bringer-forth, of ingenious things. The sense of the word had been better preserved on the Continent of Europe, in such designations as *Ingenieur* and *Ingeniör.*

In the author's opinion it was a mistake to overload the training of engineers with mathematics, especially at the beginning. A propensity for mathematics was not to be reckoned as the highest gift for an engineer. Much more important was that aptitude, that quality, which was comprehended in the Greek word *nous.*

The primary occupation of an engineer was necessarily with facts. When he formulated a theory, it had to comprise every known fact. If but one insignificant fact did not "square" with the theory, then the theory—no matter how cherished—had to be scrapped, not the fact ignored. It was a curious thing that, immediately men left facts and drifted into opinions, emotionalism supplanted reasonableness. People with strong prejudices were difficult. When contentious matters were under discussion somebody inevitably said that a principle was at stake. It was, however, far more likely to be a prejudice! Similarly, opinions and facts were not interchangeable entities. Because a man believed a thing intensely, that did not make it a fact. Nor did an ardently held notion become a fact simply because an assembly of powerful men turned it into a dogma.

The references to engine room automation, as made by Professor Benford, were more in line with what the author would have expected the attitude of United States engineers to be in connexion with American flag-operated ships. But apparently American seagoing engineers were no more gadget-minded than were British engineers.

The author thanked the Professor for his kindly remarks.

Commander H. A. Jackson suggested that, by searching through the files of old patents and similar things, one would doubtless find many applications for old-time ideas or inventions which were made in advance of their time and which, with our better manufacturing techniques, could well be valuable today. The author fully concurred. To take but one simple example at random; how many engineers were now familiar with the Rapson slide and the principle of its operation?

On reading the author's replies to other contributors it would be clear to Commander Jackson that the section entitled "Engines without Engineers" had been provocative and had been intended to bring out opinions of experienced men who knew far more about operating conditions on board ship than the author could ever know.

As a man whose life had been spent on the creative side of engineering, the author was in complete agreement with the closing comment of Commander Jackson. The almost transcendental satisfaction of seeing a great creative team effort brought to a successful conclusion could, of itself, be a very real, if a completely non-material, requital for the arduousness and the fraying anxieties attendant upon the development of a new prime mover. Never had the author stood upon the engine room floorplates of a great liner, in contemplation of a new and powerful propelling engine quivering with mechanical strength, but what, instinctively and perhaps inevitably, he had called to mind two literary scraps, widely dissimilar in form, but each singularly apposite in essence. The first, from Holy Writ, was: "A woman, when in travail, hath sorrow, but as soon as she is delivered she remembereth no more the anguish, for joy that a man is born into the world". And a new engine could truly be a manchild, with its fractiousness, its teething troubles and its growing pains! The other was from *McAndrew's Hymn,* that saga of the steam reciprocator, familiar to every seagoing engineer of an older generation but now out-of-mind: "Whaurto—uplifted like the Just—the tail-rods mark the time. The crank-throws give the double-bass, the feed pump sobs an' heaves, an' now the main eccentrics start their quarrel on the sheaves.... They're all awa'! True beat, full power, the clanging chorus goes.... fra' skylight-lift to furnace bars, backed, bolted, braced an' stayed, an' singin' like the Mornin' Stars for joy that they are made; while, out o' touch o' vanity, the sweatin' thrust-block says: 'Not unto us the praise, or man—not unto us the praise'!"

On the last notes of this marine engineering *Non Nobis* the closure might fittingly be applied.

The author deeply appreciated his being accorded the honour of presenting the first paper under the joint auspices of The Society of Naval Architects and Marine Engineers, New York, and The Institute of Marine Engineers, London. Additionally, he sincerely thanked all the contributors to the written discussion for their forbearance and for their kindly remarks.

Discussion Held at The Institute of Marine Engineers, London, on 26th November 1959

Mr. H. N. Pemberton (Member of Council) said that one had only to read Mr. Pounder's paper to appreciate the great effort that he must have put into its writing. It seemed worthy of being a Presidential address—perhaps it should, indeed, have been one.

He had seldom read a paper more provocative of criticism or more stimulating both to technical argument and philosophical discussion, but he would leave the first section, which was mainly historical in content, and pass on to the philosophic section which abounded in characteristic statements. Mr. Pounder had reached a stage in his life and career that entitled him to be looked upon as an elder statesman of the profession. His long association with the marine engineering industry had not resulted in an industrial tycoon but in a man whose observation and interest in the humanities enabled him to comment on their current problems with wisdom and understanding.

The historical section of the paper was, of course, Mr. Pounder's own. Each man wrote or interpreted history according to his own individual interests and prejudices. The fascination of history was not as a catalogue of chronological events but as a commentary on selected facts. They could not, therefore, quarrel with the author's history of marine engineering. It was history as he saw it and had interpreted in his own inimitable way. Mr. Pounder could also be forgiven for a little gentle plugging for Harland and Wolff's Diesel engines because, after all, the name of Pounder was itself synonymous with the great shipbuilding firm that he had served for so long.

Whilst it was always interesting to look back, as the author had done, it was today more vital to look forward, and Mr. Pounder had indicated that they now saw an ever-increasing application of science in engineering. Indeed, a new breed of man had emerged, or was emerging, called the engineer-scientist. The great danger was that he might well prove to be neither engineer nor scientist, but it was still clear that the marine engineer of today could not do without the scientist. On the other hand, the one thing that the engineer must not do was to surrender his initiative and responsibilities to the scientist. That would be especially unfortunate in nuclear propulsion, where he thought there was a tendency for the engineer to look to the scientist to design a nuclear ship for him.

The paper referred to the fact that engineers no longer appeared to be interested in seeking a career at sea, despite the very much improved conditions and amenities offered by most shipping companies. His own view was that the reason was the wide field of opportunity now available to these men in industry. With few exceptions, one would say that the better trained and educated the engineer might be, the less likely was he to go to sea, or to stay at sea.

The result of that was that the shipowner was being forced to recruit engineers of lower technical calibre, but the "alternative training scheme" was a wise and imaginative effort on the part of shipowners to solve their difficulties, and was proving successful in providing junior engineers at any rate, particularly in the "liner" companies. What percentage of those young men would stay at sea remained to be seen. In regard to tramp ships, the picture was different, and the solution was not easy to see.

Mr. Pounder's remarks on that subject were realistic. Although he did not specifically refer to tramp ships, the tramp ship problem was a challenge to designers and engine builders to produce highly efficient but simple machinery that required the minimum supervision at sea. They must again look at the possibility of multi-unit installations with spare units that could be easily and quickly interchanged while units were withdrawn for repair and overhaul.

There was also the possibility of simplifying direct coupled prime movers which, again, would require the minimum technical supervision at sea. For tramp ships that would be worth while even at the cost of another decimal point on fuel consumption. Such engines, however, would undoubtedly require to be of a very high mechanical standard to ensure trouble-free running.

That was one part of the solution. The other part was one that the Ministry of Transport could contribute by introducing a third statutory certificate based on an examination for engineers or mechanics who were suitable to operate such simplified machinery. He believed that good and competent men could be obtained to carry such limited responsibility; men of the artificer class who could not, and need not, aspire to the present First Class Certificate.

There was much else in the paper that could be commented upon and discussed. It gave much food for thought, and much philosophy to help marine engineers in both their technical and their human problems, and he himself was grateful to Mr. Pounder for producing such a paper.

Mr. Stewart Hogg, O.B.E. (Member of Council) said that he had been fortunate to read many of Mr. Pounder's very erudite dissertations to various professional institutions, but in his present most interesting paper Mr. Pounder had changed his whole field, and had treated them to a review of the evolution in marine engineering during the past one hundred years and the social problems of those associated with ships, drawing his thoughts largely from his long experience in Harland and Wolff's shipyard and with such customers as the White Star Line.

Unlike most frail mortals, Mr. Pounder had disciplined himself to progress, firmly believing that they must progress or die, and he had never lost sight of the human social problems while pursuing the physical ones. The basis of the physical problems in sea transport was purely commercial—the provision of vehicles to move X tons of goods and/or Y passengers from A to B as cheaply as possible—and generally as quickly as possible. That problem was as old as the pyramids.

The first outstanding contribution to accelerating transport was the introduction of the steam engine to supplement sails in propelling vessels. He was reminded of an incident many years ago when he was discussing the plan for a new vessel with a shipowner's superintendent. Suddenly he became aware of someone looking over his shoulder, and when he turned round he found himself face to face with the superintendent's chairman. "Oh", said the chairman, "plotting as usual to spend my money. You should always remember, young man, that engineers and engines are only a necessary evil in my business of transporting cargo and passengers".

The change from sail to steam gave birth to a new type of human problem, and one that they still had with them to a lesser degree—the manning of the machinery spaces. It was not altogether a new type of problem, as the author clearly indicated. It existed in another form in the days of the sailing ships, which were frequently referred to, with pride by some in terms of "wooden ships and iron men". Then, as now, and as it would be in the future, the dreams of owners and shareholders were of dividends.

They had all read of the hardships endured by seamen in windjammers on a voyage round the Horn, but few books told of the toil and sweat of the firemen and trimmers in the North Atlantic liners maintaining the steam pressure in under-boilered vessels. Keeping the steam pressure up was a challenge to the seagoing engineers of that era with the difficult background of too-few shore jobs, which meant that many engineers had to adapt themselves to the role and become the so-called stokehold bullies referred to in the paper. A few of these engineers became superintendents in that era, and it was little wonder that those faithful company superintendent engineers were at a disadvantage in board rooms where the weapons were words, not fists. He (Mr. Hogg) added that at that point he should make it clear that such men were not confined to the White Star Line.

They would all be pleased to learn from Mr. Pounder that the modern breed of seagoing engineer produced some men with all the qualifications necessary for the board room. Might their numbers multiply.

He himself had known some of these characters in the late 'twenties, just when the end of that era was in sight. He remembered surveying the machinery of one of those North Atlantic vessels—a post-first war vessel with turbines. He had had the temerity to ask for the removal of the casing and rotor of one of the turbines to the shop for extensive reblading. They could all imagine the scene that followed in the chief engineer's cabin when he had suggested that they must have been driving the turbines with water and not with superheated steam. The vessel was fitted with superheaters—comparatively new contraptions at that period—which always gave trouble with leaking joints. He had learned that some years previously the engineers had isolated the superheaters to save feed water. Their minds were evidently quite obsessed with the one subject of steam pressures and revolutions. That had happened thirty years ago, when signs of the end of the coal burner and the passing of a breed of firemen and engineers, slaves and task masters were apparent. New problems such as oil firing, new types of boilers and machinery, internal combustion engines, etc., were rearing their heads. Those new machines, with their gadgets, were more costly and required a new breed of engineer. Many of the older breed of superintendents were slow to recognize those changes and even in present times some thought only in terms of the "hammer and chisel fitters". They refused to believe that they had reached a technicians' era of preventative maintenance, which he considered to be one of the continuing human problems.

About 100 years ago the losses at sea of life and property attributed to propelling machinery mishaps were the cause of much public concern; so much so that a House of Commons containing many shipowners passed the Merchant Shipping Amendment Act of 1862, instituting examinations for Second and First Class Certificates of Competency. The contributions that those examinations had made to safety and progress had never been properly understood by many who should know better. How correct were Mr. Pounder's observations about the opponents of examinations, who had maintained in each generation that the best engineers could not pass examinations. He regretted to say that in his own experience he had met members of the Institute itself who subscribed to that line of thought. Despite such opinions, the Ministry's examinations had made progress down the years and were held in great respect by all maritime countries.

It would be appreciated that his own journey down the years had touched at a few points in Mr. Pounder's story. As a surveyor, he had had some contacts with the machinery spaces in that great fleet, the White Star Line, and, in particular, with a number of the Scotch boilers which it always fell to the lot of young Board of Trade surveyors to crawl through each winter. He was sure that Mr. Pounder's contacts were conducted in a more pleasant atmosphere, but why did designers not study such details as the size of boiler manholes?

He wholeheartedly agreed with Mr. Pounder's suggestion on page 101 that it was economic necessity that had driven many eager, ambitious young men to seek a living at sea in the past, but times had changed. The engineering industry had expanded and spread its activities to many centres. With more national prosperity ahead, fewer young men would be available in an expanding market under current social conditions, but he firmly believed that a number of the well-trained young men would continue to go to sea to get further experience. In no shore establishment could a young man in his early 'twenties get the same opportunities to develop his character and sense of responsibility as he could in a ship's engine room, where he had to take charge of men and very valuable machinery. When, as it would, the day of nuclear reactors and part automation arrived, the human problem would still be present. Suitable men would be found to match the challenge, although the problem of numbers required might be more difficult to resolve than it had been in recent years.

MR. R. MUNTON, B.Sc. (Member of Council) said that although he always enjoyed Mr. Pounder's philosophy, on the present occasion he would have enjoyed himself much more sitting in a comfortable chair going through the various points in the paper with the author. Their present surroundings were a little austere for the discussion of such friendly philosophy. On the other hand, the Institute building being a memorial building, the human problem aspect was a very good subject. Those who were at all concerned with the design and superintendence of ships' machinery should always remember that whatever they did their future was in the hands of the seagoing personnel. If they did not look after the job properly then, however clever the designers tried to be, they had not been clever enough. The human problem was probably their major one.

Mr. Pemberton had suggested that the quality of engineers going to sea nowadays was not so good as it had been, but he himself would quite categorically refute that. The quality of a junior engineer now going to sea was higher than ever before. The majority of the juniors joining his own company had either the Ordinary or the Higher National Certificate, and a very large proportion had the Higher Certificate. The problem was not the quality of the young engineer but the many opportunities offered ashore, and the expanding appreciation that an engineer naturally had of those opportunities. The values of engineers and of coal were rather alike. At one time, when there had been more coal than they needed, it had been little valued and was not appreciated. It was now very much appreciated, so the cost had gone up. The same applied to engineers. They were now greatly appreciated, and the cost had followed the demand.

Although he was not pessimistic about the seagoing engineer, he was very pessimistic about the idea that a time would ever come when a ship could be sent on a voyage of days without a qualified engineer in charge of the machinery and be expected to arrive at the other end. He was not that hopeful.

Another aspect of the problem of getting juniors willing to go to sea was that in recent years some had gone essentially to avoid National Service. The result was that when they were about 26 years of age, one was faced with a build-up of three things: they were no longer eligible for National Service, they had a first-class qualification, and they had young wives who naturally wanted them at home. Together, those three things were very trying indeed.

Mr. Pounder had rightly stated that one of the differences between an engineer and a scientist was that the engineer was engaged in a commercial business, but a lot of engineers ruined their own chances by not appreciating that vital fact. A few months earlier, a young engineer had started with him—a graduate of one of the universities, holding mechanical and electrical engineering degrees. In answer to a question, the young man had said that in the latter part of his studies he had read economics, but had no interest in economics as it had nothing to do with engineering. Mr. Munton had been at pains to alter that view before the interview finished.

MR. A. C. HARDY, B.Sc. (Associate Member) remarked that he took part in the discussion as much from a feeling of sentiment as from an actual discussion point of view because, in effect, there was little to discuss in the paper. As had already been said, it was more in the nature of a presidential address. He hoped that the Papers and Transactions Committee would realize that the idea for the paper was born some years ago. It had taken a long time to come to life, it had caused much worry and anxiety to Mr. Pounder, and the author and he had had many interesting discussions about it to develop it to its present state. It was a paper that had had to be written, because the human problem was tremendously important at the present time.

One point that speakers had so far missed in the paper was the author's statement that one day the ship of the future would be controlled entirely from the bridge. That had slipped in almost unnoticed, although Mr. Munton had partly touched on it. The trends all pointed to such a thing taking place, partly because of the rise of automation, and partly because of the gradual elimination of human beings as time went on. He had reason to believe that Mr. Pounder had tried to find out the actual down-curve of bodies employed in ships from the days of the sailing ships to the present time. It looked as though they would be able to reduce the number of engine room staff to a greater and greater extent. However, the present was no occasion on which to voice such sentiments, as surely no one could stand at that rostrum and suggest that the marine engineer might eventually go out of business and have his place taken by the mates.

Mr. Pounder's latest contribution was another of the "Pounder Papers", and in 25 years' time, when a little more marine engineering history came to be written, the "Pounder Papers" would form a very considerable source of information for marine engineering students.

Mr. Pounder had a puckish way of putting things. He began with philosophy, and then put in some good solid historical facts, on which he commented with philosophy of a type that he alone could write. It was very rare to find an engineer with the gift of literature and philosophy. The paper represented a great triumph for the Institute, and he hoped that they would have many more similar papers from such a distinguished author.

MR. A. G. ARNOLD (Member) agreed with Mr. Pemberton and other speakers about the greatness of the paper and thought that, together with Mr. Pounder's previous paper,* made a wonderful study for engineers in the future. He congratulated the Papers and Transactions Committee upon having selected Mr. Pounder and his paper to represent the Institute in the United States of America and was pleased to hear that it had been well received there.

It was extremely unusual for Mr. Pounder and himself not to have a little argument on these occasions and this occasion would be no exception. On page 85 Mr. Pounder said that the introduction of the marine Diesel engine some forty years ago had brought seagoing men from a life of animal-like toil. If Mr. Pounder had in mind the toil resulting from the burning of coal, etc., he of course agreed, but if he were thinking of the engineer officers, then his own experience as a second engineer some 38 years ago was quite the reverse. The main and auxiliary Diesel engines were of a good type, and built by first-class builders. No fuel oil separators were installed and this, together with the fact that the ballast tanks had to be used for either oil or water ballast, the engine cooling medium was salt water, for both pistons and jackets, and these combined created a great deal of animal-like toil.

The omission of fuel oil separators and fresh water cooling were due to false economy recommended by the engine builders in order to make the more costly Diesel plant a little more competitive with the steam engine. But despite the difference in cost at that time, and with these "refinements" included, the differential in cost was overhauled in eight years of average trading. He hoped the present day engineer and for that matter shipowner, realized the great contribution that the installing of efficient fuel oil separators and fresh water cooling had made to the development of the marine Diesel plant.

He would like to refer to two of the many interesting ships listed in the paper. First the *Glenogle*, built in 1920, gave excellent service until 1953, a matter of 33 years; some of these occurred during the great economic blizzard and some during the period of the second world war, both very difficult times. He thought the results paid a great tribute to both the engine builders and the people who manned the ships. It was fair to say that in these ships the builders had provided two large tanks in the centre of the ship, which were exclusively for the carriage of fuel oil.

The *Amazon*, now building, would no doubt be a very fine ship. He was familiar with the type of machinery being installed and very much hoped and expected that someone in the future would be able to refer to her in the same favourable terms as many of them could of the *Glenogle* and her sisters.

In Mr. Pounder's reference to the *Olympic* being converted from coal burning to oil burning, he showed an increase of speed from 21·89 knots to 21·97 knots, only 0·07 of a knot; his own experience of similar conversions, but not in ships with anything like the power or speed that the author referred to, was a greater increase in speed, and he wondered if the author could explain this.

He was very interested in Mr. Munton's reference to his discussion with a young student of economics. He agreed entirely that the real engineer was as much an economist as any professor of economics and he thought Mr. Pounder had proved this in his most interesting paper.

COMMANDER E. TYRRELL, R.N.(ret.) (Member) was lost in admiration of the courage that Mr. Pounder had shown in the preparation of his paper. To deal with such a complex subject as human problems required very much greater courage than that required to deal with engineering. Engineering usually contained a number of clearly defined problems, whereas the human reaction to a set of circumstances was often very varied and illogical.

They had been told that marine engineers were difficult to obtain, and he had sometimes heard it said that owners were not prepared to use advanced machinery; they did not know where they would get the engineers qualified to run that advanced machinery. Shipowners who did not accept what technical progress had to offer were attempting to fight the economic battles of the future with bows and arrows.

There had been great changes in the duties and status of an engineer. Today, the engineer looked upon himself as a designer of machinery, and in the case of the motor car and the aeroplane that idea had been followed to its logical conclusion by enabling someone without engineering qualifications to drive or fly. Maintenance was carried out by maintenance

* Pounder, C. C. 1957. "The Harland and Wolff Pressure Charged Two-stroke Single-acting Engine". Trans.I.Mar.E., Vol. 69, p. 161.

engineers who followed a schedule prepared by the engineer designer.

That was a revolution of thought if applied to marine engineering. On this point he appreciated that he was at variance with many others in the marine engineering industry, but he still believed that such a revolution would occur and that they would eventually find that the true engineer would make automatic marine machinery for a comparatively unskilled man to run.

This required careful consideration. The responsibility for running the ships of today was being transferred from the operator to the designer. Was Mr. Pounder satisfied that the quality of the present marine engineering designers was adequate to carry out the revolution that was upon them? Theoretical knowledge and the electronic computer were replacing the arts of engineering. It was a matter of bringing together people with a large number of sciences, skills and specialized knowledge at their command to produce the best possible answer. The necessity of that had been shown very clearly in the development of nuclear engineering.

One trouble was that men who served under a dictatorial management tended to become "yes men", and later, when the original dictator had disappeared, became petty dictators themselves to cover their own ignorance. There was nothing more distressing than to see a company that had been a great name go soft at the top because it was directed almost entirely by old men who were living on what Mr. Pounder had so clearly referred to as "experience". It had to be clearly understood that experience was only experience of those things that were past and today, as in the past, technical development could not be carried out by experience alone. It required young men with faith to look for those things that were new. Any good organization that intended to make use of this revolution for the production, by qualified engineers, of a ship or machinery that could be run by people who were not qualified, required a good team composed both of the men of experience and the younger men, technically qualified, and with faith in themselves and the new equipment they had to produce.

Mr. J. Foster Petree expressed pleasure that his first visit to the Institute's new hall should be the occasion of such a memorable paper. It was really two papers; one, the historical, which was a most valuable record and certainly worthy of preservation, and the other philosophical. On this he disagreed with Mr. Hardy: there was any amount in it to discuss.

The philosophical part was really what one would expect. Nevertheless, it was surprising because, if one might presume to bandy quotations with Mr. Pounder, about 300 years ago Thomas Hobbes said, "Leisure is the mother of philosophy". How any man who had obviously had no leisure for many years could have developed so much philosophy suggested either that the age of miracles had not passed or that Hobbes was wrong.

Among the human problems of the marine engineer, there was very little reference to the fact, certainly evident in his own young days though it might not now apply, that it was practically impossible for an Extra Chief to get a seagoing berth because, it was alleged by the Extra Chiefs, superintendents themselves did not have that certificate.

Mr. Pounder evidently wanted them to believe that he was older than he was, because he said that in his childhood there were "no motor cars, no cinemas, no cameras, no gramophones, no typewriters, no electric lighting, no aeroplanes". In part, that might be true, but there were then cameras, typewriters, gramophones, and, although not in the ordinary seagoing engineer's household, electric light.

One of the basic difficulties of getting people to go to sea nowadays, he thought, was the enormous improvement in domestic conditions on shore. That change had largely passed without notice. He was not referring merely to such amenities as television, but to the ordinary living conditions in the ordinary middle class household, which had a good deal more bearing on the problem than was sometimes thought.

He (Mr. Foster Petree) said that he did not know exactly where Hewgill Terrace in Newcastle was, or whether it still stood, but No. 7 Hewgill Terrace was the address of Thomas Thaw, the recipient of the first marine engineer's Certificate of Competency issued by the Board of Trade, which had been shown on the screen, and he would like to suggest that if the house were still standing—and even if it were not—the Institute might combine with other possibly interested parties such as the Newcastle Museum of Science and Engineering and the North East Coast Institution to unveil, on 15th April 1963, a centenary tablet to commemorate the award of the Board of Trade "ticket".

Mr. P. T. Christensen, M.Sc., thought the author would doubtless fully agree—and, indeed, he implied in the course of his remarks near the beginning of the paper—that there were many new problems to be solved by their forbears in the course of making the reciprocating engine a success. One of these problems was the construction of bearings in such a way that overheating was avoided and friction was reduced.

He was sure that, in his earliest days in marine engineering, the author would remember seeing main bearings for crankshafts which were made of solid bronze, hand lubricated. This construction was very satisfactory when speeds and loads were very moderate, also when the alignment and fitting were good; but it involved a great deal of skilled hand work. In due course this construction gave place to white metal lined cast iron bearings.

White metal bearings were sometimes—especially in the U.S.A.—described at babbit bearings. This word babbit had a wide currency and re-babbiting a bearing simply meant relining it with white metal. The word—which was the name of a man—had its origin in the title of a well known firm, namely, Babbit's White-metal Company.

In the paper reference was made to the dilemma which the machinery designer was often faced with: that was, to make important decisions on a basis of imperfect knowledge; he would just like to supplement this observation with an example, as he thought it was very true.

In fact, the observation could, it seemed, be expanded in both directions: that was, to the bigger context of which the engine was a relatively small part; but also to the details of the design. Being from a firm of white metal producers, his experience in connexion with marine engineering was mainly concerned with the bearing problems. The bearings were, of course, a relatively modest part of the whole engine, but they could be very important, especially if they did not function in the way anticipated by the designer. He thought that perhaps the question of the designer's decision as to which alloy to use in the bearings was a typical illustration of a case where the choice was made on a basis of tradition and perhaps feelings rather than actual scientific calculation. The number of various alloys for bearing metals was virtually unlimited, yet a particular one had to be chosen. Here the designer was in addition faced with having to make a compromise. He wanted ideally the best with regard to such properties as fatigue resistance, resistance to wear, good heat conductivity, good lubrication properties, and so on; not forgetting, of course, price. Many alloys could satisfy him in one respect, some in more; but none in all.

The example he wanted to give was one where a practical decision was made about the composition of bearing metal and where science was some twenty years behind in substantiating the correctness of the decision. In the infancy of the marine Diesel engine, pioneers in that field were to be found in Copenhagen. Already in those days the firm he represented worked on bearing problems in close co-operation with those who could probably be described as the world's most prominent constructors of Diesel engines. Mainly on a basis of empirical experience, it was decided that a tin based alloy with 1 per cent or 2 per cent lead for some reason or other was superior to an alloy completely free of lead. This was more than twenty-five years ago, and no metallurgical explanation seemed at the time to be at hand. The situation was taken by his firm's metallurgists as one of those challenges mentioned by Mr. Pounder, and some hard work and thinking was put in to produce an acceptable answer. It was only during the last decade, however, that real progress had been under way in the theoretical field of white metal. New testing technique had now been developed, and accurate laboratory experiments could be carried out. Such tests seemed to indicate that the small lead content referred to improved the white metal's ability to form an oil film, especially under boundary conditions, due to its effect upon the chemical interaction between metal, lubricant and the surrounding atmosphere. In order not to be misunderstood, he would like to add that although this small lead content was beneficial in certain types of bearings—for instance, those in heavy, slow moving machinery—it did affect other properties than the oil film building ones, and was therefore not to be recommended under all circumstances.

As mentioned, he just wanted to supplement Mr. Pounder's observations with an example, but he would like to add that the paper had been exciting reading—in fact, hearing; and that the value of Mr. Pounder's observations and comments seemed to him to go far beyond the range indicated by the title.

Mr. F. H. S. Scriven (Associate Member) said that although Mr. Pounder's paper looked back, it directed their thoughts to the future. Mr. Pounder had thereby indicated how great was their responsibility to the generations ahead. It was a valuable experience to read the paper, and to listen to the author's' presentation. It was also a pleasant change, because the paper, although full of food for thought, was not a technical one.

The past had produced many great men, but did the people of those times then realize the greatness of these men? He personally was encouraged by the thought of one who started by serving his time in a locomotive works, went on to invent a successful marine steam engine and eventually founded the great shipping company which still bore his name.

He did not agree that there had been a complete and final emancipation from animal-like toil for engineers at sea. He himself was fairly young and had not been at sea for many years, but had had to learn to use a munday hammer and was proud of the ability. However, they were now entering the age of atomics and automation and he believed that the younger engineers were prepared and eager to accept the challenge.

Mr. W. F. Jacobs (Member) said that in the ordinary way the papers read at the Institute were on technical or educational matters. Accordingly it might be well, now and again, to have a paper on human problems, because, after all, it was human beings who were in charge of the machinery and final efficiency must therefore depend upon the men themselves.

The author stated that his own special interests lay with designers and with operating engineers. Of the first group of men he could not say much, but regarding the second he could say something, because he had spent forty years at sea in high class vessels; also, for twenty-five years, he had been chief engineer in refrigerated cargo and passenger ships. Except for the two wars, the voyages had been to Australia and New Zealand.

Certainly life in these vessels set many human problems for the chief engineer, and these were sometimes more troublesome than the machinery.

In coal fired vessels the human problem loomed large owing to the need to drive firemen for steam through the watch engineers, whom the chief had to back up in their various troubles, many being caused through ignorance. No matter how technically well educated and capable an engineer might be, he could not use these qualities because he had to drive for steam. And too frequently, if an engineer *could* get steam, he was accounted a good engineer, while a much better man would be passed over if he was unable to get revolutions, at least until he became second engineer.

It must be said here that, although the fireman was frequently a "tough specimen", this was not always so. For example, in vessels out of London, the "Marsh Boys"—otherwise the crews from Poplar and Canning Town—were a cheery, hardworking set of men as a rule, and fairly easy to handle. If the vessels were on a regular run and the "grub" was good, things went quite well. Frequently, several members of the same family would be in the crew, the senior member acting as an unpaid leading hand. In the present ships, the descendants of these men were valued donkeymen and greasers.

Another problem to be taken account of was that due to love and affection; that was serious. Thus, a man might have left home with wife or children sick, or he expected sad news. Such matters reacted adversely on his technical efficiency. Some wives, also, while absolutely correct in their lives, were bad correspondents and did not write much; and this could cause anxiety on the part of the man concerned. He remembered one instance, caused by the captain's wife not writing to him; there was nothing at all wrong; she was just unable to write, or something of the kind.

In respect to the human problems of the chief engineer: he, like most men in charge nowadays, did not choose his staff. Sometimes, therefore, it happened that he had two men who were qualified technically but were quite incapable of working with each other. Each man got on the other fellow's nerves. This was not so bad ashore, where men were only in contact during working hours; but, at sea, where engineers lived together, ate together, worked together, it was different, and severe disagreements could result. This meant that the chief engineer, and the second engineer, had to ease things as much as might be possible.

Then there were the occasional entanglements of engineers with lady passengers. These would occur no matter how strict the regulations might be. Members of the engineering staff had necessarily to work around the passengers' quarters and, men being men and women being women, complications could easily start—to cause anxiety to the officer, especially if he, himself, was a good type.

One factor which had eased problems on shipboard was the passing of coal. After all, how could the deck department be expected to look kindly on another department which was responsible for soot pouring out of the funnels, for sparks setting fire to awnings, boat covers, etc., to say nothing of the damage to ladies' frocks. In addition, there was the dirty business of coaling ship, with all its horrors. In all these things the engineers themselves could not do very much to improve matters.

Regarding boiler power: while good class vessels probably had boiler power enough to ensure sufficient steam with good or fairly good coal, they did not have enough margin of power when using various overseas coals. Some of these were very dirty and very gassy, with heavy clinker. He doubted if any tank or Scotch boiler had enough combustion chamber volume to cope with these coals. In his opinion a watertube boiler, say of the Babcock and Wilcox type, where the combustion chamber volume could be as large as was wanted, would be the only one to be of efficient use.

With oil firing, the engineers could devote their time to technical matters. Incidentally, they could come off watch looking different from the firemen and the trimmers; it was thus easy to consider them as being decent chaps.

Dealing with other matters in the paper: the author stated that the simple design won and that the elaborate design faded out. He thought most of them had seen this happen in their own experience, e.g. in Diesel fuel injection systems. At first they had troublesome blast air compressors, and the injector was a complicated affair with high pressure air valves, pulverizing plates, spraying plates, etc. These systems had faded away as a bad dream and had been replaced by much simpler arrangements for solid injection.

On page 97 there was a statement about the men who improved engines, etc. He very much doubted if these men had any high visions; they simply wished to make bad engines good and fair engines better. There was a spirit in man which urged him to do this.

Coming to the fact that engineers did not wish to go to sea or, if they did go, did not remain: this seemed true and, although a social trend, it was rather difficult to pinpoint the causes. Years ago an engineer at sea had chances to get somewhere, chances which he could not have if he remained ashore. Now one had only to look at the advertisement pages of the daily and weekly papers to realize the wide assortment of positions which these men could take, with the correct training. These positions did not exist a generation ago, but many kinds of engineers had sprung up since then. Thus, from his own knowledge, a man could get a very good living from a moderate garage.

He thought feminine influence had something to do with the matter. From the many articles which appeared in the different papers, it would seem that living one's own life was more important than doing a good job. He did not say that this was so with everybody, but it was so with many. Moreover, many people thought that life owed them an easy living; again, he did not say all. One did not hear these ideas expressed in times past.

Another thing: discipline aboard all good class vessels was much stricter than, say, student nurses would tolerate, especially in regard to entertaining, etc. As far as he could see this must be so. He had heard many muttered growls about having to get visitors off a ship by 6.0 p.m., 8.0 p.m. or 9.0 p.m., according to the regulations of the Line concerned. Might he sav here that his own social relaxations were, and are, almost nil.

Passengers, with their criticisms, might be a headache to the chief engineer because of services not being always just what was expected, e.g. availability of hot and cold water; also because air supply fans made a noise, or water hammer noises occurred in the night, or a moaning feed pump or other machine disturbed their rest.

In regard to engine controls being on the bridge: this might be very good, if carried out reliably; it certainly obviated the chance of mistakes being made in engine movements. A good modern engine, either steam or internal combustion, should not require a skilled engineer to handle the controls, provided they were fitted with interlocks and time relays; but it seemed a little difficult to see how this could save many men on the engine room staff. Older, in fact most, engines needed men present to operate them, because the open type at least would not be safe for the staff otherwise and might also get stuck. Bringing the gauges to the desk was very good and lessened the chances of errors in reading them, in contrast to trying to read them a long way off in dark, hot, inaccessible places—indeed through bulkheads sometimes!

About physical toil aboard ship being out of place: this was true but, until recently, gear to obviate this was not available, and hammers were cheap. Torque spanners were not invented, or at least were not available. Years ago he tried to plan a tail end nut hydraulic spanner which would apply a couple to the nut. The difficulty was the taking up of the reaction on the hull, or on the bottom or side of the dock. If this could be done he would advise that the nut should be jarred, to break the "sticktion" between nut and boss. Power lifting gear should be fitted wherever possible, and with direct leads not requiring guys. At the same time there were very many jobs where the use of light blocks could be easy and quick.

About younger men being annoyed at older—and not nearly so clever—men being right when they were wrong: the reason was that these older men had a vast store of experience as a part of their being; and some hardly comprehended memory caused them to decide correctly.

The sad fact that engineers were not called into the highest councils of the shipping concerns was because, in most cases, the engineers were not ready for it. Few engineers took the trouble to understand administrators or their problems, particularly the overall finance problems of ships. The directors were "office wallahs", and that was that! Now, through broader knowledge, most engineers had a good grip of the problems involved in management with the result that, in the author's words, here and there an engineer had been elevated to the directorate. Might he suggest that the operative word should be "translated", not "elevated". Among the seagoing staff the knowledge that an engineer—as well as a junior office man—could become eligible to become a director would remove a cause of resentment.

On page 103, second column, "If and when nuclear propulsion, etc.:" might he repeat a statement he made when the *Viceroy of India,* the first turbo-electric vessel of the P. and O. was built? A boyhood friend—then a qualified electrical engineer—said to him: "Now, I suppose electrical engineers will be in charge of the ships". My reply was: "No; marine engineers—as marine engineers—deem it their job to take charge of all ships' machinery, no matter how actuated". Accordingly, if and when atomic propulsion came along, it would be marine engineers who were in charge.

As one who had been in charge of ships' machinery for many years, he had always listened to anyone who had something to say about a machinery defect; then, out of a mass of statements, had picked out perhaps one item which gave the clue to the trouble. Thus, in the early days of oil burning they had one source of supply from which they were bunkered with a fuel oil different from the others. This oil caused trouble throughout the fleet; the boiler fronts panted and there was trouble all round. A chance remark of a fireman that the fires seemed to burn better with the flame cone pulled back caused him to think out matters along lines by which all the trouble was stopped. They then burned the same oil easily and cleanly.

About scientists: he had read in his youth that science was organized common sense. Did the scientists always possess this quality of common sense?

The last paragraph of the paper read a little oddly to him: "Methinks I see in my mind a noble and powerful Institute rousing herself from sleep," etc. Come, come! the Institute had never been asleep, but had progressed as much as possible under the conditions of the time; and when new ideas were brought forward the Institute was the first to welcome them.

Mr. A. J. Morton (Associate Member) referred to the author's reference to the relationship between the engineer and the scientist:

> "If and when, for merchant ships, nuclear propulsion becomes an accomplished fact, it will be . . . the engineer who will control and be responsible for the machinery design and arrangement; it will be the engineer who will be responsible for the execution of the work. The highly meritorious labours of the scientist will—or should—begin and end at the nuclear reactor . . . ".

To him that seemed to be a completely indefensible demarcation agreement, but he was sure that Mr. Pounder had not meant to give the impression that the reactor could be separated from the rest of the equipment as easily as that. The engineer had to concern himself closely with the reactor, as otherwise it would not work, and similarly there were many conventional engineering problems where they called in the scientist very cheerfully—corrosion problems and all sorts of other things.

Engineers could not shut themselves off from the world of science and push scientists out of the engine room just because they were, perhaps, a little "long haired". If they insisted on doing so, they would certainly find that when they really needed the scientists, the scientists were not there. He did not want the industry to give an appearance of being crusty, or to frighten people with horrible stories of hardship at sea.

They had to go out of their way to co-operate with the scientists and the so-called research engineers, even though these men were not engineers at all in the all-round sense of of the word. The engineers needed these people, and should give them by means of a properly thought out training scheme the practical experience that at present they so often lacked.

Correspondence

Mr. L. Baker, D.S.C., wrote that he welcomed the opportunity of contributing to the paper by Mr. Pounder. He could not think of anyone in the marine industry more suited by his personal characteristics to comment on this subject, comprising as it did a review of the history of the marine engineer and the influence of history on the person.

The human problems of the naval engineer had been well set out by Engineer-Captain Edgar C. Smith, O.B.E., R.N.(ret.) in his book, "*A Short History of Naval and Marine Engineering*", and by Commander Penn in his book, "*Up Funnel, Down Screw!*".

It would appear, from a perusal of the text of the paper and these books, that there had been times when the naval engineer was behind his merchant counterpart and times when he was ahead, and it was interesting to note that a very great deal of time and money had been expended on questions involving status. That battle was by no means ended and the author's remarks on the representation of marine engineers at board room level were particularly pertinent.

In connexion with the difficulties of finding an adequate supply of seagoing engineers for merchant ships, it was precisely this problem that led to the introduction of engine room artificers in 1868. Whilst it was commonplace to talk of the high salaries of seagoing engineering staff, it might perhaps be worth while mentioning that in 1849 a chief engineer in a P. and O. ship earned £26 per month, which was not very different from that paid during the slump eras, and no way in step with the depreciation in value of the pound in the intervening 100 years.

He could not but agree with the author in the view that the rates of pay and living amenities were merely a demonstration of the definite social change. Unfortunately, neither the status nor the reward had really kept pace with the demands made by technical progress and there was some measure of agreement between the view expressed in 1885 and today:

> "I must say, however, that though they were emphatically cads, this old class of engineers was composed of thoroughly practical men, who were not above their business, and managed to keep themselves apace in a most commendable manner with the development and progress of steam and other machinery; . . .
>
> An engineer was, and will continue to be for a considerable time longer, a social pariah—both afloat and ashore. If the Admiralty were to recruit this branch from the aristocracy, they would not alter that, so undying is prejudice . . . ".

Finally, he would like to say that he was in complete agreement with the author in his views on the original causes of the difficulties of demarcation, etc. Whilst it was undoubtedly true that the trade unions were engaged in an "ostrich-like" operation, it was also true, unfortunately, that the exigencies of day to day business had guided managements' views on the problems, and it frequently led to compromise solutions that were demonstrably unjust, with subsequent further friction in an inherently smooth running organization.

Mr. S. D. Batra (Associate Member) wished to comment on some statements made on page 101 of the paper with regard to keeping engineers at sea. He felt that whereas the author had investigated the question thoroughly from the viewpoint of a shipowner, certain points that had caused considerable dissatisfaction among the engineers afloat had escaped his attention. The problem of status was a very important one. The marine engineer of today was different from one of twenty-five years ago. His responsibilities had increased to a great extent but his status was only a little different from what it was then. Many companies still regarded the engineering department in a ship as a junior department and officers of this department were given poorer facilities than those given to the deck department. There were not a few companies in which the chief engineer of a ship was not allowed to correspond directly with the superintendent engineer even on engineering matters and all his correspondence had to be forwarded through the master, who might not have any understanding of a modern installation. He remembered an instance when a ship was laid up for survey and there were only two deck officers on the staff list, both of whom had only First Mates' Certificates, and the management insisted that all correspondence for the chief engineer be forwarded through one of them. Instances such as this had caused much dissatisfaction amongst many good engineers and these people left the sea at the first opportunity. It seemed that Mr. Pounder was bent on making engines that would need no engineers at sea. He hoped the author would consider the problem of a marine engineer's status once again, and this time from a marine engineer's point of view, not from that of an engine builder or a shipowner. If the status of an engineer at sea could be raised to the extent that he might be able to hold the most senior position on a ship, engineers at sea would not only remain there but many of those ashore would long to join them.

Mr. A. J. S. Bennett, M.B.E. (Member) referred to Mr. Pounder's statement that engineering was a craft, and, coupling this with his reference to the trend towards the elimination of manual labour, it was evident that when both points were applied to the present new training schemes for young marine engineers, a conflict of claims arose. Such conflicts were not likely to be settled by edict and would more easily be dealt with if leading authorities were more able to come into the open with personal opinions.

One claim was for the practise of basic skills on good solid marine work, meaning broadly the steam engine and the Scotch boiler or something similar. Bearing in mind that training time was limited, the conflicting claim was that it was known that the young engineer needed some preparation to help him to deal with the new labour saving devices and techniques that had replaced the older ways of doing things. He would be confronted with the new devices, which would include treatment of all the engineering fluids, and would have to deal with them as they stood, and where they stood, which was quite often on the high seas.

The more time spent on the acquisition of traditional skills, the less time there was available for the newer skills. Where was the cut to be made? Had the time now come when the old faithful steam reciprocating engine and its associated equipment should be honoured with a place in the training museum? This was indeed a human problem, and a vital one, involving sentiment towards the familiar and hesitance towards the new fangled. How far must one go back before it was safe to go forward?

He would be most grateful for Mr. Pounder's remarks on this matter.

Actually the time was now ripe for action, and what was done or not done must influence the future pattern of ships' engineers, as wide and sweeping changes were occurring.

Many of these were reviewed in the Symposium on Training printed in the TRANSACTIONS*. One suggestion then was that the full apprenticeship requirements for marine engineers could, if necessary, be met in suitably equipped technical colleges, though he felt sure that it was not anticipated at that time that this would ever come to pass. Now, two years later this type of training was about to start! This surely must be part of the mutation which the author identified in the first part of his paper. No wonder things were moving.

MR. J. W. BULL (Member) had been very interested in, and indeed heartened by, this paper. He was extremely glad that an engineer of long experience and great standing in the profession had said again so many of the things that were due to be expressed about the present stage of marine engineering. He would like to comment on one or two items.

He fully agreed of course from his own experience over the past forty years that the cessation of coal hand firing of boilers was a most significant event. They could now savour the great benefits that had since accrued to the marine engineer; at the least he was now free on big ships from the stultifying effect of supervision of stark manual toil in the stokehold and the added preoccupation of urgent necessity for disposal of ashes. This clearing of floor plates had literally prepared the way for the present era of developments in marine machinery and the increasing part the properly trained engineer was necessarily taking in the control of the industry. Even in the old days some engineers emerged from the turmoil with administrative ability and culture unimpaired, but the improved attention to professional training and reasonably early education in fundamental science was now assuring the engineer of his rightful place.

He personally accepted without qualms the challenge of the new outlook in regard to the seagoing engineering personnel. To him the present day international scale of shipbuilding and design itself ensured the successful application of all possible forms of scientific and technical knowledge towards improvement of marine machinery. He thought most maritime nations would in due course adopt more or less similar practices whereby the most efficient use was made of available manpower in association with automatic controls of high reliability.

PROFESSOR G. H. CHAMBERS, D.S.C. (Member) considered it to be a privilege to have a paper of this sort open to discussion since it was of a calibre normally read as a lecture and not discussed.

The paper showed that an important reason for the change from sail to steam was the reduction in personnel, that is, labour costs, which resulted. A similar factor applied in the change from coal to oil. The effect of such labour costs ashore as well as afloat had continued to influence the choice of machinery, as was shown by the way in which their locally high level had virtually excluded the direct drive Diesel from United States ships. One could not help thinking that with a continually rising standard of living, this trend would persist, spreading eastwards, and must eventually favour rotary rather than reciprocating machinery.

Did Mr. Pounder think that within the next decade the direct drive Diesel would reach its zenith before being supplanted by the gas turbine? The steam turbine, of course, remained a competitor, particularly if the maintenance and operational problems of the boiler could be reduced.

A second point was that Mr. Pounder left one to wonder who was the better man; the superintendent engineer who could wring revolutions from recalcitrant firemen or the superintendent engineer who could wring pounds, shillings, and pence from the recalcitrant shipowner. No doubt there was room for both in the organization, but the more senior the individual, the more important became his powers of advocacy.

This gave a pointer to the logical sequence of the professional education of all engineers, marine or otherwise. Such education started with the theory and technical practice of their art, followed by the handling of people and administration, and culminating in an ability to negotiate at the highest level, which was something to which every complete engineer should aspire.

While some educational establishments might be able to give a grounding in all aspects of this art, they could do little more than this; the engineer must really teach himself by observing and understudying his seniors, by actually doing the various jobs, and by making mistakes.

In compounding a university course, one had to consider whether one should rely on a boy's schooling for imprinting forcibly in his mind the lessons in human relations that could be learnt from a study of the more frequently quoted passages in literature and ancient history. It might be that the answer would depend on the country where the education was taking place. Perhaps in the U.S.A. education emphasized human relations directly at an early stage, while at a corresponding period education in the United Kingdom would be dealing with literature and Latin without tying them very closely to present day life.

He wondered if Mr. Pounder's wide experience with his more junior staff would enable him to express preference for any particular method of improving their ability to deal with people and situations as well as machinery.

One of the main reasons why Mr. Pounder's paper was so important was that it emphasized, from what might be called the user angle, the value of an education which included intense study of certain items not normally found in an engineering curriculum.

MR. JAMES GRAY, C.B.E., commented that, as ever in the past, when Mr. Pounder addressed them, he provided rich food for creative thought. Not for him the beaten track. He awakened them, he invited them to appraise, to assess. Never did he lose sight of the man in relation to his machine.

In the penultimate paragraph of this latest paper he contrasted the service of the marine engineer of 1959 with that of his predecessor a hundred years earlier. Truly, the call upon him was entirely different today. Comparison of respective personnel called for identification of unit and of datum line. As they were without these they were left with a loosely defined opinion. In the comparison, the object was entirely changed, but what of the subject?

At all levels and in all compartments of marine engineering over the century, accumulation of knowledge was enormous. Application of knowledge became corporate and automatic. It was a poor measure of character, wisdom, or intelligence.

Over more than half of the hundred years, he could look back upon more or less intimate contacts with individuals enjoying widely differing degrees of fame and of responsibility, in design, construction, and operation. He did not think that the seagoing engineer of fifty or sixty years ago was a lesser man than his successor of today. Perhaps his "Mathematics" and his "Theory of heat engines" were inferior, but he was an able craftsman with confidence in himself. Many of his achievements were epic. Today, in many ways, less was required of him. A watchkeeping engineer with a lively and creative brain was less apt to be content with watching gauges and revolutions. Divine discontent provided the urge to make more satisfying use of the talents with which the Almighty had been pleased to endow the more fortunate. Mr. Pounder must accept serious responsibility for his great contribution to this grave unrest. Had he ever considered the appalling rate of change in the seagoing personnel?

In earlier days, when faults and failures were frequent, many of them even standardized from common but unrecognized origin, interest was stimulated and talent was gratefully and generously exercised.

Perhaps, over the turn of the century, there was a rela-

* "Education and Training of Naval Architects and Marine Engineers". 1957. Trans. I.Mar.E., Vol. 69, p. 327.

tively long period of quiescent design. Development was largely based upon "rule of three" and wisdom was expressed in requiring "ten per cent above Lloyd's", even though the sage might have been quite ignorant of how Lloyd's Register arrived at their requirement. He ventured the opinion that the greatest relative advance had been in the quality and experience of those responsible for design and workmanship.

There was little reason to criticize the substance of the examination requirements for certificates of competency, but was there not a call for improvement in the preparation of the candidate so that he might profit the better from his subsequent experience? Could not the aim be more to teach and less to cram, to till the ground for fertile growth instead of to cram with that which finally might be only disgorged at the coming examination? Conventional cramming permitted no critical faculty and invited no subsequent growth.

He had referred to breakdowns, from the benefit of which Mr. Pounder had so largely deprived today's seagoing engineer. In the past, crude judgment had suggested "bad metal" where the fault was fatigue, and "insufficient strength" where the fault was concentration of strain. Good engineering economy should provide the least costly metal and accept the highest calculated stress which would ensure the stipulated service without foreseeable risk of failure. Quality of workmanship should be appropriate to particular requirement. It was rare indeed that defective or insufficient metal had been the real cause. On the contrary, effective elimination of failure had followed reduction in weight and calculated strength. Distribution of strain was generally more important than a low calculated stress. The need to absorb energy was often less obvious than the need to resist force.

Captain(E) W. Gregson, C.B.E., R.N.R., M.Sc.(Eng.) (Member) wrote that the advance copy of Mr. Pounder's paper was indeed fascinating reading. Listening to his exposition thereof was even more exhilarating.

The evolution of the steamship was contemporaneous with the industrial development of Britain which, in turn, meant growing attention to overseas markets. This called for increased passenger trade, and the steamship afforded reasonably stabilized time schedules as compared with the sailing ship —the latter being subject to the vagaries of wind and weather. In fact, the steamship became an important asset in establishing overseas trade by facilitating the movement of personnel.

The author had made it perfectly clear that the struggle for the supremacy of steam over sail extended over many decades. At the presentation of the paper at the Institute he showed a slide of the passenger steamship *Teutonic* built in 1889, and also showed another slide of the large sailing ship *California* built in the Belfast Yard in 1890. These illustrations showed very clearly the overlap that was taking place at that time, and he trusted it would be possible for Mr. Pounder to include the illustrations of these two vessels in his reply to the discussion. *Teutonic* and her sister *Majestic* (built in 1890) were outstanding steamships of that period, setting a pattern for the general development of all later passenger ships.

He would further suggest that the slide of the first seagoing engineer's certificate granted by the Board of Trade should also be reproduced as an illustration.

The paper would be even more enriched by including the comments made by the author when showing these three slides.

Mr. A. C. Joseph congratulated the author on the excellent way in which he had written the paper. The first half was full of history and information and it would be a reference paper for all marine engineers of this and the coming age. The second half of the paper dealt mostly with human problems in shipbuilding and shipowning. There were many problems also which concerned the operating engineer and the author had failed to mention these.

On page 101 the author doubted if men were ever keen to go to sea. Men were keen to go to sea from Biblical days and perhaps the author would be more correct to ask if men were keen to go to sea after one trip. He also stated on the same page that qualified engineers tended not to remain at sea. This last remark was well worth consideration.

From his own experience as an operating engineer, and as a result of conversations with many young operating engineers, he was of the opinion that many qualified engineers who went ashore did so due to the poor conditions on board and not for any other reason. "Conditions" is a very general term. Living conditions were definitely better but in many ships could be much better still. They should be ashamed to mention that there were still ships afloat where there was no running water and where one had hardly any room to move in the cabin. Was it any wonder if a man sought work ashore where he had all the modern conveniences?

The main factor was the status of a marine engineer on board. On page 104 the author wrote that in many companies it was the master who had the voice of authority in regard to engine revolutions, coal consumption, etc. It was a pity that in many ships the condition still existed. Any marine engineer below the rank of chief engineer had no status on board many ships (in certain companies it was different). As the author said, man is egregious, and particularly a sailor. Even the status of a chief engineer on a ship was not very attractive. Was it a wonder if a chief engineer also wanted to be independent? In his opinion a chief engineer should be given rank and pay equal to that of a master and the chief engineer and no one else should be responsible for the running of his department. The signing on of the crew for the engineering department, inspection of engineering department cabins, despatch of engineering department correspondence, etc., should all be left to the chief engineer of the vessel. The modern marine engineer was well trained to do these extra duties. He could mention such ships built in 1958 and 1959 where there was air conditioning and other facilities in the master's cabin, while the chief engineer was treated as any other officer. Was it any wonder if chief engineers sought posts ashore—perhaps with lower wages but at least where they could keep their self-respect?

The social status of the marine engineer was the crux of the problem and unless something was done in this direction it would be worth while considering engine designs where there would be no operating engineer officer. The days of "I am master of all I survey, my right there is none to dispute" must come to an end and then and then only would they find qualified marine engineers staying at sea.

Mr. W. H. Lindsey considered that the author had presented a most interesting concise history of the evolution of ships since the introduction of propulsion machinery. In particular, he had shown how social changes had influenced the design of ships, and especially of the machinery. Since social change apparently occurred at an ever-increasing rate, it might well be reasonable to assume that propulsion machinery would keep in step with this process and an examination of certain engine types lent support to this argument.

Fig. 16 showed four broad types of marine propulsion machinery, three employing Diesel engines, and the fourth light weight gas turbine engines. The engines were to the same scale and each example provided nominally 8,000 s.h.p. The figures for specific weight and specific volume included reverse reduction gears where appropriate, and the volume of each set of machinery had been defined by the dotted outlines.

The first example showed a direct drive two-stroke marine Diesel engine running at 120 r.p.m. and it had a specific weight of 112lb./b.h.p.

The second example showed a 400-r.p.m. direct drive Diesel, the higher speed resulting in a substantial reduction in size and weight.

The third example depicted a high speed four-stroke Diesel engine complete with reverse reduction gear. The picture gave a useful indication of the relatively small space occupied by this machinery and the specific weight had come down to 18lb./b.h.p.

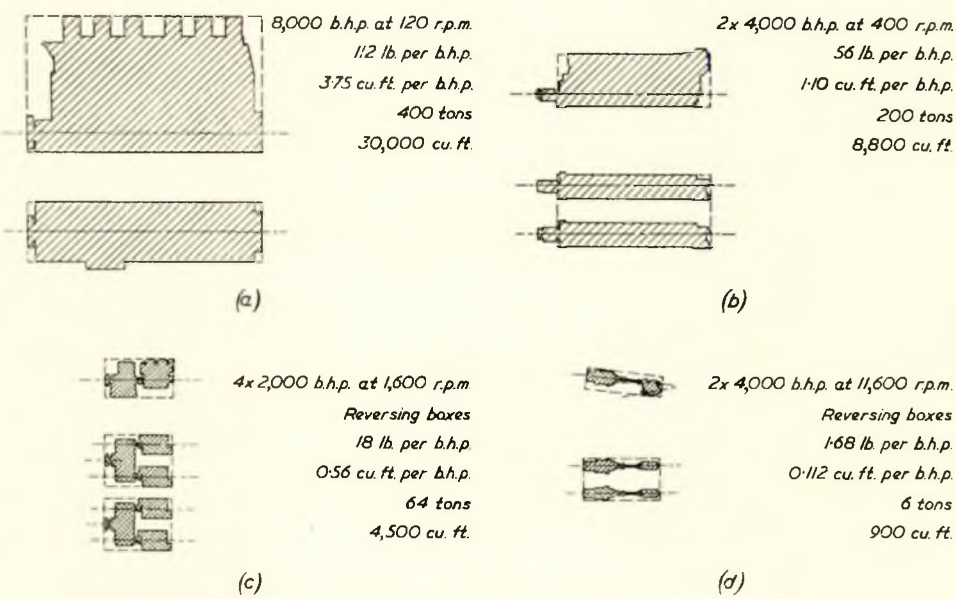


FIG. 16—*8,000-b.h.p. installation*

a) Typical marine Diesel two-stroke turbocharged crosshead type direct reversing.
b) Typical marine Diesel two or four-stroke turbocharged direct reversing.
c) Bristol Siddeley Maybach Diesel engines, four-stroke turbocharged non-reversing.
d) Bristol Siddeley Proteus gas turbine engine: open cycle free turbine.

The fourth example showed the further enormous reduction in size and weight that could be brought about by the adaptation of aero-type gas turbines for marine use.

It was of interest to note that development of machinery, as typified by the examples, was punctuated by discontinuities produced by the acceptance of a new arrangement and, frequently, these involved additional complexity. It was, of course, important that additional complexity was not introduced until the complete plant showed overall economic advantages over the more conventional arrangement. Thus, for example, there would appear to be little point in changing from a low speed direct drive Diesel to a higher speed, necessitating reduction gearing, unless a substantial increase in engine speed was involved, so as to show a large reduction in the weight and volume of the machinery. However, the diagram made it quite clear that this could be achieved.

The author had described the necessity for operating and maintaining ships' machinery with fewer personnel. Apart from the difficulties produced by social changes, this necessity must be desirable from purely economic considerations. In some cases, the difficulty might be overcome by developing low rated machinery which required a minimum of attention but he suggested that the adoption of much smaller and more highly rated engines could provide a better solution. The latter approach, involving engine overhaul in factories ashore, was fully justified provided that the engine overhaul period was sufficient not to interfere with normal operation of the ship and that the marine designer provided facilities for easy and quick engine replacement. Reference to the diagram showed that such enormous reductions in volume and weight were possible by the adoption of high speed engines that the problem of facilitating engine changes should not prove insuperable.

The last example on the diagram showed light weight gas turbine engines and indicated the further enormous possible reduction in machinery weight and space requirement. Bearing in mind the higher fuel consumption and lower overhaul life of this type of engine, it was clear that it did not compete with the other engines for the propulsion of most conventional types of ship. However, its existence presented a challenge to marine engineers in that this type of machinery demanded a new approach to ship design if its basic merits were to be fully exploited. In particular, this kind of light weight propulsion machinery proved to be most desirable where endeavours were being made to produce vessels of higher speed. Reference to the details of ships given in the paper suggested forcefully that drastic changes would be necessary to produce higher speeds.

Examination of other forms of transport showed that increasing operating speed, at least up to a certain point, had resulted in improved economy and a better service to the public. Judging by the examples in the paper, the speed of ships had not increased materially in this century, and, while this might be a satisfactory state of affairs where the transport of bulk cargoes was concerned, it was difficult to believe that much higher speeds would not prove entirely beneficial where passengers were carried. For longer sea routes, appreciable speed increases might be unnecessary (except possibly for economic reasons) since the majority of people regarded luxury travel by sea, unlike other forms of transport, as a satisfactory end in itself.

Human beings had a particular ability in making new surroundings feel like home very rapidly, but that was not possible on short water crossings. In these circumstances, it seemed unlikely that they would accept for ever a speed in the region of 20 knots for the journey. The challenge to marine designers was to produce faster vessels that would show overall economy and automatically provide more frequent services and thereby attract greater passenger traffic. The advent of the light weight gas turbine should make a solution of this problem possible.

The marine designer could now choose his engines from a wide range, with atomic propulsion at one end of the scale and light weight gas turbines at the other: in the centre were steam plant and a wide variety of oil engines. The optimum choice of engines and transmission must be made in each case and would be decided by the type of ship and its duties. He had tried to show the differences in weight and volume of some of these types of engine and he suggested that these differences were so great that they provided a considerable increase in design scope to the marine engineer. He would no doubt continue to use all the tools at his disposal, carefully selecting the most appropriate according to requirements, to keep pace with continually changing human needs and aspirations.

Mr. W. E. McConnell (Member) wrote that the author had ranged over a large area for his survey of this subject, which was one of great importance to the Institute. His historical investigation provided a spacious background for his exposition of the evolution at sea and there was a large measure of agreement with his conclusions. Having shared in this growth in the workshop, the drawing office, and afloat, he would like to reinforce some of the points raised in this remarkable paper and emphasize one or two aspects of the subject as it concerned the engineer at sea.

The author showed with what diffidence the marine engineer first made his appearance on board ship, and many of them would have memories of the "oil and water don't mix" phase. To the mariner, inheriting the traditions of a thousand years, the mechanic (Shakespeare's "base mechanic fellow") was an unwelcome interloper, his company was "the black squad", and undercurrents of friction persisted for many years and even around the indignation of Admiral Jackie Fisher, whose scornful castigation of "the executive" helped so much to create a better atmosphere. They could rejoice that those unhappy days were past and that a harmonious fraternity of mercantile officers, integrated by the experience of two world wars and their aftermath, now worked together for their mutual benefit, and with memories of the earlier meetings in the original Romford Road premises he asserted that the Institute had borne a worthy part in furthering this development; and he cherished the memory of co-operating with their Member No. 1, who laboured so faithfully and so long in this work.

A great deal of time and effort had been spent on the subject of the training of marine engineers, and every means to this worthy end would be welcomed, but it should be borne in mind that the marine engineer in this country had taken every technical advance in his stride, and the great change described in the paper occurred so smoothly that most people outside the craft were blandly unaware that there had been any changes of greater importance than those produced for the annual motor shows; this phenomenon deserved a moment's consideration. It was not generally appreciated that progress in scientific design in marine installations was so rapid that it would have led to difficulty in obtaining engineers suitably educated to take charge of them if the municipal authorities of the larger industrial cities had not made preparations for this development by providing technical schools; these, from the later years of the nineteenth century, provided an adequate technical education for those apprentices who were willing to make the effort; for an effort was required, as the classes were usually at night, and the scholars clocked in at 6.0 p.m. and when transport, often horse operated, was not on the scale demanded today. Yet enough of their fellows faced these conditions and produced, just in time, the generation which met the challenges of high pressures and temperatures, the turbine, and the internal combustion engine. The troubles which still afflicted the aeronautical industry emphasized the facility with which progress at sea was effected; and the native genius of their people was still free and virile, available for every demand that the future might make, but the grim lineaments of Fig. 15 in the paper brought them up sharply against the core of the matter. Even sixty years ago men with a First Class Certificate were not commonly found at a fitter's bench unless they had succumbed to the then prevalent tendency to intemperance or had some infirmity, and many men left the sea without obtaining any certificate. Those who did could always find appointments ashore in charge of power installations, and there was a steady demand for certificated men for such posts; and this demand was much more insistent today.

The advanced designs of machinery today required supervision by men with technological training as advanced as the plant they were to control, but the conditions of former days, when men of very modest achievement could be got in great numbers—either because other employment was not available or because the position offered some improvement in their social or technical status, for which they were willing to pay the price of life at sea—had gone for ever, and the men needed for today's conditions must come from a class from which commerce and the other professions drew their recruits. They were offered a life with the enjoyment of home and family, with car and caravan, tennis, golf, and all the manifold amenities of life ashore. If Dr. Johnson's sour comparison of ships and prisons was true in his day, it had not lost all its force today, and it was of no avail to complain that altruism was dying. As the author said, an effort was needed to create the conditions which would offer a highly trained engineer sufficient attraction to induce him to forego the blessings of suburban life and society for the seclusion of a one-roomed home afloat. Much had been done, but much remained to be done, as Fig. 15 demonstrated. Yet, for generations, service at sea had had honourable associations for the British people, and when these shrivelled or atrophied the writing would be on the wall; the honour, assisted by authority, by the press, and by skilfully directed public opinion, could be spread a little wider. A number of master mariners of famous ships had received, and richly deserved, the honour of knighthood, and decorations, and their achievements were given honourable prominence by the press; some modest recognition of the part played by the marine engineer, some evidence of awareness that the "black squad" had taken its place in maritime history with the "square-rigged Cape Horners" would, no doubt, encourage a trend in the desired direction. The alternative mentioned by the author—control of the engines from the bridge—was a measure very strongly advocated by the salt water school of former years, but surely no solution of the problem lay in that direction. For if the bridge control proposed consisted of stopping, starting, slowing or accelerating the main engines, like the driver of a motor car, innocent of any idea what was going on under the bonnet, leaving all the duties of simultaneously regulating the auxiliary machinery to an artificer class, suitably concealed, anyone who had seen or shared the operations involved would realize that even this hermaphrodite arrangement would require technically trained men, and as their status would be even further reduced the supply would further diminish, for only a mechanic of inferior attainments would accept sea conditions for such a position. And if atomic installations were installed there would be need for even higher technical training, as the disaster at Windscale showed, though the measures available there would not be at hand in a ship, and it was not likely that the Ministry responsible for such matters would look favourably on such a proposal as bridge control for such an installation. So the conclusion seemed to be that means must be found to make the career of a marine engineer as attractive as a life on the ocean wave was to those in other departments afloat which had no problems of recruitment. He thanked Mr. Pounder for his excellent paper and it was meet and right that he should have been invited to present it, for among the many responsibilities of his own work he had always been active in every effort to instruct and guide the succeeding generation.

Mr. R. N. Newton, R.C.N.C., considered that this paper, so rich in gems of knowledge and wisdom from the long experience of an author who might truly be regarded as an altruist in the light of his faithful devotion to the good of marine engineering and those engaged in the field, must surely be regarded as a jewel in the Transactions of the Institute.

It was not without some diffidence that the writer, a mere naval architect, dared to suggest that the section of the paper dealing with engine development in the last century and the summary of progress that followed it might be enhanced by a reference to the turbine yacht *Turbinia,* even though she was not built at Belfast.

The suggestion was made for three reasons. First, as a tribute to the genius of Sir Charles Parsons, whose work was manifested in many branches of industry and science; secondly, because the *Turbinia* was the pioneer of steam turbine propulsion; and, thirdly, to call attention to a human characteristic in keeping with the context of this admirable paper. The characteristic referred to was the attribute of the marine engineer to recognize and appreciate the problems which beset his naval architect associates, and *vice versa*—even though the author might be correct in his low estimate for the component of reason in man's make-up! No better example of this respect for the abilities of other professional contributors to the overall design of a ship could be quoted than the association which developed between Sir Charles Parsons and R. E. Froude in the search for the best possible propulsive efficiency for the *Turbinia*, i.e. the matching of engine performance with those of the propeller and hull. The extent to which this mutual search was successful could be gathered from Sir Stanley Goodall's 1942 Parsons Memorial Lecture*.

It would not be exaggeration to state that the transformation of this pioneering effort from one of complete failure to outstanding success was achieved only by close attention to the design of the propellers, including the reduction of cavitation erosion, a menace which even to this day had not been entirely eliminated.

Here then, for the record, were the relevant details of the *Turbinia*.

T.Y. Turbinia, 1894/97

Three shafts, separate direct coupled turbines (originally single shaft and single turbine).

Three propellers in tandem per shaft.

Working pressure	=	155lb./sq. in.
S.H.P. total	=	2,000
Speed	=	32·75 knots
Length	=	100ft.
Beam	=	9ft.
Depth	=	7ft.
Draught	=	3ft.

* Goodall, S. V. 1942. "Sir Charles Parsons and the Royal Navy". Trans. I.N.A., Vol. 84, p. 1.

Commander J. R. Patterson, O.B.E., D.S.C., R.N.(ret.) (Member) remarked that on page 85 of the printed copy of the paper it was stated that "the coal burning steamer needed firemen and trimmers for the arduous muscular work of its stokeholds. As an example of what this could mean: in a high powered Atlantic liner, 1,000 tons of coal per day had to be manually lifted from the stokehold floor and thrown into the boiler furnaces".

Could Mr. Pounder give any figures to show the capacity of firemen in those days? In other words, what was the normal rate of firing in, say, tons per hour, or tons per watch, which individual firemen were expected to maintain?

Author's Reply to the London Discussion

The many, varied contributions to the discussion presented, in turn, almost every facet of marine engineering life. Accordingly it would be reprehensible of the author to attempt to dissect what was essentially an anthology of miniature papers. Only those items, therefore, which seemed especially to invite comment were reviewed in the following pages.

Mr. H. N. Pemberton correctly implied that each man's interpretation of the past tended to be influenced by his own sectional interests and his own prejudices.

In referring to the evolution of marine propelling machinery the author had been conscious of the necessity—if accuracy and balance were to be preserved—of presenting as many facts as possible and of expressing as few opinions as possible. The picture of any age was always apt to be inexact and indistinct.

On what might be termed the human side of history, methods of interpretation had varied. Mediaeval chroniclers had regarded history in terms of kings and rulers steering a path between saintliness and sin; to Carlyle, in the nineteenth century, history was—in essence—a sequence of lives of great men; with others the anthropomorphic mode of explanation had prevailed. Then there had been the so-called "scientific" interpretation of history; and, later, there emerged the idea that all aspects of human life should be brought together, with a refined kind of Marxism as the key. Hence, one writer would interpret the past in terms of great men; another in terms of trends, currents and class structures; another would see in it a clash of forces—economic or social—capable, as it were, of vector analysis; and so on. As the author saw the matter it was doubtful if, at the time of the industrial revolution, capitalistic employers, labouring men, or anybody else, really grasped the significance of the swirling changes that were enveloping them on all planes. What was needed for analysing the mass behaviour of human beings was a Fourier series method.

The author fully concurred in what Mr. Pemberton wrote in his fourth paragraph, where he referred to the danger of the marine engineer surrendering his initiative and responsibility to the scientist in matters pertaining to nuclear propelled vessels. He said, truly, there could be a tendency for the engineer to look to the scientist to design a nuclear ship for him. Now was the time, in the author's opinion, for correct ideas to be rammed home to the marine engineer, before nuclear propulsion became an accomplished fact in the mercantile marine.

Mr. Stewart Hogg referred to the size of boiler manholes. According to the author's understanding, the minimum size for a manhole was laid down long ago as 15in. by 11in. for cylindrical boilers. The standard shell manhole in all Harland and Wolff Scotch boilers, for as long a time as he could remember, had been 16in. by 12in. Before 1912, manholes between furnaces were 15in. by 11in. On the inadequacy of these dimensions the author was at one with Mr. Hogg, probably for the same reason, namely, that his own physical cross-section had always exceeded the said dimensions of 16in. by 12in.

Mr. R. Munton rightly indicated that those who were in any way involved in the design and superintendence of marine machinery should remember that, whatever they themselves might essay, the future lay always in the hands of the seagoing personnel.

As would no doubt be clear to Mr. Munton, and indeed to the other engineers who had discussed the paper, the reference to the running of engines without engineers was intended to be provocative, to bring out the opinions of men better qualified to adjudicate upon this matter than was the author.

The reference to the young man who had read economics but averred that he had no interest in the subject, as it had nothing to do with engineering, brought out an aspect of training, and possibly of temperament, that the author himself was always attacking. If that young man and all others of his class, irrespective of age or standing, would only have the wit to realize it, engineering in its technical aspect had always to wait upon engineering in its commercial aspect. That was what sometimes made life so very difficult for men engaged on, and interested in, advanced designs of machinery. The greater the knowledge the engineer possessed of the financial and commercial sides of his work—in other words the more he was grounded in the grammar of power—the more likely was he to be able to suggest ways and means whereby engineering projects could be made possible and prove remunerative. An engineer in high executive position had to engineer many things besides engines, if his engines were to be engineered properly.

Mr. A. C. Hardy and the author became acquainted in the days when the first marine Diesel engines were being built in Belfast.

The author had understood that it was Mr. Hardy who had initiated the idea of a paper on human problems in marine engineering and had framed its original terms of reference. It was no doubt reasonable for the members of a progressive community to pause for a moment, once in a long while, and consider the path along which they had come; and then, from contemplation of the past, to obtain inspiration and a sense of direction for the future, for there could be no gainsaying the fact that tomorrow grew out of yesterday as inevitably and as inexorably as a tree grew from its root. Now that the Institute had settled down in its new and noble building in Mark Lane, the present could be the appropriate moment for such reflection. Most probably this—or something like it—was what was in the mind of the Council and the Papers Committee in requesting the delivery of such a paper as the one now under discussion.

The author had intended, *inter alia,* in his interpretation of the terms of reference, to equate, for sailing ships and early steamships, the numbers and quality of men against size and type of vessel. It was to this point that Mr. Hardy referred. But, despite the assistance of the chairman and managing director of one of the best known shipping lines, and despite the searches of other important shipping men, no information of the kind sought was forthcoming. On reflection this was not, perhaps, surprising.

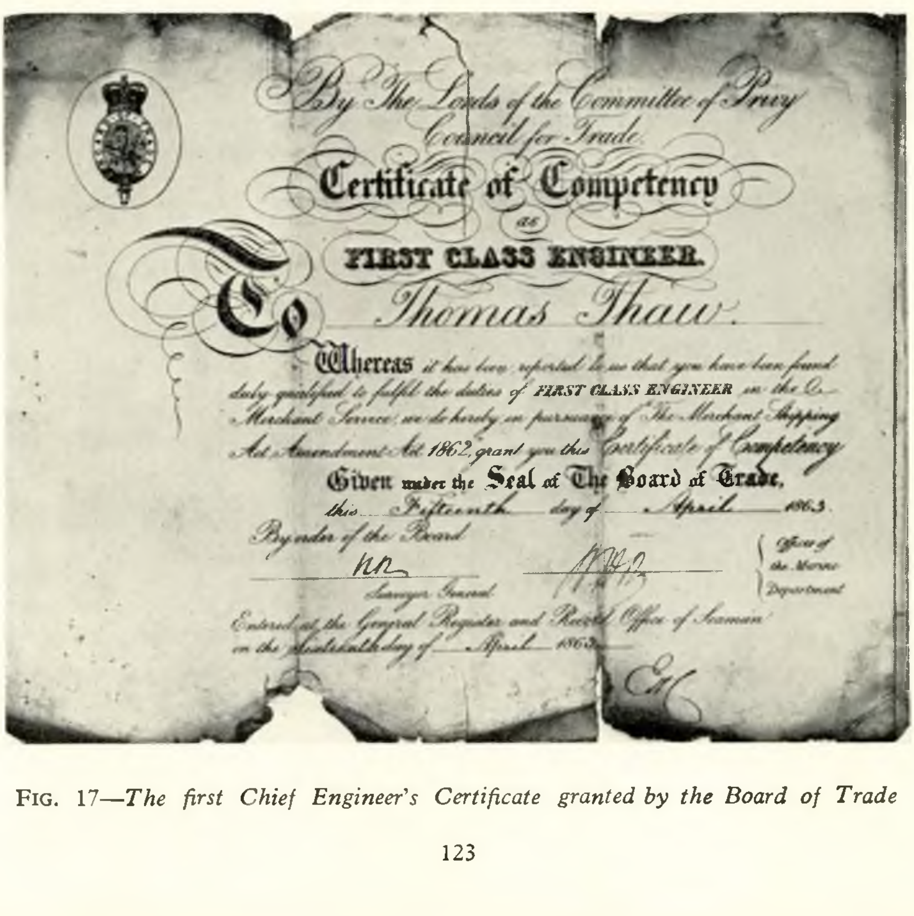
Many records would be lost in the war years, but this would not be the whole story. The fact was that, in the busy world of industry and shipping, the present and the immediate future were all that mattered. What was current and commonplace was seldom recorded; everybody knew the facts. Gradually practice changed and earlier things were forgotten. Only if a person, here and there, made a special record or kept a journal, and only if the account were preserved, could the future know what had occurred in the past.

In the end the author had to modify the scheme of the paper and, but for the persistent pressure of Mr. Hardy, the paper would not have been written. In the author's opinion the perennial freshness and enthusiasm of Mr. Hardy were important factors in the corporate life of the marine engineering community.

Mr. A. G. Arnold mentioned that it was usual for him and the author to have disputatious argument whenever they met. That was refreshingly true. It was a clash of flint and steel, Mr. Arnold being the flint—as was symbolically proper for a servant of shipowners.

The author well remembered the days and the incidents to which Mr. Arnold referred. In this connexion, however, a distinction must be drawn between the individual and the general. The general position was undoubtedly as the author had stated it to be; the here-and-there contradictory but incidental examples were what Mr. Arnold himself had experienced.

The non-application of fuel oil separators and fresh water cooling certainly retarded progress, as Mr. Arnold mentioned, and for the reason which he also stated. Other things could be itemized to pinpoint the penny-wise outlook of so many owners; thus, to name only two, there was the over-rating of auxiliary Diesel generators and persistence in the use of hand operated cranes. Something fractionally better at the same price always seemed to be more attractive to clients than something radically better at a rather higher price.


By The Lords of the Committee of Privy Council for Trade

Certificate of Competency

as

FIRST CLASS ENGINEER.

To Thomas Shaw.

Whereas it has been reported to us that you have been found duly qualified to fulfil the duties of FIRST CLASS ENGINEER in the Merchant Service we do hereby in pursuance of The Merchant Shipping Act Amendment Act 1862, grant you this Certificate of Competency

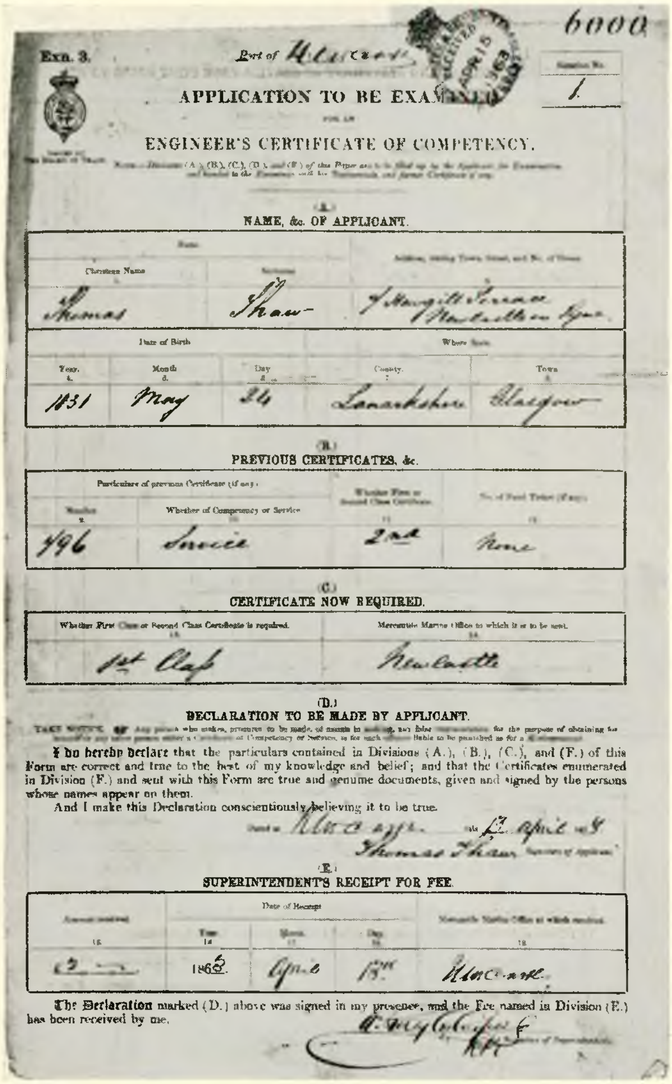
Given under the Seal of The Board of Trade, this Fifteenth day of April 1863.

By order of the Board

Officers of the Marine Department

Entered at the General Register and Record Office of Seamen on the Sixteenth day of April 1863.

FIG. 17—*The first Chief Engineer's Certificate granted by the Board of Trade*



6000

EXH. 3. Port of Newcastle

APPLICATION TO BE EXAMINED 1

ENGINEER'S CERTIFICATE OF COMPETENCY.

(A.) NAME, &c. OF APPLICANT.

Christian Name	Surname	Address
Thomas	Shaw	7 Haugill Terrace Newcastle on Tyne

Year	Month	Day	County	Town
1831	May	24	Lanarkshire	Glasgow

(B.) PREVIOUS CERTIFICATES, &c.

Number	Whether of Competency or Service	Whether First or Second Class Certificate	No. of Fund Ticket (if any)
496	Service	2nd	None

(C.) CERTIFICATE NOW REQUIRED.

Whether First Class or Second Class Certificate is required	Mercantile Marine Office to which it is to be sent
1st Class	Newcastle

(D.) DECLARATION TO BE MADE BY APPLICANT.

I do hereby declare that the particulars contained in Divisions (A.), (B.), (C.), and (F.) of this Form are correct and true to the best of my knowledge and belief; and that the Certificates enumerated in Division (F.) and sent with this Form are true and genuine documents, given and signed by the persons whose names appear on them.

And I make this Declaration conscientiously believing it to be true.

Dated at Newcastle this 12 April 18[illegible]

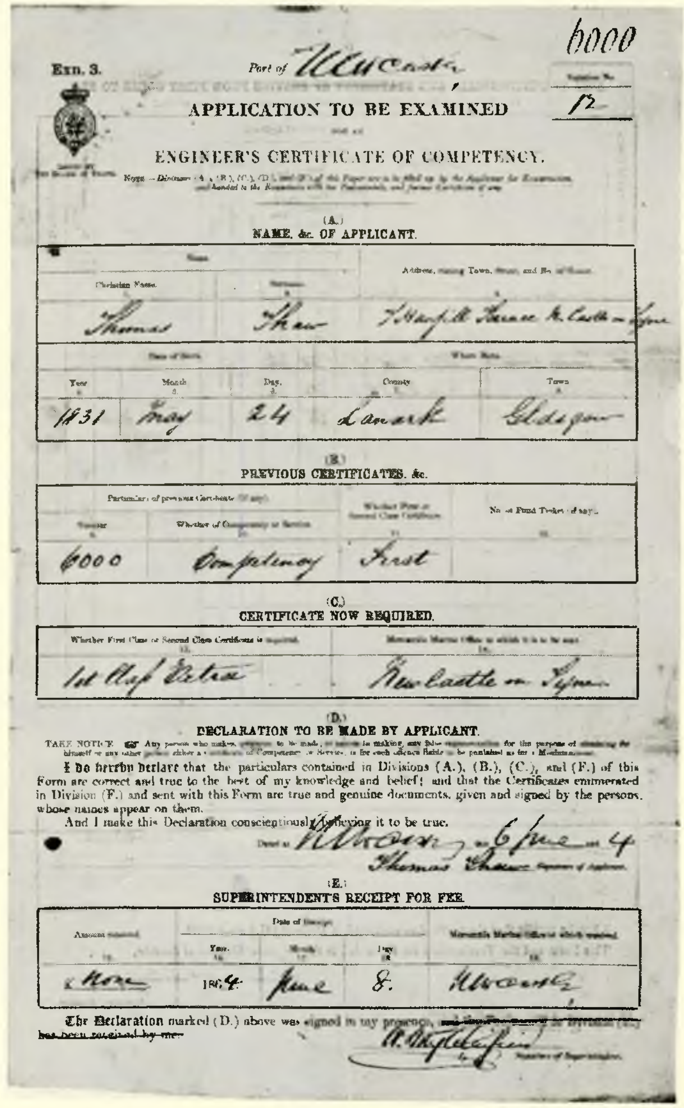
Thomas Shaw

(E.) SUPERINTENDENT'S RECEIPT FOR FEE.

Amount received	Year	Month	Day	Mercantile Marine Office at which received
£2 —	1863	April	13th	Newcastle

The Declaration marked (D.) above was signed in my presence, and the Fee named in Division (E.) has been received by me.

FIG. 18—*Application to be examined for First Engineer's Certificate*



6000

EXH. 3. Port of Newcastle

APPLICATION TO BE EXAMINED 12

ENGINEER'S CERTIFICATE OF COMPETENCY.

(A.) NAME, &c. OF APPLICANT.

Christian Name	Surname	Address
Thomas	Shaw	7 Haugill Terrace Newcastle on Tyne

Year	Month	Day	County	Town
1831	May	24	Lanark	Glasgow

(B.) PREVIOUS CERTIFICATES, &c.

Number	Whether of Competency or Service	Whether First or Second Class Certificate	No. of Fund Ticket (if any)
6000	Competency	First	

(C.) CERTIFICATE NOW REQUIRED.

Whether First Class or Second Class Certificate is required	Mercantile Marine Office to which it is to be sent
1st Class Extra	Newcastle on Tyne

(D.) DECLARATION TO BE MADE BY APPLICANT.

I do hereby declare that the particulars contained in Divisions (A.), (B.), (C.), and (F.) of this Form are correct and true to the best of my knowledge and belief; and that the Certificates enumerated in Division (F.) and sent with this Form are true and genuine documents, given and signed by the persons whose names appear on them.

And I make this Declaration conscientiously believing it to be true.

Dated at Newcastle this 6 June 1864

Thomas Shaw

(E.) SUPERINTENDENT'S RECEIPT FOR FEE.

Amount received	Year	Month	Day	Mercantile Marine Office at which received
None	1864	June	8.	Newcastle

The Declaration marked (D.) above was signed in my presence, ~~and the Fee named in Division (E.) has been received by me.~~

FIG. 19—*Application to be examined for Extra First Class Certificate*

Glenogle and the four sister vessels were successful because, in their day, they were built in accordance with the soundest canons of marine machinery design. Since then far too many engines had suffered from the over-cleverness of their designers.

Regarding the results obtained by changing the boilers of *Olympic* from coal burning to oil burning: the ship speed remained the same, as there was no reason to alter it; the emphasis was upon the saving of fuel and the reduction of running costs by the elimination of firemen and trimmers. For equal speeds and equal displacements, the fuel consumption as a coal burning ship was 1·37 times that as an oil burning vessel. When *Olympic* was sixteen years old, its machinery, which was designed for 51,000 i.h.p. + s.h.p., was run comfortably at 58,000 i.h.p. + s.h.p., with appropriate increase of speed. That is: after conversion the ship could either be run faster for the same amount of fuel or at the same speed—which was the usual routine—for substantially less fuel.

Commander E. Tyrrell asked if the author were satisfied that the quality of the present marine engineering designers was adequate for carrying through the revolution that he said was upon them. The author's reply to this point was that he was never satisfied, either with himself or with anybody around him. This point would be reverted to.

The author fully concurred in almost all of the comments made by Commander Tyrrell. With the last paragraph of his statement he was particularly in agreement.

In the presence of the swiftly flowing stream of progress shipowners, and others, could do one of two things. They could confidently launch out into mid-stream and take advantage of the current; or, alternatively, they could wade, square-jawed and obstinate, into the moving water and, with arms outstretched, they could attempt to stem the current, but only to be overwhelmed and swept away. Whether men liked it or not, they lived in a dynamic world, a world in which nothing was truly static and they had either to take the current when it served or lose their ventures.

In referring to the making of decisions on a basis of experience, and in referring to the efforts of clever young men who were so often wrong whereas older, apparently less clever men, were so often right, the author was not thinking primarily, or even at all, of older men who tended to checkmate the venturesomeness of enthusiastic youth. Rather had he chiefly in mind the many diverse occasions on which younger men had attempted to show him that his projected ventures could not possibly succeed and had produced reams of paper work in support of their contentions. He, the author, mentally survey-

By The Lords of the Committee of Privy Council for Trade

Certificate of Competency

as

EXTRA FIRST CLASS ENGINEER.

To Thomas Thaw

Whereas it has been reported to us that you have been found duly qualified to fulfil the duties of FIRST CLASS ENGINEER in the Merchant Service we do hereby in pursuance of The Merchant Shipping Act Amendment Act 1862 grant you this Certificate of Competency

Given under the Seal of the Board of Trade, this Fourteenth day of June 1864.

By order of the Board

Office of the Marine Department

FIG. 20—*Extra First Class Engineer's Certificate*

ing in silent retrospection the many kindred past problems and their successful resolution, had swiftly guillotined the objections. Occasionally he would probe the reasoning offered, when a typical reply to his comment would be: "my calculations show me that what you suggest is absolutely unrealizable". To this type of rejoinder the author's stock reply was apt to be: Quite! now shift your assumptions 180 deg. and give me a couple of kilometres of calculations on this basis; or, better still, accept the positive results I am determined to achieve and then work back to whatever assumptions will please you most". Sardonic? No, just educative!

Experience was, of necessity, experience of those things that lay in the past, as Commander Tyrrell pointed out. But, however regarded, the future—in any realm of activity—could not be divorced from the past. Even Isaac Newton, as he himself averred, stood upon the shoulders of giants. If a new datum line were to be drawn and knowledge of the past were to be expunged from the record, faith in the future there could not be; there could only be speculation, a gamble, a species of credulity.

Arising out of its achievements in the last hundred years, the author had undimmed faith in the future of marine engineering and in the men who would labour in its design offices, however different the pattern might be. As Commander Tyrrell would himself have observed, the race was not always to the swift nor the battle to the strong. If the author's opinion proved to be wrong, then one of the reasons would lie with inquisiturient men inside its ranks who seemed to lose no opportunity of decrying the efforts of some of its most earnest workers.

Mr. J. Foster Petree referred to a group of four documentary slides which were projected on to the screen at the meeting. Figs. 17 to 20 were the documents mentioned.

Fig. 17 showed the first marine engineer's Certificate of Competency issued by the Board of Trade. It bore the date 15th April 1863 and was granted to Thomas Thaw, 7 Hewgill Terrace, Newcastle upon Tyne, a native of Glasgow. It was a First Class Engineer's Certificate.

Fig. 18 showed Thomas Thaw's application to be examined for a First Class Engineer's Certificate, he then being a second engineer, by reason of service, in accordance with the provisions of the Act of 1862. Fig. 19 showed his application to be examined for an Extra First Class Engineer's Certificate, and Fig. 20 showed that he duly obtained this Extra First Class Certificate, the date being 14th June 1864.

The interesting suggestion for a plaque to commemorate the granting of the first Board of Trade certificate to a marine engineer was what one would naturally expect from Mr. J. Foster Petree, a pillar of the Newcomen Society and its 1953 President. His London presidential address entitled "History is Human" was repeated in New York in April 1953 before the Newcomen Society of America. Inside the cover of the American issue of Mr. Petree's address, words spoken on an earlier occasion by the Senior Vice-President for North America of the Newcomen Society of England were quoted. These words, singularly apposite to the present occasion, ran: "Were American Newcomen to do naught else, our work is well done if we succeed in sharing with America a strengthened inspiration to continue the struggle towards a nobler Civilization—through wider knowledge and understanding of the hopes, ambitions, and deeds of leaders in the past who have upheld Civilization's material progress. As we look backward, let us look forward". And on the back cover were quoted equally cogent words, by an American member of Council: "The roads you travel so briskly lead out of dim antiquity, and you study the past chiefly because of its bearing on the living present and its promise for the future".

The author had verified that Hewgill Terrace still existed; it was located near Manors Station, Newcastle upon Tyne, 2.

The author was indebted to the kindness of Mr. Stewart Hogg, O.B.E., Chief Examiner of Engineers, Marine Crews' Division, Ministry of Transport, for the loan of the original documents from which Figs. 17 to 20 were made.

The essential explanation for the list the author gave of things unknown to him in his childhood lay in the fact that he was born in a peninsula not much larger than Queen's

Island, Belfast, and the main stream of life tended to pass it by.

Mr. P. T. Christensen was the London (U.K.) technical representative of Messrs. Paul Bergsöe and Son, i.e. The Scandinavian Metal Corporation. The sight of his name awakened pleasant recollections of his company's works in Glostrup, Denmark, which in the author's opinion was a remarkable organization, whether regarded as a technico-commercial business or as an aggregation of human beings.

On a number of occasions the author had been indebted to Mr. Christensen and his associates for advice on the metalling and re-metalling of troublesome bearings. This advice had been all the more freely given and accepted because Bergsöe and Son confined themselves to the manufacture and sale of non-ferrous metals for many purposes, engine white metals being one of the products.

The story of the evolution of the white metal lined bearing was a subject in itself, the essential history of which went back at least a century and a quarter. For the chief bearings of reciprocating steam engines, as the author first remembered them, the idea was to lock the white metal into the bearings by peening the metal into dovetails. The bonding of white metal to the bearing shell was but indifferently understood. Later, and in better class work, slabs of thick white metal were arranged to slide into place, between dovetails, especially at such places as crosshead guide shoes. With present day Diesel engine loadings, these primeval methods were of no avail; nothing but the highest skill and most expert knowledge would ensure the grades of bonding which current designs required.

The author remembered clearly the discussions to which Mr. Christensen referred, twenty-five and more years ago, regarding the value of tin based alloys with a small addition of lead.

Mr. F. H. S. Scriven stated correctly that one of the intentions of the paper was to direct the thoughts of engineers towards the future, especially the near future, in an endeavour to sense likely technical trends. In the author's opinion there was much to be said in favour of the theory that the past, the present and the future were not so much a continuum as a single —almost discrete—entity, clear and understandable to those strangely gifted people of extra-sensory perception. Human free will was a complicating factor, standing, as it seemed to do, a thing apart; but theories of determinism were not within the terms of reference of the present paper.

A question raised by Mr. Scriven was: the past had produced many great men, but did the people of those times realize the greatness of the men? To this question there could be many answers, but all of them would be predominantly speculative, including references to the engineer-shipowner which Mr. Scriven had in mind.

The author directed the attention of Mr. Scriven to his reply to Mr. Arnold, wherein it was stated that the general must not be confused with the particular. On some occasions, and for special reasons, heavy physical work might still be necessary; but this did not impugn the accuracy of the general statement. Mr. Scriven found joy and satisfaction in his ability to swing a heavy hammer; and why not?

Mr. W. F. Jacobs, in his long and interesting contribution, rolled back the blanket of the years.

Amongst other things, Mr. Jacobs touched upon what, in the author's opinion, must surely be one of the most wearing problems of sea life, especially in cargo vessels on long voyages. That was the difficulty of a small community of men, consorting together day by day in a closely circumscribed environment, endeavouring to maintain an equable social life upon the monotonous basis of a limited stock of incompatible ideas, an exasperating series of personal idiosyncrasies, wide differences in temperament, training and outlook—and so on. These and cognate things must, at times, tend to send a sensitive soul "round the bend".

Regarding lack of boiler power: it was always a cardinal feature of the passenger ships built by Harland and Wolff that the boiler power should be more than adequate. If the boilers could produce ample quantities of steam, in all circumstances, the engines could be depended upon to use it; but if the steam was not there, nothing else availed. Until relatively recent times, there was real lack of knowledge regarding requirements for the effective burning of fuel; consequently many combustion chambers were much too small.

In dealing with the automatic control of machinery, Mr. Jacobs rightly drew attention to what might happen as engines became old.

The words with which the printed paper closed, and which seemed a little odd to Mr. Jacobs, were taken from John Milton's essay on civil and personal liberty. The burden of his argument was directed against censorships, especially of the printed word, which men of his generation were struggling to abolish. Milton visualized a time when these curbs to the spirit of man would be removed. In thus contemplating the future of the nation, progressive and enlightened, he pictured it as a giant at the peak of his freshness, i.e. when just aroused from sleep. English being a living tongue, certain words had changed their meaning somewhat since Milton's day; thus the word "mewing" implied renewal as if by moulting. And so, having first likened the nation to a giant of optimum strength, he then changed the picture and visualized it as an eagle renewing its strength by a process of shedding the things which hindered. The eagle is said to be the only bird that can look directly and unflinchingly at the sun. Milton therefore compared the nation to an eagle growing ever stronger, a vigorous creature able to look straight at the source of all light and life even when at its maximum brightness. In the author's quotation from *Areopagitica* the Norman-French word puissant was changed to the native equivalent word powerful; and Institute was substituted for nation.

Mr. A. J. Morton drew attention to what, in his opinion, could be an indefensible demarcation line in vessels propelled by the use of nuclear reactors.

If the relevant paragraph in the printed paper were studied in its entirety it would be seen that there was not any thought of demarcation in the author's mind. On the contrary it was a simple question of thesis or arsis. His thesis was that in an atomic ship the engineer must be the man in charge of the power aggregate. Let the specialists employ their skill and knowledge wherever there might be effective opportunity of so doing; but the top man must be a qualified seagoing engineer. In high powered turbo-electric installations, or in passenger vessels having groups of turbo-generators and attendant complex electrical systems, or again in large refrigerated cargo liners, it was always the chief engineer who was in complete charge. There were, of course, electrical specialists and others on his immediate staff.

The nuclear reactor could not be separated from the remainder of the propelling equipment any more than a conventional steam generator could be separated from the propulsion turbine.

The author hoped that at least one British ship of commercial type would be built, to ensure that everybody concerned —shipbuilders, engine builders, shipowners and others—would have ample opportunity of becoming thoroughly familiar with the manifold problems involved. In seeking for a suitable prototype, one's mind instinctively turned to tanker tonnage. Be that as it might, it seemed to the author that, within say five years, a suitable ship could be completed and be ready for service.

Mr. L. Baker, as an ex-Naval engineer officer, made valuable comment of a nature which was complementary to the contents of the paper. Whereas the author's life had been entirely spent in the design and construction of mercantile marine machinery, Mr. Baker had had wide executive and design experience in the Royal Navy.

With the last paragraph of Mr. Baker's remarks the author was in full agreement.

Mr. S. D. Batra raised points appertaining to the status of the seagoing engineer similar to those raised by Mr. A. C. Joseph. Certainly there was nothing here for complacency; but unfortunately, also, there was nothing that the author could say that was not already obvious. "The fault, dear Brutus, is not in our stars but in ourselves, that we are underlings".

Mr. A. J. S. Bennett referred to the training of engineers, especially with regard to the acquisition of handicraft skill. The author regretted that the matters mentioned by Mr. Bennett were outside his scope and competence; therefore, if he were to venture an opinion, it would be valueless. In the text, the author's actual words—which Mr. Bennett appeared to have in mind—were linked to the design of machinery.

Mr. J. W. Bull, in his comments, underlined with admirable clarity and brevity some of the points made in the course of the paper. He stated that, even in the old days, some engineers emerged from the turmoil with administrative ability and culture unimpaired. That was quite true; but it was probably in spite of the difficult circumstances rather than because of them.

Professor G. H. Chambers asked if, within the next decade, the direct driven Diesel engine could be expected to reach its zenith before being supplanted by the gas turbine.

In January 1943, when delivering the fifteenth Thomas Lowe Gray lecture* of the Institution of Mechanical Engineers, the author ventured the opinion that, within five years of that date, the gas turbine would be ready to take its place as a propulsion unit. That was seventeen years ago. If the author were asked for an opinion now, after all these years, he would postpone his answer *sine die*. The direct driven Diesel engine could be expected to retain favour for a long period of time ahead. For the engines in which he was interested, the author was initiating designs, now, that should remain current for about the next 15 years.

Decisions affecting machinery types did not at any time hinge upon whether or not a prime mover was a rotary or a reciprocating machine. The factors to be considered by an owner before ordering a ship were: (a) capacity and deadweight on the prescribed draught; (b) speed; (c) first cost; (d) running and maintenance charges; (e) general suitability.

Items (a) and (b) indicated the shipowner's requirements for his particular type of vessel. The information to be supplied by the engine builder lay in items (c), (d) and (e).

The factors which influenced the choice of machinery were: (i) the engine power necessary to ensure the required ship speed; (ii) the effect of weight and space of machinery plus bunkers on the ship dimensions for the stated carrying capacity; (iii) the fuel bill; (iv) machinery upkeep costs, i.e. overhaul, replacements, lubricating oil, consumable stores, etc., including an assessment of the effect of the time required for overhaul; (v) special points, e.g. personnel.

The first cost of a ship complete with machinery depended —other things being equal—upon what was offered in connexion with (i) and (ii). The machinery running and maintenance costs followed from (iii), (iv) and (v). Hence, the size and type of machinery which, after the analysis implied by (i) to (v) best satisfied the shipowner's items (c), (d) and (e) was the machinery which could be expected to be ordered. Charges upon capital, allowances for depreciation, and kindred things, were matters for the accountant. One further factor which could have an important influence on engine type—and to a lesser extent on engine size—was the ship's itinerary. This involved such matters as: the total sea time between terminal ports; the length of the different "legs" of the voyage, enabling minor adjustments at ports of call; the facilities available at the various ports; the nature of the overhaul routine, e.g. whether or not there was a running survey system.

The reasons why steam machinery predominated over Diesel engines in the United States had no counterpart in the United Kingdom. As the author was preparing these notes he received an unsolicited and spontaneous message from a well known shipowner stating that his latest Diesel engined ships, fitted with Belfast built engines, had an overall fuel consumption for the round voyage of exactly one-half of that of his latest turbine propelled ships of the same dimensions and speed, built elsewhere.

The author regretted that he could not offer a satisfactory reply to the Professor's penultimate paragraph. He took his young men from many sources and did his best with them. When the author looked into the future he was disconcerted to see there an increasing number of very able, highly trained technical men, deeply versed in the theory and practice of their profession, but completely without knowledge of the humanities. Such men could never be engineering statesmen of the first rank. Men with one-track minds, or with ability to do only one kind of task, stood a smaller chance of survival, in prolonged periods of depression and adversity, than did more versatile, less highly specialized, men.

Mr. James Gray, an amateur of truth above all else, compressed the quintessence of a long lifetime of deep and searching experience into 70 lines of print.

The author fully agreed with what Mr. Gray wrote in his third paragraph. He also concurred in Mr. Gray's statement that he did not think the seagoing engineer of many years ago was a lesser man *per se* than his successor of today. The engineering problems of a particular period could only be appraised properly if there were cognoscence of the then-existing state of knowledge, experience and equipment. Accordingly, there could be no doubt that the problems of the engineer and the engine builder of, say, 80 or 90 years ago—simple though they might appear in retrospect—were just as formidable, relative to the state of knowledge and the level of equipment, as any that confronted their successors today. Present day engineers could wrestle mightily with the problems they had not yet mastered, but a generation or two hence their successors would have difficulty in understanding why the problems had loomed so large.

With the opinion expressed in Mr. Gray's penultimate paragraph the author was also in full agreement. The quip of Thomas Huxley was worth recalling in this connexion: "They learn to pass, not to know; and outraged science takes her revenge; they do pass and they do not know".

At the close of his statement Mr. Gray wrote: "Distribution of strain was generally more important than a low calculated stress. The need to absorb energy was often less obvious than the need to resist force". There was not space adequately to describe an experience in which the application of this reasoning overcame a serious technical difficulty that had been gnawing at the vitals of a number of engineering people for a long time. The problem concerned the chain drive between the crankshaft and the layshaft of Mr. Gray's most powerful Diesel engines. The original arrangement comprised two chain wheels, each having 28 teeth, on a pitch circle of 1,313 mm., and a duplex chain of 54 links, 147-mm. pitch, the chain wheel centres being 1,775 mm. With this arrangement, chain component failures were frequent. The drive was replaced by one comprising two chain wheels, each having 38 teeth, on a pitch circle of 1,230 mm., and a three-strand chain of 78 links, 4-in. pitch. The substitution of the lighter chains completely solved the problem.

The author was a very young man when he first had the pleasure of meeting Mr. Gray, and for a continuous period of over thirty years had had close association with him, first as a superintendent engineer, then as a general manager and director of repair works, and ultimately as the technical director of the great steamship line with which his name must always be linked.

The author's early association with Mr. Gray quickly developed into a Sherlock Holmes/Dr. Watson combination; and thus it continued, razor-and-whetstone, over all the years. This close professional friendship had been one of the happy things in the author's life.

When, with the flux of time, the long association came to an end with the retirement of Mr. Gray, the author had reason to recall the story of the man who had immersed himself in the eight volumes of Gibbon's "Decline and Fall". When at

* Pounder, C. C. 1943. "Some Types of Propelling Machinery Available to Shipowners". Proc.I.Mech.E., Vol. 150, p. 37.

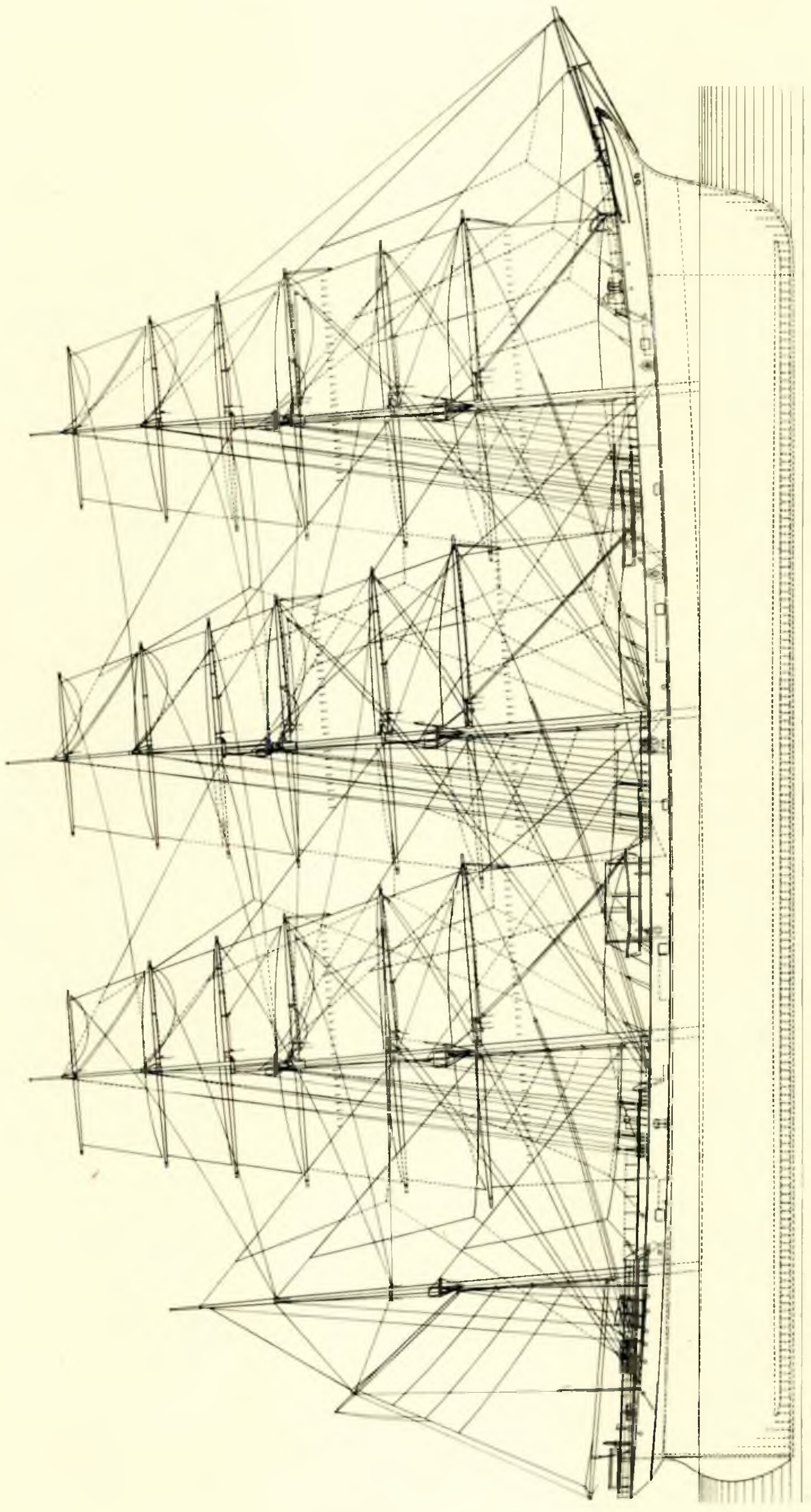


FIG. 21—*Steel barque* California *(1889/1890)*

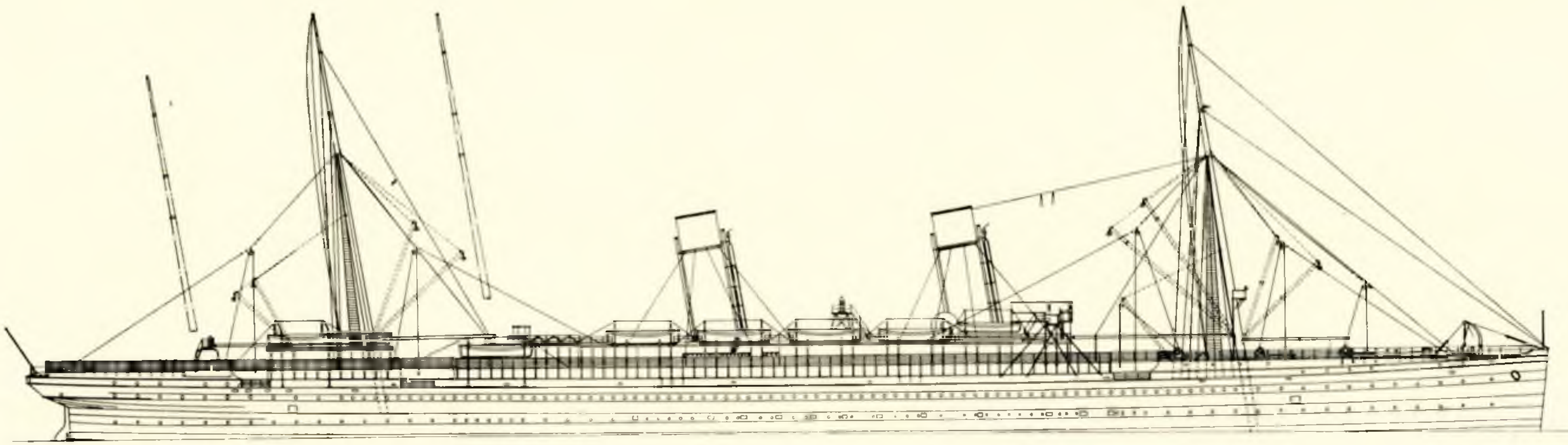


FIG. 22—*Twin-screw passenger liner* Majestic (*1889/1890*)

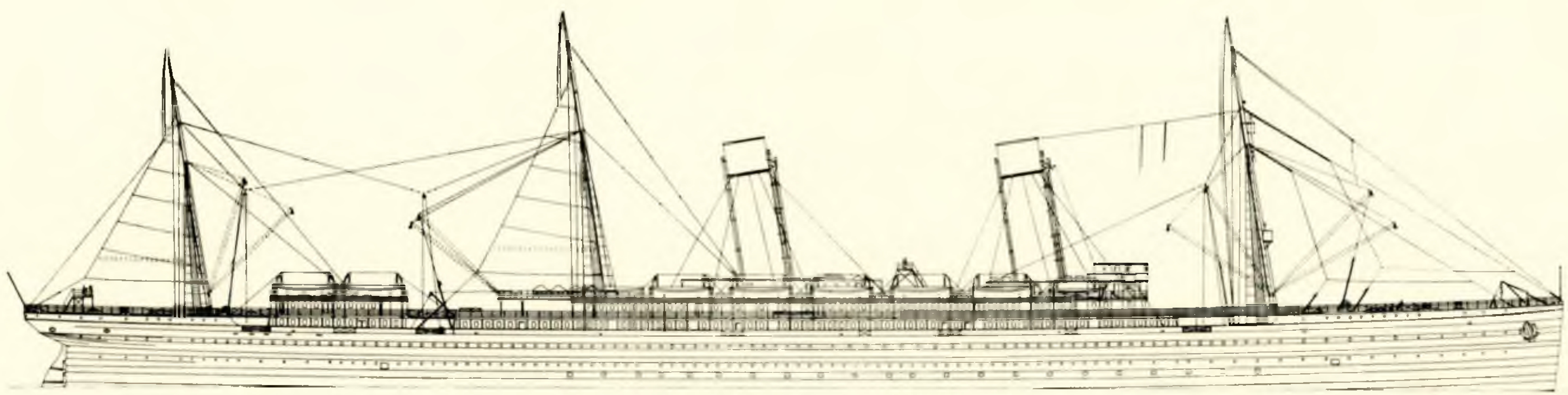


FIG. 23—*Twin-screw passenger liner* Oceanic (*1899/1900*)

last his absorbing persevering study came to an end, he exclaimed: "What, no more Gibbon? am I left to the daily papers?" And so, when Mr. Gray retired, the author felt it incumbent to write to him: "What, no more Gray? am I left to the Pig Iron Polishers?"

Captain W. Gregson, within the compass of a few short paragraphs, summarized the inter-relationship of expanding overseas markets and the growth of important shipping fleets. Figs. 17 to 20 embodied the information requested.

Figs. 21 and 22 were rigging plans of the two contrasting vessels mentioned by Captain Gregson. Both were built in the same shipyard, in the same year, for the same owners. Fig. 21 was the steel four-masted barque *California,* the last sailing ship built by Harland and Wolff, completed early in 1890. The leading particulars were: length overall 392·3ft.; waterline length 329·3ft.; beam 45·2ft.; moulded depth 28·4ft.; depth of hold 26·7ft.; freeboard amidships 6·7ft.; two decks; poop 48ft. long; topgallant forecastle 35ft. long; box-shaped midship section; tonnage gross 3,100, net 2,991. The lower masts and topmasts were one steel tube, divided by the tops at fore, main and mizzen into the length: deck beams to top, 55·5ft.; top to cross-trees, 41ft.; a total of 96·5ft. from deck beams to cross-trees, above which the topgallant mast extended 51ft., with a pole of 11ft. From deck to top of main mast, the overall height was 158·5ft.

The spike bowsprit stretched 43ft. outside the knight-heads, and the yard lengths for fore, main and mizzen masts were: lower yards, 88ft.; lower topsail yards 76·5ft.; upper topsail yards 68ft.; lower topgallant yards 60ft.; upper topgallant yards, 51·5ft.; royal yards, 41ft. The lower three yard-arms were steel.

California was the last of four ships made from the same plans; the other ships were for other owners. *California* was a unit in the great fleet which was wont to assemble at San Francisco in the '90s to load wheat and barley for the United Kingdom or the Continent. The voyage from Liverpool to San Francisco took 130 days; San Francisco to Liverpool 121 days; Newcastle N.S.W. to San Francisco 53 days. *California* changed ownership five times and nationality four times. The ship was wrecked in April 1927, being then 37 years old.

At the time the sailing ship *California* was being built there were also being constructed the two steam passenger liners *Teutonic* and *Majestic. Teutonic* went into service in July 1889 and *Majestic* in March 1890.

Fig. 22 showed *Majestic,* as remembered, perhaps, by old engineers, i.e. with two masts. As built, the vessel was equipped with three masts and appropriate derricks. The original after-masts were shown dotted in Fig. 22. With *Teutonic* and *Majestic,* the modern passenger liner had arrived.

As stated in the text, *Teutonic* and *Majestic* were the first ocean going vessels built and engined by Harland and Wolff to have twin-screw engines; and they were the longest vessels afloat at that time. These ships were also the first merchant vessels built to comply with British Admiralty requirements for cruisers and, accordingly, seatings for twelve guns—four of them 5in.—were built into each ship. The port and starboard engines were isolated by a longitudinal bulkhead, which extended from the aft end of the engine room to the forward end of the coal bunkers, intersecting twelve of the ordinary watertight compartments and completely isolating the boilers, engines and pumps for each screw. The port propeller was located some distance behind the starboard propeller, because the propellers overlapped by a few feet. The propellers were 19ft. 7in. diameter, 29ft. 6in. pitch. There were 12 double-ended and 4 single-ended boilers.

Between 1877 and 1890, when the rate of development in steam propelled vessels was very high, the greatest number of Harland and Wolff's most notable sailing ships were built, ending, as already stated, with *California* in 1890.

Fig. 23 showed *Oceanic* (1899/1900), the first ship slightly to exceed the length of *Great Eastern. Oceanic* was, however, narrower in the beam. A comparison of Figs. 22 and 23 showed that *Oceanic* was a larger and better edition of *Teutonic,* but no striking changes had occurred in the separating decade.

Mr. A. C. Joseph, unlike the author, could write with knowledge and conviction regarding contemporary engineering life on board ship. Some of his comments left no doubt that there still remained much effort to be applied—in at least a section of the mercantile marine—before the marine engineer's status could be accepted as satisfactory. Apart from the fact that there could be only one titular head on board ship, irritating differentiations between the essential status and living conditions of master and chief engineer—as described by Mr. Joseph—must surely be condemned as examples of anachronistic provocation.

Having read the comments of Mr. Joseph, it was hardly a matter for wonderment that the engineers affected should forsake the sea for a better life ashore.

Mr. W. H. Lindsey, who was a director of Bristol Siddeley Engines Limited, approached marine problems with the freshness of a man outside the industry, away from its prejudices and its circumscribing notions.

Fig. 16 showed the specific weights of, and the spaces occupied by, four types of propelling engine. The results in favour of schemes (c) and (d) were spectacular and, if the data given in Fig. 16 were the whole story, there would be no doubt about the issue. There were, however, as Mr. Lindsey fully realized, other matters to be taken into consideration. One of these was the fuel bill. For the engine shown at (a), i.e. a direct coupled single-acting two-stroke pressure charged engine, the fuel burned was heavy oil, of viscosity 3,000-3,500 seconds (Redwood No. I) and the fuel rate was 0·34lb./b.h.p. hr. For the engines at (b) running at 400 r.p.m.—as against 120 r.p.m. for engine (a)—the fuel presumably would be of Diesel quality; also, the specific fuel rate could be expected to be fractionally higher.

Direct coupled engines of 400 r.p.m. would not ordinarily be suitable for ships for which the slow moving crosshead type of engine illustrated at (a) was standard. For such ships there would be so heavy a loss in propulsive efficiency that this factor, alone, would make the scheme unattractive. The somewhat higher fuel rate of (b), compared with (a), would necessitate a greater bunker weight for the same steaming radius which, in turn, would mean either a larger, heavier, more costly ship for the same deadweight carrying capacity or, alternatively, for the same size of ship, a reduction in the cargo carrying capacity of the vessel.

Fig. 16 (c) was a twin-screw arrangement. Duplication of shaft lines, propeller, etc., might not be important, but it was, nevertheless, an item in the balance sheet. Presumably engines running at 1,600 r.p.m. would have a limited life. One advantage of a small engine assembly would be the ease of complete withdrawal and replacement in port. An adverse factor would be the total cost of all the engines required in the lifetime of a ship. In the absence of suitable data the author could not express an opinion on the bunker weights required for schemes (c) and (d).

As indicated to another contributor, the essential factors in the balance sheet of a marine propelling installation were: first cost, fuel and lubricating oil costs, weight, space occupied, and cost of maintenance. These remarks were not intended to discourage Mr. Lindsey; on the contrary, he should again look at the matter and explore ways and means of obtaining an overall balance sheet favourable to his schemes (c) and (d). The author had mentioned some of the points involved for those types of ship which constituted the overwhelming bulk of the mercantile marine. But there were doubtless forms of craft for special services where normal arrangements did not apply.

Mr. W. E. McConnell, who was the author's predecessor as Vice-President for Belfast, wrote from the vantage point of a highly responsible man who in the course of a long life had served in all the departments of marine engineering activity. His contribution to the discussion was so clear and factual, and the pattern of his reasoning so well knitted, that comment on the part of the author would be gratuitous. Not the least of its attributes was its moderateness.

The reference which Mr. McConnell made to base mechanic fellows was to the incident in *Antony and Cleopatra,* Act V, Scene 2, line 246, where Cleopatra, speaking to her attendant Iras regarding what would happen if they were placed on exhibition in Rome, said: "mechanic slaves, with greasy aprons, rules, and hammers, shall uplift us to the view; in their thick breaths, rank of gross diet, shall we be enclouded, and forced to drink their vapour".

The author suggested that shipowners and their leading executives would be well rewarded by a close perusal of Mr. McConnell's statement and a careful weighing of his well timed words.

Mr. R. N. Newton, writing as a naval architect, had no need for diffidence in entering the discussion. In the conception and development of a ship, the naval architect was the man who determined everything that was of importance. The engines were there to propel the ship; but it was the ship that ultimately mattered. The successful power driven ship had of necessity to be a great corporate effort and its many problems had to be so approached. The author, as a man of authority, would not countenance any cleavage between naval architect and engine designer.

He, the author, was in full agreement with Mr. Newton's comments upon *Turbinia,* especially his reference to the propeller cavitation problems. With any invention the first step was to demonstrate that it would work, as a mechanism; the second step was to make it work efficiently; the third step was to ensure that it was commercially profitable. Sir Charles Parsons must have realized at a very early date that the essential hope for the future of the steam turbine lay in its development in large powers. The first step was demonstrated at the Diamond Jubilee Review. The necessary courage was quickly forthcoming for the second step and within ten years the battleship *Dreadnought* and the passenger liner *Mauretania* had been built.

The triple-screw combination arrangement, which in the printed paper was mentioned as being identified in the public mind with Harland and Wolff, was the invention of Sir Charles Parsons.

Commander J. R. Patterson asked about the working capacity of firemen in the days of coal burning vessels.

The records available to the author varied more widely than might have been expected. For a passenger vessel steaming on nine double-ended boilers, i.e. 54 furnaces, three typical sets of results, as shown by the available logs, were:

		(a)	(b)	(c)
Coal burned per 24 hours, tons	=	185	200	256
Coal per furnace per watch, tons	=	0·57	0·62	0·79
Coal raised per man per watch, tons	=	1·71	1·86	2·37

The figures in column (a) were low averages; those in (b) were good averages; those in (c) very unusual.

In another passenger liner, burning 720 tons per day in 144 furnaces as a maximum, the coal raised per man per watch was 2·5 tons. For coal burning steamers in which emigrants were carried, there was a Board of Trade rule which stated that, when the coal consumption exceeded three tons per day per man employed on the boilers, the number of these men had to be correspondingly increased.

And now to conclude: the most human of all problems must always be the steering of one's own self through the baffling day to day cross-currents of industrial life. The chief superintendent engineer of a well known shipowning company, a man who had served the Institute long and well in the several offices which he had held, in the course of a serious technical discussion in the author's private room one day said that, especially of late years, he had lived in a state approaching mental confusion and wished he had some simple rules to steady him. The author's brief comment was to suggest that, just as all the important rules of algebra could be written on a sheet of notepaper, the complete rules for engine balancing on the back of a postcard, Newton's laws of motion—the foundation of the whole science of dynamics, terrestrial and celestial—on the back of a postage stamp, so the basic rules for the day to day guidance of men of the world could be written on the back of a visiting card, in words as simple as they were familiar. These were the words: (i) go on your way in peace; (ii) be of good courage; (iii) hold fast that which is good; (iv) render unto no man evil for evil.

They would take the wayfarer most of the way; their observance would certainly reduce the thrombosis casualty rate.

The prime difficulty with engineering was its vastness relative to the individual. If the author should live out his full term: when the day came for him to initial his last plan and sign his last letter he would surely say to himself: "Now, my boy, your apprenticeship is just about ended. It is a pity you cannot continue as a journeyman and do something really useful!"

INSTITUTE ACTIVITIES

Minutes of Proceedings of a Joint Meeting Held at The Memorial Building on Thursday, 26th November 1959

A Joint Meeting of the Institute of Marine Engineers and the Society of Naval Architects and Marine Engineers, New York, was held at The Memorial Building on Thursday, 26th November 1959, when two papers that had already been presented at the S.N.A.M.E. Annual Meeting in New York on 12th—13th November, were re-presented. Mr. R. Cook, M.Sc. (Chairman of Council) who, with the Secretary, had attended the New York meetings, was in the Chair.

The first part of the meeting was held at 3.0 p.m., when Mr. C. C. Pounder (Vice-President I.Mar.E.) presented the paper entitled "Human Problems in Marine Engineering" that he had written for the joint occasion. Eleven contributors took part in the discussion that followed.

After an interval for tea the meeting was resumed at 5.40 p.m. for the presentation of the paper* by Messrs. H. C. Andersen, B.S., and J. J. Zrodowski, B.S., on "Co-ordinated Alignment of Line Shaft, Propulsion Gear and Turbines". Eight speakers took part in the discussion on this paper.

A vote of thanks to the authors of both papers, proposed by the Chairman, was accorded by acclamation, and the meeting ended at 7.25 p.m.

Section Meetings

Bombay

A Joint Meeting of the Bombay Section and the Institution of Marine Technologists was held on 17th February 1960 at 6.30 p.m. at the B.E.S.T. Conference Hall, Bombay. Rear Admiral T. B. Bose, I.N. (Local Vice-President) was in the Chair and there were seventy-five members and visitors present.

A paper on "Selection of Lubricants for Marine Machinery" was presented by N. J. D'Sylva (Associate Member), which was followed by a lively discussion initiated by Mr. S. Kasthuri. Messrs. D. Dyer, R. G. Sathaye, B. Ananda, Lieut. Cdr.(E) D. K. Bhandari, R. D. Raje, G. Biswas and the Chairman took part in the discussion, asking questions that were answered by the author.

The meeting ended at 8.45 p.m., after a vote of thanks to the Chair and the author, which was passed with acclamation.

Kingston upon Hull and East Midlands

Junior Meeting

A Junior Meeting of the Section was held at the Hull College of Technology, Park Street, Kingston upon Hull, at 7.30 p.m. on Thursday, 18th February 1960, which took the form of a lecture entitled "Modern Marine Steam Turbines" given by Mr. J. H. Gooch, B.A.

The lecturer described the construction, layout, and latest design developments of modern steam turbines for various types of vessels, ranging from small cross-channel steamers to those used in the latest supertankers. The lecture was illustrated with the aid of lantern slides and a very interesting film on "The Blading of a Turbine".

The very appreciative audience consisted of students studying under the Ministry of Transport Alternative Apprenticeship Scheme and students from the Marine Engineering Department of the College. Also in attendance were the Principal, Mr. Emlyn Jones, Mr. Bryan Taylor, B.Sc.(Eng.) (Chairman of the Section), and Mr. G. W. Hill (Vice-Chairman).

A vote of thanks was proposed and seconded respectively by two of the students, Messrs. D. A. Fox and R. J. Metcalfe.

Mr. F. C. M. Heath (Vice-President) then presented prizes on behalf of the Institute to a number of students.

The meeting ended at 9.30 p.m.

General Meeting

A meeting was held at the Royal Station Hotel, Kingston upon Hull, at 7.30 p.m. on Thursday, 28th January 1960, at which Dr. R. V. Hughes, B.Sc., gave a lecture on "The Need for Research in Diesel Engine Development".

He described the latest techniques used by the research engineer, illustrating his lecture with lantern slides. He also showed how improvement in bedplate design had resulted from the use of models of the bedplate made in rubber. Within the model were means of placing a load on it similar to that experienced in practice and the effect on each member of the structure was readily discernible. Dr. Hughes also showed a film on the "Ramrod" timed lubricating oil system for bearings which members found very interesting.

The discussion that followed the lecture centred mainly on the cracking of Diesel cylinder heads.

Mr. F. C. M. Heath (Vice-President) then proposed, and Mr. Bryan Taylor, B.Sc.(Eng.) (Chairman of the Section), seconded, a hearty vote of thanks for the extremely instructive and thoroughly enjoyable lecture.

The meeting ended at 9.30 p.m.

Northern Ireland Panel

At a meeting held on Tuesday, 23rd February 1960 in the Central Hall of the College of Technology, Belfast, Dr. J. E. Garside, M.Sc.(Tech.) delivered a lecture entitled "Metallurgy in Marine Engineering". Mr. C. C. Pounder (Vice-President) was the Chairman.

A vote of thanks to the author was proposed by Mr. R. S. Punt (Associate Member) and seconded by Mr. E. C. Sides (Member).

Scottish

"Marine Valve Design Developments"

Following the Annual General Meeting of the Scottish Section on 10th February 1960 at 7.30 p.m., at the Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, a paper entitled "Marine Valve Design Developments" by Lieut. Cdr.(E) J. Tinneveld, R.N.N. (Associate) and J. R. Peacock (Associate) was presented.

This paper proved to be of great interest to the fifty members and visitors present and in the discussion that followed Lieut. Cdr. Tinneveld dealt in a very able and interesting manner with the questions raised. A vote of thanks to both authors was proposed by Mr. J. W. Bull (Member) and carried enthusiastically.

* This paper, with the reports of the discussions that followed its presentation in New York and London, and the authors' replies, will be published in the April 1960 issue of the TRANSACTIONS.

The meeting ended at 9.40 p.m., after which light refreshments were served.

Sixth Annual Dinner

The Sixth Annual Dinner was held at the Central Hotel, Glasgow, on Friday, 19th February 1960, and was attended by some 350 members and guests. Mr. G. J. Thomas (Chairman of the Section) presided, and he and the President, Sir William Wallace, C.B.E., LL.D., received the guests.

General Sir Gordon MacMillan proposed the principal toast, to which Sir William Wallace replied. The toast of "Our Guests" was proposed by Mr. W. B. Johnstone (Vice-President for Glasgow) and replied to by Professor James Small.

The top table guests included representatives of the Admiralty, shipowners and shipbuilders, etc., and from headquarters in London Mr. W. R. Harvey (Vice-Chairman of Council), Mr. Stewart Hogg, O.B.E. (Member of Council), and Mr. J. Stuart Robinson, M.A. (Secretary), were present.

After the Dinner a conversazione was held until 11.30 p.m., and the whole evening was thoroughly enjoyed by all present.

Toronto

A meeting was held by the Toronto Section on 21st January 1960 when Mr. J. H. Edlund, P.Eng., of Ruston and Hornsby Ltd., read a paper on "Simple Gas Turbines for Marine Applications". Unfortunately there was only a small attendance to hear this very interesting paper.

Student Section

A meeting of the Student Section was held at The Memorial Building, 76 Mark Lane, London, E.C.3, on Monday, 7th March 1960 at 6.10 p.m., when a short film preceded a lecture on "Reciprocating Machinery and Its Application in Ships" which was given by Lieut. Cdr. M. B. F. Ranken, R.N.(ret.) (Member). A short question period followed the lecture.

Mr. R. S. Brett (Associate Member) was in the Chair and sixty members and visitors were present.

A vote of thanks to the lecturer, proposed by the Chairman, was carried by acclamation, and the meeting ended at 8.35 p.m.

OBITUARY

Walter Allan Harrington

From 1952/58 Walter Allan Harrington was manager of the Government dockyard in Rangoon, Burma, and during that period he represented the Institute of Marine Engineers as Local Vice-President in Rangoon.

Mr. Harrington was born in Burma in 1887 and served an apprenticeship with the Irrawaddy Flotilla Co. Ltd. of Dalla, Rangoon. For four years thereafter he was employed in their river transport paddle steamers as an engineer. After further experience in local companies he started his own business as engineering contractor in 1913, and was responsible for the building of several steel bridges in various parts of Burma, including the Shan States. In 1917 the British Government invited him to become assistant resident engineer of the dockyard at Dawbong, Rangoon, an appointment he accepted; he was promoted resident engineer in 1927.

He joined the Burma Navy Volunteer Reserve in 1939 as Engineer Lieutenant Commander, and in February 1942, when Burma was being evacuated, he was engaged on the construction of Fairmile motor launches and minesweepers and was instructed to take the unfinished vessels in tow to India by a chartered British India steamship. On arrival there he was appointed to the office of the Director General of Shipbuilding and Repairs in Calcutta and was charged with the completion of these craft. He retired from Government service in 1944.

Later that year Mr. Harrington joined as manager James Alexander and Co. Ltd., mechanical and structural engineers in Calcutta. He stayed with this company until 1950, when he came to the United Kingdom with the intention of retiring, but was asked to undertake a three-year contract as manager of the Rangoon Dockyard, a period that was extended to six years before his final retirement in December 1958. He arrived in London in January 1959 but had only enjoyed twelve months' rest before his death after a short illness on 12th January 1960.

Mr. Harrington was elected an Associate Member of the Institute in 1925 (number 5422) and transferred to Membership in 1931. He was an Associate of the Institution of Naval Architects.

George Havelock Allen (Member 4004), who died in December 1959, started his career as an apprentice with the Shields Engineering Company, North Shields. After three years' sea service with James Westoll of Sunderland, and having obtained a First Class Board of Trade Certificate, he joined Harland and Wolff Ltd. at Liverpool in 1914; three years later he was appointed senior engineer manager to the firm's branch at Southampton and his long connexion with that port began. He became deputy manager in the early 1930's and manager in 1942, holding the position until his retirement ten years later.

Mr. Allen was a member of the Institution of Production Engineers and a past president of their southern section. From 1948/52 he was chairman of the South Coast Shipbuilding and Engineering Employers' Association. He was also a keen golfer and had been a member of the Southampton Shipping Golf Society since its formation.

William McConkey (Member 14611) was apprenticed to K. Craig and Sons Ltd. of Belfast from 1918/23 and attended the Municipal College of Technology, Belfast, until 1926. He then joined the Antrim Iron Ore Co. Ltd. and sailed in their ships as second engineer until 1929, when he was appointed third engineer with the Ulster Steamship Co. Ltd., and remained in their service for many years, as second and then chief engineer. He obtained a First Class Board of Trade Certificate in 1931. Latterly, he was employed as chief engineer by G. Heyn and Sons Ltd.; his last ship was the *Roonagh Head*, but he was taken ill on a voyage to Montreal in December 1958 and died on 10th May 1959.

Mr. McConkey was elected a Member of the Institute in 1953.

Edwin Francis Partridge (Member 6973) was apprenticed to J. S. White and Co. Ltd. and J. I. Thornycroft and Co. Ltd. He served for five years or so with the Royal Fleet Auxiliary and in 1927 joined the Union Castle Line as a seagoing engineer; he obtained a First Class Board of Trade Steam Certificate with Motor Endorsement and joined the Institute as a Member in 1932.

The following year he was employed by the Ruston Lister Marine Co. Ltd. and in 1935 went to Cape Town to employment in the Texas Oil Company. During the early part of the second world war he served in the Royal Naval Reserve and in 1943 obtained a commission in the S.A.N.F.(V) as Commander(E). In 1948 he was employed by Caltex (Africa) Limited in Cape Town and died on 16th November 1959, aged fifty-six.