INSTITUTE OF MARINE ENGINEERS,
INCORPORATED.

Patron: HIS MAJESTY THE KING.

SESSION 1919-20.

President: LORD WEIR.

VOLUME XXXI.

OPENING
OF THE
International Shipping, Engineering and Machinery Exhibition,
AT
OLYMPIA, LONDON.

Thursday, September 25, 1919.

CHAIRMAN: SIR ARCH DENNY.

THE Shipping, Engineering and Machinery Exhibition was officially opened by our President on Thursday, September 25th. Sir Arch. Denny (Past President) presided on the occasion. The exhibits occupy the whole of the main building, annexe and the gallery, and are representative of the various industries connected with shipping and engineering, and they are so many and of such great variety that to give even a few descriptive lines to each would occupy a large volume, and the catalogue published by the exhibition authority is a very large one. The educational value attaching to the exhibition is such that it is hoped several papers bearing upon the more striking exhibits will be written for the awards which have been announced for each grade of our membership.

At the luncheon which took place after the opening ceremony, Sir Arch. Denny presided, and after the Royal toasts the health of Lord Weir was proposed by the chairman, who referred to the history and development of the firm of Messrs. G. and J. Weir, giving many interesting reminiscences covering the period during which Messrs. Jas. and George Weir were advancing stage by stage in the interests of economy and improvement of appliances for marine engineering, until to-day when the firm has reached a high eminence, their specialities being known throughout the world. The excellent work done by Lord Weir during the war is well known, from the early days when he was instrumental in organising national war material output in Scotland and subsequently when he was appointed to organise and superintend the Aviation Department in London, showing in both cases the essential characteristics which command success.

The toast was hailed with hearty acclamation, and Lord Weir after acknowledging the gratification he felt on being invited to open the exhibition and the reception he had met with, referred to the interesting exhibits assembled in the building, a study of which would prove valuable to all visitors, both in the interests of educational knowledge and of industrial commerce. Turning from the more immediate subject before them, Lord Weir proceeded to a consideration of the very important standing which it is necessary to take in order to deal with the industrial progress of the country and recover what the nation has lost during the war. Lord Weir said:—

"When we think of the present position not only of these industries but of British industry as a whole, it would be worse than folly to disguise its gravity. It is no exaggeration to compare it with the emergency of August, 1914. Then we united to defeat an enemy who challenged our liberty and freedom. An even greater unity to-day is required to defeat the enemies of unrest, indecision and irresolution which are paralysing our industrial enterprise and development, on which depend the livelihood and prosperity of our people.

"Now I cannot speak to you on these matters as a politician —my short experience of that is over—but I make no apology for addressing you as an engineer on a few aspects of the industrial situation. I need not attempt to detail the disabilities which so profoundly affect that situation other than to mention the weight of our war debt, our depreciated exchanges, our daily debit balance of expenditure, and our small exports, the growing actualities of lost markets and outside competition, and lastly the unrestful spirit of the workers and the community. Let us take the last, as in its cure lies the remedy for the other factors.

"I intend to speak very frankly on this point, as there is nothing which has contributed and is contributing more to fog and obscure the situation than the lack of sincerity and frankness. Sincerity and conviction, a reasoned constructive policy, and, based on these, resolute action seem to me the essentials in successful world building. In endeavouring to analyse the main currents of opinion which present themselves in the Labour world to-day, we find two distinct movements—one seeking to improve existing conditions, with legitimate aspirations and ideals, the other a definite movement for a something labelled nationalisation, and ultimately involving the abolition of the wage system. In face of this position it is surely clear that those whom we elect to govern us, must, in holding office, decide either for a policy of improvement built on existing foundations, or for one of demolition and experiment—either they must plan for evolution or for revolution. In the best interest of the nation, it is imperative that they make their choice.

"On one hand, they must visualise a plan for running the country without the wage and capital system clearly and definitely enough to warrant them in subordinating the happiness and contentment of this and the next few generations to the achievement of something which to-day no one dare term other than fantastic, divorced from experience and the actualities of life. If they do, then let them declare it so that all may know what to expect. On the other hand, if they appreciate its fantastic unpracticability, then let them equally clearly say so and at the same time decline to allow that influence to affect them in their plans. What success can we anticipate if in the councils and conferences charged with the constructive work of remodelling our industrial relations and our production conditions, there exists strong sections who firmly believe in something else, and strive steadily to handicap, to compromise, and to obstruct the action which is so obviously necessary. We need the unity of frank and unflinching effort pulling on the rope before any substantial results are achieved. Let me give you an example.

"The Iron Moulders of England are on strike. Our national position is not precarious enough for them; they must stab it in the back. They are on strike because they are selfish enough to demand priority of consideration for their wages question before those of other Trades Unions, notwithstanding that they had been parties with these Trades Unions to an agreement determining a date when their claim would be heard. True, they have seceded from that agreement, but a tactical movement cannot hide the character of their action. These are facts, but I wish to point out that this very Society whose members want more wages have absolutely declined over many years to allow their members to accept legitimate systems of payment by results and thereby afford them with the opportunity to increase their earnings. They decline to allow freedom to anyone except a moulder trained for seven years to work a moulding machine which can be learned in a few days by almost anyone. They decline to allow freedom to anyone but a skilled man to make cores, a large proportion of which can be made by a girl or a limbless soldier after a few days' training, even although the employer is willing to pay the skilled man's rate.

"There has been less progress in the ordinary iron foundry in this country in the last twenty years than in any other class of engineering, due to the influence of restrictive customs and the consequent lack of incentive to employers to extension and enterprise in a department of industry on which all classes of engineering are directly dependent. To-day, the labour cost of certain drysand castings in Great Britain is double that of corresponding castings in the United States, and the American moulder is earning double the wages of the British moulder. This Society which recommends the strike and denounces agreements joins in the chorus which sings of the necessity for production, and in practice does nothing in its power to promote production. If the individual iron moulder of to-day wants more money, let him purge his Union of a policy and of principles which will ultimately ruin him. This moulders' strike is a perfect example of how neglectful we are in telling the community of the gravity of such actions and of the facts, so that they may understand how rapidly industry is being ruined. The other course—the policy of frankness and sincerity—was exemplified in Mr. J. H. Thomas's action some time ago on a threatened railway strike. He refused to be a party to a strike which he knew was unwarranted. Mr. Arthur Henderson is a great Labour leader, a great Labour power, and he is secretary of these ironmoulders. Cannot he follow Mr. Thomas's example and show that another great labour leader has the courage of his expressed convictions? I give these as examples of what insincerity does to prevent new world building. Now in the task of remodelling our industrial conditions and of securing efficient conditions of production, by far the largest and most comprehensive part is that of the employer. In a large measure, by efficient directional control he has to so improve conditions of production as to secure to the workers the realisation of their legitimate aspirations. In practice he must initiate a campaign of analysis of his processes and methods to conquer waste and revivify effort. He must adopt a practical policy of domestic conference with his workers or their chosen representatives to explain his schemes and changes and thereby secure co-operation and elimate distrust and suspicion. These must be far more settled domestically in the future, and Trades Unions and Federations must accord more freedom to this policy of domestic conference. There must be a great development of system of payment by results carefully designed to meet the specific conditions of the individual shops and classes of workers, with safeguards that will protect the worker from exploitation.

"Here let me draw attention to an element in industry on which wholly insufficient stress has been put—the duty which falls on an employer of providing good costing systems. The revision of methods, the problem of remuneration, and the intelligent initiation of new methods are all impossible of realisation without the searching and discriminating light of accurate cost figures.

"Finally, let us not forget that industry is but a sum of services given by each of us in his degree. Let the employer remember the human side, the essential relationship of man to man, the side which calls for tolerance and a universal sympathy.

"Now, as to the Trade Union programme to help the cause, it must involve a recognition in every practical way of the fundamental character of the element of efficient production. If in the new world the employer is called to regard his relationship to the worker in a new and more human light, equally must the Trade Unions revise their attitude and accept the responsibilities which the progress of economic thought demands from them. They must swing their whole strength round to eliminate the elements in their present policy which obstruct progress. They must frankly recognise the necessity for the Directional Authority in workshop methods and conditions. "Under any social order from now to Utopia," says Mr. Sydney Webb, "management is indispensable and all-enduring."

"Further, they must set their face against the encouragement of waste of human time. They should teach the value of the "man hour," aye, even the "man minute." Let me give you an example quoted to me the other day by a well known shipbuilder. Five minutes lost by each man at the start and finish of each working period in the day represent a non-effective wage payment to his men of exactly one-half of the total sum paid in dividend on the Ordinary Stock of his Company. Rather an interesting reflection on the share of labour in the wealth it produces. In other words, the Trades Unions must re-adjust their precepts and practices to a world reborn in which co-operation, not conflict, is the dominating note.

"I have spoken of the employers and the Trades Unions, and I now come to the base of the triangle,—the foundation of authority and discipline on which our national and communal interests depend—I mean the Government. We ask of them good guidance, sincerity of purpose and resolute action in industrial affairs. For example, when they submitted the Restoration of Pre-war Practices Act, why did they not declare that they and the Unions were agreed that it perpetuated many evil practices? It was given to the Unions to bargain with. Let us have done with this bargaining spirit—this spirit of petty advantage-taking—and let us consider together what are the difficulties of industrial relationships, what are the evils which have attached themselves to our industrial body. Let us face them squarely and by reason and good will endeavour to eliminate them together. In the National Industrial Council to have a wise and statesmanlike conception, and I would ask the Government no longer to delay in making it a living entity, but to utilise it for the solution of our problems. It is the business of the State to ascertain and maintain the means by which our national life can be increased and developed, and I would submit that it is the duty of the Government to ask the Trade Unions for a statement of the means which they in their representative capacity are taking to solve the problem of production, and equally to ask from the Employers' Organisation what steps they on their part are taking, and what disabilities are preventing them respectively from the fullest exercise of their activities in the upbuilding of our national industrial welfare. Such a statement prepared by both parties and submitted to the Industrial Council would clarify a multitude of vague ideas and form a basis for adjustment and reconstruction which has hitherto been wanting."

"Success to the exhibition" was proposed by Lord Aberconway and responded to by Sir Arch. Denny.

Dr. H. S. Hele-Shaw proposed "The Dutch Royal Commission" coupled with the name of Dr. W. R. Bisschop, who replied in amicable terms, and expressed the hope that the British and the Dutch would join together in many ways to mutual advantage.

The health of the Chairman was proposed by Sir Eustace Tennyson D'Eyncourt and received by the audience with enthusiasm for the good and kindly offices performed by Sir Archibald owing to the trying time between the arrangements for the exhibition in 1914 and the opening ceremony on this day. These entailed much work and many meetings in order to satisfy the requirements of the situation, which involved heavy expenditure from start to finish.

J. A.

The History of the Steamship.

BY JOHN HOUSTON (Member).

READ AT

THE SHIPPING EXHIBITION, OLYMPIA,

ON

Tuesday, September 30, *at* 7.15 *p.m.*

CHAIRMAN: MR. JOHN CLARK (Member).

The CHAIRMAN: In the absence of the author of the Paper, Mr. J. Houston, who is resident at Barrow-in-Furness, our Hon. Secretary, Mr. Jas. Adamson, will read it on his behalf.

THOSE who are interested in the progressive advancement of industrial enterprise, will no doubt desire to hear something about the vessels that were afloat on the face of the great waters, prior to the advent of the Steamship, but within the limits of a lecture of this description, and in the time at one's disposal, it will only be possible to merely mention them. When men first sought to visit distant lands and explore continents, their means of transportation were primitive in the extreme. The earliest navigators went to sea in vessels which were propelled by oars, and known as galleys, and the representations of the ships with which the Normans invaded England, show them to have been propelled with sails.

From the earliest period of which we have any record down to quite recent times, ships were built of wood, the usual arrangement in their construction being transverse ribs covered with longtitudinal planks. The earliest recorded, is of course, the

Ark of Noah, which was built for the specific purpose of preserving life, by floating on the water, and it is interesting in passing to note that its dimensions correspond approximately with the recognised proportions for modern sailing vessels. Assuming the cubit to be 1·8ft., the dimensions would be 540ft. by 90ft. by 54ft., the proportions being $\frac{L}{B} = \frac{6}{1}$ $\frac{L}{D} = \frac{10}{1}$.

Merchant ships have never until late years been of large size. The records of Lloyds' Register of Shipping from 1764 to the end of the century show that by far the greater number of British ships were under 300 tons. Even in 1834 a vessel of 500 tons was considered large. In that year, out of 19,000 ships on the Register of the United Kingdom, about 12,000 were under 100 tons. The use of iron about ten years later tended very materially towards increasing the sizes of ships, and between the years 1860 and 1870 when the Suez Canal was opened, large and fast sailing ships were employed in the China tea trade.

The celebrated ocean race between the *Taeping* and *Ariel* will be remembered. These two vessels left their loading port on the same day, lost sight of each other till they reached the English Channel, and docked in London on the same tide, 99 days from the date of starting.

The following views will illustrate the foregoing remarks to some extent.

The Ship of the Desert.
Primitive Boats.
Surf Boats (Madras).
Eastern Bridge and Boats.
Sail Boat.
Sailing Ship *Inaigon*.
Sailing Ship *Olivebank*.
Sailing Ship *Largiemore*.
Sailing Ship Race in 1864—*Taeping* and *Ariel*.
Sailing Ship *Ben-y-Glos*.
Sailing Ship *Ben-y-Glos*. Wrecked (two views).
Sailing Ship *Great Nicholas*.
Sailing Ship *Bermuda*.
Sailing Ship *Maria Rickers*.
Sailing Yacht *Scotia*.
Sailing Yacht *White Heather*.
Sailing Yacht *Jaberwock*.
Sailing Yacht *Vigilant*.
Sailing Yacht *Gertrude*.
Sailing Yacht *Group*.
Sailing Yacht *Thistle*
Sailing Yacht *Princess May*.

But while the opening of the Suez canal was undoubtedly a very important factor in the transfer of tonnage from sailing ships to steamers, yet the future of steam navigation was fully established before that time, and this brings us to our subject proper, "The History of the Steamship."

From the days of Jonathan Hull's proposed boat in 1737 and Millar's first boat in 1787 to the present day is a far cry, yet in that comparatively short period of less than 150 years, much has happened. The seven seas are ploughed by wonderful constructions in size, power and luxury, developments move so quickly in marine circles, the shipbuilder and shipowner are men of such infinite enterprise, skill and ability, that now-a-days the public ceases to wonder. The marvellous of to-day becomes the common-place of to-morrow.

Symington, who had been associated with Millar in his creation, built a larger vessel and tried it on the Forth and Clyde Canal with successful results, but was not satisfied. He persevered and went on improving until, in 1801 the *Charlotte Dundas* steamed along the Forth and Clyde Canal at six miles an hour. She was considered a great success, but the Canal Company obtained an interdict against her, as they feared the wash would destroy the Canal banks.

In 1807 Fulton, an American engineer, launched a steam vessel *The Clermont* in New York, she was 130ft. long, 18ft. beam and 6ft. depth of hold, and her success led her builders to build two other vessels the *Car of Neptune* and the *Paragon*, which plied their trade with great benefit to their owners.

In 1812 Henry Bell, to whose memory a monument has been raised overlooking the scenes of his triumph, placed the steamer *Comet* on the Clyde to ply between Glasgow and Greenock. This vessel was built by Wood, of Port Glasgow; she was 40ft. keel by $10\frac{1}{2}$ ft. beam. Her machinery consisted of a 3 h.p. engine built and fitted by John Robertson. The vessel made a speed of five miles an hour, and she heralded the way to rapid improvements and the years 1813 to 1820 gave the world ocean-going steamships.

There has been considerable diversity of opinion as to whether Fulton or Bell was the first inventor of the steamship. The Americans claim the honour, seeing Fulton's first steamer appeared on the Hudson River in 1807. But admirers ignore the fact that he got his ideas from Bell, and even followed the latter's advice. Bell submitted his scheme for steam propulsion to the British Government, and as was to be expected met with a rebuff. The inventor then communicated with the U.S. Government, who instructed Fulton to get in touch with Bell. That the interview was fruitful is supported by the fact that the American obtained his engine from Boulton and Watt.

No history of the steamship would be complete that failed to make mention of James Watt. His genius really was behind the successes in steamship propulsion already mentioned. In 1769 he took out his first patent for a steam engine, and in the same year he joined Roebuck, of the Carron Ironworks, in partnership. This partnership continued for a year or two, but on the failure of Roebuck, Boulton, of the Soho Works, Birmingham, took over his share of the patent, and in 1774 Watt removed to Birmingham and the famous firm of Boulton and Watt was begun. Up to this time, Watt had only been able to experiment with his engine, but now he was able to put it to practical use, first as a pumping engine, then as an engine suitable for all purposes. To the improvements of the condenser and the air pumps he was able to add those of double acting and expansive working, and later to obtain rotary motion first with the Sun and planet device, and afterwards with the crank. He also applied to the steam engine the pressure and vacuum gauges, the conical pendulum as a governor, and not the least important, the indicator. To him also we are indebted for the constant of 33,000ft. lbs. as the unit of horse power. When Watt was able to give the rotary motion to his engine, it became the model upon which all engines, used afterwards in propelling vessels by steam were made. (The recent Centenary Commemoration of Watt's death in 1819 will have brought back to our memories the genius of this great man, and we need not pursue his career further.)

Soon after the introduction of steam on the Clyde, David Napier of Glasgow entertained the idea of establishing steam communication on the open sea. He commenced a series of experiments with models of vessels so that he could decide on a suitable one. He was led to adopt the fine wedge-like entrance, by which the vessels built under his superintendence were afterwards so distinguished. In 1818 he established a regular steam communication between Glasgow and Belfast by means of the S.S. *Rob Roy*, a vessel of about 90 tons burden and 30 h.p.

She sailed for two years between those ports with success, and afterwards was transferred to the English Channel as a steam packet between Dover and Calais. In 1819 Napier built the *Talbot*, 150 tons fitted with two of his engines, each 30 h.p. This vessel sailed between Holyhead and Dublin, thus establishing rapid communication with Ireland. Napier in 1822 introduced the surface condenser which enabled him to use fresh water in the boilers. In 1820-1823 the *Comet*, *Lightening* and *Meteor*, the first steam vessels to be built for the British Navy were laid down at Deptford, London, by Oliver Lang, and fitted with side lever engines by Boulton and Watt.

In 1822 Wood built, on the Clyde, the *James Watt* and *Soho* to run between Leith and London, the engines being from the works of Boulton and Watt. In 1826 the *United Kingdom*, a vessel 160ft. long by $26\frac{1}{2}$ft. beam, with engines of 200 h.p., was built by David Napier.

In 1822 Robert Napier, a cousin of D. Napier, commenced to build marine engines, and he had associated with him as his foreman and manager, David Elder, to whose ability in design and workmanship the marine engineering world owes so much.

Perhaps a digression may be permitted here for a moment to mention that about this time—in 1829 to be exact—George Stephenson brought out his celebrated locomotive *Rocket*, on the Liverpool and Manchester Railway, and the superiority of the *Rocket* was due to the introduction of tubes into the construction of the boiler.

Whether it was this fact which gave the brothers James and William Napier the idea or not, cannot be stated as a certainty, but shortly afterwards, in 1831 they patented their return tube boiler, with its large back-end or combustion chamber, commonly called the "Scotch Boiler," with which all engineers are familiar. These boilers gave every satisfaction, and were the precursors of our modern return tube boiler. They admit of a large amount of grate and heating surface in a limited space, which is most important on board ship.

In 1834 Wolff patented his compound engine, and for some years the great question of the expansive properties of steam was much to the fore, and in 1838 John Bourne took out a patent for using high pressure steam expansively in steam vessels, the success of which was immediate.

During this decade 1830-40. the side lever engines continued to be used, but about the latter date, the direct acting engine began to come into use, and before 1850 many types had been designed.

The following views will illustrate early types of steam vessels :—

The Industry on the Clyde. *The Sea Horse*—early passenger steamer, built and engined at Dundee. *Edinburgh*. *Guiana*.

As early as 1819 the Atlantic was crossed by a vessel fitted with a steam engine. This was the *Savannah*, but she could not be described as a steamship in the proper meaning of the word. There was so little faith in the steam engine for ocean travelling, that the paddle wheels with which she was fitted could be detached or lifted on board when desired, and sails set instead.

In spite of the success of the *James Watt* and other steamers, there were still those who doubted whether it would be possible to cross the Atlantic under steam alone, but this was accomplished in 1838 by two vessels, the *Sirius* and the *Great Western*, vessels built for the purpose. The performances of these two vessels was so successful that Samuel Cunard along with George Burns and David MacIvor, conceived the idea of building vessels for the carrying of mails between Britain and the U.S.A., and in 1840 the famous Cunard Company was formed. Their first vessel, the *Britannia*, was 207ft. long, 34ft. beam and 22ft. deep, fitted with two side lever engines, cylinders 72¼in. diam. by 82in. stroke, jet condenser, driving paddle wheels 27ft. 9in. diam., steam pressure 12lbs. This company rapidly forged ahead, and the *Persia*, built of iron in 1855, 360ft. long by 45ft. beam by 30ft. deep, showed a distinct advance in naval architecture.

The introduction of iron about this time into the construction of the hulls of vessels, in spite of the mournful prediction of those who maintained that iron could not be induced to float, was a great factor in the improving of steamships with regard to their dimensions and displacement, and also to the comfort of the passenger accommodation, together with the power and speed of the engines. Each succeeding vessel embodied some important modification as compared with its predecessor as the shipbuilder and marine engineer kept pace with scientific development.

Thus far all the vessels mentioned were fitted with paddle wheels, but the inventive genius of several engineers had been at work, and in 1836 the propeller was patented by F. P. Smith. He and some of his friends built a small vessel and fitted her out with a six horse-power engine driving a propeller. This vessel sailed from the Thames along the Kentish coast and back, and created quite a stir, the report of which reached the Admiralty in due course. Smith was requested by the Admiralty to have his vessel tried by inspectors appointed by them, which he did, the results being still satisfactory. Not quite convinced, however, the Admiralty desired to see a larger vessel fitted with this mode of propulsion before committing themselves to it, so Smith and his friends built the *Archimedes*. She was 106ft. long by

21ft. beam, fitted with engines of 90 h.p., having two cylinders 37in. diam. and a stroke of 3ft., and she gave a speed of $9\frac{1}{2}$ knots. After various trials and comparisons with the mail packets, fitted with paddles, the result was a highly favourable report to the Admiralty.

In 1841 the *Rattler*, the first screw vessel built for the Navy was laid down at Sheerness. She was 176ft. long by 32ft. beam, fitted with 200 h.p. geared engines, having four cylinders 40in. diam. by 4ft. stroke. During the following year or so, extensive trials and experiments were carried out, principally with a vessel named *Alecto*, similar in dimension, but fitted with paddles, in which screw propulsion was proved to be superior.

It will be observed that Smith, when he introduced his propeller on the *Rattler* adopted geared engines, with the propeller shaft making four revolutions to one of the crank shaft. Another school of thought arose later however, which connected the engines direct to the propeller shaft, and for several years the two methods were violently contested, but the direct drive ultimately won, and the engines instead of being horizontal, assumed the vertical position and developed into the type we all know. It is rather strange that in our day gearing is ousting the direct drive, this of course taking place with the advent of the geared turbine, but in the present day the gearing is in the downward, in the forties of last century, it was in the upward direction from the engines to the propeller.

With the advent of the screw propeller the advance in size and horse power of ocean-going vessels was soon apparent, and the success which had attended the Cunard Company brought other competitors into the field. The greatest rivalry between steamship companies has always existed on the Atlantic, and a few words with reference to the race for the blue ribbon of the Atlantic will at the same time illustrate the subject we have in hand, as the growth in power, speed and tonnage of steamships was stimulated by the desire of the steamship companies to reduce the duration of the Atlantic voyage to the shortest possible.

The question might be asked—Why all this incessant struggle for speed? Then, as now, the passenger was the deciding factor to a very great extent. The fastest vessels received the traffic, also the mails. In early days rapid evolution was to be expected, as marine engineers and naval architects advanced by leaps and bounds, and the contest for the blue ribbon was one of the most satisfactory circumstances for the British shipbuilding industry. Although various nations competed for the honour, the vessels in nearly every instance were built in British shipyards. The North German Lloyd even obtained their vessels on the Clyde or Tyne until the closing years of last century. But that is anticipating our subject somewhat.

The *Sirius* and *Great Western* might be termed the first trans-Atlantic racers. Then, when the Cunard Company's S.S. *Britannia* was eight years old, the U.S. steamship *Washington* was put on the same run, but she proved no match for the Cunarder. This roused the blood of the Americans and the Collins Line was founded with Government assistance, and the *Arctic*, *Atlantic*, *Baltic* and *Pacific* were built and commissioned in 1850. The Cunard Line was deposed from first place by these vessels, but the Collins Line was suffering heavy financial losses in holding the honour, and in 1858, on the withdrawal of the Government subsidy, it collapsed, and the Cunard Company was left in undisputed command of the Atlantic. The harvest that this Company was reaping was too rich not to tempt others, and the celebrated Inman Line came into being with vessels fitted with screw propellers, and by slow and well considered evolution they at last eclipsed the Cunard Company and brought New York within eight days of England by the S.S. *City of Brussels*.

Mention ought to be made here of the S.S. *Great Britain*, built in 1845, from designs by Brunel, and in 1857 the world famous *Great Eastern*, Brunel's masterpiece, or as some people have called it, his colossal failure. This vessel's dimensions were 680ft. long by 82ft. beam, 58ft. deep, draught loaded 30ft., tonnage 19,000. She was built with double bottom and longtitudinal framing, with iron decks planked above. So great a length in a steamer was not again reached until 1899 when the second *Oceanic* was built. These figures tend to show how far in advance of their time were the ideas and aims of Brunel, the designer, and Scott Russell, the builder of our first leviathen. She had both paddle wheels and screw propeller. The paddle engines built by Scott Russell were on the diagonal oscillating plan, four cylinders, each 74in. by 14ft. stroke, the screw engines by Boulton and Watt were horizontal direct acting four cylinders 84in. diam. by 4ft. stroke. There were four boilers for the paddles and six for the screw engines, pressure 25lbs., I.H.P. 8,000. speed 14 knots. The vessel did good service in laying the Atlantic cable, but not being a success commercially was broken up on the Mersey in 1890.

In 1856 the Hamburg American Line came into existence, followed two years later by the North German Lloyd, and by the

French Company, La Campagnie Generale Transatlantique in 1862. Other companies were the Guion, National and White Star, so that by 1880 the Atlantic was somewhat crowded, and the fight for mastery commenced in grim earnest. The Guion Line beat the Cunard *Sidonia* by their S.S. *Adelaide*, and the Inman Line, which had also been beaten, replied with the *City of Rome* in 1882. She was 586ft. long by 52ft. beam, with compound tandem engines developing 10,000 I.H.P., which gave the vessel a speed of 18 knots. She, however, was returned to the builders on account of not fulfilling all the conditions of the contract. They afterwards transferred her to the Anchor Line, and that company ran her for many years on their Glasgow—New York Service. The White Star *Germanic* and *Britannic* next held sway until the Guion Line produced the *Alaska*, of 7,000 tons, fitted with engines of 10,000 I.H.P. She reduced the passage to $6\frac{3}{4}$ days. In turn the *Alaska* was eclipsed by the *America* of the National Line, which ultimately succumbed to the Cunard *Oregon*. The Cunard Line improved on the *Oregon* with the *Umbria* and *Etruria* with a speed of $19\frac{1}{2}$ knots, I.H.P. 14,500, which held the honour until 1891, when the White Star *Teutonic* and *Majestic* did $20\frac{1}{4}$ knots. The Inman Line again accepted the challenge with the *City of New York* and *City of Paris*, but these four vessels were much alike both in speed and horse-power, viz., 20 knots, 18,000 I.H.P. The pace grew hot in the early nineties, when the *Campania* and *Lucania* were built for the Cunard Company by Fairfield Shipbuilding Co.

They were 620ft. long by $65\frac{1}{4}$ft. beam, fitted with twin screws developing 30,000 I.H.P. They swept all rivals from the Atlantic with a speed of 22 knots. But the closing years of last century brought a change. No doubt as part of their bid for world dominion the German Liner Companies, especially the North German Lloyd and the Hamburg American were coming to the fore. The former brought out the *Kaiser Wilhelm der Grosse* in 1897, a vessel 649ft. long by 60ft. beam, 20,000 tons, with a speed of 23 knots, which was eclipsed by the rival German company about 1900, when the *Deutschland* appeared on the scene. This vessel remained as undisputed mistress of the seas until 1907, when the Cunard fliers *Lusitania* and *Mauritania*, 780ft. long by 88ft. beam, 43,000 tons, appeared on the scene fitted with four steam turbines, developing 70,000 S.H.P., which gave the vessels a mean speed of $26\frac{1}{2}$ knots on the voyage, Liverpool and New York. About the same time as the Germans acquired the blue ribbon, the White Star Line were coming to the front with their leviathans, but they did not attempt to combine great speed with size.

With the advent of improved auxiliaries and no doubt with the demands of trade, vessels had gradually assumed larger and larger proportions. When the *Celtic* appeared in 1901, we read of her dimensions almost with awe, and our wonderment had scarcely subsided when the *Baltic* appeared dwarfing her predecessor. Their respective dimensions were *Celtic*, 21,000 tons, 680ft. by 75ft. by 44ft.; *Baltic*, 24,000 tons, 709ft. by 75½ft. by 45½ft., both quadruple twin screw. Although these were large vessels they were completely dwarfed by the *Olympic* in 1911, dimensions 852ft. by 92½ft. by 59½ft., 46,500 tons gross, fitted with twin screw engines and one low pressure turbine.

Whilst all this activity was taking place on the Atlantic, other companies, too numerous to mention, had been opening up intercourse with more distant parts of the Globe, and the following names of steamship companies with one or two of their respective vessels will illustrate our subject: The Union Line to South Africa with their S.S. *Scot*, the Orient Co. to Australia with their S.S. *Ophir*, 482ft. long by 53½ft. beam, the British India Steam Navigation Co. to India with their *Rasmara*, *Malda* and *Dilwara*, and the Canadian Pacific Co. on the Pacific with their *Empress of Japan*.

It may be interesting to note what the Admiralty was doing while these advances were taking place in the Mercantile Marine.

In 1854 John Elder had invented a compound engine which gave great promise of success, as it reduced the machinery space and boiler power very considerably, but still gave higher speeds and reduced consumption. In 1859 the British Association began to enquire into steamship performances, and this gave a fillip also to the Admiralty to see if the best and most economical engines were being installed. To arrive at some conclusion they had three sister vessels built in the dockyards, and contracted with three firms for competitive machinery and offered a premium of £2,000 to the builders whose engines propelled their ship under similar conditions at the greatest speed or the greatest distance with the least fuel. The three vessels were the *Constance*, *Arethusa* and *Octavia*. The *Constance* was fitted by Randolf Elder and Co. with their compound engines, the *Arethusa* by Penn and Son with two horizontal engines, the *Octavia* by Mandsley and Co. with three horizontal engines.

In due course the trials took place. the vessels all left Plymouth at the same time, each coaled to the same amount. They were soon separated and the *Constance* was the first to arrive at the destination—Madeira. On the third day after her arrival the *Octavia* appeared under canvas, all coal consumed, and five days after the arrival of the *Constance* the *Arethusa* put in an appearance under canvas, and all coal consumed. The superiority of the compound engine was placed beyond doubt by these trials. About 1874 the compound engine developed into the triple expansion engine, and of course the greater number of expansions necessitated higher initial pressures, and this in turn required improved boilers. One of the earliest vessels in the Mercantile Marine fitted with triple expansion engines was the S.S. *Aberdeen*. This vessel was built in 1881 by R. Napier and Co. for the Australian Trade carried on by Geo. Thompson and Co., and the success she achieved led to the introduction of the triple expansion engine into naval vessels, as exemplified in the cruisers *Thetis*, *Edgar* and *Blake*. The triple expansion, and a little later, the quadruple expansion engine easily held first place from the point of view of general efficiency, until the advent of the turbine.

Mention has already been made of several vessels which were fitted with turbine machinery, such as the *Lusitania* and *Mauritania*, and no history of the steamship would be complete which did not make mention of that epoch making event, the invention of the Marine Steam Turbine.

Ever since 1884 the Hon. C. A. Parsons, F.R.S. (now Sir Charles), had been experimenting with his parallel flow turbine, but the earliest success recorded took place in 1888, when the first Turbo-Generator was set to work in a power station in Newcastle-on-Tyne. But Sir Charles worked on with a view to ship propulsion by turbines, and in 1896 the marine engineering world was electrified by hearing of, or reading about, a little vessel named the *Turbinia*, a small ship 100ft. long by 9ft beam by 45 tons displacement, travelling through the water at the hitherto undreamt of speed of between 33 and 34 knots per hour.

The British Admiralty were not long in recognising and adopting this new motive power, as the Admiralty experts were fully alive to its possibilities for high speed vessels, and in 1899 the destroyer *Viper* was launched fitted with Parson's turbines. On trial, this vessel was propelled at a speed of 37 knots per hour, the turbines developing 12,000 S.H.P., this power being practically twice that of similar vessels fitted with reciprocating engines. A sister vessel, the *Cobra*, was also fitted out with turbines, but both vessels only enjoyed short lives, and their loss adversely affected the progress of the marine turbine for a short time. In 1903 and 1904, however, the Admiralty were able to make the historical comparative trials between the sister ships *Amethyst* and *Topaz*, fitted with turbine and reciprocating machinery respectively, with the result that the Naval Estimates for 1905-06, included the battleship *Dreadnought*, and the three armoured cruisers of the *Inflexible* type, all fitted with turbine machinery, and since that date all the propelling machinery of H.M. ships has been of the turbine type.

The first turbine vessel for the merchant service was the Clyde pleasure steamer *King Edward*, which was completed and placed on service in 1901, and she was soon followed by the *Queen Alexandra*. These vessels plied between the pleasure resorts on the Clyde with satisfactory results, but for pleasure purposes the turbine has not yet altogether ousted the paddle steamer, as can be seen from the following views of paddle steamers :—

Lord of the Isles, *Galatea*, *Duchess of Hamilton*, *Koh-i-noor*, *Neptune and Saloon*, *Sultan*, and *Iona*.

The Allen Steamship *Victorian* was the first turbine vessel to cross the Atlantic, and the success which attended the Cunard fliers *Lusitania* and *Mauretania* put the seal on the turbine as the motive power for high-speed vessels. But the fact that merchant vessels are, in the majority of cases of low speed, and as it was soon apparent that the minimum speed of a vessel for which an efficient and economical installation could be designed was about 15 knots, methods of combining a high-speed turbine with a slow revolution propeller were gradually evolved.

The gearing which has superseded other methods is the mechanical reduction and transmission gear, and the first vessel thus fitted was the S.S. *Vespasian*, which was converted from reciprocating engines to two turbines geared to one shaft, for experimental purposes in 1910. The gearing was in the ratio of 20 to 1, the revolutions of the turbines being about 1,500 per minute, those of the propeller about 75. The success of that experimental vessel led other ship-owners to take up the idea of geared turbines, and it is recognised to-day as being the marine motive power of the moment.

It was also early demonstrated that a better vacuum was necessary with turbines than with reciprocating engines, and with the improvement in condenser design to this end, a combination system of reciprocating engines with a low pressure turbine was evolved, which gave an additional economy of 10 per cent. to 15 per cent. over good quadruple and triple expansion reciprocating engines respectively. The S.S. *Otaki*, built by Denny Bros., Dumbarton, was the first vessel thus engined, and the White Star Liner *Olympic* is another example.

If we follow the various advances from the low pressure engine of Watt's time by means of the compound, triple, and in some cases quadruple expansion engines, then later by the turbine, and at the present day by the geared turbine, it will be seen that from the first use of the steam engine for ship propulsion until the present time, improvements have continually been made tending towards economy of fuel consumption, and the attainment of higher speeds over long voyages. Consumption of fuel has gone down from about 6lbs. per I.H.P. per hour to $1\frac{1}{4}$lbs. This has been in conjunction with enormous increases of steam pressure from 12lbs. per sq. inch, to say between 200 and 250lbs. per sq. inch. These increases of pressure were made possible by the introduction of corrugated furnaces and steel plates into the construction of the boilers. Like most innovations the introduction of steel met with little encouragement, and when an addition of 100 per cent. to the pressure and a reduction of 20 per cent. in the scantlings were mooted, underwriters looked askance. It can safely be said that mild steel would not have supplanted iron as quickly as it did, if the whole shipping interest had not had unlimited confidence in Lloyds' Register, the Committee of which took the utmost pains to assure themselves that mild steel was a thoroughly safe material, and who accepted it as such.

We have for so many years been accustomed to the use of the word steamship when talking about ocean going vessels, that it is with difficulty we bring ourselves to speak about "Motor Ships," but to be correct we must do so, when we come to discuss vessels fitted with some form of internal combustion engine.

The Diesel engine first appeared towards the close of last century, and as was the case with the turbine, it was employed for many years on land work before being applied to marine purposes. But technical knowledge and science are always progressing, and in due course a marine engine was designed, which, in the lower powers at any rate, gave fairly satisfactory results. The motor ship *Vulcanus* was amongst the first to be built, and engined with those engines. Generally speaking the number of motor ships has not yet reached very great proportions in the mercantile marine, chiefly because the ordinary cargo steamer has to seek employment all over the Globe, and the supplies of the necessary oil are not available. Those companies whose vessels are in the oil carrying trade can with advantage to themselves instal the Diesel engine in their vessels, as the consumption of oil in that type of engine compares very favourably with the consumption either of oil or coal in steam propelled vessels.

The mention of geared turbines and Diesel engines brings us up to present day practice, and it remains to be seen what progress in shipbuilding and marine engineering the future holds in store. We may think the very last word has been said and that we have reached the acme of perfection, but to show how things progress take only one example and that on an essential feature of all marine engines—the thrust-block. We have always been accustomed to the thrust shaft with its multiple collars and have apparently been satisfied with it, but one man evidently was not, and we now have the Michell Patent Thrust Block with its single collar, and that more efficient than what we have accepted all these years as sufficient.

In view of the great advance in shipbuilding which other countries are making at the present time, Great Britain's pre-eminence, not ony as an owner, but also as a builder of steamships, is being threatened. It behoves everyone therefore to see to it that the position and supremacy which have been bought by a century of experience are not taken from us, and that the future History of the Steamship will still show this Island Home of ours to be in the premier position, as our existence as a power amongst the nations is so closely bound up with our shipping and shipbuilding industries.

The CHAIRMAN: We tender our thanks to the author of the paper and to Mr. Adamson. The subject is of interest to all engineers, as indicating the developments which have been, and are still, taking place. The discussions on the papers read at the exhibition will follow at our own premises.

———o———

Special Form of Ship Keel Structure providing a clear Fore and Aft Passage,

By E. F. SPANNER (Member),

READ AT

THE INTERNATIONAL SHIPPING, ENGINEERING AND MACHINERY EXHIBITION, OLYMPIA, LONDON,

On Tuesday, October 14, 1919, *at* 7.15 *p.m.*

CHAIRMAN: MR. B. P. FIELDEN (Chairman of Council).

THE following paper has been written with the idea of bringing before the members of this Institution some more or less novel proposals in connection with the arrangement of the keel structure of steel vessels.

It has long been recognised that broadly speaking the safety of any floating vessel of the character of a steel ship depends almost entirely upon the manner in which the vessel is subdivided, and from time to time committees have been appointed thoroughly to review the subject and to draw up schemes and rules, by following which one could reasonably expect to obtain a vessel which would remain afloat in calm weather and under favourable circumstances, after having sustained serious damage.

The labours of the Bulkhead Committee appointed in 1912 resulted in the production of rules which must be recognised as tending to produce vessels so sub-divided as to ensure the maximum amount of safety for which one can possibly hope, without going to such a degree of sub-division as would render these vessels of little use for ordinary service such as the carrying of cargo or passengers.

Even so, the degree of safety produced is very far from absolute, while the restrictions imposed on the length of compartments, the stepping of bulkheads, etc., prove very irksome, in the first place to the designer and later and perhaps more forcibly to the shipowner.

In these circumstances it is of the first importance to ensure that the bulkheads which have been arranged for, often at much cost and inconvenience, shall be as efficient as possible to withstand a considerable head of fluid, *i.e.*, to ensure that they will remain watertight under conditions placing a serious strain upon them, such as would follow if the vessel were bilged.

This essential was fully recognised by the Bulkhead Committee, who directed considerable attention to the carrying out of experiments on bulkheads and to the formulation of tables of scantlings, etc. Further, the Committee devoted a good deal of thought to the question of attachments to bulkheads, and the following is an extract from a paper on the strength of watertight bulkheads, read before the Institution of Naval Architects in 1916, by Mr. Foster King, which has particular reference to the question of maintaining the intact character of the bulkheads:—

"It is therefore essential that those responsible shall consider not only the required stiffness of each bulkhead, but the efficiency of everything which is attached to or which passes through it, in the light of the knowledge that the whole structure is going to move in all sorts of ways and to very distinct amounts in the event of being called upon to keep out the ocean. A very serious view of this responsibility is necessary if sub-division is to be that actual safeguard which is intended."

There can be no question but that every pipe which passes through a transverse bulkhead very adversely affects its efficiency as a watertight division, and conversely that any scheme the adoption of which results in a reduction of the number of pipes passing along a vessel from one compartment to another just above the inner bottom and therefore through one watertight bulkhead after another, must favourably affect the sub-division of the vessel.

In a normal design of passenger or cargo vessel a number of different piping systems have to be provided for. The leads for each of these systems involve a series of holes through watertight bulkheads, which holes are almost invariably at the bottom and therefore most likely to cause serious trouble in the event of a mishap. In a vessel burning oil fuel and carrying this fuel in the D.B. tanks and in some of the holds, provision has to be made for oil fuel suctions and oil fuel heating pipes, in addition to the provision necessary for ballast water suctions, suctions to reserve feed tanks, to freshwater tank, and to bilges. Of the several systems mentioned, that for dealing with ballast water will probably already be fitted in the double bottom spaces, but most of the other systems are usually arranged for above the inner bottom.

The possibility of water entering intact compartments, via one or other of these lines of piping, following damage to the ship, is guarded against in many cases by the fitting of special non-return valves and screw-down bulkhead valves, but even so the danger is not eliminated so effectually as by the adoption of the proposal outlined in the following remarks, as valves of any kind are rarely infallible, and they have been found to give a good deal of trouble even in war vessels, in which class of ship it has been fairly common practice to fit a substantially constructed screw-down valve at every watertight bulkhead pierced by a pipe line low down in the vessel.

Figures 1, 2 and 3 illustrate in a diagrammatic manner the proposal in question as applied to a ship with a double bottom. It will be seen that a watertight duct or passage is provided running along the length of the vessel between the inner and outer bottoms, this passage being one through which pipes can be led, and which in addition or alternatively can be used itself as part of a liquid carrying system.

Figure 4 illustrates the proposal as it applies to a single skin vessel, *e.g.*, an oiler. In this case it is possible to accommodate the main lines of the oil pumping system in a clear and easily accessible passage as indicated, with the advantage among several others that a large number of bulkhead valves can be dispensed with.

Considering the proposal as it affects the efficiency of the watertight sub-division of a vessel, it can hardly be denied that the safety of the bulkheads would be very materially improved by its adoption. It is a common occurrence at present to see a watertight bulkhead pierced by from four to as many as ten or more pipe lines for bilge services alone, repairs being necessary on occasions to some or all of these lines of piping. Severe strains on such a bulkhead following damage can hardly fail to affect the intactness of the pipe connections, with the result that it might happen that a bulkhead built into a vessel at great expense and adversely affecting the loading and discharging of the ship during the whole of her life afloat, would be practically worthless when called upon to keep the vessel from sinking.

The locating of all the pipe lines in a strong box girder running fore and aft on the middle line of the ship would, as can be seen from the drawings, beneficially effect the safety of the vessel for the following reasons.

1. The pipe lines would be far less likely to be damaged by collision or other sea risk than they are at present. The usual position of the bilge pipes, *i.e.*, running along through or on top of the tank margin brackets is one exposing them to almost

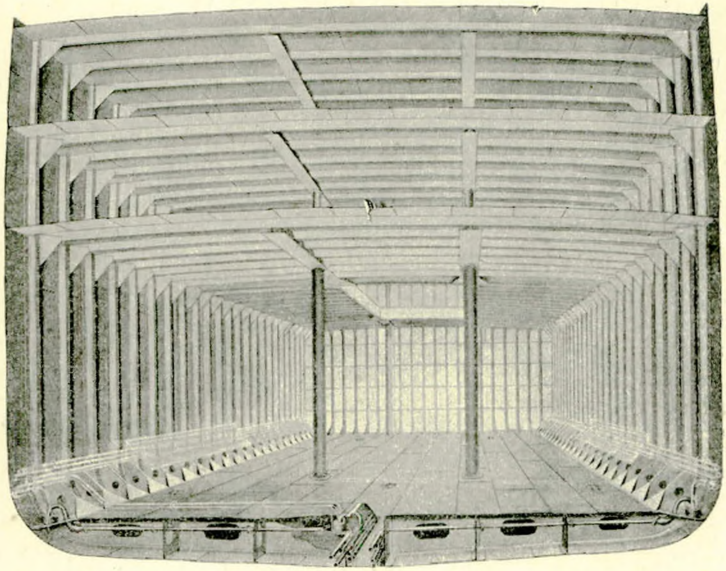


Fig. 1.

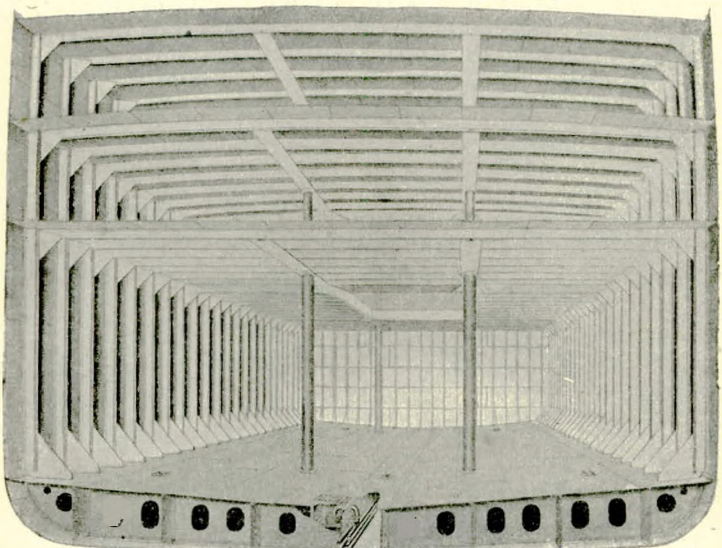


Fig. 2.

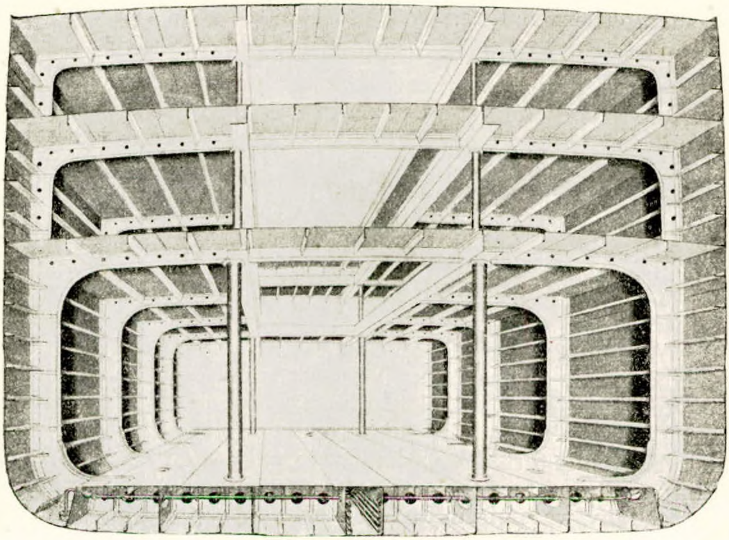


Fig. 3.

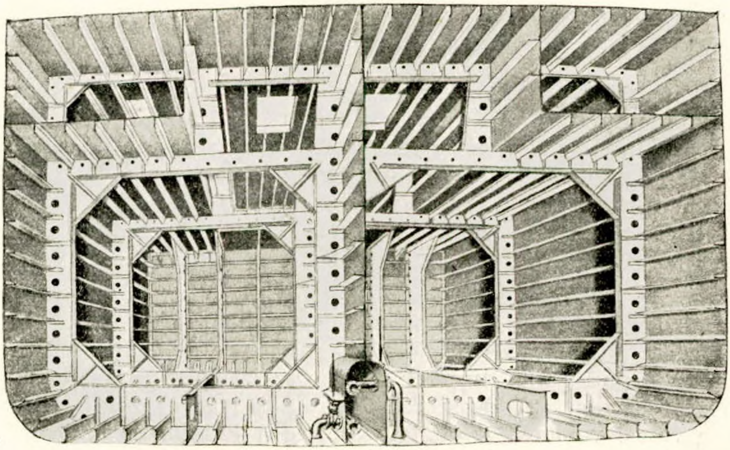


Fig. 4.

certain damage in the case of collision, while, should the vessel take the ground heavily on either bilge, damage is again likely to result to the pipe line.

With the pipes running through a substantially constructed girder as is proposed, this being amidships, damage to the pipes due to collision is well nigh impossible; while if the vessel grounds the stout girder is unlikely to take any severe local distortion such as would be necessary to fracture the pipes or break the joints. The practical elimination of the possibility of collision affecting the pipe lines is a very valuable point as some of the most serious maritime disasters have been due to collisions at sea, and this type of risk has an important bearing on the fitting of bulkheads.

2. Assuming a vessel, having the bilge pipes in the bilges, to be loading heavy cargo, it is not unusual for these pipes to be damaged, as after a vessel has been in service a few years the ceiling wears thin and rots and occasionally pipes are broken and brackets distorted by a badly stowed cargo. This provides communication for water between compartments otherwise separated by watertight bulkheads.

Such a risk is obviated when the pipes are carried in a duct keel, for they are then entirely protected from the possibility of damage from cargo.

3. Pipe lines are often strained and broken owing to the vessel having passed through heavy weather and in such a case the intactness of the bulkheads is very much prejudiced.

With the proposed arrangement straining and breaking through this cause is very much less likely, and even if pipes are strained so that they leak, they merely leak into the duct passage and not into another large compartment, *i.e.*, the watertightness of the bulkheads is not effected.

There are other advantages attaching to the use of the duct as a means of eliminating the various pipe lines from the holds and cargo spaces, which are likely to appeal most strongly to the ship-owner and marine superintendent, while the Naval architect and shipbuilder will also find that certain difficulties hitherto met with in providing for the necessary piping systems, are obviated when it is rendered possible to lead the pipes through the vessel without piercing watertight bulkheads and further through a space which is straight and relatively easy of access.

Considering the matter first from the point of view of the shipowner and marine superintendent. In the coming period of severe competition much will depend on the expedition with which a vessel can be turned on reaching port, and sent to sea loaded with a fresh cargo. In the past it is hardly going too far to say that with a large number of vessels' valuable earning time has been lost owing to delays in port necessary to allow of the pipes for bilge and other services being repaired, and to admit of damage caused through leaky pipes being made good. Particularly is this the case with insulated vessels, and where enquiry shows that little time has so far been lost due to this cause it will probably be found that the vessels concerned are comparatively new and that therefore, their troubles have yet to develop.

With the slight modification in construction now proposed, it will be possible to have the holds clear of practically all these piping systems. Systems can be run along the vessel similar in every way to those at present fitted, *i.e.*, running from valve boxes in the machinery spaces through separate leads of pipe to the bilges, holds or tanks to be cleared. The general scheme of each system need not depart from that usual at present, so that no difficulty need arise due to new schemes of piping being necessary. The advantages to the shipowner and marine superintendent of having leads arranged along a compact but accessible duct, clear of cargo spaces may be summed up as follows:—

1. The piping systems are very simple and easily located after installation in the vessel. After being led into the duct the pipe leads are practically straight, and owing to the strong construction of the box and the fact that no bulkheads have to be pierced, expansion bends or joints would be much fewer in number and less likely to be severely strained by the working of the vessel. Consequently repair to these joints after heavy weather or other straining of the vessel would be less than at present.

2. The fitting of the bilge pipes in such a manner that they are not likely to be attacked on their outsides by bilge water, etc., having a very powerful corrosive action, would result in the life of the pipes being increased. Further, it would be possible to clean and coat such pipes much more easily and efficiently than at present, so that they could be better maintained.

3. As fitted at present special ceiling is required in the holds to protect the pipes from damage from cargo. This results in a certain loss of space, due to broken stowage while the ceiling deteriorates and rough handling of cargo or other mishaps results in damage not only to the pipes but to the brackets and structure through which they run or from which they are supported.

4. Should leaks develop in a bilge system as at present fitted, due to corrosion, damage following heavy weather or any other cause, it is possible for bilge water to find its way along the ship so that sufficient may collect in a compartment to cause serious damage to the lower tiers of cargo, or in an insulated ship appreciably to affect the insulation. This contingency is entirely obviated if the pipes are led along a duct.

5. The result of having the various pumping systems easily accessible would be that in the event of a leak occurring its detection along the length of the pipe would be much easier than where ceiling has to be removed and access obtained to the pipe under dirty and unfavourable conditions.

6. In the event of attention having to be given to the pipe systems, either to overhaul or repair, it is necessary at present to undertake the work when in harbour, and to arrange an interval between the discharging and loading of cargo whether or not such interval is necessary for other reasons. As a consequence the time in port may be lengthened by a day or so over and above the period otherwise necessary, and this represents a distinct loss to the shipowner.

7. The presence of a long W.T. compartment along the length of the vessel passing between the D.B. compartments, permits of access to those compartments otherwise than when in port and with holds empty so that tanks can be entered under any condition of loading and can also be cleaned out at sea—an important consideration in itself in some types of vessel.

8. Should it be desired to introduce new leads of piping for a new service or as found necessary by experience, the installation would be much simpler to arrange through a duct, than where it is necessary to lay the pipes through the holds above the inner bottom.

The advantages of the duct from the Naval architect's point of view are important. In the first place the vessel is stronger with this modified form of construction, while at the same time there is an appreciable saving in structural weight.

Again as a passage for pipes the duct keel is of value, in that by clearing the pipes from the hold the difficulty of arranging for the leads along either above or through the brackets at the foot of the frames above the bilges is obviated. The pipes further do not pass through W.T. bulkheads so that no anxiety need be felt on the question as to whether or not the efficiency of the bulkheads has been impaired by the passage of pipes through them.

With the modification introduced by the Bulkhead Committee to the height of the bottom of the margin plate above the line of bottom, the size of the bilge corner available for drainage is much reduced and sumps of some sort or other are more or less necessary in each hold. Having pipes running through a central duct and not through or above the bilges, the inner bottom can be economically worked straight across and a sump or pocket formed each side at the forward or after end of the compartment according to the manner in which the vessel normally trims. Access to these pockets for cleaning could be obtained from the double bottom through the sides of the duct. This would admit of the cleaning of these spaces when holds were full of cargo. See Figs. 5 and 6.

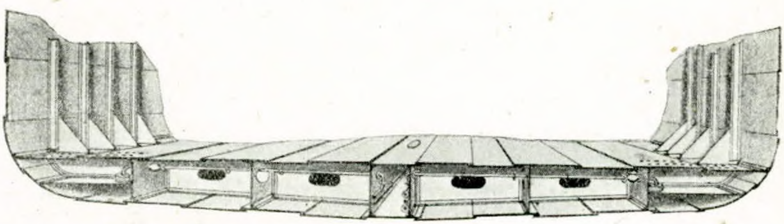


Fig. 5.

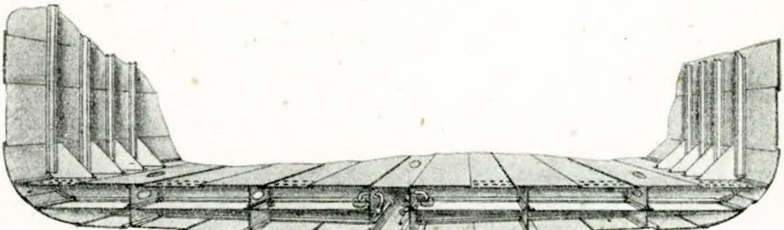


Fig. 6.

An alternative arrangement is shown in Fig. 2 where sufficient rise has been given to the inner bottom to render a midship pocket quite capable of dealing with the water collecting in the hold. With this arrangement only one suction is necessary to the compartment, and the structural work involved is not difficult. A further advantage of these schemes is that an awkward bend at the foot of each side frame is avoided.

Where insulated vessels have to be dealt with a considerable decrease in the amount of complication necessary to make provision for the bilge suctions results from the arranging of these leads in the duct keel.

So far as the shipbuilder is concerned the actual construction of the duct involves very little more work than is required in the case of the ordinary ship structure, as, although there are two W.T. longitudinal divisions to fit instead of one division which would only be watertight for a part of its length, the actual weight of material required would be less than at present owing to the length saved on each of the floors. Further, as this keel structure would be one of the simplest portions of the vessel to be built, there should be no difficulty in obtaining a satisfactory job.

When one considers the work involved in the installation of the piping systems, very obvious benefits arise from the adoption of the proposed scheme. Pipes can be laid before the inner bottom plating is worked and before bulkheads are put into the ship. Expansion bends and joints need be very few. Pipes can be in long lengths, and the cost of installation should be considerably reduced also owing to the absence of any necessity for special ceiling. If the vessel is insulated the fitting of the insulation is not interfered with by the piping systems and the complication of lagging, etc., at present necessary to effectively insulate the bilge pipes would be avoided. The pipes could be clipped to small angle bars worked vertically at intervals along the two sides of the duct, these bars being riveted in place before the side plates were erected. By this means it would be possible to obviate any difficulty such as might otherwise be found in making provision for supporting the pipe lines.

In the case of oil fuel tankers the value of the idea can be readily appreciated if consideration is given to the following statement of the advantages to be gained by working the main oil pumping pipes through a "duct keel":—

1. A number of very heavy oil-tight valves, ordinarily necessary where each of the pipe lines pierces a transverse tank bulkhead, are dispensed with.

2. The absence of these pipe attachments to the bulkheads renders the latter much more efficient in the case of damage to the vessel.

3. The pump lines are always accessible whether the tanks are full or empty of oil.

4. When the branch valves are closed the pipes themselves can be disconnected and turned, repaired or rejointed as may be necessary. The duct can be kept thoroughly well ventilated by a proper supply and exhaust, and access obtained to the pipes very much more readily than at present, when it is necessary to empty the tanks, and leave them open for many hours before men can enter.

5. At present, if oil of different grades is being carried at one and the same time, it is possible for the lighter oils to be discoloured or for the flashpoint of the heavier oils to be spoilt, owing to leakage in the pipe lines. With the proposed system any leakage in the pipe line would be at once noticeable as oil would leak into the duct. The leak could easily be found and repaired without difficulty. It would be very difficult for oil to leak from one tank to another through the pipe lines as it would have to pass two valves, and consequently the spoiling of the cargo is unlikely.

In the foregoing it has been the aim of the author to deal with the proposed innovation as briefly as possible, while, however, drawing attention to points most likely to appeal to the practical shipbuilder and to the shipowner. In the appendix will be found notes and sketches dealing with the questions of the effect of the adoption of the proposal on the strength and weight of a vessel.

It may be remarked that the principle underlying the idea, *i.e.*, that of constructing the keel of a vessel as an externally stiffened box girder, has been accepted by the Registration Societies subject to the usual procedure as regards the submission of drawings, and at least one vessel embodying the idea is in an advanced state of construction on the Continent, while it is believed that several others are projected in America.

It is hoped that the proposals will be thoroughly discussed by the members of this Society, and assistance thereby given the author in his endeavour to increase the efficiency of our merchant shipping by reducing the time spent in port, improving the watertight subdivision, protecting the cargo, and rendering easier the task of those whose duty it is to maintain the vessels when they are at sea.

APPENDIX.

The strength of a vessel is very beneficially affected by the adoption of the duct keel form of construction as the rigidity of the ship against longitudinal and docking stresses is substantially increased by the box formation of what is the principal fore and after member of the bottom framing. The possibility of severe straining of the vessel due to local failure of the keel or of the bottom plating adjacent to the keel, following a mischance in docking is practically entirely eliminated, as unless the vessel is docked a very considerable distance out of centre, or has a very abnormal list, a stout fore and aft girder is certain to be on the blocks. The solid construction of the box girder forming the keel, renders it an ideal link between the port and starboard elements of the transverse framing, it being possible to obtain a longer and more rigid connection of these floors to this central member, and thus to one another, than is the case at present, while in addition the longitudinals forming the sides of the keel very effectively tie adjacent floors to one another, and prevent any individual failure. Sketches Nos. 7, 8 and 9 show sections of the duct keel in different types of construction.

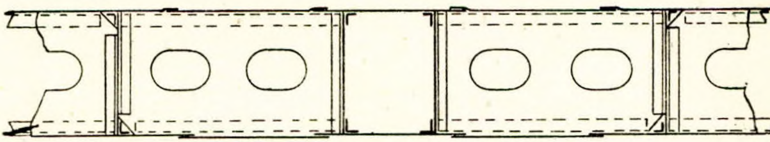
The effect of the innovation on the structural weight of a vessel is an important one, and a reduced hull weight can confidently be predicted if the duct keel is specified. The general question of the scantlings necessary for the different members of the keel has been submitted to Lloyds' Register of Shipping, and approval has been given the proposal, that the sides of the duct should be of the same scantling as the adjacent floor plating, no alteration being made to the poundage of the top and bottom angles or of the flat keel and gutter plates.

The following short calculation shows that the claim that hull weight is saved has substantial foundation :—

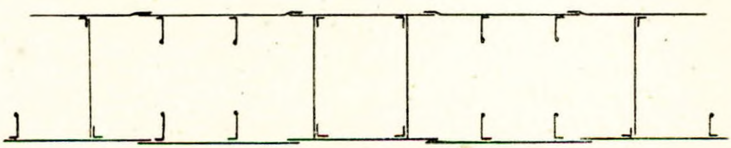
Weight of one frame space length of vertical keel in a 450 ft. ship :—

Plate - $4 \times 2\frac{1}{4} \times 22 = 198$ lbs.
Angles - $2 \times 2\frac{1}{4} \times 30 = 135$ lbs.

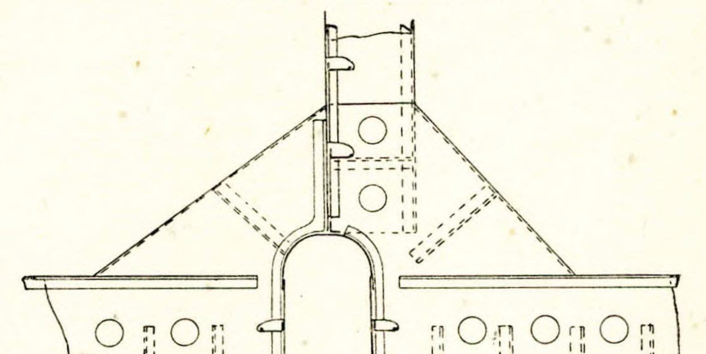
333 lbs.



SHIP WITH TRANSVERSE FRAMING



ISHERWOOD SHIP (WITH DOUBLE BOTTOM)



ISHERWOOD SHIP (SINGLE SKIN)

Figs. 7, 8 and 9.

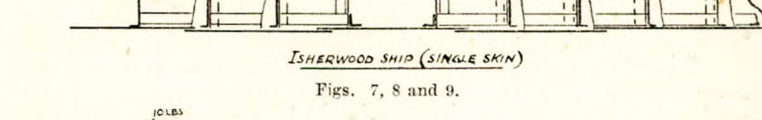


Fig. 10. Length of Ship 450ft., Frame Spacing $2\frac{1}{4}$ ft.

Weight of one frame space length of sides of fore and aft **box**:—

Plate - $4 \times 2\frac{1}{4} \times 34 = 306$ lbs.
Angles - $2 \times 2\frac{1}{4} \times 30 = 135$ lbs.

441 lbs.

Weight saved on one floor:—

Plate - $4 \times 3 \times 17 = 204$ lbs.
Angles - $2 \times 3 \times 10 = 60$ lbs.

264 lbs.

Net weight 177 lbs.

Difference—$333 - 177 = 156$ lbs. This on a length of $2\frac{1}{4}$ft., *i.e.*, roughly 70 lbs. per ft. run is saved. Or on a 450ft. ship say 14 tons.

This represents a saving in costs of material alone of about £200. To this must be added the saving in the handling and working of this weight of material and also the very appreciable saving in working the bilge and other piping systems running through the duct. Practically no bulkhead connections have to be made, pipes can be worked in long lengths and such watertight connections as are necessary lie in directions not likely to be called upon to stand heavy strains.

The following sketches Nos. 11 and 12 illustrate the general character of the piping arrangements in a typical case, it being possible to accommodate in the example chosen, all the necessary bilge and ballast pipes in the "duct keel." It will be seen that sufficient room is available to carry out the necessary work of rejointing and repairing the pipes. Generally speaking it will be found an easy matter to make good use of the proposal in any type of ship once the principle has been thoroughly accepted, each particular case being tackled on its merits by the Naval architect preparing the design.

A further important service for which the duct keel can be utilised is that of providing a passage through which large volumes of water could be pumped to one end or the other of the vessel to counteract excessive trim following severe underwater damage. For this purpose it would be proposed to take advantage of the fact that the duct is a long watertight passage of substantially clear cross section extending from the machinery spaces to the ends of the vessel, and those interested

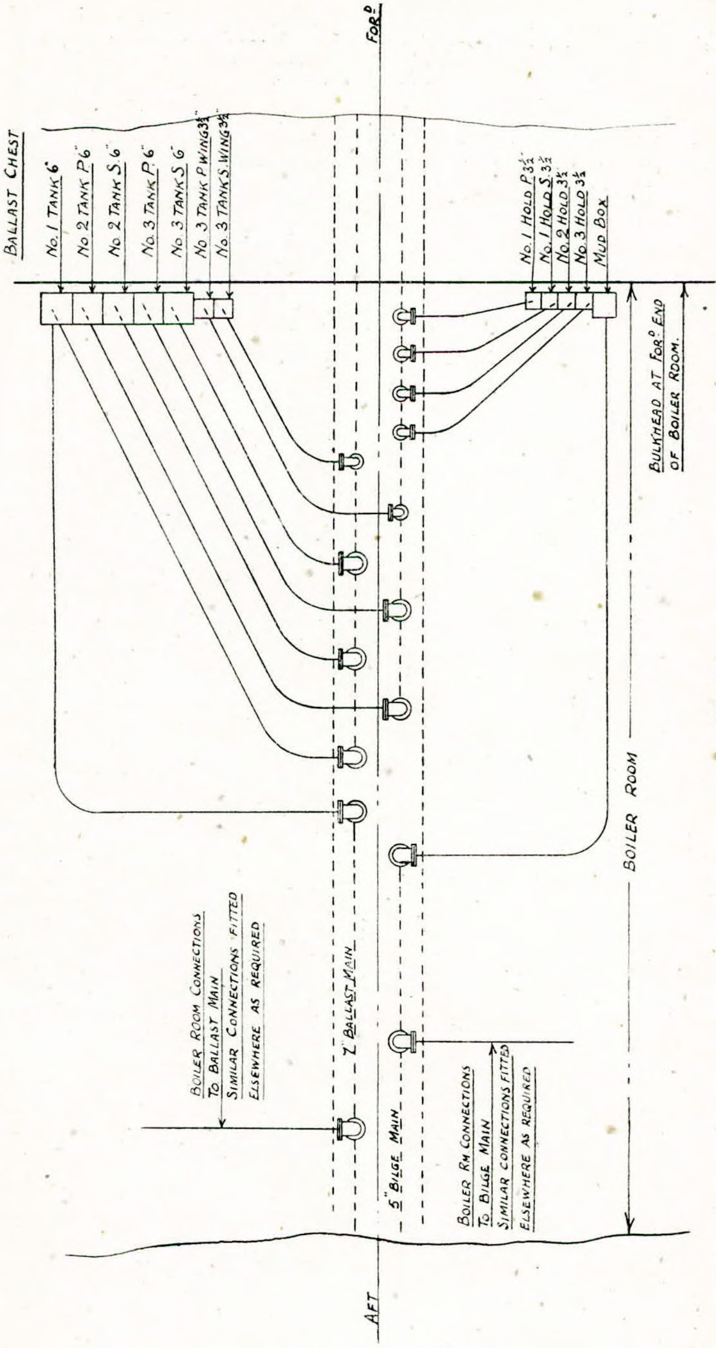

FORD
BALLAST CHEST
No. 1 TANK 6"
No 2 TANK P 6"
No 2 TANK S 6"
No. 3 TANK P 6"
No 3 TANK S 6"
No 3 TANK P WING 3½"
No. 3 TANK S. WING 3½"
No. 1 HOLD P 3½"
No. 1 HOLD S 3½"
No. 2 HOLD 3½"
No. 3 HOLD 3½"
MUD BOX
BULKHEAD AT FORD END OF BOILER ROOM.
BOILER ROOM
BOILER ROOM CONNECTIONS TO BALLAST MAIN
SIMILAR CONNECTIONS FITTED ELSEWHERE AS REQUIRED
7" BALLAST MAIN
5" BILGE MAIN
BOILER RM CONNECTIONS TO BILGE MAIN
SIMILAR CONNECTIONS FITTED ELSEWHERE AS REQUIRED
AFT

Fig. 11.

in the valuable advantages to be obtained from the adoption of the Brunton System, will readily appreciate the value of the "duct keel" idea in this connection.

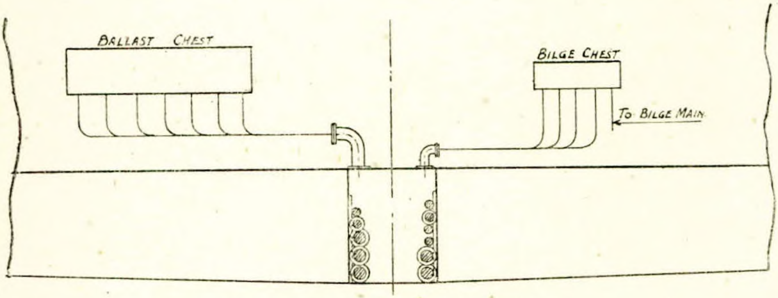


Fig. 12.

The CHAIRMAN: The subject of this paper will, after it has been studied, raise many questions and much discussion when we have the opportunity at our own premises. There may be some present to-night who would like to place questions before Mr. Spanner for his reply, and the Hon. Secretary would be glad to receive these in writing so that they might be dealt with at the meeting.

———o———

Correspondence.

From THE MINISTER OF LABOUR, Montagu House, Whitehall, S.W.1.

On behalf of the ex-service men who laid aside their careers at the call of duty, I make a strong appeal to you to aid them to fit themselves fully for the highest posts in the great professions. The Government have decided to supplement private effort by means of Maintenance Grants under the Training Grant Scheme, which has been described in the Press and elsewhere. Training for professional qualification is usually best undertaken by service in an office or works, and it is in many cases the custom to charge a premium for pupils who take up such service. More openings for training are urgently wanted, and many ex-service men cannot now afford to pay premiums.

These men have proved themselves ready to give up everything. Their sacrifice cannot be measured in money. But it can be repaid in part. I urge you to think of your debt to them as their premium, and to waive for them the usage of the profession, as many public-spirited firms have already done. For over four years the normal supply of fully trained men has been stopped or diminished. More must be obtained in the next few years than ever before, if the profession is to recover its strength and face the economic struggle that is before the whole nation. I ask you, therefore, to make room for pupils to the utmost of your capacity and to aid the Appointments Department in the work of resettlement, by telling them of what you can do to help.

R. S. Horne,

Minister of Labour.

Note.—Communications should be sent to the local office of the Appointments Department, the address of which can be obtained at any Post Office, or from the Appointments Departments, St. Ermin's Hotel, Caxton Street, Westminster, S.W.1.