from which the water is to be raised, and the top water level in Waverley reservoir, into which the water is to be pumped, is 219 feet. The contractor must, from the foregoing data as to quantity to be pumped, and sizes and lengths of mains, calculate the frictional head which has to be added to the actual head to determine the total resistance in the pumps. The bends may be taken as equivalent to four right angle bends, of seven feet axial radius on the 24 inch pipe. In addition to the above duty the engines will be required to raise 40,000 gallons to a further elevation of 20 feet, into an elevated tank adjacent to the Waverley reservoir. This work can occupy one hour if necessary.

2nd.—The ordinary working steam pressure will be 90 lbs. per square inch in the boiler.

3rd.—The general design of the engine should be a compound jet-condensing engine. The plan herewith shows the available floor space, but the basement floor can be made use of for the pumps, air pump, condensers, and other parts usually placed below the floor level.

4th.—The work throughout shall be of the very best description and workmanship, as well as materials, any provision in the contractor's specification or drawings to the contrary notwithstanding, and the strength of the several parts shall, in every respect, be such as to provide an ample margin for safety under all possible stresses to which they may be subjected under all contingencies of work, and ordinarily probable accidents.

5th.—The steam cylinders to be steam jacketed, covered with non-conducting material, and finished with polished lagging.

If the author could point out where he (the speaker) had departed from the meaning of the specification he should certainly be obliged. With regard to the soleplate question he maintained that with this type of engine it is not required, and would only be a waste of money if so fitted.

The next point raised was the question of cheapness and the guaranteed duty. When an engineer spoke of a cheap engine or a cheap machine, he almost invariably meant an inferior article, Now, in order to show you that Mort's Dock

Co. had not the slightest intention to supply an inferior engine, but the reverse, he would read a copy of the description and the guaranteed duty sent in along with the design.

19th April, 1892.

PROPOSED PUMPING ENGINES FOR WAVERLEY SUPPLY.

Contract No. 169.

The proposed engines are horizontal compound condensing steam jacketed direct acting pumping engines, having two H.P. cylinders, each 15 in. diameter, and two L.P. cylinders, each 30 in. diameter, two double-acting pumps 12½ in. diameter, all having a stroke of 33 in.

The engines are coupled by means of a crank shaft at pump end, having strong polished cast iron disc cranks and heavy turned fly-wheel, for the purpose of equalising the power exerted by the steam cylinders.

The pumps are driven direct, each from its own engine, the surplus power exerted by the steam cylinders of one set at the beginning of the stroke is transmitted through crank shaft to the opposite pump towards the end of its stroke, so keeping the power applied to the pump regular throughout the stroke of both pumps. Pump suctions and deliveries are connected in the usual manner, as shown on the accompanying drawings.

The steam cylinders are fitted with hard cast iron liners, which form the steam jackets to cylinders. The steam valves are of the ordinary slide pattern, driven by eccentrics and levers in the usual way.

The cylinders are connected to the pumps by strong cast-iron framing, which also act as guides for the piston and pump rods. The pumps are of the double-acting plunger type. The plunger works through a water-packed gland in the centre division, and being close-ended displaces water nearly equal to its own weight, thus being almost frictionless and materially reducing wear and tear. There are 18 suction and 18 delivery valves at each end, giving a large area which reduces the friction through them to a minimum. These valves are of indiarubber with brass covering, plates, springs, and seats, so constructed to close the instant they are freed from pressure, thereby minimising the slippage past the valves. A large air vessel is placed above the delivery valves in the usual way. The condenser from which the water is to be raised, and the top water level in Waverley reservoir, into which the water is to be pumped, is 219 feet. The contractor must, from the foregoing data as to quantity to be pumped, and sizes and lengths of mains, calculate the frictional head which has to be added to the actual head to determine the total resistance in the pumps. The bends may be taken as equivalent to four right angle bends, of seven feet axial radius on the 24 inch pipe. In addition to the above duty the engines will be required to raise 40,000 gallons to a further elevation of 20 feet, into an elevated tank adjacent to the Waverley reservoir. This work can occupy one hour if necessary.

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4th.—The work throughout shall be of the very best description and workmanship, as well as materials, any provision in the contractor's specification or drawings to the contrary notwithstanding, and the strength of the several parts shall, in every respect, be such as to provide an ample margin for safety under all possible stresses to which they may be subjected under all contingencies of work, and ordinarily probable accidents.

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The engines are fitted with all necessary indictor gear (exclusive of indicators), drain and jacket cocks, gauges, valves, lubricators, &c. All wearing surfaces are extra large and are easily adjusted, and all parts are easily got at for examination or repair. It will be seen from the accompanying drawings that the design is essentially that of a Worthington pumping engine, with the addition of a crank shaft and fly-wheel The advantages of this arrangement are simplicity of construction, regularity of motion, and positive length of stroke, and the important feature that in case of break down in one engine the other can be kept at work by simply disconnecting one rod.

P.S.—The quality of the material and workmanship will be equal to the Worthington pumps now working at Crown Street. These engines will perform, when working together, a minimum duty of 90,000,000 ft. lbs., with a maximum consumption of 112 lbs. of Southern coal, subject to the provisions, and under the penalty prescribed in the specification.

You will observe Mort's Dock Co. guaranteed to supply an engine equal in workmanship and material to the Worthington pumps now working at Crown Street, and as they are of the highest class he failed to see how a charge of cheapness could be laid against our design. It was true the design was a simple one, as simple as they could make it, but this they considered to be a merit instead of a disadvantage. Our engine was so designed that all the parts were easily made, and could be finished off the machines, hand labor being reduced as low as possible, hence the price.

In conclusion, he might be permitted to say that the fact of Mort's Dock and Engineering Co. being able to design and construct this machine of the best material and workmanship, and having a higher duty than any other in the competition, and also at a more moderate price, was a matter entitled to some credit, and he would leave it with all confidence to the judgment of the members.

Mr. J. Trevor Jones said he was very glad to find that the paper had met with a discussion worthy of its importance. Sixty years ago land engines gave a duty of 100,000,000 ft. lbs., but it was only a test duty. They had attained the same duty from the Worthington's in Sydney, they would very probably come near that in ordinary duty if they worked constantly. Sixty years ago marine engines gave 25,000,000 ft. lbs. They had advanced from 25,000,000 to 100,000,000 ft. lbs, therefore they had advanced at a greater rate than land engines, but is it not more correct to say that whereas land engines were nearly perfect 60 years ago, marine engines had not attained that perfection. With reference to the price of the new engine the Board considered it low, but being satisfied with the firm who tendered, they did quite right in accepting the tender. Mr. Selfe had complained that the specifications were vague. He (the speaker) was surprised at that statement, seeing that an American firm had written out stating they were the most complete set of specifications they had ever seen.

Mr. J. W. Grimshaw (a visitor) said that he could not agree with the author with regard to his views on the competitive designs. Surely an engineer should be able to make his own designs, and know best what he wanted. It seemed to him little else than getting cheap information by offering small prizes.

But it was entirely different when a contractor or manufacturing engineer was allowed to send in his own designs and show what he was prepared to make, enabling him to use his own patterns and patents, &c., and thus save unnecessary expense. However, he believed it far better that an engineer should select the type of engine and maker free from competition.

He concurred with the author that a pump should be judged by its "steam consumption" and not by its "coal consumption," and he was sorry that in the examples given in the paper this had not been done. He thought it would have freed his (the author's) mind of several false impressions which he would refer to later on. He did not think any pumps should be made responsible for the efficiency of their boilers or the quality of the coal burnt.

As to why marine engines have made, of late years, more rapid progress than pumping engines, there were several very simple reasons. Pumping engines had already reached a very high state of efficiency when marine engines were in their infancy, and consequently there was far less room for improvement. The importance of high efficiency and economy in a marine engine was much greater than in a pumping plant. The former worked continually through the 24 hours for weeks together, from port to port, after which it could undergo complete overhauling. The carriage of fuel and water was also very important. A pumping engine had to run for a few hours, say six or eight, and then stop for another six or eight hours, during which time the boilers must be kept hot and fires going, but the engines were never expected to go wrong or be renewed for 50 or 80 years, or even more, hence, as the author stated, the economy of steam was by no means the only consideration, and when speaking of the greatly decreased efficiency of pumps after trial, he should bear in mind that the consumption of coal by which the efficiency was unfortunately based was going on all the time that the pump was still. This might perhaps explain his (the author's) statement on the Ryde pumps. There were also times when a pump should be considered simply with regard to the relation of discharge to cost, as for example:—For emptying a dock, pumping flood waters, or where coal was no object, as at the pit's mouth.

He did not altogether disagree with the five reasons for the slow progress in the improvement of the pump, although he thought that competition had been very keen. He did not think that it was always advisable to go in for high piston speed and high pressures. High speed meant wear and tear. High pressure increased cost and increased cost of repairs. It was also in some degree true, but the main reason was, that there had been more scope and more necessity for improvements in marine engines, and it would not be surprising if eventually they were substituted by pumps, that was to say, vessels be more economically propelled by water jets (of course we know it has been actually done on a small scale).

With regard to the author's suggestion as to probable improvements in the direction of piston speed, a pump had been mentioned which took the Atlas Co. 60 working days to construct, which seemed a long time if, as he believed, the engines had been previously made in America. The pump is 8 in. dia. and 3 ft. stroke, making from 48 to 60 rev. per min., which would correspond to a piston speed of 288 to 360 ft. per min., but it had scarcely ever been used since erected. Why, he did not know.

Then there was the Paris Farcot Pump, with a speed of 360 ft. per min., and the author stated that he believed a pump made on this principle might be constructed to run smoothly at 500 ft. per min., but surely this was rather behind the times and was not doing justice to the pump.

At an Exhibition at Prague, 1891–92, there was a pump running up to a piston speed of 531 ft. per min. It had a stroke of 2·9 ft. and made 90 rev. per min.; the plunger dia. $= 11\frac{1}{2}$ in.; the piston $= 20\frac{3}{4}$ in.; delivery, 5,700,000 gallons per 24 hours, against 88 lbs. pressure (203 ft. head.) It was fitted with controlled valves of the Riedler type. The controlling of the valves was a most important point although it was so very simple. Immediately before the end of the stroke controlling arm brought the valve to within $\frac{1}{16}$ in. of its seat, the suction of the pump did the rest, and closed the valve without shock or noise.

It would at once seem that with this type there was no requirement of weight in the valves, and that this system had the following advantages :—

1. The valves being lighter opened more rapidly, absorbed less power, and offered less obstruction to the water flowing through while valve was closing.

2. There was no back flow of water.

3. The valves lasted very much longer being lighter and having no shock, for they are cushioned by water still flowing through the pump.

4 They allowed of almost any piston speed, and as there was a fly-wheel any expansion of steam was admissable.

One of the pumps at Rotterdam had a slightly different controlling gear. The valves in this case were loaded with strong springs, but were relieved by the controling arm just before they were required to open, but he did not think this an improvement. This type of pump had become very popular in Europe and had been adopted at the water-works at Leipzig, Heilbron, Pilsen, Budapest, and some eight other towns, Professor Riedler, of Berlin, appeared to hold the patents and make most of the designs. The pumps were made by different makers, and seemed specially suited for high speeds. The usual speed was from 50 to 60 rev. per minute, and 300 to 400 ft. piston speed.

Mr. R. G. Edgell considered that the valves of all pumps should be so arranged that they partially rotated in lifting, by which means the wear was much more even and resulted in less frequent renewals of valves and seats.

Mr. W. D. Cruickshank agreed with the remark made by the author regarding the troubles which resulted in working under an indefinite specification, and those whose duty it was to draw them up should always endeavour to make them as concise and clear as possible.

Referring to the specification for the Waverley pumps, which had given rise to this discussion, he had read it carefully through, and considered it quite sufficient for the work required.