But there was no necessary connection between the two, for, generally speaking, it was possible to have a slow running engine as economical in fuel as a high speed one. High piston speeds had been forced on the marine engineers in order to develop large powers in a comparatively small space. It was stated in the paper that, about the year 1840, some pumping engines attained an economy of fuel which compared favourably with our best modern marine practice, but it must be remembered that this result had been attained by competition over a a period of 100 years.

In 1760, Newcomen first used a cylinder with a piston working in it, which was credited with a consumption of 30lb. of coal per H.P. In 1767, Smeaton, by his improvements, brought it down to 20 lbs. In 1782, James Watt, by his double-acting engine and separate condenser, reduced it to 10lbs., and latterly to 4lbs. per H.P., since which it has been gradually brought down to say below 4 lbs., and a well designed modern pumping engine should be, and was, as economical of fuel as any marine engine, quite independent of its piston speed.

When engines for driving vessels were introduced, the makers did not profit as much as might have been expected from the long experience of his pumping brethren, but went in for very low pressures, and when the pressure was raised it was exhausted into the condenser at such a high temperature that there was not much gain in economy.

The introduction of the compound engine, and latterly of the triple and quadruple expansion engines had now placed us on a par, and perhaps a little ahead of the pumping engine in economy of fuel, but instead of blaming the pumping engineers for standing still for 40 years, he thought it was we (the marine engineers) that were to blame for not making better use of their experience.

He wished to point out that our American cousins boldly placed engines of the same type as the pumping engine, including the boiler, on to the decks of their vessels, and, as a

consequence, for many years were far ahead of the British marine engines in economy of fuel.

With regard to high piston speed, there was no difficulty in driving pumps at a much higher rate of speed than was usual. It was entirely a question of finances—first cost *versus* breakdowns and maintenance. In his opinion, with all due deference to Mons. Farcot, he did not consider the pointed plunger was a necessity for a high speed pump. Given a large suction pump with air vessel, and large area through the valves, so that the water was always in contact with the plunger, he could not see that it made any difference whether the ends of the plunger were made round, square, pointed, or any other shape.

High speed had been forced on the marine engineer, owing to the limited space into which he had to put his machinery. Competition required the greatest indicated horse-power from the smallest space and least weight, and the marine engineer although he took so many years to attain the present economy of fuel, had shown great ingenuity in reducing the weight and space per horse-power, but the engineer who designed engines to be erected on land, either for pumping or any other purpose, had no such necessity, and it became a question for mature consideration, whether he should go in for high speeds, with heavy expenses for repairs, detention, &c, or a lower speed with comparatively light repairs and less liability to break-downs; each designer would settle that question to his own satisfaction. At the same time he might say that the greatest boon ever conferred on marine engineers was the introduction of slow going duplex pumps for feeding the boilers, and if high speed pumps were such a desideratum, it appeared strange that we were so glad to get rid of them out of our engine rooms. It might be that the marine engineer did not want to monopolise all the good things, but he doubted it.

Mr. T. Irons considered the practice of the Government of asking contractors to tender for machinery and supply their own designs might work very well where there were several

speciality shops, but he was of opinion much better results would be attained in New South Wales by first offering a premium for design, and then calling tenders for the accepted design, as carried out sometimes in our Colonial Architect's Department. There was no doubt that the specification was a good one to call for designs on, but was vague from a maker's view, as the various designs proved. One point was very definite, and that was the penalties should the pumps not do the specified duty, and an entire absence of premium should they exceed it. While the contractor must take all risk of the evaporative power of boilers, loss of pressure through some 100 ft. of pipe, with six right-angle bends before entering his engine, over which he had no control.

Improvements in pumping engines had not advanced equally with the marine type from the reasons given by the author. There was no doubt that the introduction of the surface condenser was a very large stride in marine improvement, while the introduction of the direct-acting pump at about the same time was a very doubtful advancement to increased duty, although it was much cheaper in construction. Great skill and ingenuity had been devoted to this class of pump during the last ten years, which, by results obtained in Sydney, were not yet equal to the fly-wheel type, and had the same skill and determination been expended on improving the fly-wheel pump, we should probably have results now, per cwt. of coal, equal to best marine records. The actual working duty, intermittent running, of the Ryde pump, was 79,000,000 ft. lbs. per cwt. of coal, and of the Worthington direct acting, 63,000,000 ft. lbs. He gave these two pumps as illustrations of their respective types, both being manufactured and erected by eminent makers of the present day, and under the control of the same Board Engineer. The objections to high speed pumps because of their greater need for repairs was imaginary, for the contrary was proved in marine practice, as many here recollect the large number of fitters employed upon the arrival

of a steamer in port after a three months' round voyage, when the piston speed did not exceed 350 ft. per minute, and to-day, with twice the piston speed, scarcely more than an additional hand was needed upon arrival, demonstrating conclusively that machinery could be so accurately designed that less repairs were requisite, and greater certainty of continuous running assured, than in the times of slow piston speeds when breakdowns were the rule, instead of, at the present time, the exception. Again, modern pumping plants were so designed and arranged that if one engine should fail the other could do the duty necessary for a time.

The pointed or round-ended plunger, if not an advantage, could not prove a detriment, and with the results of the Paris Water Works engine before us, and his own personal experience of the trials and working of the emergency pumps at Botany, he believed it would yet prove an advantage for high speeds. Mr. Houghton had stated that his firm had made experiments with this form of plunger and found no difference, but, he presumed, it was a slow speed pump the experiment was made upon. To obtain the very highest duty an expansion valve was a necessity. Some of the designs showed Corliss gear, others piston valves, and some the plain slide valve, while the successful competitor had dispensed with expansion valves altogether. The objection stated to this design, of wanting a sole plate, was a doubtful one; it is not necessary, because there was a stay girder above the centre, between pumps and cylinder, and a massive concrete block connecting them underneath. The design, generally, was of the simplest, with no attempt at anything very costly, showing the designer had had the experience to utilise his own firm's patterns to make his cost low and yet to be within the requirements of the specification. Had he been one of the Tender Board he should have accepted this design at the price sent in, while, at the same time, had he wanted the greatest value for his money, Messrs. Vale's tender for Mr. Auldjo's design would have been prefer-

able. The design of the pump was new to him, but was most certainly a good one. Generally it appeared like the Ryde engine, with the exception of the pump valves being in groups and not single.

Mr. Cruickshank compared the cost of pumping and marine engines, but it was unfair to make a comparison with marine engines while we had imported pumping machinery near us. The Ryde engines furnished last year by James Watt and Co., under a very similar specification to those of the Waverley pumps, and for which they were the lowest tenderers, after months of advertising in England. The Ryde machinery cost about £10,000 to lift 4,000 gals. 350 ft.; the Waverley were required to lift 1,666 gals. 240 ft., giving 1,400,000 against 400,000 foot lbs., therefore as 14 : 4 :: £10,000 : £2857, it is fair to add 20 per cent., being a smaller machine, making a total of £3,428 as the price of the English made pumps, and even making no addition for a lighter class, say £2,857, the Colonial price was very much under the price Mr. Cruickshank considered would be a fair value.

Mr. N. Selfe, in reply to the remarks of the various speakers, said it was not his intention that the principal object for discussion laid down, viz., the comparison of the Pumping Engine with the Marine Engine, should be lost sight of beneath a conflict of opinions on the designs before us. As Mr. Christie, however, seemed grieved that the absence of a sole plate in his design had been noticed, it was therefore necessary to say, now that a very close examination of the design had not revealed its presence, and if it had one an apology was certainly due to him.

With regard to the word *cheap*, also objected to, it was used in its proper and not in any depreciatory sense. If two fifteen and two thirty inch cylinders for £2,800 was not a cheaper price than one fourteen and one twenty-eight for £4,600, then another apology was due to the same speaker.

The accepted design certainly had no sole plate. The large cylinders and the pumps were supported on masonry

foundations, and the small cylinders on columns. It appeared that it was not fitted with a great number of those accessories which were often considered essentials of a high-class pumping engine.

Mr. Auldjo criticised the supplementary pumps, which were only introduced into the paper to show that local manufacturers had already had some experience in pump building. It was certainly true, as he said, the Atlas Co. bought the steam cylinders, but the 40 or 50 tons weight of the pumps was all made in the time stated, erected and started, and it certainly was far and away the smartest job of the kind ever yet carried out in Sydney. A point was made that M. Farcot was not the first introducer of the pointed plunger, but that could certainly make no difference in its merits. Mr. Houghton, who had a larger experience of pump construction than any gentleman present, said plungers had been tried with removable points and no difference was perceptible, but this, without knowing the velocity they were worked at, was of very little value. The President also did not think the pointed plunger reduced the resistance, but if the pointed end did not reduce the amount of waste energy in the disturbance of the water particles, it must be because a conical body of water remained on the end of the plunger on the out-stroke, and a vacuum formed there on the in-stroke.

Mr. Grimshaw made some very pertinent remarks as to piston speed and the value of mechanically operated valves, citing several German examples, but it seemed they mostly had pointed or round-ended plungers. Mr. Grimshaw did not agree with the author as to competitive designs, believing that the pump maker should furnish his own, as he had patterns, &c., in stock, but he forgot that true progress should ignore old patterns when they stood in the way of advancement. Surely there was nothing whatever to connect the designer necessarily with the manufacturer, except in perhaps such points as adapting the mechanical details to the machine tools

available in his factory generally. Mr. Grimshaw's views confirmed those of the author, and without propounding a solution of the main points raised, he referred to pumps of very high speeds, and consequently very small steam engines for the work performed, without showing there were any countervailing disadvantages, and must therefore be understood to favor the higher speeds referred to in the paper, the more so as he quoted a Prague pump with a speed of 530 ft.

Mr. Houghton had added by far the most valuable contribution to the debate in his carefully compiled table of pump performances, which it was to be hoped would be printed with the papers. The author agreed very generally with the statements made by him, which were mostly incontrovertible, and one great object of the paper had been attained in thus eliciting the information Mr. Houghton had laid before the Association.

With regard to the observation of the President that there was no difficulty in running pumps at any speed, and that it was entirely a matter of pounds, shillings, and pence, the author most candidly confessed he did not understand what was meant. The successful design and construction, and working of all machinery was, or ought to be, a matter of £ s. d. If it was meant that running pumping machinery at higher piston speeds, than was the custom formerly, meant more wear and tear, how was it that mail steamers arrived here now, and went back to Europe, and while here hardly spent a penny on their engines for repairs, while 25 years ago, when the speeds were so much slower, they had nearly to take the engines out of the ship every trip, surely that showed advancement. If the President, however, meant that to run some of the pumping engines now around Sydney at double or treble their present crawling speed would only necessitate a few extra repairs, it was to be feared that a very short trial in that way would result in a mass of scrap, and scrap only.

Some remarks were made by Mr. Edgehill with regard to the rotation of indiarubber valves. The bracing of the supple-

mentary pumps showed they fitted with such valves, and it was suggested to the author by the great wear and tear on the old temporary pump valves at Crown Street.

Mr. Cruickshank confirmed the facts stated in the paper as to the duty of the boiler being separate from the engine, and by quoting the price per horse power and size of engine required, showed how a much smaller and cheaper machine was required to do a given amount of work on ship-board than with pumps on shore, and he showed that one 14 in. and one 28 in. cylinder was more than ample to do the work required, although they had only two piston rods and packings, but he stopped short just when he was getting interesting, and did not say why two 15 in. and two 30 in. should be preferred to one 14 in. and one 28 in., and why the friction and care of six piston rods should be preferred to two only. It was just in these matters the debate had been disappointing, although enough had been said to do some good. If it was an advance in design and con-construction to have the friction of four pistons and six rods, instead of two pistons and two rods, and to support half an engine on a solid masonry foundation and the other half on a tall column, instead of having one good sole-plate or foundation, then there was nothing more to be said.

With regard to the contention that the specification was clear, it was only necessary to compare Mr. Auldjo's design with the one adopted.

By official figures supplied through the courtesy of the Water and Sewerage Board, it was found that the Ryde vertical pumps gave 112,000,000 on trial and 79,000,000 under all the difficulties they now labour under, while the Crown Street horizontal engines only gave100,000,000 on trial and 63,000,000, in regular work. From this, ordinary persons would assume that when high duty pumps were asked for the horizontal type would certainly not be intended.

In conclusion, the author would say that if the several firms had been led into a great deal of unnecessary expense

when only a common Worthington pump was wanted, fitted with a fly-wheel their plans had certainly been of great service in affording much information to the members of this Association He heartily congratulated Mr. Christie on having been so fortunate as to catch the exact requirements, which all the other designers missed, and he sincerely trusted his design would exceed the 90,000,000 duty guaranteed.