of the air were disturbing effects which influenced the suoply of vapor, and the facility of igniting it, besides the variation in the quality of the petrol itself. The word "petrol" was used because it had come to have a distinctive meaning, that of the lighter and more volatile products of petroleum distillation, and included under it, distillates having a specific gravity of from .65 to .75, and a low flash point, under 75deg. F. The petroleum Acts of 1871-79 in Great Britain made the storage and use of such light oils very inconvenient there, and in 1896, regulations were made in the interest of oil-engine owners, modifying them, and defining a "light oil" as one having a flash point under 73deg. F., but the petrol commonly used would flash at a much lower temperature. The Author mentioned 55deg. as the flash test of distillate, and gasoline as from 60 deg. to 88deg., but "Hiscox" states that the flash point of gasoline was 10deg. F., much under freezing point. "Grover" gave in the case of gasoline 32deg. or freezing point as its flash temperature, and 14 deg., or 18deg. of frost, as that of benzine light oil. These light oils were known as petroleum, ethers, and petroleum spirit, and were called by trade names, gasoline, benzoline, and various grades of naptha. The petrol of commerce might be a mixture of all of them, and vary indefinitely in its vaporising temperature and calorific power.

The legal restrictions on the use and transport of such obviously dangerous fluids in the United Kingdom had prevented the development of their use there; and Mr. Dugald Clerk, in his work on gas and oil engines dismissed consideration of them, by saying they were much too dangerous for successful use by the general public in engines. But the mania for "Motoring" had familiarised the public with petrol, and with its dangers. For motor launches, the dangers of use and transport were appreciably less than with land vehicles, while the opportunity of gratifying the passion for mad rushes of speed were greater afloat than ashore; so that the petrol motor launch industry was booming in Europe, and there was no reason why it should not boom in Australia also, especially, when we considered the care taken by the Authorities here to prevent undue danger. But it was difficult to provide for all contingencies, and as recorded in the "Engineer," of April 15th, one of the favourites, "Parisienne 11," came to grief, and met with an untimely end in the great motor launch speed competition at Monaco, in April last. It was a large launch, constructed of steel, fitted with three propellors, driven by "Mors" engines, developing more than 200H.P., and had 1000 litres (220lbs.) of petrol aboard in two tanks. During the race, the pipe connecting the tanks broke, and the launch was flooded with spirit. In an instant all was ablaze, and the three men and the pilot were scorched before they had time to jump overboard. The steel shell with the flaming spirit was towed inshore. The vapor may have been ignited by flame issuing from the exhaust pipe at high speeds.

In America they appeared to run greater risks than in Great Britain, and had quantities also of these light oils to dispose of, so that the petrol motor was more in vogue. But the average American design, and workmanship did not impress him as nearly coming up to the standard of the Otto Crossley gas engine, or internal combustion engines turned out by British makers in general, as America had not, in many things, passed out of the age of cast iron. In British engineering of 60 years ago, they knew how extensively cast iron was used, even for shafts and connecting rods, and in American designs it was still found in use for links, small levels, and various fittings where stampings or forgings would be preferable. When these small parts are made of cast steel, or malleable cast, there was not so much objection, but too often the iron was chosen for ease in machining, rather than durability or strength. Of course, this was not peculiar to oil motors.

but appeared very markedly in agricultural machinery, pumps, etc., where high mechanical talent was often lavished on inferior material. Another feature in American machine design, was the use, very often, of light bolts and studs for connecting the different parts, for valve motions, and so on. In pumps and hydraulic machinery, for instance, it should be endeavoured to use a few large studs for valve covers rather than a multitude of small ones, and not as in oil-motor designs, where the tendency seemed to be to use small screws and fittings, which slipped through the fingers of an ordinary mechanic, and often got lost, or were easily damaged. This sort of work might be all right when special lightness was required—for massive studs require suitable castings to hold them—but it was not commendable in engines that had to stand every day work. The fact that these engines had been most looked upon as toys or luxuries for pleasure boats or vehicles, might have something to do with this, but as they were used more and more for commercial purposes, no doubt it would be found advisable to build them on the lines of a good steam engine.

One striking difference between oil and steam motors was, that while a slight derangement of the valve setting would not necessarily stop the steam engine, it would the oil-motor, and the setting of the latter included also the timing of ignition which was usually produced by an electric spark in the compressed mixture, and as the batteries or dynamos used were liable to failures of their own, they increased the difficulty of diagnosing troubles, when they occurred. There should be no difficulty in installing an effective battery, and it should be in duplicate, so that one could be switched in if the other failed. The tube kept hot by the exhaust was a great improvement, and the battery was only used when starting or running idle. When the mixture was fired by the heat of compression or the hot surfaces of the piston and chamber only, very nice adjustment and steady running were obviously necessary to ensure success. When a small dynamo was used, it might fail though the engine itself was all right.

An oil-motor schooner was wrecked crossing a bar in New Zealand last year, through the dynamo being put out of action at a critical time by a sea coming over, so that the engine stopped and the vessel went ashore with loss of life. The igniting electrodes themselves might fail by getting foul with soot, oil, or oxidation, and should be arranged for easy cleaning and inspection. When the sparking points had a rubbing motion on each other it assisted in keeping them clean and efficient, and as the valve stems had a tendency to foul and stick, they should be easily accessible. The cylinders must be kept cool by water jackets, as a failure of the circulation was fatal to them, and even when the water seemed to be passing through, there might be air pockets in the jackets, producing ineffectiveness, and the small centrifugal pump often used, would have to be run at a very high speed, rendering it liable to wear and tear. All these troubles might be easily got over, but they showed that a mere theoretical knowledge of the principles of the motor was far from sufficient to make a good motor man.

The petrol engine had come to stay, nevertheless, it was one of the powers that be, and the only valid drawbacks to it were the danger of fire, and the high price of the oil, caused by the precautions necessary in transport and the comparatively short supply of it. Pensylvanian oil contains about 10 per cent. of these lighter oils, but in that from the new fields in Texas, the Russian, and much of the East Indian oil, it was less abundant. Even America had to look abroad for its petrol, and he had noticed in a Singapore paper, a short time since, that benizne was being largely shipped to the States from Palembang, an oil field in Sumatra, where it was produced in large quantities.

Kerosene and the heavier oils were far safer to handle and cheaper than petrol, and developed more energy, but their flash or vaporising temperature being so much higher, dfficulties and complications occurred. There were engines in which they were used with fair efficiency, but they were liable to all the troubles of the petrol engine and many more of their own. One of the best makers advertised that his engines made no tarry deposit, due to the fact that the working charge was vaporised only and never gasified, and three months' running was guaranteed without cleaning or attention. They used any kind of heavy or bulk oil, and any number of different brands might be mixed together in any proportions in the tanks, without affecting the running or the economy of the engine. This eulogium indicated the difficulties met with usually in heavy oil engines, and if they were really surmounted, the makers were to be complimented.

One point to be noted in the use of these heavy oil engines was that compression could not be carried so far as with petrol engines, owing to the danger of pre-ignition. Beau de Rochas demonstrated that a high compression was necessary to high efficiency, and the economy effected of late years in gas engines was mostly due to using higher compression, but the conditions of maximum economy were also those which favoured pre-ignition, and the compression of the vapours of heavy oil seemed to develope more heat than that of petrol. The principal art in designing internal combustion engines seemed to be to ensure the ignition occurring at exactly the right instant; for, if it happened before the engine had turned the centre, heavy stresses were brought on the cylinder end and the crank shaft, which might be fatal to them. A device coming into use in such engines was the injection of a spray of water with the working charge, which kept down the temperature, and enabled compression to be carried much further—this involved nice adjustment of the quantity of water used, and thus another source of trouble, but it seemed to render heavy crude oils suitable for use in such motors.

It would be interesting to learn if in engines made to use either petrol or kerosene, any difference in the degree of compression employed was advisable with the different oils. The Diesel engine, which used heavy crude oil, was worked with ignition by compression, but it was of the air only, the oil beng sprayed into the cylinder at the beginning of the working stroke by a high pressure blast of air. It burned in the cylinder rather than exploded, and gave very economical results in oil consumption, but the very high pressure of the air blast—800 to 1000lbs. per square inch—demanded high-class workmanship, and an expensive engine. This type of engine was made up to 80 brake horse power, with one cylinder, perhaps the most powerful single oil engine yet made, the power being usually got up by increasing the number of cylinders. Brake horse power was the only real datum for comparing such engines, but some simple formula, such as given by the Author, gave an idea of their size and weight, and, presumably, their power. But why not use area of piston only, as in the marine steam engine, to give a nominal horse power, which might have no fixed relation, indeed, to the real one, any more than that of the steam engine, but would serve the same purpose? A triple expansion steam engine with cylinders 10 inch, 15 inch, and 24 inch diameter, would be called 30 N.H.P. by the Board of Trade rule of 30 circular inches of piston area per N.H.P.; the same rule might be applied to the oil engine, and a four cylinder engine with pistons 15in. diameter, would be also called 30 N.H.P., though its brake power, as with the steam engine might be 8 or 10 times as much.

This was of interest, because the Navigation Acts regulated the grade of engineer to be carried in the case of steam, by the N.H.P., that was by the area of the piston only, while the new Act brought forward by the Commonwealth Government proposed to do so in the case of oil engines by the "brake" horse power, of course, without saying how or by whom the latter was to be determined. One rule would then do for both motors in this respect.

Mr. W. H. German wished the Author to explain how the constant used in calculating the horse power of oil engines was arrived at?

Mr. J. W. Fell said that he wished to congratulate the Author for the able and lucid description given of oil engines. It was not his (the speaker's) intention to enter into details upon the design, construction, or efficiency of any one type, but to enlarge upon that information.

The definition of the engine under discussion was a misnomer, (a steam engine should be called a "Water" Engine, because the force was derived from coal and water) because as the propulsive force of oil engines was an artificial gas, produced from volatile hydro carbons, they should correctly be known as "Hydro Carbon Gas Engines," which embraced the four qualities of ether and oils, viz.—Gasoline, benzine, kerosene, and residual—from whence the gas was produced. The oil engine differed but little from the ordinary coal gas engine in construction, further than that it was self-contained; boiler and engine combined so to speak. The valve arrangements were actuated by different motions all of which claimed some special features, but tantamount to the same.

The valve action in a gas engine played a different part to that of the steam engine, which allowed a condensable gas to enter the cylinder and be used expansively; but the action in a gas engine was reversed, the valves of which—there are generally two, inlet and outlet, chiefly of the mushroom type, lifted against the pressure of a spring by means of a cam—performed the duty of admitting and releasing charges of air, air saturated with volatile hydro carbons or gas, and then releasing the spent gases (carbonic acid) after the explosion. The gas engine cylinders were jacketed for cooling (owing to the violent generation of heat, possible 1790deg. Cent. at moment of explosion) to enable lubrication and prevent escape of gases by the expansion of metals.

The means of supplying liquid fuel was either gravitation or pumping to the carburettors, vaporisers, etc.

Having generally outlined the engine, the next matter for consideration was the all-important gas producer—in other words, the oil engine's steam boiler. Here, and only here was the crux of the reliability of all classes of hydro carbon engines, whether operated by suction or force, dwells the full calorific value, and for that end the process at present adopted for gas producing must be treated separately:—

CARBURETTING.

This process was that the air was sucked through a chamber which contained either of the following ethers:—

GASOLINE.—C. 6, H. 14, specific gravity, .650; flash point, 32deg. Fah.; is the lightest hydro carbon known. When mixed in the proportion of one volume to eleven volumes of air, it produced a violent explosion.

BENZINE.— C. 8, H. 16, specific gravity, .700; flash point, 40deg. Fah.; is the next lightest volatile hydro carbon; explosive mixture one volume to 13 volumes of air.

NAPTHA.—C. 10, H.22, specific gravity, .730; flash point, 75deg. Fah.; is the third lightest; explosive mixture 1 volume to 16 volumes air.

The evaporative and absorptive powers of these three ethers, or spirits, were controlled by the air density due to temperature and moisture, hence it would be seen that some provision must be made, in the first place, to dry the air, and, secondly, to maintain an even temperature, so that the power of hydro carbon saturation would at all times be balanced, so as to produce equal explosions, for it must be understood the amount of volatile hydro carbon admitted to each charge was infinitesimal. These ends were arrived at by sucking air through lime or calcium chloride chambers, and the temperature regulated by air passing through a jacketed chamber, heated by the exhaust gases from the engine. The appliances were simple in construction and, if practised, the reliability of the gasoline engine would be assured. As things were, it was a simple matter to follow the trail of a motor using any of these ethers by the smell of the unconsumed fuel due to imperfect combustion.

CARBONIZING.

The oils used in this process were kerosene, C.13, H.28, specific gravity, .800; flash point 100deg. Fah.; residual C.87, H.12, specific gravity, .965; flash point, 212deg. Fah. It would be seen, therefore, that the characteristics of these oils differed greatly to the others already dealt with.

The present process of gasifying, was oil spray by gravitation or pump injection into a vaporizer attached to the end of the engine cylinder, wherein the oil came into contact with the walls of the vaporizer, which had been previously heated externally to a temperature sufficient to gasify. In oil spray cases, the oil and air mixture was sucked into this chamber, gasified and self-ignited. The next method was pump injection into the vaporizer, air mixture being admitted independently, and also self-igniting.

The laws of compression, being the foundation of economy, every molocule should filter through solids of a temperature not exceeding 1750deg. Fah., which end might be attained, by placing copper turnings in the vaporizer, the entrance to the cylinder being guarded by a screen of brass mesh. In this process, the admission of a small per centage of water helped to produce a higher compression, together with the complete absence of carbon deposit.

RESUME.

The following tables of explosive mixtures, analysis, and efficiency value of fuels, would help to explain his contention that the principal factor at all times in an oil engine was the reliability of the standard strength of the gas produced.

A steam boiler with varying pressures gave indifferent results, so with an oil engine with varying gas mixtures.

The values of ethers to oils were as wood was to coal.

The ideal oil engine, self-contained, should not be of heavier construction than a good steam engine; should have a series of cylinders for var--ing loads; and be capable of using any form of hydro carbon.

Where the duty of an engine was intermittent, or power required at short notice, the gas or oil engine had a decided advantage over the steam engine, and also by means of its economy, cleanliness, cost of installation, and depreciation.

As experience was gained, the march of improvements in gas engine efficiency would be as great as in the case of the quadruple expansion steam engine during the last quarter of the nineteenth century.

He was still of the opinion that it will be many generations before the use of the steam engine will be outlived.

Explosive Mixtures.

	Volumes of Gas.	Volumes of Air.
Natural Gas	1	12
Coal ,,	1	6
Water ,,	1	1.15
Hydrogen ,,	1	2.5
Acetylene ,,	1	12.15
Gasolene ,,	1	11
Benzine ,,	1	13
Kerosene ,,	1	16
Residual ,,	1	50

ANALYSIS.

	C. O.	H.	CH_4	CO_2	N.	C_2H_4
Natural Gas	2.0	...	2.0	....	4.0	92.0
Coal ,,	7.0	46.0	37.0	4.0	1.0	5.0
Water ,,	11.0	29.0	2.0	16.0	42.0	...
Hydrogen ,,	...	...	...	...	...	C_2H_2
Acetylene ,,	...	...	...	...	...	
Gasolene ,,	...	...	...	...	...	6.14
Benzine ,,	...	...	...	...	...	8.16
Kerosene ,,	...	...	...	...	...	13.28
Residual ,,	...	...	...	...	...	87.12

EFFICIENCY VALUE.

	lbs.	Cubic Feet.
Natural Gas	...	11 per I. H. P.
Coal ,,	...	22 ,, ,, ,, ,,
Water ,,	...	56 ,, ,, ,, ,,
Benzine ,,	.88	... ,, ,, ,, ,,
Kerosene ,,	1.09	... ,, ,, ,, ,,
Residual ,,	1.13	... ,, ,, ,, ,,

Mr. A. Christie said that the Author, in his paper, had stated that the oil motor was now used extensively, and would be used much more extensively if it were only better understood; also that the steam engine was so well known that everybody with the slightest pretension to engineering knowledge knew all about it. The inference which he (the speaker) drew from that was that in the Author's opinion, an oil motor was a more suitable source of power than a steam engine. That he entirely disputed.

He would, first of all, deal with the oil motor as a heat engine, and, for this purpose would take the consumption of oil as being 1.1lbs. per horse power per hour. That, he might mention, was the quantity stated in one of the makers' catalogues, and he, therefore, felt sure it was not too high an estimate. If the calorific value of the oil was assumed to be 22,000 B.T.U—which was equal to 9.43 horse power—it would be seen that the oil engine utilised 10.6 per cent. of that power, and that 89.4 per cent. was lost. Let that be compared with an ordinary triple expansion steam engine using 1.7lbs. of coal per horse power per hour, the coal having a calorific value of 14,000 B.T.U., equal to 9.28 horse power. In that case 10.77 per cent of the power was utilised, and 89.23 per cent. lost; so that, as far as a heat engine was concerned, the steam engine was equally as good as, or perhaps better than, the oil engine. One naturally might ask—and the question had been dinned into the steam engineer's ears ever since he, the speaker could remember—Why does a steam engine use so little of the heat of the coal, and why is so much lost? There was one thing which could not be got over, and that was a natural law. In converting water into steam, or steam into water, a large percentage of heat was lost. In the case of an engine working at 150lbs. pressure, with a steam temperature of 1222.7 degress, 966 degrees of latent heat (79 per cent) were absolutely lost, so that, of the total temperature, 21 per cent. was left to work upon. Of that, practically one-half was used, and the other half lost. In the case of the oil engine, the loss was fully 89 per cent., and he would like to hear how that was accounted for.

In order to make a comparison as to the cost of running launches driven by oil motors and steam engines, he recently gave instructions to the drivers of four of his company's launches to keep a daily record for one week of the work done by each launch, and the amount of coal consumed. The following table gave the results. The coal consumed, as marked in table, was used in getting up steam, lying under steam, running the launch, and lying with banked fires; in fact, the whole of the coal used from Monday morning to Saturday at noon. The number of hours actual running marked in the table was 20 per cent. less than recorded by the respective drivers, in order to allow for unrecorded short stoppages. The total amount of coal used was divided by the number of hours so obtained, and called the hourly consumption, and on that basis the costs mentioned in the table were worked out.

TABLE OF RESULTS OF ONE WEEK'S WORKING TRIAL OF FOUR LAUNCHES BELONGING TO MORT'S DOCK ENGINEERING COMPANY, LIMITED.

Type of Engine	High Pressure.	Semi Compound.	Semi Compound.	Semi Compound.
Size of Engine	6½″ x 6″ Str.	5″ and 9″ x 7″	7½″ and 12″ x 8″	8″ & 14″ x 12″
Boiler Pressure	150 lbs.	150 lbs.	150 lbs.	150 lbs.
Average Estimated H.P.	15	15	35	50
Hours under Steam	58½	56¼	56¼	64
Hours actual running	30	25⅓	29	24
Hours under banked fires	66	68¾	68¼	64½
Coals consumed in cwts.	27	13¾	27⅓	30
Cost of fuel per H.P. per hour	·576d.	·346d.	·261d.	·24d.
Total cost of fuel per hour	8·64d.	5·2d.	9·12d.	12d.
Cost of fuel for Oil Motor of same power per hour	22·5d.	22·5d.	52·5d.	75d.
Cost of fuel for Oil Motor compared with Steam Engine	261%	432%	575%	625%