SESSION 1911-1912

President: THE MOST HON. THE MARQUIS OF GRAHAM, C.B., C.V.O.

The British Association

PORTSMOUTH MEETING,

August 30 *to September* 6, 1911.

The British Association for the Advancement of Science met this year at Portsmouth, the meetings extending from August 30 to September 6. A feature of the gathering was the large number of foreign men of science who were present. The numerous papers read were of a high order and the meetings were well attended. In his opening address, the President, Sir William Ramsay, F.R.S., touched upon many matters of importance, although public attention was mainly directed to his remarks upon our coal supply. Extracts, which are of great interest to marine engineers, are given from this address and from some of the engineering papers read before the Association.

THE STORED-UP ENERGY OF RADIUM.

Sir William Ramsay, whose name is principally associated with researches and discoveries in connexion with radium, naturally devoted some of his remarks to that subject, and in the course of his address said :—

Attention has repeatedly been drawn to the enormous quantity of energy stored up in radium and its descendants. That in its emanation, niton, is such that if what it parts with as heat during its disintegration were available, it would be equal to three and a half-million times the energy available by the explosion of an equal volume of detonating gas—a mixture of one volume of oxygen with two volumes of hydrogen. The major part of this energy comes, apparently, from the expulsion of particles (that is, of atoms of helium) with enormous velocity. It is easy to convey an idea of this magnitude in a form more realizable by giving it a somewhat mechanical turn. Suppose that the energy in a ton of radium could be utilized in 30 years, instead of being evolved at its invariable slow rate of 1,760 years for half-disintegration, it would suffice to propel a ship of 15,000 tons, with engines of 15,000 horse-power, at the rate of 15 knots an hour, for 30 years—practically the lifetime of the ship. To do this actually requires a million and a half tons of coal.

Exhaustion of the Coal Supply.

We have in this world of ours only a limited supply of stored-up energy ; in the British Isles a very limited one—namely, our coalfields. The rate at which this supply is being exhausted has been increasing very steadily for the last 40 years, as any one can prove by mapping the *data* given on page 27, table D, of the General Report of the Royal Commission on Coal Supplies (1906). In 1870 110 million tons were mined in Great Britain, and ever since the amount has increased by three and a-third million tons a year. The available quantity of coal in the proved coal-fields is very nearly 100,000 million tons ; it is easy to calculate that if the rate of working increases as it is doing our coal will be completely exhausted in 175 years. But, it will be replied, the rate of increase will slow down. Why ? It has shown no sign whatever of slackening during the last 40 years. Later, of course, it must slow down, when coal grows dearer owing to approaching exhaustion. It may also be said that 175 years is a long time ; why, I myself have seen a man whose father fought in the '45 on the Pretender's side nearly 170 years ago ! In the life of a nation 175 years is a span.

This consumption is still proceeding at an accelerated rate. Between 1905 and 1907 the amount of coal raised in the United Kingdom increased from 236 to 268 million tons, equal to six tons per head of the population, against $3\frac{1}{2}$ tons in Belgium, $2\frac{1}{2}$ tons in Germany, and 1 ton in France. Our commercial supremacy and our power of competing with other European nations are obviously governed, so far as we can see, by the relative price of coal ; and when our prices rise, owing to the approaching exhaustion of our supplies, we may look forward to the near approach of famine and misery.

Different Sources of Energy.

The British Science Guild has enlisted the services of a number of men, each eminent in his own department, and each has now reported on the particular source of energy of which he has special knowledge. Besides considering the uses of coal and its products and how they may be more economically employed, in which branches the Hon. Sir Charles Parsons, Mr. Dugald Clerk, Sir Boverton Redwood, Dr. Beilby, Dr. Hele-Shaw, Professor Vivian Lewes, and others have furnished reports, the following sources of energy have been brought under review :—The possibility of utilizing the tides ; the internal heat of the earth ; the winds ; solar heat ; water-power ; the extension of forests, and the use of wood and peat as fuels ; and lastly, the possibility of controlling the undoubted but almost infinitely slow disintegration of the elements, with the view of utilizing their stored-up energy.

However interesting a detailed discussion of these possible sources of energy might be, time prevents my dwelling on them. Suffice it to say that the Hon. R. J. Strutt has shown that in this country at least it would be impracticable to attempt to utilize terrestrial heat from bore-holes ; others have deduced that from the tides, the winds, and water-power small supplies of energy are no doubt obtainable, but that, in comparison with that derived from the combustion of coal, they are negligible ; nothing is to be hoped for from the direct utilization of solar heat in this temperate and uncertain climate ; and it would be folly to consider seriously a possible supply of energy in a conceivable acceleration of the liberation of energy by atomic change. It looks utterly improbable, too, that we shall ever be able to utilize the energy due to the revolution of the earth on her axis, or to her proper motion round the sun.

Attention should undoubtedly be paid to forestry, and to the utilization of our stores of peat. On the Continent the forests are largely the property of the State ; it is unreasonable, especially in these latter days of uncertain tenure of property, to expect any private owner of land to invest money in schemes which would at best only benefit his descendants, but which, under our present trend of legislation, do not promise even that remote return. Our neighbours and rivals, Germany and France, spend annually £2,200,000 on the conservation and utilization of their forests; the net return is £6,000,000. There is no doubt that we could imitate them with advantage. Moreover, an increase in our forests would bring with it an increase in our water power; for without forest land rain rapidly reaches the sea instead of distributing itself, so as to keep the supply of water regular and so more easily utilized.

Various schemes have been proposed for utilizing our deposits of peat; I believe that in Germany the peat industry is moderately profitable; but our humid climate does not lend itself to natural evaporation of most of the large amount of water contained in peat, without which processes of distillation prove barely remunerative.

Means of Economizing Coal.

We must therefore rely chiefly on our coal reserve for our supply of energy and for the means of supporting our population; and it is to the more economical use of coal that we must look in order that our life as a nation may be prolonged. We can economize in many ways—by the substitution of turbine engines for reciprocating engines, thereby reducing the coal required per horse-power from 4 lb. to 5 lb. to 1½ lb. or 2 lb.; by the further replacement of turbines by gas engines, raising the economy to 30 per cent. of the total energy available in the coal, that is, lowering the coal consumption per horse-power to 1 lb. or 1¼ lb.; by creating the power at the pit mouth, and distributing it electrically, as is already done in the Tyne district. Economy can also be effected in replacing "beehive" coke ovens by recovery ovens; this is rapidly being done; and Dr. Beilby calculates that in 1909 nearly six million tons of coal out of a total of 16 to 18 millions were coked in recovery ovens, thus effecting a saving of two to three million tons of fuel annually. Progress is also being made in substituting gas for coal or coke in metallurgical, chemical, and other works. But it must be remembered that for economic use gaseous fuel must not be charged with the heavy costs of piping and distribution.

Methods of Concentrating Energy.

The two great principles which I have alluded to in an earlier part of this address must not, however, be lost sight of; they should guide all our efforts to use energy economically. Concentration of energy in the form of electric current at high potential makes it possible to convey it for long distances through thin and therefore comparatively inexpensive wires; and the economic coefficient of the conversion of mechanical into electrical, and of electrical into mechanical energy is a high one; the useless expenditure does not much exceed one-twentieth part of the energy which can be utilized. These considerations would point to the conversion at the pit-mouth of the energy of the fuel into electrical energy, using as an intermediary turbines, or preferably gas engines, and distributing the electrical energy to where it is wanted. The use of gas engines may, if desired, be accompanied by the production of half-distilled coal, a fuel which burns nearly without smoke, and one which is suitable for domestic fires, if it is found too difficult to displace them and to induce our population to adopt the more efficient and economical systems of domestic heating which are used in America and on the Continent. The increasing use of gas for factory, metallurgical, and chemical purposes points to the gradual concentration of works near the coal mines, in order that the laying-down of expensive piping may be avoided.

An invention which would enable us to convert the energy of coal directly into electrical energy would revolutionize our ideas and methods, yet it is not unthinkable. The nearest practical approach to this is the Mond gas-battery, which, however, has not succeeded, owing to the imperfection of the machine.

It may be remarked that this subject engaged the attention of the members in October, 1902, when the Hon. Secretary, Mr. Jas. Adamson, read a paper on "Our Fuel Supply," in which he stated:—

"According to the mean of various approximated computations, our stock of known fields of coal would last for about 400 years. Since these computations were made the consumption and output have materially increased, and if they continue to increase the end is approaching all the more rapidly." The following methods of restricting the consumption of coal were mentioned: (1) Economizing in the burning of coal. (2) Adopting the best methods of utilizing the products of combustion. (3) Utilizing to the best advantage the elements, whether steam, water or electricity, brought into service from the fuel. (4) Maintaining in the highest efficiency the machinery whose motion is directly due to the fuel expended. (5) Testing and adopting other fuels as substitutes for coal. (6) Testing and utilizing the refuse heaps from mines, where such exist, for certain purposes where a high evaporative power is not of such moment as in a steamship. (7) Experimenting with and testing the refuse from sewage works, with a view to making use of the combustible portions.

The question was referred to by Dr. J. Bell Simpson at the annual general meeting of the Institution of Mining Engineers at Cardiff on September 13. Dr. Simpson referred to the statement of the President of the British Association as to the duration of our coalfields, and said while it was true some areas would be exhausted before others, there was every reason to believe there were many districts in which more coal would be discovered. The new explorations in the neighbourhood of Doncaster led them to consider whether it was within the bounds of possibility that the Yorkshire coalfield might extend from the neighbourhood of Doncaster to the Ferryhill district of the South Durham coalfield. Some of our scientific associations seemed to be much alarmed at the duration of the British coal supplies, but he thought it would be more useful if they applied themselves to discover the means of getting more out of coal than was done at present. It was said we only got out one-tenth of the specific heat of coal ; and scientists should endeavour to improve this and find out means of utilizing some of the wasted products in the burning and use of coal. The mining engineer of the present day and the future had great problems to solve, and he felt sure when the time came for working at Plutonic depths, he would be found equal to the emergency.

The Rolling of Ships.

Professor J. H. Biles, as President of the Engineering Section, delivered an address on the rolling of ships at sea. He remarked that engineers had thought that if a vessel had a certain metacentric height and a certain range of positive stability she was quite safe from the action of a series of waves of any kind known to exist, but the occasional mysterious disappearance of ships in circumstances which led to the assumption that they had capsized rendered it desirable to review the grounds of this belief, to see whether there was any known possible combination of circumstances that might cause disaster. After describing the investigations on the problems of rolling carried out fifty years ago by Mr. W. Froude and at a later date by Mr. R. E. Froude and Colonel Russo, of the Italian Navy, he summarised as follows :—

1. With wave-slopes of 3·6 degrees the angles of maximum roll obtained by them in the Revenge with bilge-keels may be taken at 22 degrees.

2. This roll takes place when synchronism exists between the wave and the ship, when the wave is 910 feet long and 18½ feet high, and has a wave-slope of 3·6 degrees.

3. Waves exist which are of this length, but which may have a height of 50 feet and possibly more, and a wave slope of 10 degrees.

4. In such steeper waves we should expect to get much larger angles of roll.

5. Each ship has peculiarities of rolling due to its form as well as to its lading and bilge-keels, etc.

6. These peculiarities, and the effect they have upon rolling, and the effect different waves will have upon the rolling of the ship, can best be studied experimentally.

He mentioned that it had been his intention to bring before the section the results of an experimental study on lines similar to those followed by the last-named investigator, but extended to a wide range of types of ship, waves, and resistance ; but though the apparatus was practically complete an accident had incapacitated him from carrying out the work proposed.

Electric Drives for Screw Propellers.

A paper on " Electric Drives for Screw Propellers " was read by Mr. H. A. Mavor, in the course of which he said :

Various methods of making the required adaptation of generator to propeller are at present under trial. For this, mechanical gearing by toothed wheels or hydraulic transmission may be considered serious competitors with electric transmission, but for large powers it seems reasonable to expect that electric transmission, which is already developed for this very purpose on land, is likely to find an equally useful field where the conditions are such as to require an intermediate device at sea.

The cost, weight, and efficiency of electric transmission compare favourably in the examples which have been examined with either of the two competing methods. There are other important qualifications of electric transmission in which it stands altogether unrivalled. The most important of these qualifications are :—It provides a ready means of reversing the direction of rotation of the propeller without changing the direction of rotation of the power-generator.

The electric transmission also provides means for changing the speed ratio between generator and propeller, so as to permit of the power of the generator being developed under the most favourable conditions at all speeds of the ship.

Lastly, it provides means for applying the power of one or more engines to one or more propellers, so that the power-generating units may be so disposed as to give the highest efficiency, and when they are not required they can be stopped. These properties of the electric transmission supply exactly what is required to render steam-turbines, and also internal-combustion engines, completely adaptable to the purpose required. Both types of power-generators give their best efficiency when full speed of rotation is maintained, even when running below full power. It is, therefore, advantageous to keep the engine revolutions within the range of governor control, while the required speed change is accomplished by electric combinations.

The properties of the electric motor lend themselves well to the requirements of manœuvring. The rate of reversal is under perfect control.

The author gave the following examples of the application of the system, together with a description of a small vessel built to demonstrate and illustrate the principles of operation and to provide experience in the use of the plant. In all cases alternating 3-phase currents are used, and interlocking devices connect mechanically the main reversing switches with the existing switches, so that no change can take place in the connexions while they are passing currents.

Description of the Turbo-Electric Steamship "Frieda," for American Owners.—This vessel has been specially designed for the transport of bulk freights between the Gulf of Mexico and New York City. The vessel is to be 300 feet long, and will carry a dead-weight of approximately 5,000 tons, at a mean loaded speed of 12 knots at sea. The propelling machinery is aft, and consists of a turbo-electric outfit for 1,500 kw. three-phase 50 cycles when running at 3,000 revolutions per minute. The turbine is supplied with steam at a pressure of 200 lb. per sq. in. at the turbine stop-valve. This electric generating plant is arranged on foundations on a platform deck in the engine-room, and the condensing plant in the engine-room hold. The condenser is fitted with a vacuum augmenter, and is suitable for dealing with the full-load quantity of steam from the turbine. The vacuum obtained will be 28½ in., with cooling water about 85 deg. Fahr. This condensing plant consists of a vacuum condenser, three-throw air-pumps, and centrifugal circulating pump with electric-motor drives. The current is led to a three-phase motor, which is keyed direct to the main propeller shaft, and is capable of developing 1,900 brake horse-power at a speed of about 84 revolutions per minute. The steam is generated in two Scotch boilers, with Howden's forced draught, and liquid-fuel burners. This installation costs and weighs less than the normal equipment. The coal saving is over 10 tons per day. The design of the ship itself presents many other novel features. This design was prepared by Messrs John Reid and Co., 17, Battery Place, New York City.

Oil-Electric Tank-Barge for Canadian Service.—In this the system is applied to the propulsion of a 245-ft. Canadian canal-type tank-barge for the Standard Oil Company of New York. The equipment consists of three separate units of Diesel non-reversible oil-engines, each capable of developing 200 shaft horse-power, each directly connected to an alternating-current generator. The currents from one or all of the units are led to the separate windings of a three-phase motor, keyed to the main propelling shaft, and operating a single slow-turning screw. The great advantage and economy of this system consists in being able to run at full power or at one-third power using one or three engines at full-load economy at will, thus providing for an economical operation impossible with any other propulsive system. The fact that non-reversible oil-engines are used running under governor control greatly simplifies the maintenance and operation. The control is operated by a low-tension interlocking switch, operated by an ordinary engine-room telegraph stand located in the pilot-house, so that manœuvring of the vessel is at all times in the hands of the navigating officer. This equipment increases the cost of the ship about 10 per cent., above the normal, but the carrying capacity is very largely increased.

Marine Turbo-Electric Installation Proposed for United States Navy Colliers.—A marine turbo-electric installation has been submitted to the United States Navy Department for adoption in one of the four large colliers recently given out to contract. The installation consists of a steam turbo-alternator of 5,000 kw., with condensing plant ; the current is led to two motors, one being keyed to each propeller shaft. The machinery is right aft in the vessel. The steam is generated by Scotch boilers. The vessels in which it is proposed to instal this machinery are 525 feet long, and will carry a dead-weight of 12,500 tons of coal at a speed of 16 knots at sea. Here, again, the cost, weight, and economy are better than can be shown with the normal reciprocating-engine equipment.

The Diesel Oil Engine.

An interesting paper on the Diesel Oil Engine was given by Mr. Charles Day, Wh.Sc. After stating and dealing in detail with the various factors upon which the economical generation of power for industrial purposes was dependent, he said :—

The great difficulty most buyers find is in securing reliable figures of power costs from people engaged in trade, except in the case of electric-supply stations. The writer does not know of any body of large power-users who systematically prepare accounts showing their power costs on a uniform basis, and publish them. This practice in connexion with electric-supply stations fortunately does give an independent and authoritative basis, from which valuable deductions can be made. The figures published in the *Electrical Times* cover practically almost all the supply stations in Great Britain, and this information combined with information obtained direct from station engineers has enabled the author to determine the average results obtained in such stations with different types of plant. These averages for stations having a plant capacity not exceeding 1,000 horse-power are as follow :—

TABLE I.—*Average Cost per B.T.U. Sold.*

Type of Engine.	Fuel.	Lubricating Oil, Waste, Stores, and Water.	Wages.	Repairs and Maintinance.	Total Works Cost.	Load Factor.
Steam .	0·45	0·06	0·25	0·26	1·02	14·7
Gas . .	0·43	0·09	0·28	0·24	1·04	15·3
Diesel .	0·23	0·04	0·19	0·07	0·53	14·3

The limit of 1,000 horse-power was fixed owing to there being as yet no large electricity supply stations equipped solely with Diesel engine or gas-engines.

The author afterwards described the Carnot cycle, giving the conditions required for a perfect heat engine, and proceeded :—

This cycle appears to be quite an impossible one, because during the one portion of the compression heat must be perfectly carried away—i.e., the working fluid and the surrounding materials must be perfect conductors. Then during the second portion of the compression no heat must be carried away or added, meaning that the materials must now be perfect non-conductors ; thus, one part of the compression period demands perfect conducting materials, whilst the other demands that they shall be perfect non-conductors, and similarly for the expansion period. With these opposing conditions it is not surprising that no application of the Carnot cycle appeared in practice for so long. Diesel, however, propounded a scheme which, to a certain degree, met the Carnot conditions. This scheme was as follows :—

The isothermal period of compression was obtained approximately by spraying water into the cylinder during compression, this water-spray being discontinued for the adiabatic compression. For the isothermal expansion fuel-oil was sprayed in to give the requisite addition of heat. The spraying in of fuel-oil for this purpose necessitated the adiabatic compression being carried to a high degree, so as to give a sufficiently high temperature to the air in the cylinder as to cause ignition of the oil sprayed in. Unfortunately, this cycle did not meet with success in practice owing to the very high pressure required, and to the small amount of work obtained, and gradually the original cycle has become modified to that now adopted, which may therefore be claimed to be the nearest to the Carnot cycle, which present-day practical limits admit. Briefly it is as follow :—

1. During the suction stroke air is drawn into the cylinder.

2. During the compression stroke this air is compressed to a considerable pressure and temperature.

3. For a short period during the next stroke oil is sprayed into the cylinder, and burns in consequence of the high temperature to which the air has been raised by compression. During the remainder of the stroke expansion takes place.

4. The products of combustion are exhausted.

The heat efficiency of the Diesel engine, though far from perfect, is still much better than any other heat-engine, as is readily seen from the fuel consumption, which is 0·44 lb. of fuel oil per brake-horse-power per hour. The fuel consumption is also low at partial loads—viz. :—

¾ load,	0·45 lb.	per B.H.P.	per hour.
½ ,,	0·47 ,,	,,	,,
¼ ,,	0·64 ,,	,,	,,

These are not records, but every-day figures, and are for engines of quite moderate size. With larger engines the fuel consumption per horse-power is rather lower, but increase of size does not give anything like the improvement in fuel consumption that occurs with steam-engines. This is a point to be remembered when fixing the size of engine to be adopted in a station. With steam plants the size of engine should be kept up, whilst with internal-combustion engines the size within certain limits can with advantage be kept down.

Owing to the high economy at light loads it is often found distinctly advantageous to run a Diesel engine in preference to using a storage battery.

From the description of the cycle the following advantages are obvious as compared with other gas and oil-engines :—

1. There is no sparking apparatus, lamp, or burner.

2. There is no carburettor, vaporiser, or mixing valve.

3. Owing to the absence of combustible gases or vapours during compression, back-firing or pre-ignition are impossible.

4. No warming-up is required, nor is there any fuel expenditure when not running.

5. The running of the engine is very smooth, owing to there being no explosion or sudden rise of pressure.

The oil generally used is residual petroleum—i.e., the residue left from petroleum after the lighter oils have been distilled off. The increased demand for petrol will certainly tend to increase the further supply of residue; whilst the opening up of new oil-wells in various parts of the world is steadily increasing the oil supplies. Not only is residual petroleum used for Diesel engines, but residue shale-oil and gas-works tar-oil are now much used.

The fuel oil used can be almost any of the fuel oils which are used for boiler-firing, and a wide variety of oils can be used with no alteration of the engine; this being probably explained by the fact that a pulverizer which will sufficiently pulverize a thick viscous oil can easily pulverize the thinner oils. The use of oil fuel carries with it certain advantages in the way of ease of handling and of cleanliness. With coal it is difficult to avoid dust, and this must be particularly objectionable in the case of steam plant, where the engines are carried on the boilers, thus placing a considerable quantity of moving machinery in the neighbourhood of the coal. With oil there are no ashes to cart away, and thus handling of gritty materials is entirely eliminated. Usually the oil is pumped from an outside storage-tank to the small tanks near the engines.

The question may naturally be asked whether Diesel engines are suitable for long periods of continuous running. In reply to this the following instance may be quoted:—

At the Birkdale Electricity Works a Mirrlees-Diesel was put down a little over four years ago. The station engineer recently made a return which showed that the engine had, on the average, worked $23\frac{3}{4}$ hours out of every 24 hours throughout the four years, or an average stoppage of about $1\frac{1}{2}$ hours each Sunday.

Numerous cases could be given of large savings effected, but the figures already given substantially prove this, and are perhaps more appropriate for a paper of this kind.

Diesel engines of the Mirrlees make have been fitted on board many warships and first-class cruisers, for driving dynamos: also some have been used for boat propulsion.

Electrical Steering.

Mr. B. P. Haigh, in a paper on "Electrical Steering," said that electrical steering offered considerable advantages for steamers as well as for vessels propelled by internal combustion engines, for the improved economy corresponded to a saving of weight in boilers and fuel. Difficulty had been experienced in obtaining a trustworthy system of control, capable of dealing with the power necessary to put the helm hard over in emergency in the shortest possible time, and possessing sufficient sensitiveness to enable an accurate course to be kept by moving the rudder promptly in small angles. Sensitiveness was shown by absence of "time lag" between the movement of the hand-wheel and the corresponding movement of the rudder, and in this respect electrical gears promised an improvement on steam gears. Sensitiveness also required an absence of undue "idle travel" of the hand-wheel, but a certain small amount was nevertheless desirable. The steering motor might be started and stopped for every motion of the rudder, but preferably it was kept running continuously, mechanical control being introduced either in the form of hydraulic transmission or of magnetic clutches. In the latter two magnetic clutches were employed, fitted at opposite ends of the motor; and, as no gearing was kept continuously in motion, the wear and tear, as well as the current required, were reduced to a *minimum*. The clutches prevented the shock of the sea from being transmitted to the electrical system, and as they had considerable flywheel effect, the current taken by the motor did not fluctuate widely under normal conditions, and the steering gear might therefore be supplied from the ship's lighting generator. To economize power it was advantageous to arrange the gear so that greater leverage was obtained when the rudder was hard over than when amidships, and by doubling the leverage in this manner a saving of 30 per cent. might be made in the motor power.

Drawings were shown of a steering gear suitable for an $11\frac{1}{2}$ in. rudder-post, and of a smaller gear of the same type, built by Messrs. Brown Brothers and Co. (Limited), of Rosebank, Edinburgh, suitable for a 7 in. post. When tested against an artificial hydraulic load the latter gear developed a torque of 50 ft.-tons at the rudder-post and showed an efficiency of over 50 per cent. at half-load. It was found capable of moving the tiller through 70 deg. in 25 seconds, and it responded to motions of the hand-wheel equivalent to 1 deg. of helm.

Other valuable papers read under this section were on "Crude-Oil Marine Engines," by Mr. J. H. Rosenthal; "Over-Type Superheated Steam Engines," by Mr. W. J. Marshall, and "Suction Gas Engines and Producers," by Mr. W. A. Tookey.

The following were then elected at the meeting of Council held Thursday, September 7, 1911.

As Members.

F. T. Addyman, Plymouth.
Chas. H. Boddey, Shirehampton.
Lewis Crow, Cardiff.
R. H. Dawson, Gorleston.
E. C. Farmer, Gillingham.
J. T. Grearson, East Ham.
J. W Henry, Cardiff.
J. P. Jackson, Antwerp.
E. J. Jeffery, Gillingham.
Walter Johnston, Glasgow.
R. F. Jones, Althorne.
Alex. Lawrance, B. Sc., London.
W. G. McIntyre, Tientsin.
J. A. McKechnie, Shanghai.
Jas. Ormiston, Hong-Kong.
P. G. Pavlides, Athens.
Jas. C. Russell, London.
Harry Smith, East Indies.
G. C. Southron, London.

As Assoc. Member.

H. Llewellyn Rees, Liverpool.

As Companion.

S. H. Abbott, London.

Transferred from Assoc. Member to Member.

Frank Shearman, Penarth.

Transferred from Graduate to Assoc. Member.

H. K. Drewry, London.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1911-1912

President: The Most Hon. The Marquis of Graham, C.B., C.V.O.

Vol. XXIII.

DISCUSSION ON MODERN DEVELOPMENTS IN BRITISH AND CONTINENTAL OIL ENGINE PRACTICE

By Mr. E. SHACKLETON (Assoc. Member),

Monday, October 2, 1911.

Chairman: Mr. ALEXANDER BOYLE (Vice-President).

ADJOURNED DISCUSSION

Monday, October 9, 1911.

Chairman: Mr. JOHN McLAREN (Vice-President).

ELECTION OF MEMBERS

INSTITUTE OF MARINE ENGINEERS

INCORPORATED

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President: The Most Hon. The Marquis of Graham, C.B., C.V.O.
Hon. Treasurer: A. H. Mather. *Hon. Secretary:* Jas. Adamson.

Members of Council:—
Chairman: J. T. Milton.
Vice-Chairman: George Adams.

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A. E. Battle.
J. Blackett.
P. T. Campbell.
W. E. Farenden.
J. Hallett.
J. Lang, R.N.R.
W. Veysey Lang.
H. Ruck-Keene.
J. H. Silley.
E. W. Ross.
F. M. Timpson.

Conveners of Committees:—

Jas. Adamson, Awards.
Jas. Adamson, A. E. Battle, Papers.
Jos. Blackett, Property.
W. E. Farenden, Press Cuttings.
J. G. Hawthorn, Library.
A. H. Mather, J. McLaren, Recreation.
E. W. Ross, Reading Room.
F. M. Timpson, Issue of Transaction .

J. G. Hawthorn and J. Lang, *Joint Conveners, Junior Section.*
J. Clark and W. Veysey Lang, *Joint Conveners, Experimental Dep.*
George Shearer, *Representative on Advisory Committee, Board of Trade.*

Vice-Presidents:—

P. J. Adie (Buenos Ayres)
W. Birkett (Bombay).
A. Boyle (London).
W. Brock (Dumbarton).
W. J. Willett Bruce (Liverpool).
P. Caird (Greenock).
J. Dewrance (London)
T. W. Fish (Antwerp).
W. G. Gibbons (Edinburgh).
Sir A. Seale Haslam (Derby).
J. G. Hawthorn (London).
A. R. Hislop (New Zealand).
Summers Hunter (Newcastle).
A. Isakson (Stockholm).
A. L. Jones (Kobe, Japan).
R. Leslie, R.N.R. (London).
Eng. Rear-Admiral E. Little, R.N. (Royal Navy).
James Macdonald (Hong-Kong).
J. McLachlan (Paisley).
Duncan Maclean (Singapore).
John McLaren (London).
J. H. Mancor (New York).
W. J. Pratten (Belfast).
J. W. Richardson (Hull).
Alexr. Rolland (Fiume).
Jas. Shirra (Sydney).
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Jas. Weir (Glasgow).
R. Williamson (Cardiff).
J. E. Wimshurst (Southampton).

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SESSION 1911–1912

President: The Most Hon. The Marquis of Graham, C.B., C.V.O.

Modern Developments in British and Continental Oil Engine Practice

READ BY

Mr. E. SHACKLETON (Assoc. Member),
Monday, March 20, 1911.

DISCUSSION,

Monday, October 2, 1911.

Chairman: Mr. ALEXANDER BOYLE (Vice-President).

Chairman: Before proceeding with the business of the evening, I should like on this, the opening meeting of another session, to congratulate the members on the excellent position to which the Institute has attained and the very good work which has been done during the past year, and I think we may look forward with confidence to maintain that rate of progress, and even to accelerate it, as time goes on. I should also like, at the risk of repeating what I have said on previous occasions, to point out the great value to marine engineers of the papers read at our meetings, especially papers on subjects not coming within the everyday experience of the majority of our members; and the advantage cf hearing papers read on such subjects and the opportunity of taking part in the discussions, if only by asking a question on some detail which may not be quite clear, is a very great advantage indeed, and one which, I think, might be utilized to a larger extent than it is, especially by the younger members. The papers before us to-night, on "Modern Developments in British and Continental Oil Engine Practice" and on "Notes on Two-Cycle Oil Engines," are, I think, both cases in point, that is, cases to which my remarks refer. For instance, every marine engineer who has been taking an intelligent interest in what has been going on in his own profession, must, I imagine, have a general knowledge of the principles of internal combustion engines, at least in some one or other of their various forms, and is aware of the vast strides which have been made during late years in their construction and use, and also of the possibilities and advantages which are claimed for them as propelling engines in sea-going vessels. It is surely a fact of the greatest interest to marine engineers that oil engines are in being, and have been constructed to take the place of steam engines in sea-going ships, and I consider it is of the highest importance to marine engineers that they should have, not only a general knowledge, but also an intimate knowledge of the details of such engines, and that they should know what is being done and what is proposed to be done in regard to this question now confronting us. This brings me to the point which I wish to mention again, and that is the value of the Institute in giving the members an opportunity of hearing such papers and having discussions thereon. It is, I think, an excellent opportunity of acquiring the most up-to-date ideas and knowledge on the subject. Last week, in an evening paper, I saw it mentioned that a vessel, the *To ler*, with oil-engines had made a passage across to America, and this morning, in the *Standard*, I found a very interesting article about this oil-propelled ship. I might just read one or two of the points to you. I know nothing about the vessel beyond what is here given, but it is worth while to take notice of this article from a daily newspaper, because many engineers have not really accepted the fact that the oil engine for marine purposes is now with us, and gentlemen whose opinions on this subject are very valuable have assured me that it has come to stay.

The article states :—"The *Toiler* has created a record by being the first oil-propelled vessel to cross the Atlantic, and her voyage from the Tyne to Nova Scotia is notable for another reason. Hitherto only small vessels have been fitted with internal combustion engines, but at the present time a whole fleet of large motor ships is being built in Europe, and the

Toiler's record is the opening incident of a striking development in shipbuilding." The writer afterwards goes on to say: "At the present time ten of these ships are being built in Europe and nearly all are larger than the *Toiler*. The most important is a large passenger and cargo boat being constructed on the Clyde by Messrs. Barclay, Curle & Co., Ltd., for the East Asiatic Co. of Copenhagen. She will be equipped with three 2,000 horse-power engines." He then goes on to an account of the *Toiler*, pointing out that she carries a cargo of 2,700 tons, and is driven by two sets of Diesel engines developing 400 horse-power, with a fuel consumption of less than two tons of oil per day, and contrasts this with the coal consumption of an ordinary steam engine of the same horse-power. The speed was slow, because the vessel was intended for the Canadian canals, where high speed is not allowed. The point I wished to direct your attention to is that this vessel has crossed the Atlantic solely propelled by oil engines, which is a notable occurrence, and that a number of ships of considerably larger size are being built and fitted with Diesel oil engines. I understand that Mr. Shackleton, whose paper you have before you, has prepared some additional remarks as an introduction to the discussion, which I shall now call upon him to read.

INTRODUCTION TO DISCUSSION BY MR. E. SHACKLETON.

REGARDING the construction of Diesel type engines, it would appear to the author that nobody should attempt to dictate to the engine builders the particular types of engine to be built for marine purposes, strength of crank-shaft, size of scavenging pump, etc., etc.

Existing formulæ may be applied to steam engine practice in these particular matters, but to attempt to apply it to internal combustion engines as represented by Diesel engines is easily misleading. Such hard and fast lines can only be laid down after at least 100 engines have been built and run for a year. Probably it has not occurred to those who have attempted to indicate in which direction the marine engine builders ought to proceed, that they should first obtain a consensus of opinion from well-known internal combustion engineers of repute; besides, if they had first investigated the building of gas and oil engines for stationary work alone, they would have found such huge diversity in crank-shaft strength among the various makers, together with other details, such as would cause serious consideration before rushing to formulæ.

As far as the author is aware, in the case of one eminent firm of gas-engine builders they have in sizes between 50 and 200 B.H.P. in the last ten years made over 100 varying sizes of crank-shafts, fly-wheels of varying strengths and varying designs, all on engines with an output of equal B.H.P. The author considers that the reliability of the new marine oil engine will have to be left largely in the hands of the oil-engine builders for some years to come, after which time probably the new generation of experts will, by a series of evolutions, have become specialized internal combustion engineers. What one would have desired to have heard more of from the various authorities concerned with shipbuilding supervision would be the size and strength of the bed or sole plate proposed compared with steam, whether the same would be wrought-iron, mild or carbon steel and if crystallization of these parts had entered into calculations. It appears to the author that great changes in the personnel of the official staff will be the result of the installation of internal combustion engines of high power for marine work.

As far as the author is aware, however, engineers who have had practical experience and are acquainted with gas engines, ordinary oil engines, producer gas and heavy oil engines, combined with the elements of marine practice and the adoption of these engines to marine work, are few; but on a further investigation, if an engineer was desired who was able to put in a nutshell the whole reason that had underlain the present oil-engine development, which of necessity involves an extensive knowledge of a series of makes of these motors, it is to be candidly admitted that whosoever tries to find one such will indeed be endeavouring to find a *rara avis*.

Generally speaking, regarding revolution speed of Diesel system motors, except in the case of exceedingly high power units, of the two evils, propeller efficiency, or a lower engine efficiency, it appears desirable to lose a little in propeller efficiency and have a higher revolution engine, as there is reason to believe that lower speeds do not permit of such satisfactory combustion conditions and to an extent involve greater heat losses to water jacket, and tend towards dirty or tarry deposits in the piston, even in engines not using heavy oil fuel. In the matter of compression also, whilst a low one, say 350–400 lb. per square in., has advantages in keeping the mean expansion pressures within lower limits, the trouble to be confronted is that immediately the fuel varies from the free burning to the sluggish residuum oils, bad combustion ensues, with resultant sticky and dirty deposits on cylinders, pistons and valves. At slow speeds the trouble is further aggravated, and as variable speeds are part and parcel of marine work it is by no means to be ignored. The author does not claim that the oil motors under review will show an all-round fuel cost-saving in comparison with steam and where coal is purchased at 8*s*. to 10*s*. a ton. It is more reasonable to assume that the saving on actual fuel costs may be as low as 10 per cent. or as high as 40 per cent., according to the respective costs of fuels. The results afforded by the *Toiler* and *Vulcanus* afford some confirmation of this, and according to the recent paper by Mr. Rosenthal, the *Vulcanus*, of 1,900 tons, 480 B.H.P. engines consume 1 ton of fuel oil per 100 knots. Although the Diesel engine normally is a slow burning engine without violent shock, such conditions may occasionally prevail, due to bad handling in starting or running, whereby the Diesel engine becomes an explosive engine due to an excess of oil injection to the working charge. Except in the hands of competent engineers, the variable admission of fuel may cause severe shocks to the engine, but it is not anticipated that such conditions would often prevail. The author feels that the lubrication features of these engines should have attention, and regrets that statements that these engines require 10–12 per cent. of the amount of lubricating oil in proportion to that of fuel should be made by responsible individuals. If such were indeed the case, then the Diesel engine would certainly be an expensive one in this direction.

It is useless to argue that Diesel engines are quite as economical as steam, but they should not largely exceed, considering that they are higher speed engines than steam with other factors. A thorough investigation into lubrication should be made both as to consumption and general results, as in many instances a lubricant not equal to a first-class gas engine oil is employed, and the most economical and suitable lubricants, compound oils, i.e., oils containing suitable percentages of fatty oils, are strangers to Continental builders of Diesel engines. Having in mind the very extensive adoption of this class of lubricant in this country for use in gas engines, oil engines and automobiles, it certainly affords food for reflection. Apparently the impression has gained ground that as the Diesel engine can use almost any class of cheap fuel oil it can also be lubricated by any cheap lubricant that is available. A most serious error. It is to be borne in mind that Diesel lubrication is more severe than ordinary gas, e.g., piston lubrication as in gas or oil engines of the ordinary type ; the highest temperature is attained at about the moment of ignition, the piston largely covering the cylinder walls : not so with the Diesel, which by virtue of the slow propagation of the flame exposes for a considerable length of the stroke the walls of the cylinder to flame which acts upon the lubricant employed. A reasonable calculation as to lubricant consumption would be about 1 per cent. of the fuel consumption.

Since the author read his paper in March the following have definitely decided to build or are building Diesel engines in addition to those in the list then given :—

Harland & Wolff, Ltd., Belfast.
Sir W. G. Armstrong, Whitworth & Co., Ltd.
Cammell, Laird & Co., Ltd.
Richardson, Westgarth & Co., Ltd.
Fairfield Shipbuilding & Engineering Co., Ltd.
Clyde Shipbuilding Co., Ltd.
Vickers, Ltd., Barrow.

The F.I.A.T. Co. in Italy have also built a set of marine Diesel engines, The Polar Diesel Co., whose licensees in this country are Messrs. Swan, Hunter & Co., whilst Messrs. Burmeister & Wain, Stockholm, are delegating the building of a set to Messrs. Barclay Curle & Co. Whiteinch, Glasgow.

According to Mr Rosenthal's paper, the time occupied in reversing a 300 H.P. set was as follows :—

Full ahead to full astern	$=3$ seconds
Full ahead to stop	$=2\frac{1}{2}$ seconds
Stop to full ahead	$=2\frac{1}{2}$ seconds

Messrs. The M.A.N. have built for the Hamburg-Amerika Line and the Woermann Line double acting engines two cycle, of a new type for installation in vessels. As matters now stand it would appear that the following builders are foremost in marine oil engine construction : M.A.N., Sulzers, Carel Frères, Nederlandsche Fabriek.

A new type of Diesel engine is being built on the Continent on the Ochelhauser principle to designs by Professor Jonkers, but no details are available.

Reference to the engines more or less of secondary importance has therefore not been attempted, although engines of the "Körting," "Brons," "Sabathe," "Guldner" and a number of Danish engines are interesting examples.

ADVANTAGES OF THE HORIZONTAL M.A.N. DIESEL ENGINE.

The M.A.N. Co. decided about two years ago to place horizontal Diesel Engines on the market after having acquired an unrivalled experience in the building of vertical Diesel Engines and after having made exhaustive experiments with the new type in their own works.

The exceedingly favourable experience which they acquired with more than half-a-million Brake Horse Power of horizontal High Power Gas Engines in operation, convinced them that the Diesel engine also in horizontal arrangement, at least for the larger sizes, would possess many valuable points over the vertical type. The success attending the introduction of their horizontal engines has exceeded all expectations, which statement is best proved by the fact that of about forty Diesel engines with outputs of 400 B.H.P. and over, which have been ordered from them since the beginning of this year, about 65 per cent. were of the horizontal and only 35 per cent. of the vertical type. It is their firm conviction that as early as next year the proportion for larger engines will be still more in favour of the horizontal type. A great number of their customers who have vertical engines in operation, selected horizontal engines when sending repeat orders.

The outstanding advantages of the horizontal Diesel Engines may be briefly summarized as follows :—

1. *Lower Price.* Output and number of cylinders being equal and the engine being of the same slow-speed, heavy duty and substantial design, the weight and the manufacturing costs of the horizontal arrangement are lower than of the vertical type, at the same time having equally favourable fuel consumption and possessing the same longevity. Naturally all the experience gained by them in the manufacture of about 250,000 B.H.P. of Diesel Engines has been incorporated to the fullest extent in their horizontal design.

2. *Easy Survey and Convenient Attendance.* Whereas with

a large vertical engine at least one attendance platform is necessary in order to render all parts of the engine accessible, the entire horizontal engine can be attended from the engine house floor, which is a very desirable point, especially when starting. It is, besides, easily possible for the engineer to keep an eye on the entire engine room from one position. In particular, however, the dismantling of the horizontal engine for inspection and cleaning purposes can be carried out with greater facility and convenience than with a vertical engine. For example, the piston can be withdrawn from the open end of the cylinder within a few minutes without the necessity of removing the cylinder head and a large number of the gearing parts as in the case of the vertical engine. Quite apart from the appreciably longer time occupied in withdrawing the piston of a vertical engine, care must be taken to see that when reassembling the gearing parts they fit exactly into one another. This is not essential with the horizontal arrangement as there is no necessity for detaching any of the moving parts.

3. *Silent Running and Slight Wear and Tear.* The inlet and exhaust valves are worked by means of eccentrics and rolling levers in such a way that two inlet and two exhaust valves are actuated by one eccentric only, so that for a four-cylinder engine only two eccentrics are necessary for actuating all inlet and exhaust valves, whilst for the same operations the vertical engine requires eight cams. By the use of rolling levers and eccentrics, the valves open and close quite smoothly, whereby the re-action on the lay shaft and driving wheel is very small, so that not only does the engine run with the minimum of noise, but the wear and tear on the gearing is very small. Again, when the eccentric has become worn out, it is only necessary to re-adjust the eccentric strap without thereby influencing the timing of the valve. With cam gearing the re-adjustment is impossible.

4. *Better distribution of the stresses on the crankshaft and main bearings as well as lubrication.* With a vertical engine the pressure on the bearings resulting from the weight of the flywheel and the explosion pressure are both exerted in the same direction, whilst with the horizontal arrangement the two stresses have different directions. At every explosion the crankshaft is, in the case of the horizontal engine, forced against the front bearing steps and as the explosion pressure is much greater than that exerted by the weight of the flywheel,

the crankshaft is at the moment of the explosion almost lifted from the lower steps, thereby rendering exceedingly good lubrication of the main bearings possible. As a consequence of this, the wear and tear on the main bearing is comparatively slight, the more so, as with larger engines we employ the circulating system of lubrication for the main bearings and crank-pin steps, which system is known to be the most positive and automatically operating one. It might here be mentioned that only the lubricating oil running off the main bearings and crank-pin takes part in the circulating lubrication, whilst that dripping from the cylinder and piston pin is caught separately, such oil not coming into contact with the oil of the main lubricating system. This cannot always be accomplished in the same thorough practical manner in the case of the vertical engines. In addition, the main bearings of the horizontal engine are much more accessible and can be examined at all times, whilst with the vertical engine, the accessibility of the main bearings is not so great in consequence of the engine frame. It is also well-known that the lubrication of the piston of a vertical engine is more difficult to effect than that of a horizontal engine. The unavoidable residues of burnt lubricating oil (oil coke) in the cylinder are, in the case of the horizontal engine, pushed backwards into a cavity situated below the cylinder bore, wherefrom they are blown out by the blow-off valve every time the engine is stopped. On the other hand, with a vertical engine, those residues make their way downwards between piston and cylinder, thus causing seizing of the upper piston rings.

5. *Pressure at right-angles on the cylinder.* By proportionate dimensioning of the bearing surface of our pistons and by selecting the ratio between length of connecting rod and radius of crank as about 6 :1 in spite of the fact that the weight of the piston is constantly acting on the sliding surface, they have succeeded in keeping the main specific pressure on the cylinder just as low as in the vertical engine. Further, their pistons are re-adjustable so that no knocking takes place when the pistons become slightly worn.

(Maschinenfabrik Augsburg-Nurnberg A.G. London Office: M.A.N. Caxton House, Westminster, S.W.)

Mr. Shackleton: It may be of interest regarding the Diesel engine generally, to say that as far back as 1892–93

Messrs. Crossley Brothers experimented with that engine for over two years. Apparently they did not see much hope for it in this country and decided that they would not take up its manufacture. It is evident that they did not see the great future before this engine, and I regret to think that at the present moment very few of the gas engine makers feel inclined to manufacture it. I believe there is a possibility at an early date of one of the larger companies entering the field, but it is quite as hard to get the gas engine makers to make oil engines as to get the marine engineers to consider the adoption of such an engine in their boats. I may mention that another firm in Scotland has an oil engine vessel in hand, the Ardrossan Shipbuilding Co.

The Hon. Secretary then read the following communication received from Mr. WALTER POLLOCK (Member) :—It is with great interest that I have read Mr. E. Shackleton's paper on the important subject of Marine Oil Engines. The main point is whether there is, and will be, economy by adopting the oil engine for marine purposes; undoubtedly the advantages and economy are being more and more established every day, as shown by the rapid strides the business is taking. Mr. Shackleton in his paper makes a special point of bringing forward fuel consumption and the kind of fuel consumed as the oil engine makers' road to success, but I venture to state that coupled with this very important item deep consideration should be given to simplicity of design, handling arrangements and lubricating.

For an engineer to design and construct an engine capable of running on Admiralty fuel oil and reducing the fuel consumption to ·5 of a lb. per B.H.P. per hour, he has accomplished very little if his engine is so complicated that it requires an expert to handle and attend to. Moreover, the excessive wear of working parts mostly with non-adjustable bush bearings must necessitate a large overhaul bill and the use of more lubricating oil, which has not had sufficient attention paid to it. Heavy items in the repair bills of steam engines for marine purposes are, as all our members know, due to the heavy strains set up by eccentric straps, valve gear, rods and valves, both of the piston and the flap type, and also to air circulating and feed pumps, auxiliary machinery repairs and boiler scaling—a set of marine machinery that can effectively dispense with and delete such items would minimize the working costs and therefore add to its value. In November 1909 many members inspected a Bolinder Crude Oil Engine installation that carried out this desideratum. It is surely agreed that an engine, if complicated, will have to save a lot in the way of fuel economy to make up for the previously mentioned items.

For illustration an actual case in point may prove of interest. Take the canal service in the British Isles. It is a very economical company that can run a canal barge carrying about 30 tons under 11*d.* per mile, and yet I have a test case of where a similar canal barge fitted with a 15 B.H.P. motor can do this work in half the time, at a cost of $3\frac{1}{2}$*d.* per mile, including depreciation of the motor reckoned at the high figure of 10 per cent. per annum. On this score, how can the oil engine industry fail to develop into an enormous business. Look for an instant at the following figures, worked out on practical lines :—

STEAM DRIFTER *v.* MOTOR DRIFTER.

	Steam.			Motor.		
Capital Costs (estd.)—	£	*s.*	*d.*	£	*s.*	*d.*
Cost of hull	1,400	0	0	1,175	0	0
Steam machinery 160 I.H.P.	1,100	0	0	—		
Motor 60 I.H.P.	—			1,100	0	0
Total cost ready for working, exclusive of netts	£2,500	0	0	£2,275	0	0
Working Costs (estd.)—						
Interest, 6 per cent. per annum . .	150	0	0	136	10	0
Depreciation, 8 per cent. steam ; 4 per per cent. motor	200	0	0	91	0	0
Insurance, $5\frac{1}{2}$ per cent.	137	10	0	125	2	6
Annual superintendence.	30	0	0	20	0	0
Cost of boiler, scaling and repairs . .	25	0	0	—		
Cost engine repairs	25	0	0	15	0	0
Extra, cost tail repairs, due to engine racing	12	10	0	—		
Lubricating oil	10	0	0	5	0	0
Engine packing	10	0	0	3	0	0
Fire bars	15	0	0	—		
Stores	6	0	0	3	0	0
Cost of crews' wages, seven and six, at £2 per week each	14	0	0	12	0	0
Cost of fuel, 465 tons of coal at 16*s.* per ton per 24 hours for 143 days . .	372	0	0	—		
Cost of paraffin, 165 tons at an average of £2 10*s.* per ton per 24 hours for 143 days	—			387	5	0
Time cleaning out boiler, per annum, over and above overhauling engines.	22	10	0	—		
	£1,029	10	0	£797	17	6

ADVANTAGE OF MOTOR OVER STEAM.

(*a*) First cost, £225.
(*b*) Running cost per annum, £231 12*s.* 6*d.*
(*c*) Starting engines from cold to full power, 20 minutes instead of 5–6 hours.
(*d*) Taking fuel on board at third or fourth berth from quay with long fuel pipe.

Although oil engines are only in their infancy as far as commercial adoption is concerned, the following list of vessels (excluding yachts and other pleasure craft) have been constructed or are actually under construction for Bolinders Crude Oil Engines alone in this country.

One coaster with	320	B.H.P.	motor.
,, ,, ,, ...	120	,,	,,
,, tanker ,, ...	80	,,	,,
,, ocean-going barge with.	50	,,	,,
,, coaster with	80	,,	,,
,, dock store boat with	40	,,	,,
Two fishing boats with	24	,,	,,
,, canal barges with	15	,,	,,
One fishing boat with	120	,,	,,
Nine canal barges with	15	,,	,,
One ocean-going barge with	30	,,	,,
One barge with	25	,,	,,
,, coaster with	24	,,	,,
Two barges with	20	,,	,,
One canal barge with.	10	,,	,,

No doubt other Members can give particulars of commercial vessels now under construction or completed and thereby enable the Institute to know actually what progress is being made, as so many people think that only one or two vessels are only being constructed. I have met many engineers who have asked for proof of reliability and of instances of propelling work, and to that fund of information I would contribute the following—

(*a*) *Bolinders VII*, a wooden fishing vessel of the Swedish type, has navigated under her own power in less than 3 years over 1,800 miles.
(*b*) Barge *Travers*, 21 days, non-stop run from Havana to Trinidad.
(*c*) *Bolinders*, fishing vessel, built in this country this year, four months' fishing on the East coast without touching anything in connexion with the motor.

A great feeling of unrest seems to be created by the assumption that a gear must be relied upon for reversing, but this greatest of all difficulties has been overcome by Messrs. Bolinders with their direct reversible engine and by other makers, who alter the direction of rotation by compressed air or other means.

Of course the question of racing propellers has always been battled with, but I maintain even the effect of releasing and applying the load on the engine caused by the action of heavy seas on a vessel has been overcome in the modern oil engine by a positive governor. I thoroughly endorse Mr. Shackleton's general views of this all-important subject, and congratulate him on the forcible way in which he has brought out his points in favour of the oil engine, which should do a great deal to help forward this industry, as it will shortly affect ten times as many vessels as the steam turbine has done.

Mr. F. M. Timpson: I might say that the last remarks of Mr. Shackleton regarding the construction of marine oil engines are, in my opinion, entirely wrong, and not in keeping with the view of those who have gone deeply into the subject. In the course of a conversation the other day with a gentleman connected with a firm having a large boat running, he said they found it better to place the work in the hands of marine engineers. There were slight difficulties at first, but these have been quite overcome, and they have now placed an order for a larger set of engines with the same firm. These are continental engines. Most of the discredit attached to the marine motor industry has arisen through land engine makers manufacturing marine engines with no knowledge of the details of marine service. There was an amount of failure when such manufacturers took motor-car practice, etc., and endeavoured to apply it to marine work without a knowledge of the service conditions. I think it is by the marine engineers that these engines will be developed and not by the land engine makers, as the author states, although the principles come from the latter. With regard to the merits of the two types of reversing engines, I think it is fairly well established among those interested in marine work that the best reversing engine is the two-cycle engine with air impulse; there is an amount of doubt concerning the type with manipulation of the fuel injection. It is suitable enough for the small sizes, but for the rest those interested do not seem to be inclined to accept that percentage of doubt. In regard to the question of horizontal engines, I hardly think they will be considered for marine service. There is not the requisite breadth of ship to allow for easy overhauling, and they are deficient mechanically. As to the difficulty of overhauling the vertical engine, I do not see that such a difficulty exists. In the motor-car type of engine it is common to make the main parts in large complicated castings, while marine practice demands easy access and freedom for overhauling. Then again, there has been a complication of gear over the cylinder heads, while these should be as clear as possible. In regard to lubrication, two-cycle engines in small vessels are being run on a very small amount of oil, about one pint for eighteen miles—this is an average of two years' running. No doubt the internal combustion engine is the coming engine, and there seems to be a tendency towards adopting either the semi-Diesel or the whole type. The semi-Diesel offers advantage in lighter engines, but when it comes to large and heavy powered engines, it will be on the Diesel principle, and probably two-cycle because of easy reversing.

Mr. J. T. Milton: First of all I would like to say a word or two of what I thought Mr. Timpson would have said. This paper gives us a certain amount of information, but it is not by any means so complete as its title would lead one to expect, as there are several important makers of marine oil engines both in this country and on the Continent whose names are not even mentioned, amongst them being Messrs. Beardmore & Co., who are represented in London by Mr. Timpson. Messrs. Beardmore are indeed mentioned, but only in connexion with a gas engine they fitted in the *Rattler*. They, however, are makers of marine oil engines. On page 59 the author mentions only two makers of Diesel engines in this country. In reality there are several, and besides those who are mentioned as building Diesel engines on the Continent there are several builders who are making these engines for large and important vessels. It is true that on page 71 there is a supplementary list of makers, but the particulars in the table there given are incomplete and largely erroneous. In the introduction to the discussion read to-night there is the same absence of accuracy as to the firms actually making Diesel engines. In reality at the present time the oil engines being made for marine purposes are considerably more important both in number and in size than can be gathered from the paper, whilst, especially on the Continent, the number actually in successful work in small vessels is very great. As an example, in Sweden there is scarcely a sailing fishing vessel at work; all have been converted into oil engined craft.

What I must however specially disagree with is Mr. Shackleton's remarks in the introduction he has read to-day that no marine engineer should attempt to decide upon the strengths to be given to vital parts of oil engines, such as shafts, etc., but should leave these matters to the designers of gas engines. I think he has given himself and the gas engineers away when he says that an eminent firm of gas engine builders have made over 100 varying sizes of crankshafts in engines between 50 and 200 horse power. Is such a designer one whose advice shall be taken in determining the size of a crankshaft for a marine engine? I think not. A marine engineer can surely calculate the stress which is put on the shaft by the engine, whether it is a steam engine, an oil engine or a gas engine, and his experience as to the size necessary to withstand the stress when working under marine engineering conditions fits him to have the deciding of the design of such parts as shafts far better than the experience of designers of gas engines.

In matters appertaining solely to oil engines, such as the inlet and exhaust valve mechanisms, the experience of gas and oil engine makers would naturally be of the utmost value. To show, however, the inapplicability of Mr. Shackleton's remarks, it may be well to mention some of the names of makers of marine oil engines.

On the Continent Messrs. Burmeister & Wain of Copenhagen (not of Stockholm, as mentioned by Mr. Shackleton), The Nederlandsche Fabriek of Amsterdam and the Société John Cockerill (not even mentioned by Mr. Shackleton) were marine engineers of first class reputation long before they became makers of Diesel engines. In this country the same applies to Messrs. Richardsons Westgarth & Co., Messrs. Swan, Hunter & Wigham Richardson, Messrs. Doxford & Sons, Messrs. Barclay Curle & Co., and to Messrs. Beardmore & Co. The same applies also to Messrs. Thornycroft & Co., and Messrs. J. S. White, of Cowes, both firms who are not mentioned in the paper. All these firms are actually building Diesel or other oil engines. It surely cannot be even suggested that such firms as these need the advice of a gas engineer to enable them to design a crankshaft.

Regarding the notes on horizontal engines mentioned in Mr. Shackleton's latest communication, I would like to say that I know something of horizontal marine engines. I learnt my business as an engineer amongst horizontal engines of the largest type as fitted in vessels of the Royal Navy, and I have been to sea with them. These engines were made horizontal, not because they were better in any way than vertical engines, but solely in order to keep all the vital parts of the machinery below the water line. As soon as armour enabled greater height to be protected, the engines of men-of-war were made vertical and no marine engineer would ever advocate reverting to horizontal engines. With large horizontal engines it is extremely difficult to keep the pistons tight. In fact, unless the horizontal piston rods can be made to pass right through the cylinder and be arranged with guides and shoes at each end, and moreover unless the rods are made cambered upwards when unloaded so that when the pistons are on them their weight makes them straight, it is impossible to keep the weight of the pistons from bearing on the bottom of the cylinder, and for a tight piston we want the piston body to be free from the cylinder and only the piston rings to be bearing.

I am afraid that if Mr. Shackleton's remarks about unavoidable residues of burnt lubricating oil in the cylinder are correct, he has given a deathblow to oil engines for marine work. If there are unavoidable residues in the cylinders, then long voyages will be impracticable. Against this, however, we have the fact that the *Toiler* has just successfully negotiated a twenty-seven days' run across the Atlantic and the *Vulcanus* has made successful runs from Rotterdam to the Black Sea and thence to Hamburg. If there had been unavoidable residues in the cylinders these runs could not have been made. Further there is no real difficulty in lubricating vertical engines. There is a difference in the conditions of lubrication between the journals of a single acting and those of a double acting engine. In the latter, the direction of load between the journal and the bearing is reversed every stroke, in the former the load is constantly in one direction, but this condition has only to be realized for it to be provided for. One has only to remember that there are many more journals in the world in which the load is always in one direction, than there are those in which the load becomes reversed, railway axles for instance, to see that even in these conditions good lubrication is possible.

Whilst dealing with lubrication the question of suitable oil naturally arises both for lubrication and fuel. For fuel purposes there are very many oils in the market with different viscosities and different flash points, and it is quite possible that some oil engines have a wider range of adaptability so far as fuel oil is concerned than others. For instance, in the engine made by Messrs. Beardmore and in the Bolinders Engine the oil is injected into a chamber heated to redness. Very heavy as well as lighter oils can thus be burned. In the Diesel engine the oil is sprayed into highly compressed air which is heated by the compression only, the higher the compression the greater the temperature. With some oils perfect combustion is obtained with the temperature resulting from a compression of 450 lb. per square inch, with other oils, however, compressions of 500 lb. and even so high as 600 lb. per square inch appear to be requisite to obtain high enough temperatures to ensure complete combustion. Compressions of 350 to 400 lb. as mentioned by Mr. Shackleton to-day would be useless for burning heavy oils.

Whilst discussing Diesel engines it will be interesting to remember that there are three distinct types of these engines. The simplest is the four-cycle engine, which is always made single acting. It is made by Messrs. Sulzer, the Maschinenfabrik Augsburg-Nurnberg Co., Messrs. Burmeister & Wain, Messrs. Barclay Curle, and by the Nederlandsche Fabriek. The *Vulcanus* engines are of this type. The next kind is the two-cycle single acting. This is made by Messrs. Sulzer, the Maschinenfabrik Augsburg-Nurnberg Co., Messrs. Carels Frères, Messrs. Richardsons Westgarth, Messrs. Doxford, Messrs. Swan, Hunter & Wigham Richardson, Messrs. Schneider of Le Creusot, Messrs. Krupp of Keil, the Diesel Motorer Co., of Stockholm, and by other builders. It is this type which is fitted in the *Toiler*. The third type is the two-cycle double acting type, made by the Maschinenfabrik Augsburg-Nurnberg Co., and by Messrs. Blohm & Voss. Successful examples of the first two types are now at sea. The third type has not yet been placed on board ship, but is being tried in the shops of the two firms mentioned as making them. It would naturally be of interest to know which of these types is likely to be the best for marine work. Each has its own particular advantages and disadvantages. Without question the four-stroke engine is the most economical, and if fuel economy were the only consideration this type would supersede the others. It is, however, of only half the power of the two-stroke cycle for the same number and size of cylinders. The two-stroke cycle for the same power is therefore a lighter and smaller engine. Its reversing gear is much simpler, but it requires the addition of air scavenging pumps. Working these pumps takes up a considerable amount of power, and the engines are consequently about 10 per cent. less economical in fuel. For long voyages 10 per cent. in economy is a very important factor. The double acting engine also had to have scavenge pumps. It does the same amount of work with half the number of cylinders as the single-acting engine, but it has to have extra long cylinders and is consequently a high engine, and it also has to have valve gears both at top and bottom of the cylinders. It is further necessary to have water or oil cooled piston rods, and it will have to have piston rod stuffing boxes capable of withstanding higher flame temperatures and higher pressure than anything which has been tried as yet. The experience which will shortly be available with all three types of engines will be very interesting and very useful.

Mr. Wm. McLaren : I must congratulate Mr. Shackleton on bringing forward this paper, although a paper on so controversial a subject must necessarily receive a good deal of criticism. The chief difficulty to those of us who are not experts in this particular class of vessel now being introduced into sea life is the variety of the tales we hear about them. At the Electrical Exhibition now being held at Olympia, there is a Mirrlees Diesel engine using four different classes of oils. One is turned on after another, and there is an electrical resistance indicator to show any variation. That is something to be said for this engine, that they can use four different kinds of oil without affecting its efficiency, although I do not know what kinds of oil they are. The question of oils seems to be a troublesome one. Mr. Shackleton seems to be in doubt about it, also Mr. Milton, who has evidently had a great deal of experience with this class of engine, from the paper he read before the Institution of Naval Architects in April this year. There is a valuable article in the *Naval Annual* by Mr. Alexander Richardson, who seems to speak without bias, and he also appears to be in doubt on this question.

In one part of this addendum to his paper, where he refers to the time taken for reversing, Mr. Shackleton quotes Mr. Rosenthal as stating that the time occupied in reversing a 300 H.P. set from full ahead to full astern as three seconds. For a similar performance Mr. Richardson quotes 15 seconds. It is a great thing to accept, that an engine going at 200 or 180, as the case may be, is reversed in three seconds. Whoever would do so, must have great confidence in the reliability of the engine to stand such a shock. Certainly there are times when the engineer is forced by instructions on the telegraph to reverse very quickly, but when we consider what it means to stop the engine and then reverse it to full speed again in that short space of time, it appears to me to be exceptional and almost impracticable. Mr. Milton stated the case in summing up as to what kind of engine may prove to be the best, the four-stroke or the two kinds of two-stroke. It appears to me that the two-stroke would be the most flexible as a reversing engine ; that is, providing the air compression is at the back, if you have this medium at all. Why go to the four-stroke, when the two-stroke is there for you ?

Mr. Milton : There is 10 per cent. more economy ; that is what I pointed out.

Mr. McLaren : That may be a point in its favour at the present time, but I think there is a fair chance of that economy being reduced. With regard to the question of residues in the cylinder, I should like to know if that is the case with a high compression temperature. In the Diesel engine, when the fuel is injected, the temperature at the exhaust is something like 600° to 800° F. Would that be sufficient to burn up these residues ? I should like to know also why the term B.T.U. is so often quoted. Is that a comparison with coal or oil burnt as a furnace fuel ? It is not clear to me why that term should be brought in. There are other particulars which it is very interesting to have in connexion with these engines ; the indicated horse power, the brake horse power and the shaft horse power. The latter is important, as it is only reasonable that one should know the power that is being put into the shaft.

Mr. D. Hulme : It has been of great interest to me to listen to the remarks this evening. I fully sympathize with Mr.

Shackleton, and have no doubt you will all agree that his paper has put before us a great deal in the way of instructive matter. As far as the question of marine or gas engine builders is concerned, it requires a practical man, with a certain amount of common sense, to know how to go about these things. With regard to the merits of the two-stroke and four-stroke engines, if a four-stroke engine has to have double the number of cylinders, I fail to see how it will make any improvement in the consumption. Mr. McLaren raised the point of the speed of reversing. That may be taken, I suppose, as an instance when the ship is at rest, as if you have a 10,000 ton ship passing through the water at 10 or 12 knots, it would take more appreciable time to reverse. There is generally ample time for reversing when the ship is under weigh. For moving about for docking purposes there is ample time even under present steam conditions.

Mr. Milton : I am sorry I have evidently not been sufficiently clear in what I said about the difference between the two-stroke and four-stroke cycle engines as regards economy. It is mixed up with the question of shaft horse power. The indicated horse power of any engine is the power exerted by the working fluid, whether steam or gas, upon the piston. That power operates the piston from one end of the cylinder to the other, and through the medium of the connecting rod rotates the shaft. Part of the indicated power is taken up in overcoming the friction of the piston guides, crank pin and main bearing journals and in working the pumps, the remainder only being delivered as power to the shaft. In the four-stroke cycle engine the indicated power has to overcome the friction of the mechanism and the shaft, and also to compress a certain amount of air to inject the fuel. The power it takes to inject the fuel must come out of the indicated horse power and so, in that engine, there will be less shaft horse power in proportion to the indicated horse power than in an ordinary steam engine. In the two-stroke cycle engine, in addition to the injection of the oil, which takes a considerable amount of power, there is the scavenging of the cylinder to be done, and it is the provision of scavenging air which makes the two-cycle engine less efficient. For the same indicated horse power on the engine, there is less put into the shaft. The scavenging air has to be greater in volume than the volume of the cylinder. Its pressure has to be somewhere between 4 to 8 lb. per sq. inch above the atmosphere. If it is only 4 lb. it practically means that about 6 lb. is taken off the mean pressure exerted on the pistons. Mr. McLaren has very rightly drawn attention to one point—a desirable one in a marine engine—that it should be able to burn various classes of fuel. The ordinary steam boiler can be worked with some kind of efficiency with Scotch coal, North Country, Welsh, Japanese and the different kinds of coal obtained all over the world. For a marine engine to be dependent on one particular class of oil only, unless it was obtainable in every port, would be very undesirable. Mr. Shackleton has gone into the matter to show the different classes of oil available, but it must be remembered that each class of oil requires certain conditions for it to be burnt thoroughly. In the Diesel engine, and in most of the others, it is essential that the combustion should be perfect, that there should be no residuum left in the cylinders. In some of them, the "Griffin" for instance, it is not perfect. There is a "hot pot," or a chamber with a similar name, into which the oil is injected. If there is a residuum and it remains in the "hot pot" it may not do any harm. In the Diesel engine, however, where the injection is into the cylinder itself, that residuum would do harm. Some oils are called crude oils, which are the result of distilling processes, and are not natural products, but I prefer to speak of them as heavy oils. Mr. Shackleton says: "In the matter of compression also, whilst a low one, say 350–400 lb. per sq. inch, has advantages in keeping the mean expansion pressures within lower limits, the trouble to be confronted is that immediately the fuel varies from the free burning to the sluggish residuum oils bad combustion ensues." I very much doubt whether 350 lb. compression would burn anything except very refined oils. As a matter of fact, the lowest compression I know of used in a marine engine using heavy oils without a "hot pot" arrangement is 450 lb., and in that engine when trying to use another rather heavier oil, 450 lb. was not sufficient; they did not get complete combustion. It should be remembered that perfect combustion is the combination of two conditions. The oil has to be sufficiently pulverized so as to expose an enormous amount of surface in proportion to the amount of oil used, and it must be injected into a space where there is sufficient oxygen at a high temperature that will burn it in a very short space of time. If engines are running at somewhere about 200 revolutions per minute, and nearly the whole of the combustion has to be accomplished in the first tenth of the stroke, the actual time of combustion is exceedingly short. The stroke only occupies less than one-sixth of a second, and it is only a small fraction of that time in which combustion has to take place. In varying the oil fuel it will be necessary to vary the compression also. For this it is necessary to vary the clearance at the cylinder top, and that is not a difficult thing to arrange, if it is once known what compression is suitable for the oil intended to be used. So that the question of different kinds of oil is not insuperable in the Diesel engine. As I have previously mentioned, some of the Diesel engines work with 600 lb. compression, most of them at 500 and a few at 450, but none, as far as I know, as low as 350 or 400.

Mr. D. HULME : I have no doubt there are many of the members of this Institute have not an opportunity of seeing the Diesel engine running. I mentioned when on the Council during the time that the summer visits were contemplated, that Messrs. Howards at Canning Town have some very fine gas engines running. They can take in the whole of their fuel for the twelve months in one day. Visits in the summer are not always suitable, because so many of our members are away from home, and I think visits in the winter would be quite as good. The engines I referred to have been running for about three years.

Mr. TIMPSON : With regard to the remarks on the two-cycle and four-cycle engines, I know of no engine to equal the two-cycle paraffin engine for small powers. If you take up the Report of the Scottish Fishery Board you will see that the two-cycle Beardmore engine has the lowest consumption of any oil engine using paraffin. Of course, what Mr. Milton says is quite right in regarding the necessity of the air compressor for scavenging, and that the four-cycle should be the most economical, but the fact is as I have stated, both in regard to guaranteed and actual full consumption.

Mr. F. SCHUBELER (Messrs. Sulzer Bros.) : The paper read by Mr. Shackleton has certainly brought forth some very interesting information about the application of the Diesel oil engine for marine purposes, and also the discussion proves how much in the foreground this subject is at the present moment. It is only to be regretted that owing to lack of time quite a number of details, which would certainly be worth while considering, cannot be dealt with.

Regarding the subject itself, I do not intend taking up much of your time, and would restrict my remarks to a few points. Mr. Shackleton says that the marine Diesel engine cannot be very easily handled at lower speeds. To this I cannot quite agree, as it is easily possible to run the engine dead slow at about one-seventh of its normal speed. I take this opportunity of stating that also our firm advocates slower speeds for marine engines, and in this respect I quite agree with the remarks made by Mr. Milton. The slower speeds have the great advantage of allowing better propeller efficiencies than higher speeds.

One word about Mr. Shackleton's proposition re combination of steam and oil machinery for propulsion. In my opinion the power which Mr. Shackleton intends to regain from the exhaust of the Diesel engines is calculated somewhat too high. Taking two Diesel units of 1,000 H.P., as Mr. Shackleton does, the gain from the exhaust gases would hardly amount to more than about one-half the figure given by Mr. Shackleton, or in other words only 150 H.P. instead of 300 H.P. Taken in percentage the regain in steam power from the Diesel engine amounts only to about 5–10 per cent. In addition the complication of such an arrangement is not desirable. Apparently Mr. Shackleton overlooked the fact that the latent heat for producing steam out of water absorbs the greatest part of the heat, and on this account the steam production out of exhaust gases is a very uneconomical one.

Regarding reversibility, I think it worth while to make it perfectly clear that the two-stroke cycle machine has great advantages in this respect over the four-cycle machine. In addition to its other features, viz., smaller cylinder size, doing away with exhaust valves, etc., the main advantage of this type over the four-cycle type is that the question of reversibility can be solved with simpler means. This is not done by sliding cams, as Mr. Shackleton suggests. The working of the valves is absolutely the same in both running directions, the only change taking place in the coupling up of the side-shaft with the main engine shaft. This is done by a coupling, which allows a connecting clearance of an angle of say about 30° in either direction, the clutch either touching against one side of the claw of the other coupling half, or the other side of same. The reversing operation is done mechanically and only for very large engines pneumatically. When the scavenging pumps are direct coupled the slide is also reversed, which is done by means of an ordinary Stephenson type gear.

If I remember rightly, Mr. Shackleton did not discuss in his paper the somewhat delicate question, which type of oil engine, i.e., whether four-cycle or two-cycle, will represent the final solution of the marine problem.

Mr. Milton seems to favour the four-cycle type for marine purposes, being of the opinion that the same ensures the greatest reliability and should therefore be generally adopted also for the large engines. Another reason for his preference is the decreased mechanical efficiency of the two-cycle machine due to the presence of a scavenging pump. I perfectly agree that the four-cycle machine is a reliable machine, but its application is absolutely limited and impossible as soon as larger cylinder units are required. Owing to temperature and expansion difficulties it is not possible to exceed a certain cylinder size, say 40 inches at the highest. This corresponds to an approximate cylinder output of only about 800 H.P. at a speed of 150 R.P.M. Cylinder units of only this capacity would make it absolutely impossible to arrive at machines of several thousand horse output. It may furthermore be of interest to you that the increase of the cylinder size does not also involve an improvement in the consumption, which seems to prove that the combustion process does not take place as advantageously as with a somewhat smaller cylinder area. It appears that there is one certain cylinder size which gives the most favourable results. Decreasing or increasing this size influences the consumption. This feature would lead to the arrangement of several fuel valves, for greater cylinders, involving some difficulty for the operating valve gear. You will therefore see that the advent of the two-stroke cycle engine was an absolute necessity and that the same was not created for any other reason. The principal advantage of this type is the doing away with exhaust valves, which latter with the four-cycle machine always necessitate a more or less frequent cleaning, which is certainly not desirable for a long voyage. They also involve some difficulties as soon as they attain larger sizes. Furthermore the fewer moving parts coming into contact with the working fluid the better. For larger marine engines undoubtedly the two-cycle machine will universally be adopted, the final struggle having only to be fought out between a single and double acting machine.

My firm, Sulzer Bros., who probably can claim to have had the greatest experience with two-cycle Diesel machines, and who also did the pioneer work for the direct reversing, carries out the single acting machine. In doing so, we do not wish to say that the double acting machine will not be used, as it probably will at some later date. We, however, advocate a natural and steady development, which does not risk creating marine engines which do not guarantee the same reliability as the hitherto known steam engine. Some firms claim being able to already build double acting machines, but unfortunately I am not in a position to give you any respective data. The double acting principle favours the horizontal engine and the adoption of the crosshead. From the steam engine and gas engine practice it is known that heavy horizontal pistons have to be fitted with tail rods, or in other words an engine of this description necessitates as a rule two stuffing boxes at once. The passing of a piston rod through the combustion chamber is a great disadvantage for the combustion process, due to the cooling influence of the former. It is also impossible to provide a symmetricating fuel valve in the centre of the cylinder, and two or three fuel valves have to be provided with the already mentioned drawbacks. For marine engines only the vertical type can be considered, and I take it that Mr. Shackleton never intended to recommend the horizontal machine for marine purposes as anticipated by Mr. Milton. The disadvantage of the vertical double acting two-cycle machine is the excessive-building height, which would render it considerably difficult to arrange such engines for instance within the armoured height of man-of-war, not to mention the difficult accessibility of the valves in the lower cylinder cover.

[1] To conclude my remarks I would like with your permission to show you some lantern slides of the latest development of this type of engine, as manufactured by Sulzer Bros., which even within the short time between Mr. Shackleton's lecture and now has made enormous progress. It seems that the time is not far distant, which as forecasted by Mr. Shackleton, will mean an entire revolution of marine propulsion.

I may say that the largest stationary Diesel engine built

[1] In view of the lateness of the hour it was decided to postpone the lantern illustrations till the following week.

up to now, and which I am going to show you, is a unit of 2,400 H.P., or 600 H.P. in one cylinder, and very shortly cylinders of 1,000 H.P. will be no rarity. It will be of interest to you to hear that we have in construction an experimental cylinder for an output of 2,000 H.P., and I hope to have an opportunity of giving you at a later date some information about the result of these tests.

Mr. W. McLaren: There is one point which should not be neglected, and that is, the question of water cooling of the cylinder. In gas engines, the hottest part of the cylinder is on the top side, and I do not think that would be a good thing. With an unequal temperature of the cylinder there would not be the perfection Mr. Shackleton claims.

Mr. Hulme: I make a proposition that this meeting be adjourned till next Monday evening.

Mr. J. Clark: I have much pleasure in seconding that proposition. I think the subject should have more discussion devoted to it. Mr. Shackleton has given us a very interesting paper, and one well worthy of discussion.

Chairman: Although time is short, Mr. Shackleton would like to reply briefly to some of the points mentioned in the discussion.

Mr. Shackleton: In a discussion of this kind it is neither wise nor diplomatic to allow the personal element to enter into it. For diplomatic reasons one must be guarded in his remarks, and I shall not, therefore, to any extent, come down to some of the discussional points. Mr. Milton evidently thought I ought to have made a directory of British and other gas and oil engine makers. He gives the names of several firms, whom, he says, I have omitted to mention. This is not so, as they are mentioned in the paper and their work illustrated in show types. Of course some makers are left out which might have been included if I had facilities for gaining information about them; but if I had the resources which many of those who have read papers on the subject have, I could doubtless have produced something different. At the same time, a paper of this character should not be overloaded with names, or made too long. I think it is not quite fair to single out this allusion to the horizontal engine, as it was merely an allusion and no more. The proposal to put a horizontal Diesel engine on board ship would have been the last thing I would think out. With regard to that engine, however, and this applies to hundreds of them, the piston is as easily lubricated and can hold its own with any vertical engine. The old question has been raised as to who is to build the oil engine, marine engine builders or gas engine builders. Who are the leading people in the making of these engines ? who are the people who have built the largest gas engines in the world ? The M.A.N. Co., who are also one of the first firms to build Diesel engines, of which they have constructed many hundreds. With regard to the Beardmore engines, we had an excellent paper on the subject read before the members by Mr. Timpson, and I had a note to that effect in my paper, asking the reader to refer to the matter in that case. Regarding the crankshaft, again Mr. Milton makes a point against me, and asks how my remarks are applicable to marine engines. I stated that they applied to stationary work alone. The builders of gas and oil engines, as far as the stresses go, can make a reasonable amount of comparison, When one wants an internal combustion engine, one has to be guided by the makers. The makers can generally be trusted to know more about the engines than an outside man. I have seen cases illustrating this over and over again. In one case the engineer for the buyer took objection to the piston being of the usual gudgeon type with no slipper piece or crosshead. The firm built an engine of 150 H.P. to suit his view with a slipper piece. Of course it was not satisfactory, yet he still persisted that it was the proper thing to do. All the big makers of gas engines deliberately refuse to accept orders to build engines which, in the long run, they know will not prove a success. After all, it is a monetary affair. The builder has to put an engine into a boat and it has to be reliable. Very naturally he draws upon his own experience. With regard to residuum, every one will agree that in an oil engine, whether Diesel or any other, there is too much residuum, and there is plenty left behind. In some cases they are not small pieces that are left behind, and it cannot be avoided under certain conditions. It does not mean, because there is a little amount of deposit, that work has to be stopped. Mr. McLaren raised the point of reversal. To an extent we have to rely on the notes of people who have had experience on the subject. We have not all the facilities for getting information at first hand. I took Mr. Rosenthal's statement that the reversal was accomplished in the times given, and I do not see why we should not accept them. In one case I know of, a skipper said the reversal was much too rapid ; he was not accustomed to the boat pulling up in such a short time. With regard to deposits in the cylinder, I go a step further and say that with refined paraffin oils in an ordinary oil engine; heavy deposits will be formed, owing to bad combustion or other causes, and you may have a piston as fast as it is possible for a piston to be, with refined paraffin oil. In heavy pistons there is a tendency to get some deposit, and if there are heavy residuums, certainly the deposit becomes a very serious matter.

A vote of thanks to Mr. Shackleton was carried with acclamation, on the proposal of Mr. A. Cooke, seconded by Mr. J. H. Redman.

The meeting closed with a vote of thanks to the Chairman.

ADJOURNED DISCUSSION.

Monday, October 9, 1911.

CHAIRMAN: MR. JOHN McLAREN (VICE-PRESIDENT).

CHAIRMAN : As you are all aware, Mr. Shackleton's paper was discussed last week, and the discussion was adjourned until this evening. There are several gentlemen who wished to speak on the subject, and one or two wished to show lantern illustrations, so I shall lose no time in declaring the meeting open. I will call upon Mr. Shackleton for some remarks in reply to the discussion of last week, to open the discussion this evening.

Mr. SHACKLETON : In the course of his remarks last Monday evening, Mr. Timpson said that " most of the discredit attached to the marine motor industry has come from land engine makers manufacturing marine engines with no knowledge of the details of marine service." I entirely disagree with this remark, and would say that the greatest setback the gas engine industry ever experienced was the attempt by a distinguished firm of shipbuilders to build a series of high power engines for a central station, with the result that the greatest fiasco ever seen in the building of large internal combustion engines took place, the entire job being thrown back on the builder's hands. I hold no brief for builders of motor-car engines, but it is as well to bear in mind that the class of work turned out by them is of a far finer description than that of a steam engine builder of marine installations.

With regard to Mr. Milton's remarks, the justification I have for the statements which he takes exception to, is that the builders of oil and gas engines know more about the subject than people who are not specialists in this particular work. The builder of Diesel engines knows by bitter experience where formulæ and practice disagree. Regarding the "bias" referred to, it is to be expected that this reference may cut both ways. I have always agreed that only a harmonious blending of joint experience can make the internal combustion engine a success on shipboard; that is, a fusion of ideas by both builders of ships, steam engines and of internal combustion engines. I am of opinion, however, that Mr. Milton is unacquainted with the great experimental work of British makers of gas and oil engines, and with the deep study which chiefs of departments in such works have devoted to the Diesel engines, either experimental or types which have never seen the light of day outside their own shops. I think that if Mr. Milton were to go through the shops of Messrs. Crossley Bros., the National Co., or Messrs. Campbell's, he would gather that they were not such vastly inferior concerns to many shipbuilders, although the demand for their standard work precludes them, at the moment, from manufacturing Diesel engines. Standard gas and oil engine experience has in many cases paved the way with much experience for the building of Diesel engines. Mr. Milton mentions that he has given a great deal of time for the last two or three years in investigating problems regarding the internal combustion engine, and doubtless he has gained much experience. I would modestly say that I, also, have had over twenty years' actual practical experience on all shapes, types and sizes of engines operated by producer gas, heavy oil, paraffin, petrol and wood gas, and have had experience with one or two early Priestman engines in 1892–94 and a Union oil engine in 1898 for marine work. Of either boat it could not be claimed that the engines were entirely a success. A Priestman double-acting engine of 40 B.H.P. went out to the Faroe Islands in charge of a friend of mine, and, between the leaking of the soft packing in the piston glands of the cylinders and other experiences, not much of interest to present-day marine engineers can be said, except that troubles were numerous. A Union engine was installed in a small ketch of 50 tons, the makers giving the power as about 30 B.H.P. Repeated indications, however, only gave 22 B.H.P., and a total failure to get the engine to full speed. It was decided to cut down the blades of the propeller when the engine got up to speed, but $2\frac{1}{2}$ knots was rarely exceeded when there was much tide against the boat.

In reference to Mr. Milton's remarks with regard to horizontal engines, there are vast differences between horizontal gas or oil engines. I would say that no comparison is possible between the running of horizontal steam engines and gas or oil engines, and some of the phases which I have delineated will, upon further research, become apparent. Regarding my remarks on low compression engines, a number of engines are at work on a compression of 400 lbs. (Diesel). I would again say that deposits, large or small, are encountered in all phases of oil engine practice, the Diesel engine, under certain conditions, not being excepted. Deposits are even encountered in engines using town gas, which is nothing like so impure as fuel oil in an oil engine, and also in engines using petroleum spirit, the most refined fuel of the hydrocarbon series. Only when deposits are present to a large extent does trouble occur, but if very dirty or asphaltic base fuel is employed, trouble will, as a rule, result from this cause.

Mr. W. McLaren made reference to the somewhat uncertain state of feeling among engineers generally regarding the fuel oil question. On page 56 of the paper, you will find I have compiled a table as a guide to those who seek for satisfactory fuels for Diesel and other engines. I am prepared to admit that the present uncertain fuel oil, so-called standard, is very unsatisfactory. We have all kinds of engines operated by such, which in reality is refined oil, and the sooner a definite standard is set up the better it will be for all concerned.

Mr. Milton was evidently of opinion that I had not been comprehensive enough in my references to various engines. As I did not intend to write a book, I had to cut down my original paper to one-third its length, so that it was practically impossible for me to go beyond certain well-known makes. For instance, I have described altogether in the addendum and paper, over twenty makers of Diesel engines, including marine types. That should, I think, be comprehensive enough. One idea I had in view, was to go to a certain stage, as far as any views which I had should assist the marine engineer, and at that stage stop, because one can quite see that, after a certain stage, the marine engineer must then develop on his own account, and I think, by showing the various stages of evolution, I have traced the oil engine development sufficiently well to enable the marine engineer to have the cardinal points in mind when called upon to select his motor. By so doing, I think I have done better service than by running into highways and byways which would be productive of little value to the marine engineer.

In connexion with the question which was raised regarding definitions of power, the term "nominal horse power, still attached by the Board of Trade and other institutions to describe the steam engine, has long ceased to be of any effect in the internal combustion engine. With the internal combustion engine, the brake horse power is invariably given, that is, the horse power deliverable for effective work and not the inclusive horse power which is obtained from an indicator card. That is the difference between the two. One, which is more or less theoretical horse power, is arrived at by means of the indicator; the brake horse power is that available for actual work.

I had hoped that some attention would have been given to one or two points I raised in the paper, but as matters are now limited by time some of them will have to be neglected. I think I am justified in saying, as I pointed out in the addendum to the paper, that the saving in actual fuel costs of a marine Diesel engine, will not of necessity approach some of those ornamental figures we have seen stated. According to some of the figures it would appear that we had practically got perpetual motion. As I have said, we may fall as low as 10 per cent. in actual fuel economy, or may go as high as 40 per cent. over the steam engine. But if the Diesel engine were to cost 20 per cent. more in fuel, it would still pay any owner to instal that engine, for the simple reason that the fuel consumed on the main engines of a steamer is not a criterion for getting at the actual costs. The fuel consumption of many steamers is not to be quibbled at, but in the stand-by losses you sometimes see figures that are surprising. In many cases the superintendent engineers say it is not fair to charge the engines with the coal used in lighting fires, standing by, etc. The engineer has to put that down more or less by guesswork. I believe the engineers do arrive, approximately, at the accurate quantity used in the majority of cases, but it does not matter whether you charge to the engine daily consumption that which should be charged to stand-by losses or for steam raising. It does not make any difference. The ship is charged with the amount of coal it consumes, and on those figures I must place the proposition. Recently I said to a superintendent on looking over his log: "Your figures are very low; what is the meaning of this item, 'moving ship'?" "Well," he said, "you cannot include that in the mileage." Then I pointed to another, "Bringing the ship from Gravesend to the Albert Docks, 2½ tons," and he said, "We do not call that engine daily consumption." I said, "Thank goodness the oil engine has no such feature as that; items of expenditure to that extent will not be included in connexion with it."

I made a reference to the lubricating oil costs. I have before me something which will bear out what I stated regarding the great economy obtained by the oil engine over the steamer. The average Diesel oil engine would be rather close in competing with these figures, but since the economy is as great in other respects, I do not think we can quibble about it. There are figures under the heading of a log I have here showing coal used for laying fires, raising steam, lying in river, etc. The steamer did not hang about very long, but in the brief space 24 tons of coal were consumed. That is one confirmation of what I said, that if the Diesel engine were considerably more expensive on main fuel costs, she could still be a serious opponent of the steam engine on account of the auxiliary losses, things that do not appear as engine daily consumption. I do not expect these figures will go unchallenged as to whether they were stand-by losses and for raising steam, but the hard fact remains that they were charged in the total coal. I will take one or two other examples. One steamer of 4,213 tons gross, 2,679 tons nett, with an average indicated horse power of 2,000 and a daily coal consumption for the main engines of 34 tons. She has electric light and a refrigerating plant, and every one knows these consume a good deal of coal. This vessel made a voyage to the River Plate. She raised steam on various occasions at the various ports. In Cardiff this took up 15 tons;

Vigo, 3 tons; Monte Video, 9 tons; Bahia Blanca, 9 tons; Buenos Aires, 11 tons; Las Palmas, 4 tons; Liverpool, 9 tons; and Cardiff, 6 tons; a total of 66 tons of coal for raising steam. She also stood by waiting for docks, and tides, and the total amount used on that account was 30 tons for the trip. The donkey boiler and other losses I will not go into. All that would be considerably reduced by an oil engine.

Another steamer of 6,664 tons gross and 4,295 tons nett, with twin screws, and an average indicated horse power of 3,300, with four single-ended boilers and twelve furnaces, has a daily coal consumption of 55 tons. This vessel, during a voyage to the Colonies, used for raising steam at Glasgow, 20 tons, Avonmouth, 35 tons, and at other ports various amounts, making a total for the round voyage of 156 tons. The total stand-by losses on another vessel were 278 tons on the voyage. These examples are taken from a fleet of nine steamers. The Diesel engine, therefore, omitting the advantages derived from additional cargo space, would still compare favourably with the steam engine even if the cost were 20 per cent. more, on account of the saving in stand-by losses, which in a large boat are almost unavoidable.

Mr. R. W. A. Brewer: I am glad I have had the opportunity of coming to speak on this subject, because it is more than ten years since I was in this Institute, at a time when the late Mr. Macfarlane Gray gave an address. I am sorry I was not at the previous discussion, and if I go over some of the ground which has already been covered, I hope you will excuse me on that account. By way of introduction, I may say I am an oil engine man, and therefore I am rather speaking against my conscience on this subject. In the first place I would like to point out a fact not generally known, perhaps, to the bulk of marine engineers, that the reason why the oil engine has not made the developments we wished and hoped it would do, and know it would do under other conditions, is the question of the cost of the fuel, and that cost is governed, not as in other commercial enterprises by the question of supply and demand, but the price we have to pay for liquid fuel is a purely artificial one, owing to the fact that the world's supply of oil is in the hands of a very few companies. For many years engineers engaged on enterprises involving the use of oil in large quantities, not only for fuel in oil engines but for such schemes as the smelting of metals, etc., have always been deterred by the cost " bogey." I will read the following extract from this evening's issue of the *St. James' Gazette* :—" Although the utmost secrecy has been observed with regard to the negotiations between the Standard Oil Co. and the combination of European producers known as the Royal Dutch Shell Transport Combine for the ending of the world-wide struggle for supremacy, there is, says the *Standard*, unmistakable evidence that a virtual agreement on vital points has been arrived at in the past few days. Two sharp advances in wholesale prices of burning oil, on which the fiercest part of the fight has taken place, had been announced. The lowest quotation for burning oil delivered from the road tank wagons, throughout England, is now $3\frac{1}{2}d.$ per gallon, as compared with the price of $2\frac{3}{4}d.$ ten days ago.

" PRICE OF PETROL.—An even more significant indication of the change that has come over the scene is to be found in the substantial advances which have just taken place in motor spirit.

" Up to a few days ago all kinds have been retailed at 1*s.* per gallon. To-day that is the minimum wholesale price. Motorists will undoubtedly soon find that their fuel will be costing them more, and they may be thankful that the competitors did not come to an agreement until practically the end of the touring season.

" In the Far East, the most promising market for illuminating oil, the prices have advanced all round.

" In various Continental markets prices are higher, and in the domestic market of the Standard Oil Co. values have been visibly hardening for some time.

" All other refined petroleum profits are expected to advance before long, and in anticipation of such a development producers of these, as well as of burning oil, are steadfastly declining to enter into forward contracts.

" As recently stated by Mr. Deterding, its executive head, the Asiatic Petroleum Co. was called into being by the aggressive tactics of the Standard Oil Co. That Company became central selling agency of a combination which came to include nearly the whole of the principal European producers. Almost daily its strength has been added to, until it stands next to the Standard Oil Co. itself, as the world's capitalist aggregation. Behind it are the millions of the Rothschilds, behind the Standard Oil Co. are the millions of the Rockefellers ; truly titantic opponents both."

We have therefore two big groups who can control everything we do ; they can control almost the whole liquid fuel supply of the world. If you wish to buy distillates, residuals, or anything of that kind, and if you buy in bulk there is a difficulty in getting quotations, and when you do get a quotation it will be an entirely arbitrary one. It is not the market price, but a price dependent upon what the suppliers think they will be able to get out of you. It is not only my own experience, those in the inner circles know it quite well. For that reason those who *do* know are very careful about putting down big plants to burn oil. They will tell you that the cost of residual products depends on the demand for distillates. If there is a good market for the lighter distillates, petrol and paraffin, the companies can then afford to sell residuals at a lower price. But we find in many cases large stocks of residuals lying in tanks in different parts of the world, and the buyer has to pay a fairly large price for such fuel.

The high market price of oil is attributed in many quarters to the lack of transport facilities, and I believe Mr. Shackleton touches on this in his paper. This reason is given for the high cost of fuel, that there are not sufficient tankers to bring the oil to this country, but I believe he will find the supply of tankers very adequate. Many years ago it was not so, but now the price of oil is not in any degree at all dependent on an inadequate supply of tankers.

Mr. Shackleton's paper is headed "Modern Developments in British and Continental Oil Engine Practice," and in an Institute of this kind the oil engine is discussed from the point of view of the marine engineer. The oil engine has many attractions for the marine engineer, these have been brought before us by the author in his paper and particularly such points as he makes with regard to the cost of fuel, the saving of space, and the saving of stand-by losses. Such points are very attractive and important ones ; but I think he has rather put in the background the big cost, the cost of the plant, and the cost of depreciation. I will give a personal instance of what little experience I have had with regard to negotiations for big oil engines. I had occasion to ask for a tender for a 500 horse power Diesel oil engine for a particular purpose. I tried a good number of makers in this country and on the Continent for that engine, and finally got a quotation from a firm mentioned in this subsidiary paper, the F.I.A.T. Co. The price of the engine alone was £8,000, which I think you will agree was pretty heavy for a 500 H.P. engine. As I was in competition with steam, needless to say the work did not come my way. If we look through Mr. Shackleton's paper we will find that the oil engine that is going to do what is hoped from it, seems to be an extremely high-class piece of work. You cannot put into an engine of this kind, particularly Diesel engines with such high pressures, the material used for other classes of machinery. If you want to put down an engine which will run for weeks with practically no attention, and which will, at a moment's notice, cease doing the work and do something else, I mean which will reverse, you will have to put exceedingly good material into it. It does not only mean that material which costs 3*d.* a pound in other engines will have to cost 1*s.* 6*d.* and 2*s.* a pound in this; it means that the workmanship, treatment and accuracy must all be on a higher level, and you have to pay a very considerable price for the benefits which are going to accrue when you have bought your engine. From the marine engineer's point of view, we are not quite accustomed to handle the very best type of machine met with in other branches of engineering. For instance, if we have men accustomed to work on motor-cars or motor-boats of a high class, we are using the services of those who are highly skilled, who understand precision, who are thoroughly up in the best methods of lubrication, and by using men of that type you get good results from the machines. When you have to keep in order an engine which has to stand up to high pressures for long times, you must depend on a very high class of labour. I have here a catalogue of the Diesel engine, and I had a look at the engine on Saturday to satisfy myself on certain points. On page 5 there is a statement with regard to the extreme advantages of accessibility of this engine. It says that when a valve—and please remember the engine depends on it—requires attention, all one has to do is to pull it out and replace it with a spare valve; like getting furniture on the easy payment system, "it's so simple." When an engine runs on very high temperatures for a certain time it runs hot, blazing hot, red hot at times, and you cannot expect valves to be so easily manipulated as is indicated here, especially if anything has gone wrong with the oil, although theoretically and generally in practice the combustion is perfect and the exhaust clear. A very small thing which puts an oil engine out, not only affects it locally but in many parts of the machine also, and in difficult places where it is extremely difficult to remove the trouble. Some four years ago, on January 22, 1907, the matter was discussed at the Institution of Civil Engineers, and I had an opportunity of speaking as to the relative merits of gas or oil engines for marine work. The discussion was on Mr. Milton's paper. Sir William White on that occasion said, "Power was not put into ships simply to establish the triumph of the mechanical and marine engineer, but it was put there to propel the ship economically and efficiently." The Diesel engine is certainly an instance of the triumph of the mechanical engineer, but I do not think half of one per cent. of the marine engineers would appreciate such a beautiful piece of mechanism on board ship. When you have to rely for weeks on it running with practically no attention, one must have a machine simple, and more in accordance with the design one is used to. A radical departure is never favourably received at the moment.

Now I come to a point which I think you will all follow clearly, and that is, if you are going to have the internal combustion engine for marine purposes, it will have to be an engine which follows more the ordinary gas engine practice, in which the working pressures are not so high ; an engine which can be fed with liquid fuel of a high flash point and can be fed with that fuel in accurately measured quantities, and it would have almost certainly to work on the two-stroke system. There are, as I know, many difficulties to be faced by the designer of the two-stroke engines, but it seems to me those difficulties can be condensed into three chiefly, and two of the three are not easy to overcome at the present time. There is, however, only one real difficulty in connexion with the two-stroke large oil engine, and that is the difficulty of proportioning the mixture at varying loads and speeds. This is carburation, and the other difficulty is scavenging. Those of us who deal with the two-stroke engine have come up against these difficulties times without number, but I do not think they would occur in a marine engine to anything like the extent to which they occur in two-stroke engines used for other purposes. Before making large strides in internal combustion engines for marine work, the ordinary type of two-stroke engine will have to be suitably adapted and it will then have a better chance than the Diesel engine on a large scale. Such an engine is not particularly a costly engine to construct and should not be to maintain. Further, the use of an engine of that type (semi-Diesel) is not attended by any great difficulties, although some of them naturally following upon the use of oil, and inseparable from its use, will have to be encountered. Of course in such an engine the cost of fuel has to be considered, and there is always the question of economy as compared with a higher class of machine. But after all, the cost of the fuel is not a very great, item; there are other costs quite as important as the cost of the fuel the engine burns.

Mr. P. A. Low: The last speaker referred to the difficulty of carburation in the two-stroke cycle engine. I would like to point out that the Diesel engine does not carburate, so that the difficulty disappears. He also seemed to throw doubts on the efficiency of the internal combustion engine because it depended on valves for its action. As far as I know the steam engine does also, and the valves of a Diesel engine are far easier to get at than the valves of a steam engine, so I do not think that is a great point against the oil engine. His experience in the negotiations for a 500 H.P. engine was unfortunate, because I think he could have got a reversible Diesel marine engine at something like half the cost he mentioned. I propose to show a few slides illustrating the Nürnberg engine a little later in the evening.

Mr. A. C. Holzapfel: The few remarks I have to make will not be of a technical character, but chiefly of a general and commercial one. Mr. Brewer has already anticipated some things I would have liked to say and relieved me of the necessity of saying them. The only technical point I would like to make in regard to the Diesel engine or any reversing oil engine working direct on the propeller shaft, is that I understand this engine is very much lacking in elasticity. When the propeller is lifted out of the water and races, then by action of the governor the charge is reduced to such an extent that when the propeller dips back again into the water the engine is apt to stop, and has to be re-started by compressed air. That has happened repeatedly in one vessel, I have been privately informed. Perhaps Mr. Shackleton will tell us whether it is true; if it were so, a direct-acting reversing internal combustion engine would be dangerous, except in extra large vessels whose propellers would be always under water.

Speaking on the general and commercial side of this question, as many of you know, perhaps, I am interested in marine gas engines and have already raised a point in connexion with this matter in the Press, and also on other occasions, which I am going to dwell upon here. I have lived in England 37½ years. The Diesel engine has been brought from abroad; it was invented in Germany and perfected in Switzerland and Holland, and I have observed that Englishmen are averse to taking inventions from abroad. I am not an advocate of exclusiveness, but I want to call the attention of marine engineers to the fact that there is a type of engine much more practicable and much more suited to their necessities than the oil engine, which latter always will have a great disadvantage against it on account of the uncertainty of the price of fuel oil. In gas engines you depend on coal, and of coal there are unlimited quantities all over the world. It is not likely that any trust or group will be formed to capture the coal markets in Great Britain, America and other countries, and when they are formed in one country, no doubt the competition of other countries will always keep the price at a reasonable level. We could take the average price of coal for a ship in the Indian trade at about 18*s*. per ton; taking supplies in the Tyne at 11*s*. or 12*s*., Bombay at 15*s*., and again at Aden and Port Said at something over £1, and again at Malta, the same, and even allowing for the danger of getting 16 or 18 cwt. to the ton 18*s*. a ton is a fair average price. Oil at the present time is 50*s*. a ton. Out of 100 lbs. of coal we get exactly the same amount of power as from 60 lbs. of oil; therefore the comparative cost of coal with oil power is 9*d*. to 15*d*. For 9*d*. spent on coal you get as much power as for 15*d*. spent on oil. Then the first installation of gas is also much cheaper. I have had an engine running 3½ or 4 months in a cargo vessel working in all weathers on the coast, and it has worked quite satisfactorily. We had difficulties in the beginning on account of the newness, and on account of the fact that it was the first vessel to be so fitted, particularly with the gas plant, which was really a shore gas plant and not constructed by a marine engineer. In gas power there are immense possibilities, and I want to put it to the British engineer to solve the difficulties, and to use his energies and ingenuity to perfect the gas plant, and the gas engine. In doing so he will steer clear of many difficulties he would have to encounter in connexion with the oil engine. I might mention that we are not working direct on to the propeller shaft, but have a hydraulic transformer by which we reduce the number of revolutions from 450 on the engine to 120 on the propeller shaft, and by which we can very quickly reverse and go any lower speed we like forward or astern, while the engine is going full speed ahead. This is a practical arrangement, and I think, by the demonstrations I have given, that this little vessel has opened out an avenue for further progress. I sincerely hope British engineers will take this matter up and help me to solve the problem.

Mr. L. W. Johnson: There were two points raised in last Monday's discussion which I should like to remark upon. One was the question of unavoidable burnt residues. So far as my experience goes, the oil suppliers generally guarantee the oil to be free from asphaltic bases and tar, and, so long as the oil is free from asphaltic bases, etc., there are no residues to speak of except when the engine runs dead light. Then, it sometimes happens that there is a carbon deposit on the top of the piston, but it is soon burnt away again when the engine is on load. So long as the adjustment is properly done, one need anticipate no residue whatever. The other point discussed was regarding the makers of Diesel engines, and one or two of the speakers criticized Mr. Shackleton for not having mentioned various makers. In my opinion, those whose names were brought forward were, in the majority of cases, making engines under licenses from people already well established; but I think two firms who should have been mentioned are Messrs. Augustine Normand & Co., and Messrs. Sebastian. These two firms have just brought out Diesel engines distinctively their own design from beginning to end, and, if paid particular attention to, I think there is a great field ahead for them in the marine world. Certain particulars of their design, cylinder heads, method of extracting pistons, reversing, etc., might be improved upon, but they are making a step in the right direction. With regard to my own firm, we have not a reversible marine engine on the market to date. But our high speed engines have been used for some time for propelling boats and they have given every satisfaction in working and economy. Those same engines have also been used for driving dynamos for lighting purposes on battleships and have effected great economies in the Navy. Only recently one of these engines ran continuously for 800 hours, which fact in itself speaks volumes. Though this type of engine can be easily made reversible, in many cases it is preferable to perform the reversing and speed variation by other means. For this reason we have an electrical propulsion scheme, which is used when speeds below half-speed ahead are desired. This scheme is that :—

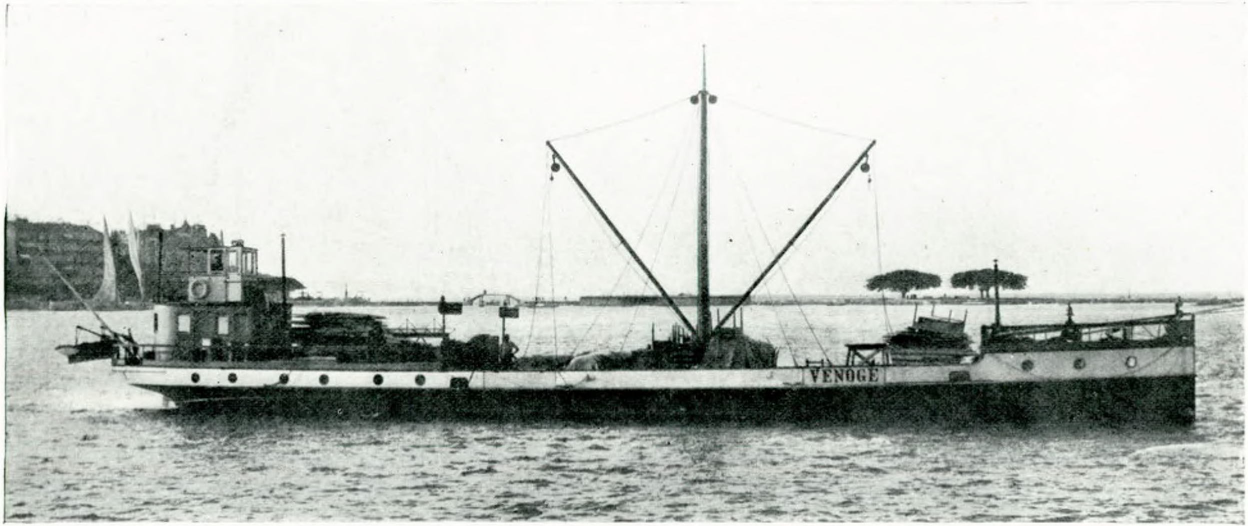
On the crank shaft of the engine is fixed a dynamo of about one-fifth the power of the engine. On the propeller shaft a reversing motor of similar power is fixed, the two shafts being connected by a clutch. As variations of speed between half and full speed ahead are obtained direct from the engines, the electrical apparatus has only to deal with lower speeds and reversing. The power required at half speed is practically one-eighth the power of full speed, but some margin is given to the electrical plant, so as to have extra power available for quick reversing. When running slower than half speed, or running astern, the positive clutch connecting the propeller shaft to the engine crank shaft is liberated. This scheme gives full efficiency when going at any speed ahead over half speed, and gives full control for reversing and at slow speeds.

It has given great satisfaction and has worked with very good results. A point was raised about the stopping of the engine after the propeller goes back into the water. I had rather an interesting experience of that in connexion with a reversible Diesel marine engine. It was an engine of 100 B.H.P. in a small launch drawing about 2 ft. of water. I am a bad sailor, but as I was in charge I did the best I could. I did not find any difficulty ; but on going back into the water on one occasion—perhaps because I was not capable of giving proper attention to the engine—I found that the engine slowed up for a brief period. So far as restarting is concerned, Messrs. Sulzer Bros. have a very ingenious device which comes into play with their method of reversing, and it has practically eliminated all difficulties in that respect, because the starting air is continually on, so that if she stops, all one has to do is to drop the wheel in front and thus put the engine on to the starting air. If the engine stops, the driver has been neglecting it. Regarding the times given in Mr. Shackleton's paper for reversal, on the 100 B.H.P. engine you can get complete reversal from low to full load in a matter of $1\frac{1}{2}$ seconds ; and complete reversal from full speed ahead to full speed astern in 2 seconds.

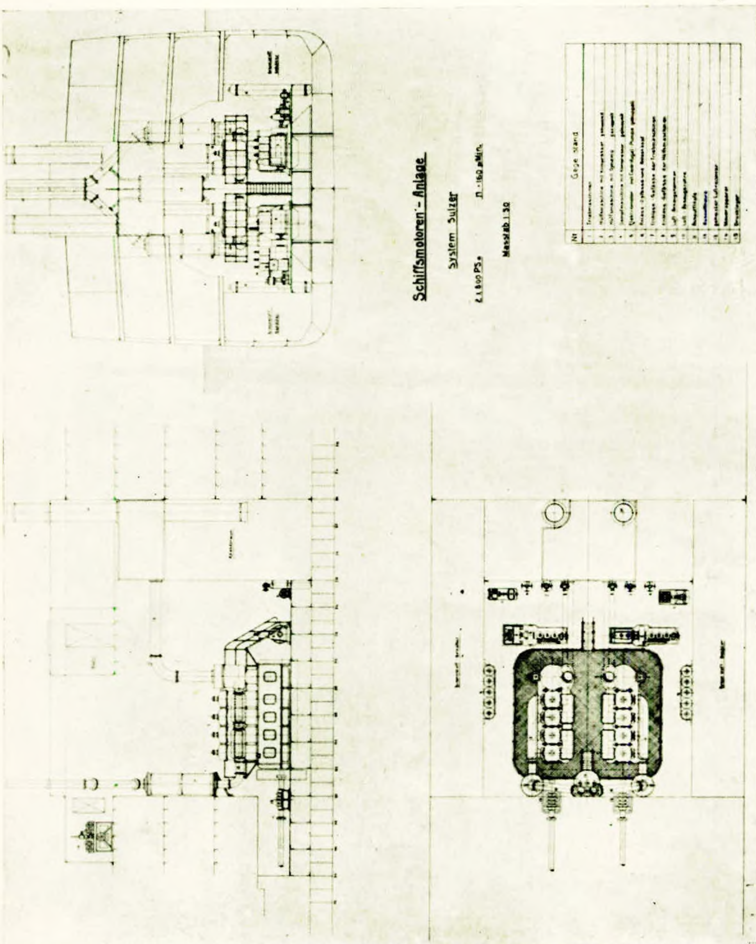
So the figures Mr. Shackleton gives are fairly well covered. Mr. Rosenthal was the gentleman who first cited these figures, i.e., those in the paper, and from what my experience has been I can endorse them as being correct. Touching on the question of fuel oils, one of the gentlemen who have spoken to night has told us that the supply is rather uncertain. For my part, I do not think so. In India within the last eight months or so, the price of suitable fuel oil for Diesel engines has fallen about £1 a ton. Oil fields are springing up in various parts of the world, Borneo and New Zealand for example, and a number of companies have been and are being formed and the prices are thus being cut down. Even in South Africa an Oil Depot is in course of formation. The supply of fuel oil is practically as unlimited as the coal supply.

Mr. F. Schubler : I fully agree with the remarks of the last speaker with regard to the prices of fuel oil. The price is rather getting cheaper than higher. The supply of oil is enormous. Regarding the remarks about gas engines, I quite admit that great advances have been made by gas engineers ; but if the two-stroke cycle type is advocated for ship propulsion, I would say that gas engines in general have several disadvantages, and gentlemen who have experience with gas engines will agree with me that for small loads difficulties of combustion arise, as the mixture becomes so weak that no good combustion is attained. Another drawback is pre-ignition and backfiring. The greatest inconvenience, however, are the gas generators. It is the main advantage of the Diesel engine that it does away with the boiler plant, and if reversible, also acts direct on the propeller shaft. As soon as the installation of gas producers is admitted, matters are again complicated. With regard to the efficiency of transforming apparatus I have some doubts. Assuming that a pump and water turbine combination is used, each will perhaps have 85 per cent. efficiency at the highest. The combined efficiency of the two, or the transformer, would be hardly higher than 70 to 75 per cent. The same applies to an electrical transformation, where a dynamo and motor are required, and the combined efficiency in this case also would not exceed the previous figures. This always means a loss of power and complications. In my opinion the best efficiency and greatest simplicity is obtained by means of the two-stroke cycle direct reversing engine.

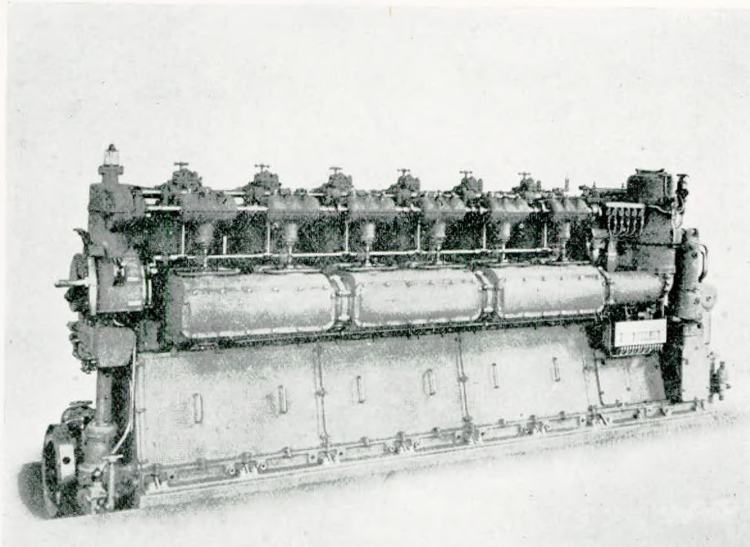
Mr. Schubler then showed lantern illustrations of various Diesel oil engines, of which the following are some reproductions.



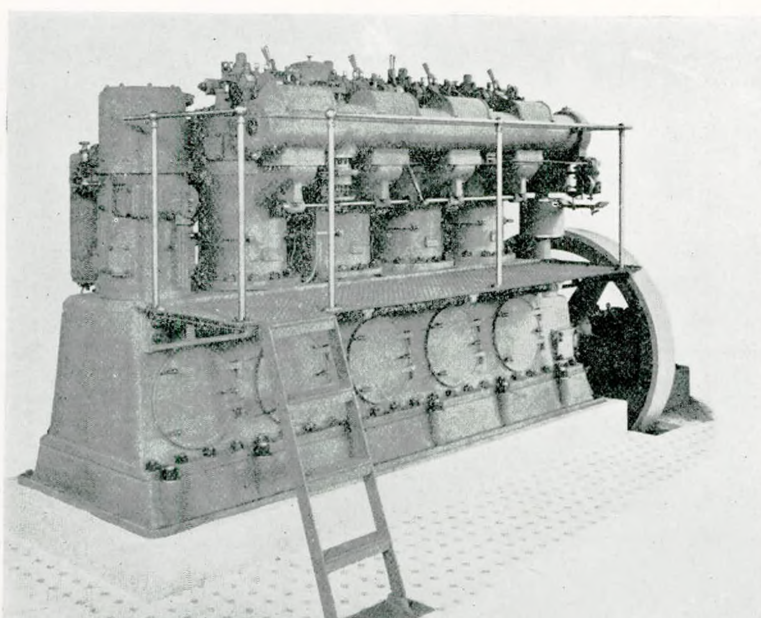
The *Venoge*. fitted with a 45 H.P. Oil Engine, by Messrs. Sulzer Bros, for work on Lake Geneva.



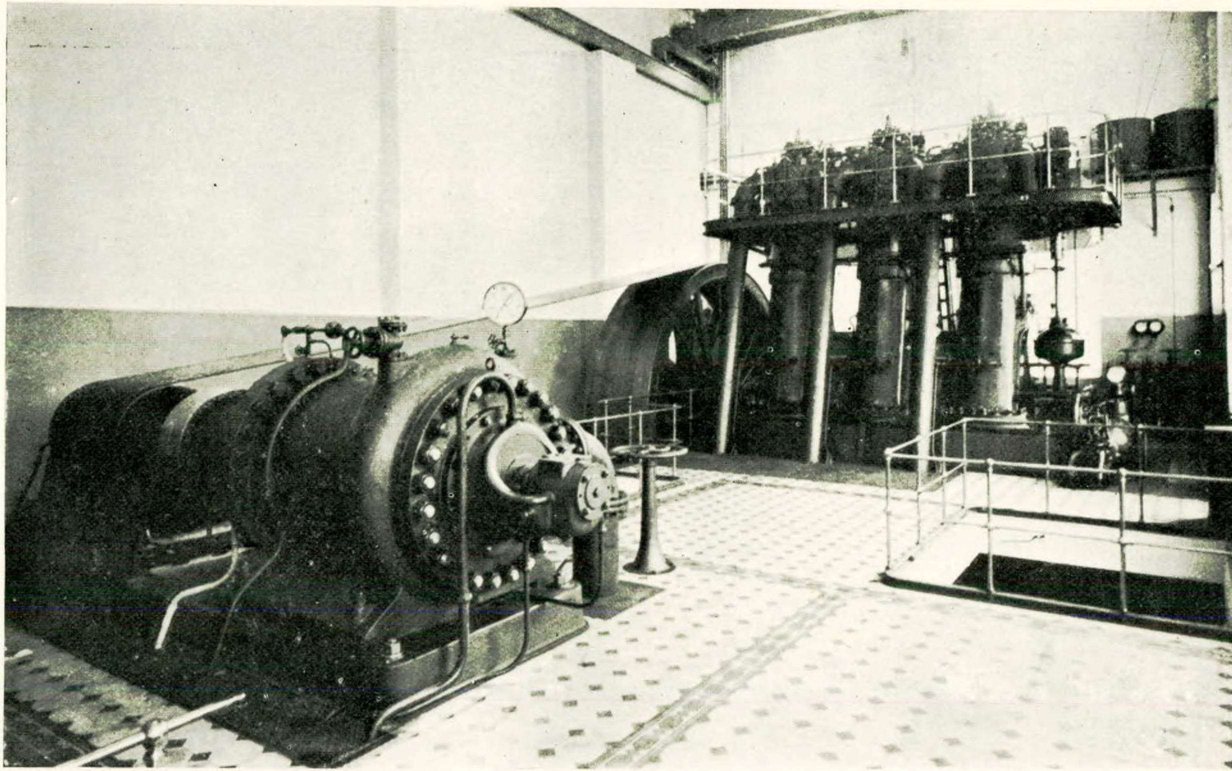
Arrangement of two 800 B.H.P. direct reversible Sulzer Diesel marine engines, with auxiliary engines.



6 Cylinder Direct Reversing Sulzer Diesel Marine Engine.



Sulzer High Speed Four Cycle Diesel Engine of 200 B.H.P.



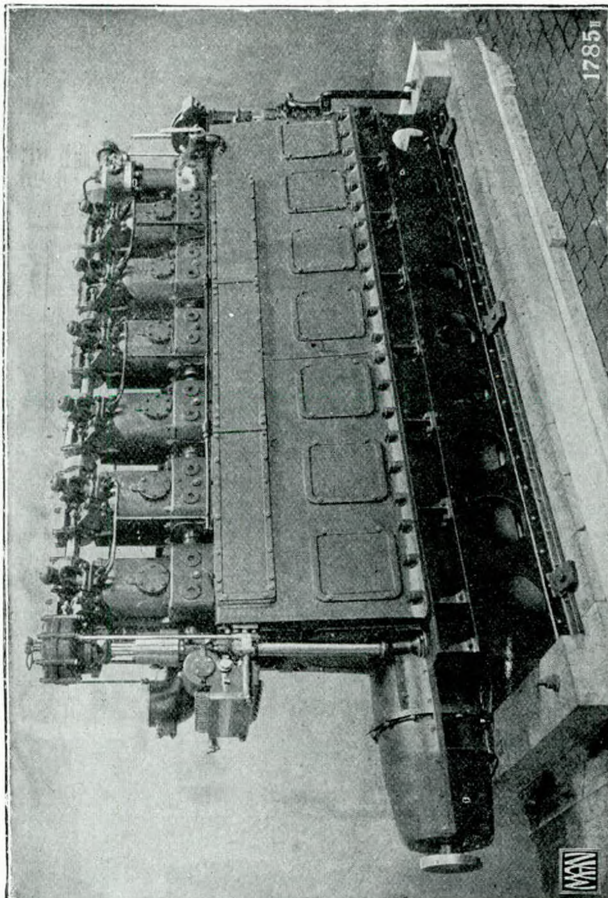
700 B.H.P. Sulzer Diesel Engine in the Municipal Pumping Station, St. Gall. The Engine works a Sulzer high-lift Centrifugal Pump, raising 1,320 gals. of water against a height of 1,080 feet.

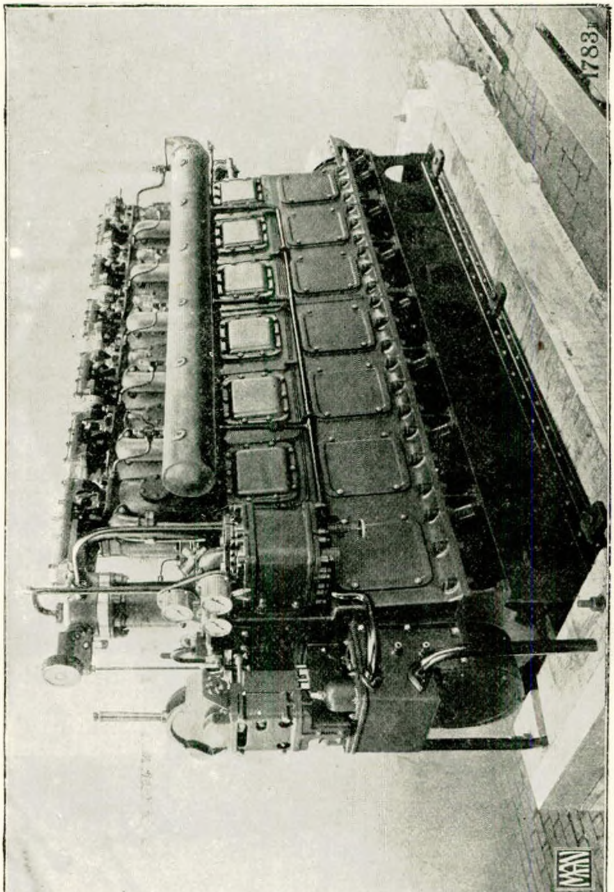
Mr. P. A. Low then showed some lantern slides of Nürnberg Reversible Diesel Engines, and in the course of his descriptions of same, remarked—

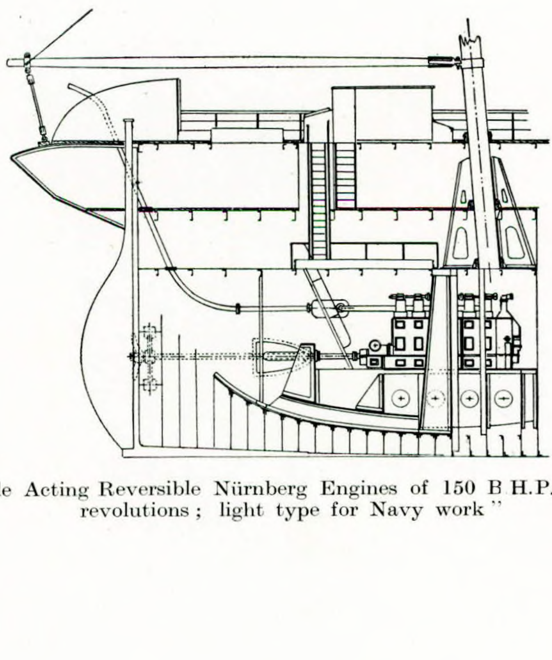
Two Nürnberg double-acting Diesel engines, each of 1,000 horse power, have for some months past been undergoing very exhaustive tests. As a matter of fact they have been given almost every trial that an engine could have in an attempt to break them down. Amongst our tests on one occasion one of the scavenge air pistons was taken out and the engine for several days ran with two instead of three scavenge pistons, with no bad effect at all. At another period they cut out one end of one of the cylinders and for several days the engine ran with only five ends working. It ran well, but of course with reduced power. It also ran with three ends cut out. These are certainly tests to which the steam engine could not be subjected. As to the question of flexibility, I might say that the normal speed of the engine I referred to was 120 revolutions per minute, but it could be run and had been run for a half-hour spell at 22 revolutions per minute. One of these engines is in the works of Messrs. Blohm & Voss, the shipbuilders of Hamburg, and it, with its sister engine (built at Nürnberg) is to be installed in a vessel for the Woermann Line.

Reproductions of some of the slides shown by Mr. Low are given over. The *Quevilly* is a French sailing ship of 3,200 tons with two 300 H.P. Nürnberg oil engines. She has made three very successful voyages to New York and back, in each case making record time, due to her auxiliary power, and taking herself in and out of harbour without a tug. In consequence of her success a larger ship, *La France*, of 7,000 tons, is being built and will be fitted with two engines of 1,000 H.P. each.

The French Sailing Ship *Quevilly*, with two 300 H.P. Nürnberg Oil Engines.

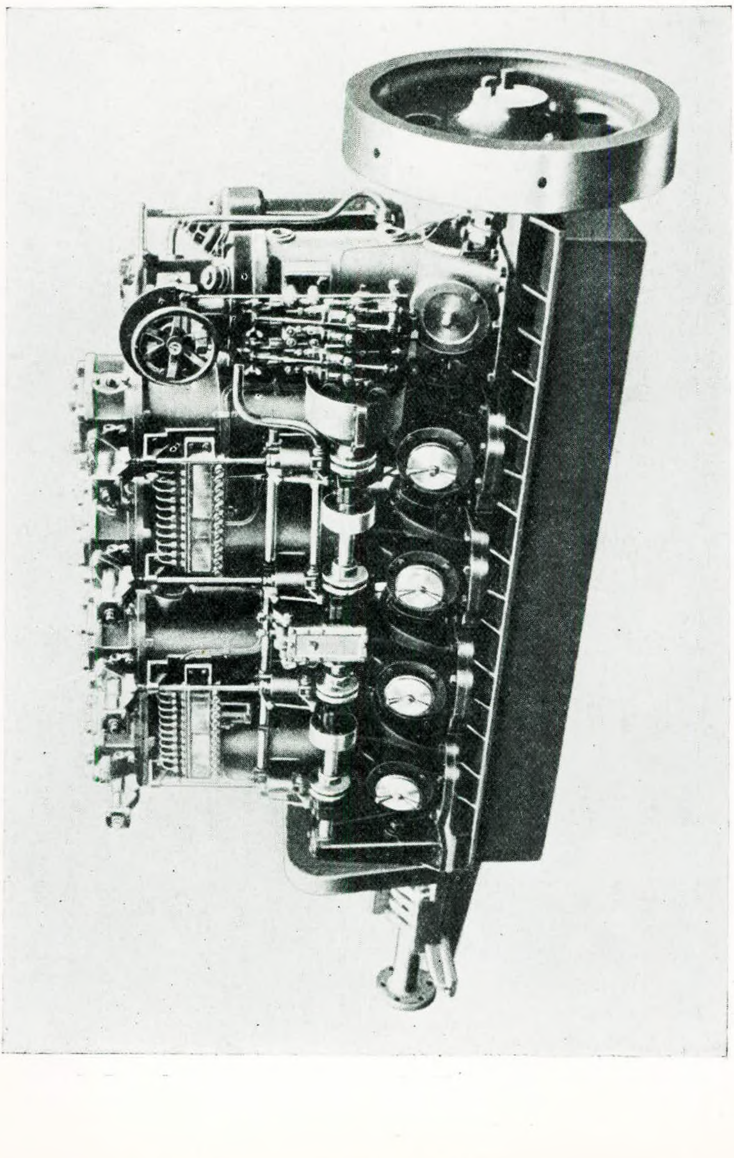

1785 II





"Single Acting Reversible Nürnberg Engines of 150 B.H.P. at 550 revolutions; light type for Navy work"

Mr. F. M. Timpson then showed an illustration of a130 B.H.P. two-cycle crude oil engine used for the Marquis of Graham's yacht and said :



The Beardmore Crude Oil Engine of 130 B H.P., for the Marquis of Graham's yacht.

A similar engine has been run for190 hours on Tarakan crude one of the most difficult oils to use. The running was very satisfactory. This type of engine is not designed to go much beyond 1,000 horse power at present. Perhaps it will interest you if I read out some particulars in connexion with it.

The "Beardmore" Engine for the Marquis of Graham's Yacht.

This engine is of the vertical type for marine propulsion which is made in units of one or more cylinders according to the power developed and style of drive. The engine has many interesting and novel features, and the special system of vaporization is such that the engine is capable of dealing with *any* kind of liquid fuel, and a change from refined to crude and *vice versa* can be made while the engine is running with no other alteration of setting than is necessary to turn one supply tap off and the other on. The engine is designed on the low pressure Diesel two-cycle system with crank case compression, and the cycle of operations is as follows.

Compressing Stroke.—The piston forms a partial vacuum in crank chamber which sucks open the air inlet valve, filling the crank chamber with air. At the same time the piston is compressing, in the clearance space, the charge of air which has been supplied from the previous stroke to a pressure of 150 lbs. per sq. inch. As soon as the piston has reached the end of stroke, the pulveriser or sprayer discharges a quantity of oil and air at a pressure of 400 lbs. per sq. inch against the hot vaporiser, causing the mixture to ignite and thus forming the power stroke. The heat of the vaporiser is maintained by the heat of compression and combustion. On starting it is heated by means of a blow lamp for a short time.

Power Stroke.—On the down stroke the piston uncovers the exhaust ports and the pressure in the cylinder rapidly falls. On the piston travelling still further, the air ports open, thus allowing the compressed air in crank chamber to scavenge out the burnt products. The cycle is again repeated as before.

Fuel Supply.—The fuel is supplied by a set of fuel pumps driven from the cam shaft and arranged to deliver the exact quantity of oil to the pulveriser for one power stroke. This oil is deposited in pulveriser previous to its opening. Governing is effected by a Centrifugal governor varying the quantity of fuel oil.

Fuel Air.—The air for ejecting the fuel from pulveriser is kept at a constant pressure of 400 lbs. per sq. inch by a two-stage compressor, driven from a separate crank on the crankshaft.

The Pulveriser.—This consists of a series of rings serving to break up the fuel and mixing same with air and thus forming a mixture easily vaporised. The pulveriser opening is timed by a cam on the camshaft.

Starting.—Starting is effected by a compressed air contained in bottles and distributed to engine by a series of cams and levers which can be switched out of gear when the engine is running by levers.

Lubrication.—The engine is lubricated by a combined sight feed and force pump lubricator, provision being made for carrying the quantity of oil delivered to any part of the engine.

The engine is much lighter than the general Diesel engine, and is entirely designed by marine engineers, taking, as Mr. Shackleton intended to convey in his paper, the best practice obtainable from engines in shore use. Perhaps an opportunity may be given later of seeing this engine working. It is a direct reversing engine, the whole of the movements being operated by a handwheel. You can start, stop or reverse, by the moving of a single wheel. I may say there is no crowding of gear over the top of the cylinders, which are easily accessible for removal of covers, overhauling pistons, etc.

It might interest you to know that we have run 190 hours non-stop trial with an engine of 95 B.H.P., the fuel used being Tarakan oil of the following particulars :—specific gravity, ·95 at 60 deg. Fah. ; flash point, 200 ; Calorific value, 18,830 B.T.U.

We could have continued running longer on this test, but our oil gave out.

Mr. W. McLaren : I think Mr. Shackleton's paper is a question of oil versus steam, and I am sorry to read some of the remarks on the marine engineer. The marine engineer has been able to hold his own, and from one of the slides shown to-night, we see that everything underneath the gland of the double-stroke marine engine, everything is similar to marine practice at its present stage. It is very gratifying to see that, because it is an admission that the marine engineer is still able to hold his own, and I do not think he is averse to being still further educated. He is looked upon as being conservative when there is something new on the market, but there are numbers of marine engineers all over the world who appreciate new things and try to make the best of them. It has been his duty to do so and he tries to act up to it. A remark I made at the previous meeting was evidently not quite clear, and Mr. Shackleton has said something about the matter to-night. It was about stand-by losses on the basis he was working upon. If it is only on the experience of one superintendent engineer, it would be good for him to know that, from my own experience, coming into this river with a ship of over 3,000 horse power, we have put no coal in from the time we were in at Gravesend and lying up at Hermitage wharf, and that when the vessel was lying up for two or three days it only required an average of 78 cwt. to get her into full swing. He has quoted over-sea practice, but it must be pointed out that the consumption on a long voyage ship coming into port may be much higher than one which has had the practice and confidence in coastwise running. I would like to know what he has taken as his basis for stand-by losses. Then he says there is a minimum of labour on the oil engine; but we would like to know what that labour is. He says there is an excess of vibration over steam. I understood the oil engine was a means of getting a constant thrust engine, which has been the aim of many engineers. Therefore I cannot see where the vibration comes in. In reference to the use of a clutch, I suppose that will not be considered. We could not think of a clutch for high powers. Further on he says, "this firm, by the way, have been the builders of the engine for the O. S. *Vulcanus*, and the American builders are the American Diesel Engine Co." Are these gas engine manufacturers, or have they had any marine practice? "Diesel engines," he says, "do not run at their best at very low speeds." What are we to make of that in view of the statement by one of the speakers this evening? Am I to understand that the twenty-two revolutions quoted were from a Diesel engine, or on the Diesel principle? Then again I would ask, what temperature do you allow or reach with the cooling water for the jackets? Here is a paragraph I would like to read: "It will be understood that the manufacture of the Sulzer Diesel marine engines calls for the supervision of a special staff, and it is obvious that the conditions are entirely dissimilar from those pertaining to stationary engines, as each engine of the marine type has to be specially designed and built for each individual ship, hence the initial stages in the construction of them are costly and slow." I do not see why the work should be slow; when we consider the experience they have had in making gas or steam engines, Messrs. Sulzer Bros. surely have them achines to do the work, which must now, for the most part be repetition work. Then I come to the question of labour. In the paper (on page 61) he gives a comparison between a steam engine of 1,500 I.H.P., and an oil engine of 1,500 B.H.P. I do not see how he can work upon such a comparison. Then he allows ten firemen and a trimmer for vessels with engines of 1,500 I.H.P. The shipowner would be very generous to allow such a number. I should say six men would be sufficient. Certainly the donkeyman would be an extra man, that would be seven instead of eleven. In the oil engine you have only one man accounted for, which is not a fair estimate. It is stated that somewhere about 60 per cent. would be saved in cargo space. That is an item upon which Mr. Shackleton might go into details, giving the whole space taken up for machinery and plant, not merely the bunker space. With regard to bad weather conditions, we have had figures given of reversals in a very short space of time. Marine engineers should be careful with this, because if the engine is easily reversed it is easy to stop. If the vessel is in a sea-way and the stern rises, that engine which is so quick at reversing is the engine which will stand still when the stern dips again. There was a point which I noticed in connexion with one of the slides shown, and that was the question of running without a cover. I myself have not taken the cover off, but I have tried an experiment with a fan engine. I cut the steam off at one end and had her running single-ended. It is a question of the steam-tightness of the piston. It would have been a very similar thing to have had the cover off, but it was just a trial of the continuous thrust or constant pressure on the crank. Mr. Shackleton goes on to say: "Now as to the question of wear and tear, this may probably be slightly higher than with steam." Why should it be higher? The marine gas engine is supposed to run itself and does not want any looking after. These are little points that the marine engineer would like cleared up so that he may have an opportunity of defending himself.

Mr. John Clark: Before Mr. Shackleton replies, may I ask whether this discussion should not be adjourned again till another evening, so as to get full justice done to it.

Mr. Timpson : I support that view. There are many of our members who would like to speak on the subject if we have a spare evening.

Mr. Shackleton : Although I am quite willing to fall in with the wishes of the members, I do not think it desirable to adjourn the discussion again. As Mr. McLaren pointed out on the last occasion, the paper is already somewhat stale, and if I were to re-write it, it would have a different phase to what it has now. In arriving at my conclusions with regard to the number of firemen employed, I think I might be justified in saying that a vessel of 1,500 I.H.P. would require the number I have given. Probably there would not be more than six or seven firemen, but other men would be required to trim the bunkers, and altogether the number would not fall far short of ten or eleven men. That was a point on which I made one or two inquiries. If I had desired to add further death-blows to the marine steam engine, I could have collected more data, and there were numerous things I left out which I might have used. The question was raised in connexion with the horse power of the two vessels I compared. I took two of identical horse power, except that the Diesel engine was brake horse power—actually a larger engine. I merely took these engines, one of I.H.P., and the other B.H.P., to assist in getting figures for the sake of comparison. Regarding the temperature of the cooling water to jacket, every one who knows Diesel engines need not be alarmed in connexion with the cooling water at the jackets. You do not want too low a jacket temperature. It is too little in many cases. One or two have spoken of the failure of the reversing engine in coming to a full stop. That has been frequently confuted. Some few months ago an engineer ran into print on the subject and that article was founded largely on a hypothetical basis. It is a difficulty never experienced in practice, the engines are governed so closely that immediately the load is off they are cut out and immediately the load touches again the pressure is on. As to broken propeller shafts, the marine Diesel engine is a better governed engine than the best possible steam engine, because the governing is so close, and if there is racing, the racing is largely because of broken propeller shafts. As to the question of coal consumption, he who gave me those figures, gave them in all good faith, and he was as anxious to have his boats running well as any one else could be. They are deep sea vessels; if they were coasting boats the losses would be just as great. I took the particulars of nine different steamers in one line. I have no bias in the matter, but it will be evident that when the coal is consumed it must be charged to something; the boat must be charged with it. Mr. McLaren says he is pleased to see the double-acting type of engine has been adapted from the steam engine. The marine authorities said they would not have an engine of high power with the gudgeon, it would require to have a crosshead. "Very well," said the makers, "we will make them with a crosshead." A single-acting engine was made so high that you could have a double-acting engine, hence the double-acting Diesel engine. I quite concede that there were some advantages found out afterwards. The double-acting engine has a greater range in the slow speeds than the single-acting for certain work. The question has again come up about the builders of gas engines. Somehow, the marine engineer seems to have an objection to gas engineers. I can only repeat that the most advanced builders of marine engines in the world, or one of the most advanced, are builders of large gas engines also, and moreover, the first builder of a Diesel engine was a builder of gas engines. Regarding my statement that the marine Diesel engines in the process of building would be "costly and slow," Mr. McLaren will doubtless appreciate that a ship's set of Diesel engines are not "shelf goods," and are specially built to suit the requirements of each vessel. Hence, largely, each new engine is a special model, which renders them costly. As to slowness of construction, generally speaking, a new marine Diesel engine cannot be obtained in much less than nine to twelve months. They have had such a lengthy expeience and have advanced to such an extent in the marine world that the accusation that they know nothing of marine practice falls to the ground. As Mr. Brewer said, the motor work is of a very high grade, and without detriment to the marine engineer, I may say that the work turned out on these engines would surprise the marine man. I have no brief for the builder of motor-cars. Motor-car engines are sniffed at, but after all the motor-car engine is a work of a very high nature. With regard to the price of fuel I do not quite agree with Mr. Brewer's remarks. I recognize that he has put his finger on one of the weak spots, but I do not think we need anticipate any further rise ; in fact I think we may anticipate a fall rather than a rise.

I fail to see where the list of makers of Diesel engines I gave is "largely erroneous" as stated by Mr. Milton, and if he will note the original paper he will find reference to various makers whose names, he states, I have omitted. As at least some nineteen or twenty makers or licensees are mentioned in connexion with the paper, the words "largely erroneous" hardly apply. It will be obvious that when concerns are taking up the manufacture of Diesel engines abroad daily, there must of necessity be some omissions.

With regard to Mr. Milton's remarks on compression, it must be borne in mind that at very low speeds there is lower compression of necessity than when the engine is at normal speed.

It was agreed, on the proposal of Mr. W. McLaren, seconded by Mr. F. M. Timpson, that the discussion be concluded, and that Mr. F. Duncanson's paper, "Notes on Two-stroke Cycle Oil Engines," be read on Monday, October 30. [1]

The meeting closed with a vote of thanks to the Chairman.

ADDENDUM.

List referred to in Mr. Shackleton's Remarks showing Analyses of Coal Consumption on Voyage by Nine different Vessels.

Port.	Raising Steam.	Standing By.	Donkey Boiler.	Refrigerater.	
I.					
Cardift	7	—	4	—	
Monte Video	9	8	12	35	
Las Palmas	—	3	—	—	
Liverpool	—	9	13	23	
Tons of coal consumed	16	20	29	58	123
II.					
Cardiff	6	4	7	1	
Vigo	—	2	—	—	
Buenos Aires	6	16	22	20	
London	6	4	12	11	
Newcastle	6	11	16	9	
Cardiff	—	3	16	14	
Tons of coal consumed	24	40	73	55	192

[1] Subsequently altered to November 6.

Port.	Raising Steam.	Standing By.	Donkey Boiler.	Refrigerator.	
III.					
Liverpool	4	2	—	1	
Monte Video . . .	6	10	22	12	
Bahia Blanca . . .	3	17	27	15	
Las Palmas	3	3	1	4	
London	3	23	17	11	
Hull	—	3	9	6	
Tons of coal consumed	19	58	76	49	202
IV.					
Cardiff	15	—	—	—	
Vigo	3	3	—	—	
Monte Video	9	5	15	12	
Bahia Blanca . . .	9	6	11	7	
Buenos Aires . . .	11	2	14	13	
Las Palmas	4	4	—	—	
Liverpool	9	5	17	15	
Cardiff	6	5	7	7	
Tons of coal consumed	66	30	64	54	214
V.					
Liverpool	10	5	—	—	
Bahia Blanca . . .	8	22	15	10	
Buenos Aires. . . .	14	14	12	12	
Vigo	—	4	—	—	
Liverpool	4	8	43	41	
Tons of coal consumed	36	53	70	63	222
VI.					
Liverpool	13	—	16	2	
Buenos Aires. . . .	9	18	12	34	
Las Palmas	—	5	3	—	
Southampton . . .	—	16	7	6	
London	8	—	10	9	
Newcastle	—	2	5	4	
Tons of coal consumed	30	41	53	55	179

Port.	Raising Steam.	Standing By.	Donkey Boiler.	Refriger-ater.	
VII.					
Glasgow	20	—	—	—	
Avonmouth	35	18	30	—	
Glasgow	10	8	20	—	
Manchester	10	70	20	—	
Liverpool	10	6	24	7	
Las Palmas	9	6	—	—	
Cape Town	—	55	—	—	
Melbourne	—	23	5	—	
Sydney	17	4	11	—	
Wellington	5	5	4	4	
Napier	—	2	2	4	
Auckland	12	4	8	8	
Lyttleton	12	—	9	12	
Port Chalmers	—	4	4	4	
Waitara	—	7	2	2	
Wellington	—	19	11	13	
Monte Video	6	11	15	22	
Avonmouth	—	11	6	10	
Liverpool	10	15	21	25	
Glasgow	—	10	6	8	
Tons of coal consumed	156	278	198	119	751
VIII.					
London	15	4	41	8	
Port Said	—	7	17	—	
Cairns	—	14	2	—	
Townsville	—	37	22	4	
Rockhampton	—	29	11	1	
Brisbane	—	42	49	16	
Broadmount	3	24	17	7	
Brisbane	8	14	34	13	
Sydney	4	—	34	23	
Geelong	—	40	10	14	
Melbourne	15	—	19	18	
Albany	—	20	—	—	
Suez	—	34	—	—	
London	—	50	93	40	
Tons of coal consumed	45	315	349	144	853

Port.	Raising Steam.	Standing By.	Donkey Boiler.	Refriger-ater.	
IX.					
Avonmouth	12	—	11	1	
Manchester	8	20	6	1	
Liverpool	9	17	12	3	
Madeira	—	26	2	—	
Durban	6	16	8	—	
Adelaide	5	34	14	1	
Melbourne	10	4	15	1	
Sydney	5	—	11	14	
Brisbane	5	4	22	31	
Sydney	6	—	14	22	
Newcastle	13	4	13	18	
Melbourne	10	34	17	22	
Colombo	—	5	—	—	
Suez and Port Said . .	2	48	—	—	
London	5	12	20	12	
Liverpool	—	22	29	29	
Avonmouth	—	3	17	5	
Tons of coal consumed	96	249	211	160	716

At a meeting of Council of the Institute held on Thursday, October 19, the following were elected : —

As Members.

Charles J. K. Grieve, Singapore.
William Hudson, Hull.
George G. Patterson, Shanghai.
Lindsay Roy, Nairobi.
Forbes D. Shepherd, Leith.
Arthur R. Watson, Port Chalmers, N.Z.
George C. Wilson, Shanghai.
T. T. Wright, Hong-Kong.

As Associate Members.

William Jessel, Leeds.
Edward R. Wadsworth, Liverpool

As Graduate.

Alan J. Walker, Glasgow.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1911-1912

President: The Most Hon. The MARQUIS OF GRAHAM, C.B., C.V.O.

VOL. XXIII.

PAPER OF TRANSACTIONS NO. CLXXVII.

STEAM TURBINE THEORY.

By F. J. KEAN, B.Sc. (LOND.), (MEMBER).

READ AT 58, ROMFORD ROAD, STRATFORD,

Monday, October 23, 1911.

CHAIRMAN: The Hon. SIR CHARLES A. PARSONS, K.C.B., F.R.S. (PAST-PRESIDENT).

ELECTION OF MEMBERS.

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