# DISCUSSION

Mr. J. Macartney said that the author's paper, on oil engines, had come at a very opportune time, as it must be patent to all that an internal combustion engine, using petroleum, or its products, was coming into more prominent use every day, and for some purposes was rapidly displacing the steam engine.

That it did not take hold faster was (as the author had said) due to the fact that it was not as well understood as it should be by either builders or users, and unfortunately this was only too true when applied to the builder. While there was nothing new in the principle of the oil engine, one had only to look at some of those on the market to see that both designer and maker had but imperfectly understood their work. The gas engine burning coal gas, having been in use for a much longer time had been gradually improved, brought to a high state of perfection, and was now simplicity itself. The engine under discussion was a gas engine, pure and simple, but complicated to a certain degree by having to carry its own generating plant.

The aim of a designer should be to combine simplicity with efficiency, placing efficiency first, but many in their desire to simplify had lost sight of efficiency altogether, and he (the speaker) had a lively recollection of having gone out for an exhibition run with an engine said to be so simple that it was everything but "fool proof." The exhibitor (having stopped the engine to pick him, the speaker, up, and also to demonstrate its easy starting qualities), made his first blunder, as it took quite ten minutes turning the fly-wheel, and adjusting the sparker and vaporiser, before the engine could be persuaded to start. Once started, it ran perfectly for quite two minutes, when it fired back into the crank chamber, of course coming to a dead stop. Re-adjusted and started, the run was continued for another two minutes, or perhaps more, when there was another fire-back and stop, and on the whole run of about a mile this occurred four times. Satisfied with the simplicity of the engine, and not caring to waste more time, he persuaded the now disgusted exhibitor to adopt a still simpler, but more efficient mode of propulsion, namely, to take to the oars (with which he, the exhibitor, had come provided), and by the expenditure of a little muscular energy and a good deal of gas, the boat made a landing. When getting out, the gentleman, who was profuse in apologies (and perspiration), still adhered to his first statement as to the engine being so simple as to be everything but "fool proof," and further emphasised it by stating that he was a fool.

Before us here we have one of these simple machines, namely, a two cycle engine, or in the language of the steam engineer, a single cylinder, single acting, high pressure engine, with a trunk piston. An ideal in theory, but unfortunately the reverse in practise. The author had described the action so well, that it was hardly necessary for any further explanation, beyond merely referring to Fig. 1, Plate II., to see what its advocates would have us believe took place. In starting from rest (by hand) the piston travelled upwards, upsetting the balance in the crank chamber. To correct this and fill the vacancy created by the withdrawal of the piston (a light hollow cylinder open at one end) a mixture of air and oil vapour of correct proportions, rushed in through a non-return valve, and on the piston descending the mixture was compressed by an amount equal to the solid contents of the walls of the hollow open ended cylinder or trunk piston. When the piston had completed about 80 per cent. of its downward journey it opened a passage direct to the atmosphere, putting the upper part of the cylinder in equilibrium. Having given a full open port to exhaust, it then began to open a port connected with the crank chamber the contents of which would be at a pressure of from 5 to 6lbs. (builders' figures), a quantity of gas by virtue of the added pressure and its lesser density rushed in, and struck against a baffle, or deflecting plate, and instinctively sought the highest point in the cylinder. By the time the piston, on its return journey, had closed the port, a sufficient quantity of the mixture had entered to sweep out the spent gases and completely fill the cylinder; the piston arriving at the upper edge of the exhaust port just in time to prevent its exit. Continuing its course, the mixture was driven before the piston and compressed into a still smaller space, until having reached the highest point it attained a pressure of from 50 to 80lb when becoming ignited, the rapid combustion and consequent expansion forced the piston outward to repeat the cycle of operations.

On this basis it was claimed that the power of a two cycle engine was double that of a four cycle, having equal cylinder dimensions, and were the assumption true, such would be the case.

Referring now to Fig. 2, Plate II., it would be seen that something like the following took place. The mixture, upon entering, not being endowed with reasoning power, blindly followed natural laws, and passing the deflecting plate a large proportion (the fuel bill showed 20 per cent. to 30 per cent.) made for the line of least resistance, and aided by entrainment cut across, and escaped through the exhaust. It could not displace all the heavier burnt gases itself, so that the upper corners of the cylinder, a portion of the sides, and the part protected by the deflecting plate could never be free from exhaust gas, little more than half the cylinder space being filled with an effective mixture; and that much impaired. Assuming that the correct mixture of oil vapour and air had been drawn into the crank chamber, it was first thoroughly drenched with lubricating oil (a splasher being fitted at the bottom end, seemingly for this purpose), and having reached the cylinder it was still further vitiated by an admixture with exhaust gas so that it could not be wondered at that fires took place, or that upon entering, as it did, to mingle with burning gas it often fired prematurely; even the baffle plate, put there for guidance, could and did often get hot enough to cause premature firing. The igniting points, however, though subjected to the same intense heat, could not very well get overheated, passing as they did through the water jackets.

Fig. 3, Plate II., illustrated a slightly better arrangement, but as would be seen this introduced a valve—the bugbear of the two cycle man—which was placed in the cylinder head covering the mouth of the inlet. On the outward stroke of the piston, and as soon as the pressure in the cylinder had fallen below that in the crank chamber, the valve was forced open by the excess pressure, gas then entered, until the returning piston and the pressure of the spring closed the valve. Fig. 4, Plate II., represented the ideal conditions, or something like what actually took place. In some engines the amount of opening could be regulated by hand, the valve doing double duty as inlet and throttle. There were other defects to be considered, as in the crank chamber the gas would be under pressure. Fresh from the builders' hands the bushes might be so accurately bored and fitted, that, by a film of oil or grease intervening they were gas tight. But how long would they remain so? The wear, though it might be slight, took place, allowing gas to escape on the down stroke, and air to enter on the up stroke. Piston rings and cylinder walls will wear, and as exhaust gas would pass to the crank chamber (leaving wear out of the question), the piston rings became oil and soot bound, and caused the piston to leak, but this applied to all oil engines, more or less.

Some makers ground the crank webs up to the ends of the bushes to make them gas tight, but by doing this they transferred the thrust from the parts that should take it, to the crank web, and it was a mechanical impossibility to so adjust a thrust ring, or rings that they would run without a slight forward or backward movement.

A two cycle engine exhausted while the piston was moving over about two-fifths of its journey, so that the noise could not be effectually muffled without putting considerable back pressure on the engine. As a rule, in marine engine work, the exhaust was submerged, and advertised by makers as being positively silent, without back pressure, and though it might be silent under such conditions the back pressure is still there, for, if only submerged 1 inch light ship, a very small load would put it down another 6 inches—not much truly—still it gave more back pressure, and considerably reduced the speed of the engine. But the submerged exhaust had its advantages, as it was silent, or nearly so, and covered to a certain extent the miss-fires; it also smothered the smell of fresh gas escaping with the exhaust gases, though it could not hide the trail of the condensed fresh gas in its wake. If a trial was made of an engine exhausting to the atmosphere, and the number of missed explosions, and the smell noted, an answer would, at once, be given to the question about the high divisor used in the horse power formula by the author.

A further claim made was that this tvne of engine would be only half the weight, and occupy half the space of a four cycle engine of equal power.

He had looked up several catalogues and taken two, two cycle, and two, four cycle engines of 5 B.H.P., and as these engines were all intended for the same class of work, they would serve for comparison.

| Makers. | No. of Cylinders. | Length. | Breadth. | Height. | Revs. | Weight. |
|---|---|---|---|---|---|---|
| Two Cycle A | 1 | 16 in. | 16 in. | 34 in. | 380 | 550 lbs. |
| ,, ,, B | 1 | 17 in. | 17 in. | 27 in. | 500 | 475 lbs. |
| Four Cycle A | 1 | 17 in. | 19 in. | 32 in. | 500 | 720 lbs. |
| ,, ,, B | 1 | 18½ in. | 18½ in. | 38 in. | 400 | 750 lbs. |

This gave an average of 101lb per H.P. for two cycle, and 147lb per H.P. for four cycle, or nearly 50 per cent. more weight, but in the case of the latter the extra space was not worth considering.

The above engines had feathering or reversible propellers, but if a reversing clutch were fitted the overall length, and the weight would be greater.

The only extra fittings on a four cycle, over and above those on a two cycle engine, were an inlet and exhaust valve, and their operating mechanism. It might be pointed out that in some late two cycle engines air only was taken into and compressed in the crank pit, the oil being introduced at or near the head, or picked up by the compressed air on its passage.

The two cycle engine as made by some engineers was reversible running in whichever direction it was started, but this could only be done by sacrificing efficiency. In some arrangements a simple "lift up" sparker was adopted, making contact with the piston, whilst others again were fitted with three cylinders, having cranks at 120deg. and sparkers worked by movable cams or eccentrics, which could be thrown in either direction by means of a lever, but the makers themselves rather depreciated their own arrangement by fitting, in conjunction, either a reversing clutch or a reversible propeller, evidently recognising the fact that it would be rather a risky experiment to reverse an engine running between 400 and 500 revolutions per minute, with a fly-wheel weighing 2 cwt. on a $2\frac{1}{4}$ inch shaft, without having first brought it to rest. Then, there followed the trouble that it could not always be relied upon to start again.

There was a reversible engine that when running normally as a four cycle, could by a system of cams and levers be converted into a two cycle for ease in handling, by using compressed air to give it a start; that was for the first few revolutions it worked as a pressure engine, but the makers themselves admitted that the mechanism employed was somewhat intricate.

In the working of a gas engine four things must be accomplished:—First, drawing in a fresh charge. Second, compressing and firing the charge. Third, expanding. Fourth, expelling the waste gases. In the two cycle engines the four operations were performed in two strokes or one revolution, and in a four cycle engine, in four strokes, or two revolutions.

Those who had read the Author's paper would, no doubt, have come to the conclusion that the four cycle engine, although more costly, heavier, and occupying more space, was, when everything was taken into consideration, the most reliable, and from the cycle of operations, the most efficient. Tests of B.H.P. and tests of fuel consumption had proved this, although a four cycle engine might be called the fourth of an engine only, while a two cycle was a half. That was, to get a turning moment on the shaft equal to an ordinary double acting single cylinder steam engine, two cylinders must be employed, in the case of a two cycle, and four cylinders in that of a four cycle engine with a considerable multiplication of parts.

As they had a very high initial pressure and open to release at a proportionately high pressure, some genius might yet give the world a compound engine.

Engines using the light, volatile oils, such as petrol, gasoline, naptha, and benzine, with a specific gravity of from .642 to .750, and vaporising at from 55deg. to 75deg. F., were usually fitted with a carburetter or a vaporiser said to be automatic in action, and though some might be nearlv so, others were far from it, requiring considerable manipulation of oil and air valves to get the best mixture.

Experiments had shown that the flash point of oils vapour rose or fell 1.6deg. F., with an inch rise or fall of the barometer, and the minimum proportion of oil vapour, to air, necessary to form an inflammable mixture was about 1.8 per cent., while an increase to 2 per cent. of vapour rendered the mixture explosive, but if increased to 4 per cent., the liability to explosion began to disappear, though the mixture continued to be inflammable.

From this, it would be seen that there were great difficulties in the way of designing a perfectly automatic vaporiser, and where oils varied a few points in density, the atmospheric conditions, such as humidity, temperature, and pressure, tended to upset the calculations of the designer, and rendered it necessary that some means of regulating the admission for both oil and air should be under the control of the operator; otherwise, the mixture would be weak, inflammable, but non-explosive, or a rich mixture, non-explosive, but inflammable, wasting fuel, depositing soot on rings, and igniting points, and eventually bringing the engine to a standstill.

The best method was that, adopted by some British makers, of spraying the oil in by means of compressed air, so arranged that both oil and air were measured, and the oil thoroughly atomised, thus producing an intimate mixture.

Where heavy, crude oils were used having a specific gravity of from .8 to .9, or kerosene from .788 to .796, means must be taken to vaporise or gasify them, and in some cases this was done by means of a lamp burning continuously, in others, the lamp was used to heat up the vaporiser at starting, and when once set going the heat in the exhaust products was sufficient to vaporise the oil.

The cost of running was considerably less, the fuel being so much cheaper, but there was, to be taken into account the time taken in heating, generally from 15 to 20 minutes, and the inseparable smell. For marine work, a lamp was dangerous, and liable to become extinguished. There were locally made engines, marine and stationary, fitted with two vaporisers, one using naptha or benzine for a few seconds to start and heat up, by the exhaust products, the second vaporiser to such an extent as to enable kerosene being turned on, and the naptha turned off. This gave us an engine that could be started instantaneously, and run at a minimum of cost for fuel. When once going, and until thoroughly heated, it was ignited by means of an electric spark, after which, the battery was cut out and the firing done by a tube, kept hot by the exhaust; the sparking device was then thrown out of gear, so that wear and tear on that part was reduced to a minimum.

Makers of engines that ignited electrically, might have their own ideas about timing gear, sparking device, and igniting points; but the objection to them all was the number of small springs employed. Of course, a rapid contact breaker must be used, but many of them could be made of a simpler and more substantial nature.

There was one thing about the timing that did not seem to be well understood, and that was, that for ease in starting, ignition should not take place until the engine had passed the centre, but when once going, ignition could be advanced or lead given to the engine. The operating mechanism permitted of advancing or retarding the spark; in fact, retarding the spark or, in other words putting lap on the valve, was the only means by which the speed of some engines could be reduced, and the engineer responsible for this design would put the brakes on going up hill. With regard to circulating water, this seemed to be a simple thing when only one cylinder was employed, but in a double or triple cylinder engine, a good deal of trouble was caused through unequal circulation, as one cylinder getting more than its share would lead to overheating of the others, and consequently bad working; but, as a rule, it was easily detected by pounding, due to a badly balanced engine, the over-heated cylinder being unable to do its work properly. This could be easily remedied, and it was rather surprising to find that makers had not given more attention to it, beyond putting in a pump, ample for its work, fitted with a pipe common to all jackets; but without proper means of distribution, which was a point worthy of notice.

Again, if the engine was stopped, the circulation stopped, and the contained heat in the mass of metal began to show itself by coming to the front, carbonising the oil in the cylinders, evaporating the remaining water in the jackets, leaving, of course, the solids behind in the form of scale, which could never be removed, and must eventually lead to trouble. This could be obviated by fitting a small hand pump so that it could be used for a few minutes to thoroughly cool down, and a drain should be put in at the lowest point for washout purposes, as fitted on engines running in cold countries where the jackets were liable to become frozen up, but makers did not appear to think that such things were necessary in this country. In the consumption of oil, makers gave different figures, some of which were very misleading, and could not be substantiated by a test trial. He possessed a maker's descriptive catalogue, in which it was claimed by one maker to be able to run on half a pint per hour, and, taking the specific gravity of gasoline as .650, that would mean .406 lbs. of fuel per horse power hour. Another maker, of both two and four cycle engines, gave 1¼ pints of gasoline per horse power hour in small two cycle engines, and 1 pint per hour in the larger sizes; whilst the consumption in the four cycle was put down at less than one-tenth of a gallon per horse power hour.

Taking the returns of six small engines (under his, the speaker's, supervision) varying from 1¾ to 5 horse power, all of which were four cycle, but by three different makers, it was found that the consumption of naptha was as near as possible, 1 pint per horse power hour, and taking the specific gravity of naptha at .730 that gave .9125lbs. of fuel per hour.

In the case of an auxiliary schooner fitted with a 50H.P. engine, he had occasion to find fault with the quantity of oil being consumed, as it had gone up to 7 gallons per hour, or

.14 gallons per horse power, but later returns showed a marked improvement, and the consumption for three months worked out at .10 gallons per horse power hour; this was principally benzine, the specific gravity of which was about .750, giving .75 lbs. of fuel per hour. It was exactly what the makers claimed in the way of consumption for an engine of that size; but not being fitted with indicator gear, means were not available for obtaining a card and one could only assume that the rated horse power was being developed, which was known could be easily done. Although this particular engine had not been tested, he had tested others bv the same maker giving 25 per cent. over their rated power. Tests had been made of engines by other makers, on the brake, and it was found that at the designed speed, they gave 25 per cent., and in one particular instance, nearly 30 per cent. over the rated horse power, and had an extended trial been given the fuel consumption would no doubt have been found satisfactory.

More rapid progress would have been made with oil engines, had the value of interchange of ideas been fully recognised by makers and designers. Steam engineers were more alive to this fact, and no sooner did one introduce an improvement, if only in a small matter of detail, than, even if patented, it was made widely known and, as a rule, either sold or worked on a royalty; but where would be found two oil engine builders using the same vaporiser or the same sparking device. Examine and inspect any make of oil engine now in Sydney, and outside the walls of the cylinder it would be found that each one differed in every detail, excepting perhaps in the oil cups and mode of lubricating; if one maker used a sparking dynamo, the other put in a magneto; and if one used a certain style of battery, the other would provide something different, and so it went on. They could not all have the best, but a combination of the main parts of, say, four types of engines now in Sydney, he considered would give a really first-class reliable engine.

Mr. J. Shirra said they ought to be grateful to the author for bringing these interesting motors under their notice. Although far from being novelties in principle, they had only become practically important within the last ten years or so; but now their use was increasing by leaps and bounds, and no engineer could afford to be without some knowledge of their working and limitations. The Board of Trade, in its syllabus of examination for Marine Engineers, had recognised this, and added this year to the "Elementary questions" prescribed for such examinations, half-a-dozen queries relating to oil-motors, such as are used in passenger launches, which all first-class engineers ought to be able to answer.

The author had clearly placed before them the principle of the oil-motor, and the cycle of operations, which were of course the same as those in the "Otto" gas engine, now an old-established prime mover, the working of which ought to be familiar to all. The Macquarie Light had, in its present form, faced the dawn on the South Head for nearly a quarter of a century with its electric energy generated by the same pair of gas engines all the time, and the light had never failed to guide the commerce of the world to our port.

The "Otto," or "Beau de Rochas" cycle, in which there was only one working stroke out of four, had been adopted by all makers of commercial gas engines since the expiry of the Otto patents, to the supersession of various other ingenious and theoretically good arrangements for producing similar results.

The ease with which inflammable gas could be produced by drawing or blowing air through light petroleum oils, naturally led to this method of gas making being early applied to gas engines; and the petrol or light oil engine differed in no respect from the gas engine, except in the difficulty of regulating the proper relative supplies of gas and air. In the gas engine these were fairly under control; in the petrol engine, the variations in the temperature and humidity