The Future of the Motor Ship.

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THE introduction of the "Otto" cycle for gas-engines by Nicolas August Otto in 1876, the construction of the compact light spirit engine by Gottlieb Daimler in 1884, and the publication of his memoir, "The Theory and Construction of a Rational Heat Motor," by Rudolf Diesel in 1893, are three of the landmarks in the history of the internal combustion engine. The first led to a great extension in the use of gas-engines, the second paved the way for the motor car and aeroplane engine, while Diesel's work gave us the most efficient of modern heat engines. Just as the petrol-engine has revolutionised transport by road, so the Diesel engine bids fair to revolutionise transport by sea. Otto died in 1891, Daimler in 1900, and Diesel was drowned in the North Sea in 1913, but each lived long enough to see his work bearing good fruit.

Diesel, who was born in Paris of German parents in 1858, was induced to take up the study of thermodynamics by von Linde, and ultimately assisted Linde in his work on refrigerators. He also worked in the shops of the well-known firm of Sulzer Brothers of Winterthur, and after completing his theoretical investigations was enabled to build an experimental engine. Many interesting details of his early work were given by Diesel himself to the Institution of Mechanical Engineers in 1912, but it was his account of a 20 H.P. engine communicated in 1897, which first attracted general attention, and it was then that, upon the advice of Lord Kelvin, a Scottish firm of engineers took up the manufacture of Diesel engines. Though, like the steam turbine of Sir Charles Parsons, it found its first useful sphere in the power-houses of the day, its application to ships was only a matter of time, and after being used in various craft, a Diesel engine was fitted in the *Toiler* by the Tyne firm of Swan, Hunter, and Wigham Richardson, and in 1911 that vessel crossed the Atlantic.

The *Toiler* was but a small vessel of 3000 tons carrying capacity and 360 horse power, but she was soon followed by the *Jutlandia* and *Selandia*, engined by Burmeister and Wain of Copenhagen, and then by the British vessels *Arum*, *Arabis*, and *Abelia*, all three of which were the victims of German submarines during the War. At the beginning of the War in 1914 there were nearly three hundred Diesel-engined ships afloat. The War, however, hindered progress in this direction, but during the last year or two much greater strides have been taken, and there are now nearly 2000 motor ships of a total tonnage of 2,000,000 tons, and about half the ships under construction to-day are designed for driving by Diesel engines. It is true this 2,000,000 tons is but about a thirtieth of the world's tonnage, but the facts are significant, and many consider that what the Americans have called the "Dieselisation of the sea" has definitely set in.

How the steam reciprocating engine and the steam turbine are being displaced can be seen from the following figures, gleaned from the returns of Lloyd's Registry of shipping, which show the tonnage classed each year and the types of machinery adopted.

Year.	Steam Reciprocating Engine.	Steam Turbine.	Oil-engine.
	Tons.	Tons.	Tons.
1918–19	2,633,570	1,051,302	75,934
1919–20	2,821,031	1,286,046	79,805
1920–21	2,373,067	754,513	101,608
1921–22	1,420,524	870,037	226,552
1922–23	842,358	603,037	165,229
1923–24	610,851	99,464	164,336

In view of these facts, especial interest attaches to the presidential address of Sir Westcott S. Abell, the chief ship surveyor of Lloyd's Registry, to the Institute of Marine Engineers, delivered on February 10, and to the lecture of Sir Fortescue Flannery to the Royal Society of Arts on the following day. "The Motor Ship in the Light of the History of Marine Propulsion" was the title of Sir Westcott Abell's address, while Sir Fortescue Flannery took as his subject "The Diesel Engine in Navigation." So firmly convinced are both authors that the Diesel engine is the ships' engine of the future, that the former remarked that "the disappearance of the steam-engine from overseas trade is largely a matter of time," while Sir Fortescue Flannery said that an examination of the figures "gives support to the belief that in a comparatively short time the Diesel engine will almost wholly displace the steam boiler at sea."

Though both containing the same conclusions, the two addresses were very different in character. Starting with the point of view that the Diesel engine has demonstrated its reliability—an essential feature in any marine engine—Sir Westcott Abell discussed what he termed the economic efficiency of the motor ship. At present, Diesel engines cost much more than steam machinery, and the cost of the oil per ton is enormously greater than the cost of coal per ton. But the reduction in the amount of fuel expended is so great that "with the present availability of and cost of oil fuel there is a distinct margin in profit in favour of the Diesel-engined ship compared with the coal-fired boiler and the steam-engined vessel." Sir Westcott's figures and diagrams illustrate this point, for with a ship of 8000 tons deadweight carrying capacity, the oil-engined ship can carry 10 per cent. more cargo than the steamship. Discussing the mechanical and thermal efficiencies possible with modern machinery, Sir Westcott Abell comes to the conclusion that even with the heavy Diesel engine at present fitted, where only 5 B.H.P. is obtained for every ton of machinery, "the principal economic gain arising from the introduction of the Diesel engine has already been obtained." The problem now is "to devote considerable attention to obtaining the maximum simplicity, gaining thereby in reliability and ease of maintenance." Also, there are the auxiliaries, in which many improvements can be made. Among the diagrams illustrating the address is one showing the decline of the sailing-ship and the rise of the steamship, and it will be interesting to see if the Diesel engine supersedes the steamship in the same way.

The crowded lecture-room of the Royal Society of Arts and the gathering of distinguished shipowners, shipbuilders, and engineers on the occasion of Sir Fortescue Flannery's lecture were ample testimony to the importance of the subject. The interest of the occasion was increased by the presence in the chair of Lord Bearsted, the pioneer of the present-day system of carriage of petroleum in bulk in tank steamers. The lecture was a review of the introduction of the use of oil and the action of the Diesel engine, and contained explanations of the types of Diesel engines, of which there is a somewhat bewildering variety. Compared with a good steam plant, which uses about 1·8 lb. of coal or 1·4 lb. of oil per B.H.P. per hour, the Diesel engine burns about 0·4 lb. Apart from the saving in the fuel bill, a Diesel-engined ship can go farther afield or more cargo can be carried. All early motor ships had twin screws, but experience has shown the oil engine to be reliable and single screws are now being fitted where suitable. Sir

Fortescue Flannery dealt with the main points in the different designs of single-acting and double-acting, and of four-stroke and two-stroke engines such as the Burmeister and Wain, North British, Tosi, Vickers, Werkspoor, Doxford, Fullagar, Polar, and Sulzer, and also of that most interesting development, the Still engine, which is a Diesel engine and steam-engine combined. Developments are still proceeding with rapid strides towards the double-acting type and the consequent increase of power in proportion to the weight, but there is at present no approach to the standardisation such as is attained in the triple-expansion engine.

During the course of the evening, Lord Bearsted read a characteristic letter on the oil question from the late Lord Fisher, written in 1911, and he also gave some figures respecting the oil-engines suitable for a light cruiser. The cruiser, it is true, would have a speed of 26 knots as against a speed of 28 knots of her sister ship with steam machinery, but she would have a very much greater radius of action. He seemed to think that the Admiralty has not done so much as it might to further the progress of the oil-engine for propulsion.

In the discussion that followed, Engineer Admiral Sir Robert Dixon, the Engineer-in-Chief of the Fleet, recalled the work done in the Navy on the Diesel engines for submarines and referred to the experimental plant founded at West Drayton. Before an oil-engined battleship is feasible, however, the Diesel engine must give far more power for its weight than those in existence at present.

It may be remarked that even the late Lord Fisher would scarcely have cared to command a light cruiser of 26 knots, even if fitted with oil-engines, when trying to overtake an enemy ship of the same class wth a speed of 28 knots. In building the famous *Dreadnought*, a thousand tons in weight and 100,000*l.* in money were saved by the adoption of steam-turbine machinery, but there seems little prospect at present of doing anything similar by the adoption of Diesel engines in a man-of-war.

The Effects of Posture and Rest in Muscular Work.[1]

THE problems of muscular activity have been investigated for many years from an academic viewpoint, yet it is only in recent times that a demand has arisen for the application of exact means of measurements of the physiological cost of muscular work in industry. The Medical Research Council's report for the years 1923–24 states that "The studies of muscle function which were almost notorious for their supposed uselessness to the student or physician have laid down basic knowledge which now underlies many parts of medical science and art, and are beginning to remove empiricism from practical studies of physical training and of industrial labour."

The output of energy of an individual may be calculated by measuring the amount of oxygen and carbon dioxide present in the expired air, and from these data the physiological cost of the work can be assessed. This method of estimating the "cost" of work or muscular activity places at our disposal a means of comparing the efficiency and capacity of the human machines under different conditions.

Two methods are available for the measurement of energy output—(*a*) direct and (*b*) indirect calorimetry. The unit of measurement used is the large or kilo calory. In direct calorimetry the individual is enclosed in a special chamber so constructed that the heat given off is measured. The apparatus is also arranged for the collection of the expired air, so that direct and indirect calorimetry may be combined.

In indirect calorimetry the subject wears a mouth-piece fitted with two valves. One valve serves for inspiration, while the other valve allows the expired air to pass down through a wide tube into a rubber bag, which the subject carries during the experiment. The expired air can be drawn off and analysed in a Haldane apparatus. The ratio of carbon dioxide given off to oxygen absorbed can then be obtained, and from these data the heat units are calculated. If the measurements are carried out on the subject at rest and during work, an exact estimation can be made of the energy required for this particular task.

In a recent publication of the Industrial Fatigue Research Board on "The Effects of Posture and Rest in Muscular Work," Miss E. M. Bedale has investigated the energy expenditure of a woman carrying loads in different positions. Miss Bedale has used the indirect calorimetric method for estimating the physiological costs of the work. It is shown from the measurements made that the energy expenditure varies with the position in which the load is carried. The physiological cost of carrying with a yoke is low and involves less physiological disturbance than any other. The experiments suggest that the continuous carrying of a load exceeding 35 per cent. of the body-weight is likely to cause rapid impairment of working capacity. A series of photographs of the different modes of weight-carrying bring out the importance of the study of body posture. Some of the methods, if used continually, will rapidly lead to body deformities, with impairment of the normal physiological functions. The use in industries of methods least injurious to the body would be an aid in the prevention of disease, and undoubtedly lead to greater efficiency. The results of further investigations will be awaited with interest. The data collected will tend to remove empiricism from studies of industrial labour, and will give a standard of measurement more accurate than that of output.

Prof. E. P. Cathcart contributes a preface which deals in a clear and concise manner with methods of measurement, and points out the pitfalls which beset the investigator in work of this type.

In the same publication, Dr. H. M. Vernon gives the results of an investigation on "The Influences of Rest Pauses and Changes of Posture in the Capacity for Muscular Work." The conclusions drawn by Dr. Vernon suggest that the promotion of circulation plays an important part in the prevention of fatigue, the value of a rest pause being increased if the worker moves about during the interval. Postural changes during work are shown to be as necessary as rest pauses if efficient work is to be carried out.

An interesting point is raised concerning the effect of additional movements during muscular work. The application of motion study to industrial processes has resulted in the elimination of many unnecessary movements and a marked increase in output. The results now obtained suggest that the removal of too many unnecessary movements may be too drastic, and even better results might be obtained if a few extra movements, sufficient to promote circulation, were allowed. The proof of this suggestion will probably only be obtained by investigating each process separately by the old method of trial and error.

[1] Medical Research Council: Industrial Fatigue Research Board. Report No. 29: "The Effects of Posture and Rest in Muscular Work: (*a*) Comparison of the Energy Expenditure of a Woman carrying Loads in Eight Different Positions," by E. M. Bedale; (*b*) "The Influence of Rest Pauses and Changes of Posture on the Capacity for Muscular Work," by Dr. H. M. Vernon. Pp. 55. (London: H.M. Stationery Office, 1924.) 2*s.* 6*d.* net.