ADDRESS BY THE PRESIDENT,
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*THE CONNECTION
BETWEEN MECHANICAL ENGINEERING
AND MODERN SHIPBUILDING.*

For the first time the Presidential Chair of this Institution is occupied by a Naval Architect. Marine engineering has been worthily represented by the late Mr. John Penn, who served as President for four years, 1858-59 and 1867-68. Mr. Robert Napier, distinguished both as a shipbuilder and an engineer, was elected President three years in succession, 1863-64-65. After an interval of thirty-three years you have conferred upon another representative of the shipbuilding industry the honour of serving the Institution as its President, at a notable period of its history. Entering its new and permanent home, the Institution must in many ways make new departures, if its highest efficiency and usefulness are to be realised. Those charged with the conduct of its affairs consequently have the greater responsibility. Speaking on behalf of the Council, I can assure you that no effort will be spared to advance the best interests of the Institution, and to provide for all classes of its members.

Mechanical engineering has intimate relations with all other branches of engineering. With none has it been more closely associated than with shipbuilding in recent times, and upon none has its influence been greater or more beneficial. The growth of our shipbuilding industry and the marvellous development of our mercantile marine during the last forty years are matters of common knowledge. The causes which have contributed to this supremacy are not so well understood, and the part which mechanical engineering has played is not generally appreciated. In this address my principal aim will be to indicate the directions in which shipbuilding and the working of ships have been influenced by mechanical engineering.

The total tonnage of steamships for the whole world is about 19,500,000 tons, and of sailing ships about 7,050,000 tons. The United Kingdom owns 54 per cent. of the total steamship tonnage, and 29 per cent. of the sailing ship tonnage. The British Empire owns 57 per cent. of the steamship tonnage, and over 35 per cent. of the sailing ship tonnage. Last year (1898) we launched more than a million tons of shipping which were registered in British ports as additions to our fleet.

British shipbuilding attained its highest production last year, when, according to the valuable returns issued by Lloyd's Register, the following ships were launched in the United Kingdom:— 761 merchant ships of 1,367,570 tons (gross register) and 41 warships of 191,555 tons (displacement). British Colonies launched 70 ships of 25,000 tons. During the same period all other countries launched 509 ships of 676,000 tons. The United States had an output of 170 ships and 241,000 tons; Germany 114 ships of 168,400 tons; France 57 ships of nearly 102,000 tons. The individual production of either the Glasgow, Newcastle, or Sunderland district exceeded the total output of the United States. Belfast alone launched 16 ships of nearly 120,000 tons, and the Hartlepoons and Whitby 44 ships of nearly 126,000 tons. Of the total tonnage set afloat in 1898, 70 per cent. was launched by the British Empire.

The salient facts in these returns, apart from the magnitude of the production, are the practical disappearance of sailing ships from the list of vessels launched in the United Kingdom; the almost universal employment of steel instead of iron; and the continued increase in the average size and tonnage of ships. Only 17 sailing ships were launched, averaging about 250 tons; as against 744 merchant steamers, averaging over 1,800 tons, and 41 warships, averaging nearly 4,700 tons (displacement). In 1860 the British mercantile marine included 8,242 sailing vessels of over 3,000,000 tons (net register), as against 527 steamers of 307,000 tons. At the end of 1897 the figures were 1,604 sailing ships of less than 2,000,000 tons, and 3,715 steamers of nearly 5,756,000 tons (net register). As it is estimated that the comparative efficiency of steam to sailing tonnage

is at least as three to one, it follows that, whereas the total steam tonnage of 1860 was equivalent to less than one-third of the sailing tonnage, at the end of 1897 it was equivalent to nearly nine times the sailing tonnage on the British register.

The use of iron for shipbuilding may be roughly stated to have commenced about sixty years ago. In 1850 out of 133,700 tons of new shipping added to the British register only 12,800 tons were iron and over 120,000 tons were wood. In 1860 out of 212,000 tons 64,700 tons were in iron ships. In 1868 out of 369,000 tons 208,000 tons were iron; in 1880 out of 404,000 tons 384,000 tons were iron and 20,000 tons wood. Steel was used to a very limited extent prior to 1875. In 1878 only 4,500 tons of steel shipping were classed at Lloyd's, and in 1881 41,400 tons. The total tonnage of steel ships in 1881 was less than 6 per cent. of the aggregate tonnage of iron and steel ships. In 1892 steel had reached 98 per cent.; and 99 per cent. of the new tonnage launched in 1898 was steel. Iron is now used only for trawlers and small vessels of less than 250 tons.

With the change from sail to steam and from iron to steel has come a great increase in the average size of sea-going ships; and in recent years the construction of a considerable number of very large vessels, designed either for high-speed passenger service, or for the conveyance of enormous cargoes at moderate speeds. The "Oceanic" of the White Star Line is the latest representative of the former class; and no less than six steamers of the latter class, ranging from 8,000 to 12,000 tons, were launched in 1898 in the United Kingdom.

In all these changes, as will be shown hereafter, mechanical engineering has played an important part. A close alliance between the shipbuilder and the mechanical engineer has been essential to success. British supremacy in shipowning and shipbuilding is not an accident. It has been won by the enterprise of shipowners, and by the readiness of shipbuilders to initiate or adopt improvements in materials and methods of construction, in types of ship, and in character of equipment. Forty years of continuous effort on these lines of progress have produced a mercantile marine which has been

valued by a high authority at 250 millions sterling, while its annual earnings are estimated at 80 to 90 millions. Two generations of workers have been trained since wood began to give place to iron, and sail to steam. Unrivalled experience has been acquired. We have become the shipbuilders and shipowners *par excellence* of the world. This is a proud position, which cannot be maintained without continued attention to all that makes for improvement and economy.

Foreign shipbuilders have carefully studied our methods, and in some respects may have improved upon them. It behoves us to take careful note of what is being done elsewhere, and to be ready to learn from all capable teachers. Although circumstances have changed in many respects, and in some to our disadvantage, the most confirmed pessimists have hardly dared to include our shipping interests in the lists where foreign competition has become serious or threatens soon to be so. Other nations are naturally making, and will continue to make, vigorous efforts to develop both shipbuilding and shipowning. Some of them have great natural resources in the materials for ship-construction. Judged by the favourite but often misleading method of percentages, the growth of foreign shipbuilding in Germany and the United States is rapid. Looked at in a broad common-sense way, our lead is commanding, and so far practically unchallenged. It should be maintained, if proper steps be taken to maintain it, and if both employers and workers unite in the endeavour. As our present supremacy is largely due to the development of our iron and steel industry, as well as to the great extension of mechanical labour-saving appliances in the construction and working of ships, so must the metallurgist and the mechanical engineer continue to lend their valuable aid to the shipbuilder. We should never forget the fact that in the later days of wood shipbuilding the United States—being rich in timber while we had to import largely, and having also designers who showed remarkable boldness and skill—made a bold bid for equality. In 1815 the United States possessed about half the tonnage of the United Kingdom. In 1861 they possessed nearly 5,500,000 tons of shipping, while the United Kingdom owned about 5,900,000 tons. With the change to iron,

and probably to some extent as a consequence of the Civil War, the competition died away. Now the United Kingdom owns over $12\frac{1}{2}$ millions of tons, as against about $2\frac{1}{2}$ millions of tons owned by the United States. Signs are not wanting however that our transatlantic cousins are not content with this relative standing; and we may anticipate a renewal of the old competition, which is another reason for taking heed to our methods and machinery and for neglecting no source of economy in either building or working ships.

On this occasion I do not purpose dwelling upon the remarkable improvements made in the steam-generating and propelling apparatus of modern steamships. Time is not available, nor is it desirable to make the attempt. The history of the wonderful advances made in marine engineering has been ably summarised in our Proceedings by Sir Frederick Bramwell, Mr. Francis C. Marshall, and the late Mr. Alfred Blechynden. Another chapter in this history is now nearly due, and I trust will be contributed before long by some equally competent writer. Nor can we leave unnoticed the valuable Reports on Marine-Engine Trials by our Research Committee, so ably presided over by Dr. Kennedy. It may be doubted whether any of the lines of Research promoted by the Institution has been productive of greater practical results, or more suggestive of possible improvement. While I am compelled to pass by without further notice this important section of the work of the mechanical engineer, it is only right to say that the change from sail to steam, even for the longest voyages, with all its contingent advantages, could never have been made but for the inventive genius which has economised the coal-consumption, increased the power developed from a given weight of machinery, and accelerated as well as made more regular transit across the sea.

Even with this omission, there remains a most extensive field to survey, when dealing with the influence of mechanical engineering on shipbuilding. It will be convenient to range my remarks under the two great divisions of the *Shipyard* and the *Ship*.

Mechanical Engineering in the Shipyard.

So long as wood was the principal material employed in shipbuilding, manual power reigned supreme in the largest and best equipped shipyards, including the Royal Dockyards. Machinery was used little, if at all, in the operations of shaping, fixing, combining, and fastening the various parts of ships' structures. Remarkable results were achieved under these conditions. The towering three-deckers, now serving as hulks at our great naval ports, are monuments of the constructive skill of the shipwright, based on the experience of centuries, with wood as his material and only simple hand-tools. If I may refer to my own recollections when as a lad I entered Devonport Dockyard forty years ago, it may serve to illustrate the changes that have occurred since that date in shipyard equipment. A Royal Dockyard then had its steam factory and machine shops for the repair of engines and boilers; its millwrights' shop for dealing with ship-fittings; its steam saw-mills for converting timber; its roperies with suitable machines; and special departments for block-making or other manufactures. A few steam-hammers were to be seen in the forges. Steam cranes and capstans were installed around the basins, and steam pumps were used for the docks. But, for shipbuilding proper, manual labour held its own. Individual pieces of the structure were shaped by hand, and lifted by hand-power winches, as their size and weight were not considerable. Attempts were made from time to time to introduce new machines and to diminish hand-labour. Few of these succeeded. Even in the joiners' shops wood-working machines were then but little used. One incident dwells in my memory. An experimental machine was erected for cutting out the frame timbers or "ribs" from the logs. It was ingeniously contrived to cut curved and bevelled timbers for large warships, and to relieve the sawyers from the heaviest work. After an extended trial however, in competition with the hand-sawyers, it was agreed that they could beat the machine, and its use was discontinued.

The contrast between these conditions and those now to be seen in a modern shipyard is extreme. Machinery and labour-saving

appliances abound, and are essential to rapid and economical working. With ships of increased dimensions, scantlings have become heavier, the sizes and weights of plates and bars have increased, special arrangements have had to be made for transporting and handling materials, and the power of all classes of machinery has had to be increased proportionately. In a well-equipped yard the most careful consideration is given to every step necessary in dealing with materials from their delivery up to the time when they find their places in the structures of ships. The stacks of plates and bars are so situated that the materials can be readily lifted from the trucks on arrival, or out of the depot when required for use. Travelling cranes or gantries command the whole depot. Bogies, in many cases running on light railways, convey the materials to the machine shops, furnaces, or bending slabs, where they are shaped and prepared for erection, being afterwards similarly transported to the building slips. A large number of cranes are used for handling the materials with a minimum of labour while at the machines. At the building slips also mechanical lifting appliances are freely used. Hitherto manual power has been chiefly employed in fixing and riveting together the several parts of the structure. Serious attempts are now being made to extend the use of machinery even to these portions of the work. Some of the leading firms have erected at their building slips large travelling cranes or gantries capable of moving along the length of the slips, as well as commanding the whole breadth. These locomotive lifting appliances can be used for both erecting and putting into position parts of the structure, as well as for carrying portable machine-tools. Messrs. Harland and Wolff made use of a very large installation of this kind in building the "Oceanic." Hydraulic power was chiefly employed by them, and powerful machine-riveters were used extensively, the plating being of unusual thickness. Messrs. Swan and Hunter of Wallsend, near Newcastle-on-Tyne, have adopted another plan. Shipbuilding sheds of special design have been built over the slips. These sheds give shelter to the workmen in bad weather, and facilitate many of the operations of erecting and fastening parts of the structures. They also carry a very complete arrangement of overhead electric

cranes, which travel the whole length of the slips. These cranes lift and put in place frames, beams, and plates, as well as carry certain machine-tools. At the Newport News shipyard in the United States electrical appliances have been adopted for work of a similar nature. In all these cases it is understood that the large initial outlay has been justified by experience, especially in building heavy ships. This is readily realised when it is remembered that from 7,000 to 10,000 tons of material have to be built into the largest ships of the present day, and traversed over lengths of 500 to 700 feet, as well as lifted to great heights in many cases.

Some firms are content with simpler arrangements, such as derricks with mechanical power for lifting. No doubt such devices are of real service, and they permit of easier readjustment under the varying conditions of shipyard work. Ships have grown rapidly in size, and will probably continue to do so. With more elaborate and permanent appliances there is a difficulty in foreseeing what margin should be provided, beyond the maximum requirements of the period when the appliances are designed. In the Royal dockyards, for example, and in some private yards, where sheds existed over building berths, they have had to be removed in order to provide for ships of unprecedented dimensions. I have seen cases where ordinary sheer-legs, with mechanical power for hoisting, have been found more useful for fitting armour-plates on the sides of a battle-ship than travelling steam-cranes. Facts of this nature however in no way contradict the general principle that well-considered lifting appliances are of great utility in building ships.

In the early days of iron shipbuilding the machine-tools of shipyards were comparatively few and simple, mostly borrowed from boiler-shop practice. Since then shipyard machinery has been greatly specialised, and reconstruction of plant has become necessary from time to time, in order to meet changed conditions. At first steam power alone was used. Now hydraulic, electrical, and pneumatic power are used as allies of steam power or substitutes for it.

One of the most notable hydraulic installations was described by M. Berrier-Fontaine in a valuable paper contributed to our Proceedings (1878, page 346). It was designed by one of our members,

Mr. Ralph H. Tweddell, and was set up at Toulon in the French government dockyard. Hydraulic power as a rule finds its most general use in cranes and other lifting appliances, as well as in powerful presses used for flanging, "joggling," punching out lightening holes, and other heavy work. It is also used for riveting work that can be brought to the machines, and to a limited extent for portable riveters.

Electrical power is being extensively used in some of the best equipped shipyards, apparently with satisfactory results. It is probable that it will be much more extensively employed before long. For large machines with separate motors, and for groups of smaller machines, electric driving has much to recommend it. For operations that have to be performed *in situ*, portable electrical machines are found most useful. As examples reference may be made to electric drills, planers for wood decks, cutters for large holes in plating on sides or decks, caulkers, and riveters. In some cases, especially in elaborately fitted warships, it is found advantageous to establish on board temporary machine-shops, which can be most conveniently driven by electric power. Many operations are thus rapidly and economically performed, which would otherwise necessitate the transport of fittings to and from shops in the yards. Portable electric-light apparatus for use on board ships while building is now generally recognised to be advantageous and economical. The arrangements made for lighting are readily extended to include driving the machines above mentioned.

Pneumatic power has not been much used in shipbuilding. It has found employment however for such operations as caulking and riveting. Mr. Babcock of Chicago has recently published the results of his experience with pneumatic riveters, and he is strongly of opinion that they can be advantageously adopted for work at the ships. As a rule nearly all such work is done by hand, although machine-riveting is largely used for work that can be taken to machines. Every shipbuilder would be glad to have a light and satisfactory portable riveting machine, which could be used in all the varying positions and conditions occurring in shipwork. Many attempts have been made to find a mechanical substitute for the heavy manual labour involved in satisfactorily "closing" and riveting shell

and deck plating. If this can be done, there should be a considerable economy in cost, and many disputes with workmen would be avoided. As yet success has not been attained, except with special appliances: such as have been described as erected by Messrs. Harland and Wolff for carrying hydraulic riveters, or others used for riveting garboard strakes and keels. I have seen steam riveters and electric riveters under trial, and now good things are said of pneumatic riveters. Here is an opening for the mechanical engineer, who should master the essential conditions by careful observation of shipbuilding practice, as a preliminary to his design of a suitable riveter.

In all branches of engineering it is essential to economy of production that the manufacturer should furnish materials of the dimensions and forms best adapted to combination in the structures to be produced. In floating structures such as ships, economy in weight, with adequate provision of strength, is of the highest importance, resulting in corresponding addition to carrying power and earnings. Even if economy of weight has to be obtained by increased first cost of materials, it is, as a rule, well worth having; and in many instances carries with it savings in the cost of construction. The principle is sound enough, and has long been recognised, especially in warship-building. With iron as the material, it had not nearly the same range of application as is now possible with steel. Special sections of bars and beams are readily produced in steel, which were hardly obtainable in iron. Z bars, H bars, channel bars, T bulbs, angle bulbs, and other sections, have come into general use, taking the place of built-up combinations of plates and angles with rivet connections. Economy in weight and labour is thus obtained; but special appliances are needed for working some of these special sections. With steel much larger plates are produced, and riveting is lessened. In the "Oceanic" the majority of the plates in the central portion of the vessel are said to be each over 28 feet long, about $4\frac{1}{2}$ feet wide, and from 2 to 3 tons in weight. Iron plates of 12 to 14 feet in length and 3 to 4 feet in width would have been considered of large dimensions, and the riveting work in butts and edges would have been proportionately greater than with the larger steel plates.

The shipbuilder is under great obligations to the steelmaker for this progress in manufacture ; but the mechanical engineer has had a hand in its achievement, by designing and making the machinery and plant used in the steel-works. In the device of new and more powerful machines for the shipyard his work has been more obvious. Without such machines the superior working qualities of steel could not have been utilized as is now done. Operations are now commonly performed on steel plates in a cold state that were not possible with the best qualities of iron. Flanging is extensively practised, to form stiffeners or to make connections such as were usually formed in iron ships by riveting angles on plates. The edges of skin-plating and deck-plating are "joggled," and the use of "liners" or "packing pieces" is avoided. Steel plates are bent and worked to difficult forms necessary in certain parts of ships, where castings were formerly used. Lightening holes are punched out of comparatively thick plates, and in many other ways weight and cost are reduced by the use of special machines. Many of these are worked by hydraulic power, and it is difficult to imagine a better application of that power than is seen in modern flanging and punching machines.

In concluding these remarks on shipyard machinery it may be of interest to enumerate briefly some of the principal machines now in use.

Flanging Machines.—Capable of flanging cold at one stroke plates up to 33 feet in length and $1\frac{1}{4}$ inch in thickness. Less powerful machines are used for thinner plates up to $\frac{3}{4}$ inch. Most of these machines are hydraulic.

Jogging Machines.—Capable of dealing with plates up to 1 inch in thickness ; also with angle bars. Most of these machines are hydraulic.

Shearing Machines.—Capable of shearing plates up to 2 inches in thickness ; and of dealing with Z bars and angle bars. These very thick plates occur in the protective decks of warships.

Punching and Lightening Machines.—Capable of punching at one stroke large lightening holes out of plates 1 inch thick. Also of punching rivet-holes in plates up to $1\frac{1}{2}$ inch thickness. A few can punch up to 2 inches thickness.

Bending Rolls.—Capable of bending plates 30 to 35 feet long and $1\frac{1}{2}$ inch thick.

Straightening Rolls.—Capable of dealing with plates 7 feet wide and $1\frac{1}{2}$ inch thick.

Planing Machines.—Capable of dealing with plates up to 35 feet long, or batches of plates. Some of these machines plane edge and butt simultaneously.

Bevelling Machines.—Capable of dealing with angle-bars and Z bars while hot.

Radial Drills and Countersinking Machines.—Fitted with revolving arms 8 feet long, traversing through 180 degrees: capable of drilling holes up to 3 inches in diameter, or much larger holes with special cutters. Countersinking machines can deal with 700 to 1,200 holes per hour, according to thickness of plates.

Most of the larger shipyard machines are now fitted with hydraulic lifts and cranes for dealing with the plates &c. while they are at the machine, and lifting them on and off the bogies or trucks on which they are transported through the yard.

Mechanical Engineering on board Ship.

The development of mechanical appliances for the equipment and working of ships during the last forty years is no less remarkable than that which has been briefly sketched in connection with shipbuilding. At the earlier date, apart from the propelling machinery, manual power only was employed in the largest and best found ships. Work on masts and sails, steering, loading and unloading cargo, lifting and lowering boats was all done by hand-power, aided by simple mechanical appliances. In warships the armaments were hand-worked; gun-carriages, training gear and ammunition-supply were all of the simplest character, and practically unchanged in principle as compared with those which had been used for centuries. Our first sea-going ironclad, the "Warrior," laid down in 1859, may be taken as an example of the best practice at that time. In the original design steam-power was applied, apart from propulsion, only to pumping and ash-hoisting. The pumping was

done partly off the main engines, and partly by an auxiliary engine added during the building, which also worked the ash-hoisting gear by means of chain and spur gearing. A full equipment for sailing was provided; all the work in this department was done by hand. When the vessel sailed, the screw propeller was raised out of water in its banjo frame. A weight of 32 tons had to be lifted, and this was done by means of special purchases. In working spars and boats the heaviest weights dealt with were from 5 to 6 tons. Steering was a formidable operation. Between the steering wheels and the tillers there was a multiplication of tackles to gain power, and at full speed forty or fifty men worked at the wheels and relieving tackles, even then moving the rudder very slowly, and to moderate angles. Heaving in anchors and cables was a slow and laborious operation, accomplished by fitting capstans on two decks and crowding men on the bars.

In the mercantile marine the conditions were very similar. Cargo steamers were equipped with hand-worked appliances for loading and unloading. The winches were similar in character to those used from early times in sailing ships, the lifting power being moderate, and working slowly except with light loads. Hand-power was used for cable work, steering, and working spars and sails.

Now the conditions of working are entirely changed. Mechanical power is extensively employed, manual power is minimised, comfort and habitability are enormously increased, steering is made easy in the largest and swiftest vessels, loading and unloading of cargoes are accelerated, anchors and cables are worked safely and rapidly by a few men. Without entering into details it may be interesting to glance at a few of the principal applications of mechanical power, and their influence on the working of ships.

Steering.

Steering naturally takes the first place. In the introduction of efficient steam-steering appliances, one of our Members, Mr. Macfarlane Gray, has played a distinguished part (Proceedings 1867, page 267). From him I learn that the first steps were in 1866, as the result of

difficulties that had occurred in steering the "Great Eastern," and on the suggestion of the late Sir James Anderson, who was the commander of that ship. Mr. Gray's invention of the differential gear enabled the steering engine, when placed at a distance from the navigating station, to be controlled by the movement of the steering wheel: so that the helm could be made to follow, and assume any desired position. The first trial on the "Great Eastern" was made in March 1867, and proved successful. It led eventually to the general adoption of steam-steering gear, although some time elapsed before the full advantages were realised. The Admiralty took the system up on the recommendation of Sir Nathaniel Barnaby, and applied it to the "Minotaur" class—the longest warships then afloat—where difficulties in steering by hand had occurred. No better illustration could be given of the advantages of steam-steering than are afforded by the trials of the "Minotaur." With manual power eighteen men were employed at the wheels and sixty at the relieving tackles. They took $1\frac{1}{2}$ minute to put the helm over to 25 degrees, and $7\frac{2}{3}$ minutes were occupied by the ship in turning through 360 degrees. After steam-steering was adopted, two men at the wheel put the helm over 35 degrees in 16 seconds, and the ship turned in $5\frac{1}{2}$ minutes and in two-thirds the space. For all ships such a gain in manœuvring power is of immense value; for warships the utmost handiness is essential, and their rudders are proportionately much larger and more difficult to work. No wonder therefore that nearly all steamships are now fitted with mechanical steering gear: mostly steam, in some instances hydraulic, and in a few recent ships electrical. Many arrangements have been devised subsequently for effecting the same object as was attained by Mr. Gray. Some of these are remarkably ingenious. It is but right however that he should have the credit of being the pioneer in this important change.

As an example of the latest practice in the Royal Navy, it may be stated that in a first-class battleship or cruiser there are two independent steering engines, each of which can move the rudder through 70 degrees in 30 seconds when steaming at 18 to 23 knots. The maximum turning moment on the rudder head, in the case of a battleship steaming at 18 knots, is estimated at 450 foot-tons.

Proposals have been made, and some of them have been worked out in detail, for automatically steering ships on a given course. While this is a mechanical possibility, the plan has not found favour in practice, nor is likely to do so. Under the actual conditions of navigation there is obviously a constant need for human watchfulness and control; while the maximum economy obtainable by the use of such automatic steering gear is comparatively unimportant.

Capstans, Windlasses, and Cable Gear.

Manual power has practically ceased to be used for working anchors and cables in steamships. Steam power is generally employed, hydraulic power has been used in some cases, electrical power is coming into use. Anchors and cables in the largest ships are too heavy to be satisfactorily dealt with apart from mechanical appliances, and in smaller vessels similar appliances economise labour. These appliances have to be devised in such a manner as will fit them to withstand sudden and severe shocks and stresses inevitably occurring in service; while they must be capable of controlling the cables when at anchor, or when mooring or unmooring. The details of the mechanism in modern capstans and windlasses show great ingenuity, as well as capacity for standing rough usage. The engineering firms who make a speciality of the design and manufacture of these appliances deserve great credit for what they have accomplished.

In the Royal Navy it is the practice to fit capstans so that they can be worked either by hand or by power. Taking a large battleship of 15,000 tons, the forward capstans have to deal with $2\frac{3}{8}$ -inch cables, weighing 16 tons for each 100 fathoms, and with anchors each weighing 6 tons. It is required that these capstans shall be capable of lifting 35 tons at a speed of 25 feet per minute; and this is practically tested in each ship.

In the largest classes of merchant steamers, cables up to $3\frac{1}{4}$ inches are now used; whereas thirty years ago there were few vessels with more than $1\frac{3}{4}$ -inch cables. The speed of lifting the anchors does not usually average more than 40 feet per minute.

Ventilation.

Artificial ventilation, chiefly by means of fans, is now largely employed in many classes of ships, and especially in warships. The arrangements include both supply of air to the stokeholds and furnaces, and supply to the living spaces. In some instances the living spaces are dealt with by exhaust fans, a natural supply of fresh air being depended upon. Perhaps the greatest demands arise in connection with the general adoption of systems of mechanical draught to stokeholds and furnaces, supplementing the funnel draught. All these requirements affect the work of the mechanical engineer, leading to the construction of new types of fans and fan-engines.

Electrically driven fans are now coming into extensive use on shipboard, and are an excellent application of that form of power. Cases have often occurred in warships where the introduction of a steam-driven fan for the purpose of ventilating a compartment situated low down in the hold and containing machinery has been of doubtful benefit. The effect of a better air-supply has been almost neutralised by the additional heat caused by the fan-engine and its steam connections. With electricity, difficulties of this kind can be avoided and other simplifications made, including smaller air-shafts, better maintenance of watertight subdivision, and less waste of power.

Warships, with their complicated subdivision, armament, and protection, present the most difficult problems. In them it is necessary to provide for ordinary conditions of navigation or service in very varying climates, as well as for the special condition where they are in fighting trim, with all the hold spaces below the protective deck closed down, and most of the doors in watertight bulkheads also closed. As an example of recent practice, not the latest, it may be stated that in a first-class battleship, outside the machinery and boiler spaces, there are fifteen 24-inch fans driven by electric motors, each fan being capable of delivering 1,500 cubic feet of air per minute at the end of its air-trunk. In the boiler rooms there are ten fans 6½ feet in diameter, driven by open double-acting steam engines; and in the engine rooms two similar fans.

Passenger steamers of high speed are commonly fitted with powerful ventilating appliances both for living spaces and for machinery and boiler spaces. In these vessels the conditions are simpler than in warships. Cargo steamers also require careful treatment as regards ventilation, especially with certain kinds of cargo, such as coals and oil.

Internal Lighting.

In all classes of steamships electric lighting is becoming the rule, and no better evidence of its advantages need be required. While it is most desirable in living spaces, it is practically essential to good working and efficient maintenance of machinery. For ship purposes, special water-tight fittings are desirable. In other respects the installations present no special features requiring mention. In warships the "search-light" fittings are of a powerful character. In merchant ships less powerful lights suffice.

It is probable that the general adoption of internal electric lighting will tend to a wider use of electrical power for many auxiliary purposes. A notable effect on the working of all classes of ships has been produced by the introduction of electric lights. The passage of the Suez Canal is now made by night as well as by day : ports are entered and left at night with safety : and coaling, loading or unloading, &c., proceed unchecked. In many other ways economy and speed of working are promoted.

Pumping.

Mechanical power is now universally employed for pumping purposes in steamships. A few hand-pumps may be fitted, but they are used only in exceptional circumstances or for special work. Steam-driven pumps are generally preferred. Pumps driven by electro-motors are now coming into use. For the ordinary service of ships ample pumping power is provided. In merchant ships, where water-ballast is commonly used with economical results, the pumping arrangements are specially arranged for rapidly clearing the ballast-tanks. Oil-carrying steamers have powerful pumps for dealing with their liquid cargoes.

While ample pumping power is desirable and of service in many circumstances, it is now generally agreed that the best protection against foundering is good watertight subdivision of the hold-space. The undue development of pumping power with a view to dealing with serious injuries from grounding or collision is admitted to be undesirable, since it is hopeless to attempt to meet a serious leak by pumping when there is free communication with the sea.

Lifting Appliances.

In no department has the equipment of modern ships received greater development than in lifting appliances. One of the most marked tendencies in recent construction has been increase in the size and carrying power of ships. Unless there had been a corresponding development in the means of dealing with cargo, this increase of size could hardly have occurred, and the advantages resulting therefrom would not have been realised. It is a principle in ship-designing that, as ships increase in size, the expenditure of power and fuel for a given speed becomes relatively less, and the "useful displacement" or "carrying power" becomes relatively greater. In other words, as far as sea transit is concerned, the ratio of earnings to expenses in the larger ship should be greater than the corresponding ratio in the smaller. On the other hand, it is well recognised that, unless there is quick despatch in loading and unloading cargoes, serious diminutions of earnings must result from the longer detention in port. Hence it follows that, for the complete commercial success of the larger classes of cargo carriers, lifting appliances of the most efficient character and of ample capacity are of the greatest importance. The prevision of the shipowner, in collecting the cargo and having it ready to load, would be ineffective unless the mechanical appliances were adequate.

Remarkable progress has been made by mechanical engineers in meeting these demands. Certain firms have made a special study of lifting appliances on board ship; and I owe the following summary of progress to my friend Captain Chapman, the head of one of these firms. Thirty years ago most cargo steamers were fitted with hand-power

crabs or winches, similar to those long used in sailing ships. Then came the fitting of engines to winches of the old pattern, the engines being placed diagonally. To reduce the strains on decks, and facilitate working and repairs, horizontal steam-winches were introduced. For many years these winches had cylinders not exceeding 5 or 6 inches in diameter with 10 inches stroke. The lifting barrel was about 10 inches in diameter, and took the cargo chain-runner. Two warping drums were fitted on the slow-speed shaft, while the quick-speed shaft carried "whipping" drums. Until twelve years ago four or five such winches formed the lifting equipment of a cargo steamer. Now in the largest steamers from twelve to twenty winches are fitted, besides cranes. Winches have cylinders from 7 to 10 inches diameter. They are fitted with large barrels and outer drums on the slow-speed shafts, as well as smaller drums on the quick-speed shafts. By this means five drums are made available on each winch, and by suitable arrangements of "spans" from mast to mast with falls attached, forty to fifty whips for lifting light loads may be kept going simultaneously by eight or nine winches. Steam is turned on to the winches, and they run all day except at meal times. As a rule light loads, say from 2 to 3 cwts., are thus dealt with. Heavier loads can of course be dealt with by different arrangements, say up to 6 or 7 tons.

Besides the winches, derricks are extensively used for lifting, being carried by the masts or by derrick posts. Cranes, standing upon the decks, are also largely used.

Great care is bestowed upon the details of all these appliances, in order to economise power and increase rapidity of working. With higher steam-pressures this is a most important matter, and considerable variations of pressure have to be provided for.

Cargoes of a special character—such as coal, ore, grain, and oil—require to have special arrangements made for both loading and discharge. Bulky materials, such as cotton, require to be compressed into the narrowest possible limits for storage in the holds of ships. Here again the mechanical engineer has played an important part. It is not possible nor desirable for me to dwell upon the details of coal shipping, grain elevators, ore piers and shoots, oil pumps and

storage, important as these are to the successful working of many classes of ships. American engineers have undoubtedly shown the way in many directions, quickened no doubt by the high price of labour in the United States. British engineers have done great things also, and must not always expect to be leaders in improvement, nor should they be adverse to benefiting by the work of others. In fact they must take care that British shipowners continue to have at their command the most perfect appliances for loading and unloading cargoes.

As an example of present conditions I may present the following facts, which I owe to the kindness of my friend Mr. Thomas Ismay of the White Star Line. The "Cymric" is an excellent example of a modern cargo-steamer. Her measurement capacity is about 19,400 tons, her dead-weight capacity about 12,000 tons, excluding coal. Her cargo space is divided into seven holds, each of which is subdivided into three compartments, namely 'tween decks, orlops, and lower hold. Five of these compartments are fitted as refrigerators, with a total capacity of about 2,200 tons. There are 9 hatchways, 15 derricks, 17 steam winches for cargo purposes, and mast-head "spans." The capability of these appliances is illustrated by the fact that she has commenced discharging a full cargo at 7 a.m. on Monday, completed her loading of cargo and taken on board 1,600 tons of coal, and undocked at noon on the following Friday. Loading and unloading were carried on to a great extent concurrently, about 400 to 450 men were employed, and the average rate of discharge was not less than 300 tons (weight) per hour, the corresponding rate of loading being about 250 tons. All the general cargo, apart from bulk-grain &c., was weighed at landing. When it is remembered that in such a general cargo there may be 30,000 to 40,000 packages to be dealt with, these results are evidence of both excellent mechanical arrangements and perfect organization.

The Hamburg American S.S. "Pretoria" has 14 powerful steam winches, 8 steam cranes capable of lifting 3 tons each, and is so fitted that about 40 lifts can be undertaken simultaneously.

Steam power has been principally employed hitherto for these lifting appliances. Hydraulic power has been used to a limited extent, but with complete success. Electrical power is now applied in some cases, and will probably be more extensively used in future.

Refrigeration.

This is one of the most recent, and at the same time one of the most important applications of mechanical engineering on board ship. It is not yet twenty years since the frozen-meat trade was begun between Australia and England. At the outset comparatively small cargoes were carried; but as machines were improved and experience was enlarged, so larger cargoes were carried, and a new branch of the shipping industry was created. Sir Alfred Haslam, who has done so much to develop this branch of mechanical engineering, has at my request given me some interesting facts. The first refrigerators were designed to deal with 150 tons of meat. Now machines are constructed capable of dealing with 3,000 tons, while they occupy only $2\frac{1}{2}$ times the space and consume about three times the coal required for the first machines. In 1881 about 14,000 carcasses were brought to this country from the Colonies; in 1899 it is anticipated that from 8 to 9 millions will be delivered from the Colonies and various parts of the world. In addition to dead meat, large quantities of butter, fruit, and other perishable cargoes, are now carried from the far ends of the earth, and delivered in good condition. Thanks to the enterprise of the shipowner and the ingenuity of the mechanical engineer, the British Empire is becoming self-contained and self-supporting, since the natural products of all parts of the Empire suffice to meet all needs, and the cost of conveyance across the sea is minimised by the skill of the shipbuilder and the marine engineer.

Time does not permit me even to touch upon the relative merits of various types of refrigerating machines. Cold-air machines were first used, and still find favour for use on board ship. Ammonia compression machines and other chemical machines are also used.

Nor can I do more than allude to the enormous scale to which cold storage on shore has grown. The first stores at the London Docks held about 400 tons of meat, or 16,000 carcasses. Stores now being completed at the Victoria Docks will hold about a million carcasses. The first refrigerating machine used in connection with these stores in 1880 was equivalent to the melting of 21 tons of ice

in twenty-four hours. A machine is now in construction which has about tenfold as great power.

All who travel by sea know how much health and comfort are promoted by the change in dietary made possible by refrigeration. In recent years refrigerating chambers have become a part of the equipment of the larger classes of ships in the Royal Navy. Two machines are usually fitted, each of which has to be capable of reducing the temperature of a chamber of 1,800 cubic feet capacity to 15° Fahr., and of easily maintaining this temperature when the atmosphere and sea-water are at 100° and 85° Fahr. respectively. The atmosphere in the chamber must also be kept perfectly dry.

Mechanical Engineering in Warships.

The auxiliary machinery of warships necessarily has much in common with the corresponding machinery in merchant ships. There are however many special requirements arising from their armament and equipment as fighting machines; and hence it happens that in warships the applications of mechanical power reach their fullest development. Modern warships are sometimes styled "boxes of machinery," and the description is not inapt. The tendency is, in fact, to multiply machines and to minimise manual labour, to an extent which is not universally approved. On the other hand, with modern armaments and equipment, an extensive use of mechanical power is inevitable, and the expenditure of fuel on auxiliary services grows greater in proportion to that devoted to propulsion.

Ten years ago, in a first-class battleship of 12,000 H.P. (maximum) for the propelling machinery, there were fifty auxiliary engines capable of indicating in the aggregate about 5,000 H.P. if they all worked simultaneously, which of course they did not. Today a similar statement would show a growth in the auxiliary power as compared with the propelling.

The multiplication of auxiliary services makes serious demands upon the coal supply of warships. Even in harbour the expenditure of coal is large on lighting, distilling, ventilation, air-compression, drilling with the heavy guns, and other services. From 10 to 25 tons a day may thus be expended in a large battleship or

cruiser of high speed. As warships cruise at low speeds and spend much time in harbour, it results that, taking the year through, fully as much coal is burnt for auxiliary services as for propulsion. Coal endurance being one of the most important factors in warship efficiency, facts such as these have tended to cause a doubt as to the wisdom of more widely extending mechanical appliances. It is pointed out that manual power with simple fittings, such as can be readily replaced if damaged in action, can compete with mechanical appliances in many directions; and that it is better to have larger crews in fighting ships, so as to provide a margin for inevitable casualties, than to use the alternative of labour-saving machines liable to derangement or injury and not easily repaired in action. The practical solution of the problem clearly lies in the due proportion being found between manual and mechanical appliances.

Gun construction in its modern form is largely dependent upon mechanical engineering. Our Past-Presidents, Lord Armstrong and the late Sir Joseph Whitworth, were famous as mechanical engineers before they undertook the design and manufacture of guns. In this Address however, the story of progress from the smooth-bore cast-iron 68-pounder, weighing 95 cwts., to the 110-ton breech-loading rifled gun, firing 1,800-lb. projectiles, can find no place. Nor can more than a brief glance be bestowed upon the interesting work done by the mechanical engineer in regard to appliances for mounting, working, and loading modern guns, supplying the ammunition, and securing rapidity and accuracy of fire with a minimum of labour.

Anyone who will study the breech mechanism and mounting of a hand-worked quick-firing gun will discover a triumph of mechanical engineering over a special and difficult problem. Take for example a 6-inch quick-firing gun of the latest naval pattern. The gun weighs about 7 tons, fires 100-lb. projectiles with a muzzle velocity of nearly 2,800 feet per second, and with an energy of 5,370 foot-tons, corresponding with a penetration of 22 inches of wrought-iron. Its breech mechanism is so devised that four or five aimed shots can be fired per minute. Its mounting is so arranged that the gun can be easily trained, elevated, or depressed by one man. The great energy of recoil is perfectly controlled, and the crew numbers

only four or five men. If such a gun is compared with the 68-pounder smooth-bore muzzle-loader, which I well remember, mounted on a wood truck carriage, with rude arrangements for elevating, and still ruder for training and controlling recoil, a striking illustration is obtained of the progress made in forty years with hand-worked guns.

When we pass to heavier guns worked by mechanical power, a still greater contrast appears. The 110-ton gun of 16½ inches calibre has charges of 960 lbs. of powder and 1,800-lb. projectiles. Fired with a velocity of 2,100 feet per second, these projectiles have an energy of 54,000 foot-tons, with an estimated penetration of 37 inches of wrought-iron. Obviously manual power alone would be unequal to working such guns. The mechanical engineer has devised suitable machinery which enables pairs of guns, mounted in a thickly armoured turret, to be loaded, trained, elevated, and depressed with ease and comparative rapidity under the guidance of a few men. Mr. George Rendel was probably the first, as well as one of the most successful, designers of mechanical appliances for working heavy guns by hydraulic power. Messrs. Armstrong have from the first taken a leading position in this class of work. Messrs. Whitworth, and in more recent times Messrs. Vickers, have also undertaken it on a large scale. Hydraulic power finds most favour in the Royal Navy. Abroad electrical power is now extensively used. Pneumatic power has been employed in a few cases.

Improvements in gun-design and in explosives have resulted in an increased ratio of power to weight in the latest types of guns. As a result in the latest completed battleships, guns of 12-inch calibre, weighing 46 tons, firing 850-lb. projectiles, with muzzle velocities of about 2,400 feet per second, and energies of 33,000 foot-tons have been used, instead of the 67-ton and 110-ton guns of earlier date. These reduced weights of charges and projectiles are more easily handled; and this fact, together with certain changes in the system of mounting, have enabled many of the operations of loading and working the guns to be performed by manual power as well as by hydraulic power. This duplication is obviously advantageous, and reduces greatly the risk of heavy guns being put out of action. There was a time when a return to guns of still smaller dimensions,

capable of being worked exclusively by hand-power, was strongly advocated. It was urged that it was unwise to depend at all on mechanical power, because it might fail at a critical moment. Such arguments are now but little heard. Experience does not demonstrate that any serious risk of breakdown need be feared in mechanical appliances. Moreover the advocates of manual power overlooked the fact that, supposing their system had been adopted, there must still have remained in all modern mountings and breech mechanisms many comparatively delicate parts, perhaps more liable to injury or derangement than the appliances which were objected to.

Steady improvement has been made in heavy gun mountings and in rapidity of fire. For example, with 12-inch guns from $2\frac{1}{2}$ to 3 minutes were formerly considered to be a reasonable interval between successive rounds, and in foreign navies twice that time was not thought too much; now the interval has been brought below 1 minute, when pairs of guns are loaded and fired. Loading has also been made possible with the guns in any position; whereas formerly the guns were brought to fixed hoists, and to a definite angle of elevation for loading. It is most interesting to watch the working of these heavy guns, by means of mechanisms controlled by a few men. All the operations are performed with rapidity and precision, from the moment when projectiles and charges are moved from their stowing positions in shell rooms and magazines situated deep down in the holds, up to the time when they are rammed home in the gun, the breech closed, and the gun made ready for firing. Then the captain of the barbette or turret is seen training or changing the elevation of the gun up to the instant when he fires by electricity, and the huge projectile is discharged.

Passing from guns to torpedoes, we find a fresh example of the important work done by mechanical engineers. The inventor of the automobile torpedo, Mr. Whitehead, is an eminent member of the profession. The torpedo itself is a beautiful example of mechanical engineering. All the machinery connected with air compression and storage, all the arrangements for ejecting above or below water, involve skilful mechanical design. Nor is this all. From the introduction of the torpedo has sprung the necessity for special

structural and defensive arrangements in warships; as well as the construction of the swift torpedo flotilla-boats, destroyers, gunboats and depot ships, whose performances are not merely remarkable, but suggestive of possibilities in regard to steam navigation at high speeds.

The smaller classes of boats using the locomotive torpedo have to be carried by warships. They weigh, fully equipped, 18 to 20 tons; or about three times as much as the heaviest load ordinarily dealt with in merchant ships by their own lifting gear. This has involved the design of special lifting appliances for warships. After long experience in the Royal Navy the most suitable arrangement has been found to be a strong steel derrick carried by the mast, with powerful steam or hydraulic hoists working tackles which lift the boats and top the derrick. Winches or capstans are also used in some instances for swinging the derricks. Admiralty specifications require that the lifting gear shall be capable of dealing with a load of about 18 tons lifted by a single wire-rope, as well as with a load of 9 tons raised 30 feet per minute. In one ship, the "Vulcan," built as a torpedo-depot ship and boat-carrier, instead of derricks two powerful hydraulic cranes are fitted (Proceedings 1892, page 247). She carries six steel torpedo-boats 60 feet long and of 16 knots speed, besides sixteen other boats, some of large size. The total weight of these boats is 150 tons, and they are placed 27 feet above water. The two cranes and their gear weigh 140 tons; the tops of the cranes are 55 feet above water. It required careful designing to meet such exceptional conditions satisfactorily, and to produce a stable and seaworthy ship. She has now been many years on service, and has a good reputation.

Besides these special boat-lifting appliances, warships commonly have special coal-hoists, transporters, and other gear for the purpose of accelerating the taking of coal on board. Rapidity in coaling must be of great importance in time of war; and keen competition between ships in the various squadrons as to the rates attained has led to great improvements in details of gear, as well as to remarkably rapid coaling becoming the rule in the Royal Navy. Recently at

Gibraltar the "Majestic" took on board 1,070 tons of coal in 6 hours and 10 minutes—a very fine performance.

All the larger ships in the Royal Navy have engineers' workshops fitted with a considerable number of machine-tools, which are driven by power, and are of sufficient size to deal with ordinary repairs. The "Vulcan" is a special vessel in this sense also, as she has an exceptionally well-equipped workshop, a small foundry, and a hydraulic press for forgings. For repairs of the boats she carries, or for those of torpedo-boats and destroyers in company, or for certain repairs to ships of the fleet to which she is attached, she has been found most useful. Besides being a floating factory and a boat carrier, she has a large torpedo and mining equipment and an electrical laboratory, and serves as a school of instruction for mining and torpedo work. In addition she is a swift cruiser, with a fair armament and well protected. As an armed ship she represents the fullest application of mechanical appliances afloat. Her construction was commenced in 1887. Other navies have since imitated her.

Another "Vulcan" was fitted up as a floating factory to serve with the American fleet during the recent war. She was originally a merchant steamer, but is said to have proved of great service. Naval opinion seems to favour the use of vessels of this class with fleets. It is held moreover that no modern fleet can be considered to be complete, unless the fighting ships are supplemented by ships specially equipped for distilling and storing fresh water, or carrying coals, ammunition, and reserve stores.

This rapid review of the intimate and extensive connection between mechanical engineering and the building, equipment, and working of ships, has much exceeded the limits I desired to impose, and I fear will have exhausted the patience of my hearers. Even now it is imperfect and incomplete. Enough has been said however to place beyond doubt the correctness of my preliminary statement that the alliance of the shipbuilder and the mechanical engineer has been of immense advantage to our great shipping interests. Since the maintenance of our supremacy on the sea, in both warships and merchant ships, is of vital importance to the Empire, may I not venture in conclusion to assert that the members

of this Institution, and of the profession it represents, have deserved well of their country by aiding its remarkable maritime developments?

Sir EDWARD H. CARBUTT, Bart., Past-President, said the privilege devolved upon him, as the senior Past-President present this evening, of fulfilling the duty of moving a vote of thanks to Sir William White for the able and instructive address he had delivered. As to a great part of this duty he had been anticipated by the frequent applause which had greeted the President during the course of his address and at its conclusion. At the beginning of the address allusion had been made to Robert Napier, the eminent shipbuilder. Though he had been President of the Institution for three years in succession (1863-4-5), he had once made a remark to the effect that he would rather build a fleet of ships than make a speech. The present distinguished occupant of the presidential chair had shown how ably he could design a fleet of ships; and all who had attended the Institution dinner yesterday evening had heard how good a speech he could make; while the present audience could testify how deserving of the most careful consideration was the address to which they had just listened. Sir William White he believed was rightly looked upon as one of the most remarkable men in England, or in Europe, at the present time. He had designed nearly the whole of the more recent ships in the existing British navy—at any rate, all those which had been built, or were now being built, for the re-construction of the navy; and those ships which had not been designed by him would not be able, he feared, to give so good an account of themselves in any battle in which they might be called upon to engage. Not only had the most powerful warships of modern times and the most powerful cruisers been designed by Sir William, but he had also designed some of the torpedo-boats and torpedo-catchers and ships for carrying coal; and in addition the “Vulcan,” which was really a floating engineering factory at sea, and

moreover carried, besides all her engineering appliances, a large number of boats for the benefit of the fleet. All this work had been done by Sir William White under great pressure. It was not as if unlimited time had been allowed him; but the nation looked to him to design their ships and get them ready in the least possible time. It was indeed remarkable that the most magnificent fleet which any nation in the world possessed—in fact the finest fleet which had ever been seen—had been designed in such a short time, and without a single failure worth mentioning. It was said that every man of energy met with failures; but no one could point to any ship as a failure which had been designed by Sir William White. No doubt complaints were sometimes heard of a piston valve having gone wrong, or a tube in a boiler having leaked; but amid such vast masses of machinery as had to be dealt with in the ships of the navy it could not be expected that everything would go on without an occasional hitch. Although he did not suppose any one objected to fair criticism, for which indeed sensible persons were thankful, yet he thought that many of the questions asked in the House of Commons had often been only carping criticisms, which had done no good. The Admiralty he was happy to believe had come well out of the ordeal; and if any body of men deserved the thanks of their country at this time he considered it was the Admiralty; and if any man connected with the Admiralty deserved the thanks of the nation it was Sir William White, who had done the Institution the honour of becoming their President. He therefore invited the members to join him in according the sincerest thanks, not only of the Institution, but of the whole mechanical world of England and the empire, to the President, Sir William White, for the address he had delivered this evening.

The Right Honourable WILLIAM JAMES PIRRIE, Member of Council, was glad to know that it was one of the privileges of a junior Member of Council to second the vote of thanks. He took this opportunity of assuring the members how highly he appreciated the honour; and he had to thank them for electing him to the Council, as one of the first Irishmen, he believed, who had ever had a seat on

(The Right Hon. W. J. Pirrie.)

the Council of the Institution of Mechanical Engineers. He also felt much gratified by the kindly reference which in the course of his address the President had made to his own firm in Belfast, in regard to the efforts they had made, not only towards producing the largest ship that had ever been built, but also in adopting some of the many mechanical appliances so rightly mentioned as a necessity for the construction of large ships. The only matter that he thought had possibly not been noticed in the President's hurried visit to the ship-yard in Belfast many years ago was the pneumatic riveting, which had been used there very largely indeed for the last ten or twelve years for the lighter class of work; it was only for larger sizes of plates and rivets that hydraulic riveting was used. What Sir Edward Carbutt had said of the President made him feel relieved to think that he was not a competitor in the designing of the merchant navy. He did not know that he could pay the President a greater compliment than to say that he and others of his profession should dread having Sir William White as a competitor in the designing of merchant vessels. In the merchant service however, no less than in the navy, the designers aimed at continual progress; and no sooner had his firm got a ship just ready for sea, and the trial trip finished, than they told the owners that they saw many mistakes in her, which they could avoid if they were given another opportunity. The navy of the country he was sure, and certainly the mechanical engineers, should feel proud indeed that this Institution had such a President as Sir William White. He seconded the resolution with the greatest pleasure, and was delighted to have the opportunity of doing so. He hoped he should long continue a junior Member of Council, in order to have the pleasure of seconding votes of thanks to the President in the future.

The vote of thanks was carried with applause.

The PRESIDENT believed it was an American ambassador who once, when speaking at the Mansion House, said that the man who made no mistake never made anything. He was not labouring under any illusion that he was himself infallible: for indeed he trusted that as long as he lived and worked he might be

always his own severest critic. The man who was satisfied with his work, apart from the commercial inducements which might prejudice his judgment in some cases, was to be pitied. He quite agreed with Mr. Pirrie that no one who was worthy of being called an engineer ever finished a piece of work without seeing where he might have done it better. This was particularly true of the address he had just delivered. Having many other matters pressing on his mind, he did not find it quite easy to produce the number of presidential addresses which the present year demanded of him. While he esteemed it a great honour to be asked to occupy the Presidency of this Institution, he could assure the members that he found the office no sinecure. The new year in the new house he hoped might in some respects witness new methods of usefulness; and to these matters the Council were giving their most earnest consideration. They wanted to make the fullest use possible of their increased opportunities for developing the work of the Institution; and signal as it already was, the success of the Institution, if it was to be sustained, must be sustained in a great measure, perhaps in the greatest measure, by the efforts of the members. Scattered about the country, they had an opportunity to increase interest in the Institution; and of course they would themselves reap a share of the benefits thence arising. At any rate he was sure all the members would desire that the Institution should continue to flourish, and they would all be more and more proud of belonging to it. Mr. Pirrie in his concluding words had betrayed his nationality by expressing the hope that he should long remain a junior Member of the Council. For many years it had been his own misfortune to be thought too young for the posts he had occupied; but year by year that argument was ceasing to have much force. He trusted he should live to see Mr. Pirrie high up in the Council of the Institution, and that the time would come when, if he was now the first Irishman to be a Member of the Council, he would also be the first Irishman to be President of the Institution. He thanked the members most heartily for their kind reception of him on all occasions, and for their particularly kind reception of his address.

(The President.)

There was one announcement which he had not made before, because it did not grow out of the formal business. Since the Institution last met, their friend and Past-President, Mr. Jeremiah Head, had been taken from them: a man who in his time had done a great work for the Institution, and had devoted himself to its interests, and whose death had come all too soon. Having made frequent business visits to America and other countries during his latter years, Mr. Head had never returned without bringing back with him much interesting and practical information, as the result of his own personal observation, which he had most freely communicated to the engineering profession at the meetings of this and other Institutions. In recent years in particular he had drawn attention to the great and rapid adoption in the United States of electric power for the performance of mechanical engineering work, even of the heaviest description. This was one of the salient points to which a portion of the address he had just delivered had been devoted. It was well therefore to bear in mind the memory of their departed friends, and of all they had done for those who were remaining to reap the benefit of their exertions.