add also the "disadvantage of going slower the other way."

It would be a poor consolation to a passenger who had just missed his train to be informed that if the boat had been going the other end on he would have got his train and some minutes to spare.

With regard to the claims "reduced first cost" and "reduced upkeep," he quite agreed with the author, although in his opinion the item "reduced upkeep," instead of being a low valuation, was greatly over-estimated.

But the crux of the whole question seemed to him to lie in the claim "reduced coal consumption." Previous to the Author reading his paper we had no actual facts to work on as to the efficiency of a bow screw compared with a stern screw. To enable us to get reliable data the Directors of the Balmain New Ferry Co. kindly placed their new steamer "Lady Northcote" at our disposal, and the results of the speed trials were now before you. He considered we might safely take this vessel as a fair type of her class, as she was specially built for this method of propulsion. With regard to the trials the committee had only one object in view, and that was to place before you reliable figures of the vessel's performances, so that you could discuss the subject from actual results instead of from estimates. The two diagrams (Plate XIII.) shewed graphically what the vessel did when driven by the screw at the stern and when driven by the screw at the bow. It would be seen that when driven by the stern screw the performances were excellent, showing clearly that the lines of the boat were well suited to the speed, but it also showed that when driven by the bow screw the performances were comparatively poor.

Amongst engineers who were not closely in touch with the propulsion of ships, it was generally taken for

granted that the power required varied as the cube of the speed. In Plate XIV. Fig. 1, which was constructed from the committee's figures, the fallacy of this was clearly shown. The diagram, measured horizontally, gave the cube of the speed, and vertically the horse power required to drive the vessel at that speed. The straight inclined lines showed the power required if the power varied as the cube of the speed, and the curved lines show the power actually used.

He found in taking half knot increases that the power varied as the 4.5 power of the speed (approximately), and from the highest recorded speed by the bow screw to the highest by the stern screw the power varied as 4.4 power of the speed. Now, as the power required to drive the 12.19 knots with the stern screw was practically the same as it took to drive the boat 11.3 knots with the bow screw then $\frac{11{\cdot}3^{4\cdot4}}{12{\cdot}19^{4\cdot4}} = {\cdot}716$, showing that the bow screw had only an efficiency of 71½ per cent. compared with the stern screw, and if we divided 100 by 71½ we got 140; that was to say, it required 40 per cent. more power to drive the vessel equal speeds with the bow screw than with the stern screw.

Plate XIV. Fig. 2 showed the power curves of both bow and stern screws. Taking the power required by the stern screw as 100, then the bow screw required from 39 per cent. to 47 per cent. more power for equal speeds.

In the face of those figures he failed to see how the coal consumption could be reduced when 40 per cent. of the power was being wasted half the time. and instead of being all round a more profitable ship, he was of opinion that double-screw was the better boat of the two.

In conclusion, he desired to express his thanks to the author for his paper. It was one of that class of papers that did an immense deal of good both to the Association and to the members individually. Papers like this created a keener interest in the meetings and made the members think.

The President said it was very evident our committee who carried out the trials had gone to immense trouble in collecting data. As Mr. Sinclair was largely responsible for this data he would ask him to make some comments in connection with it.

Mr. Russell Sinclair said we must all feel indebted to the author for submitting his paper, and enabling the Association to have carried out and placed on its records the valuable data which had been obtained by the trials of the "Lady Northcote," because accurate information on this subject had up to this time not been available; therefore the paper and the table of results of the trial together greatly added to the value of our volume of transactions.

He did not know of a ferry service in any other port which required just the same conditions to be met as in Sydney Harbour; the evolution of the double-ended screw propeller ferry boat had been due to the necessity of satisfactorily coping with special circumstances which pertain to the passenger traffic of Port Jackson, as here the ferry service at the terminal wharves required the steamers to come in end on to a quay, though discharging passengers at side, but with the exception of the Manly service all had to call at intermediate wharves en route. This meant that the steamers must be more under control than with a single ended boat.

It was the difficulty of manoeuvring a single-ended boat in crowded waters which led to the development of

the double-ended ferry boat with a propeller at each end, for Sydney, because they could be equally well handled going either way, and he could not see that the author had advanced any sufficiently strong argument, or pointed out any material advantage in favour of departing from that type, and adopting the one propeller.

It appealed to him more as a compromise to obtain possibly a cheaper boat, in first cost, and less trouble to fit out, as there could be no doubt the first cost of the boat would be less, but he questioned if it was a good thing for the sake of first cost to give up the advantages of handling and control of the vessel, which went so far towards making a safe and reliable ferry steamer.

In reduced upkeep there might be an annual saving, but he did not think it could be anything like the £100 which the author had estimated; possibly he intended this sum to be an average to cover the cost of occasionally having to re-line the shaft, lift or lower the engines to suit a change in shape of hull, which he mentioned; if so, he (the speaker) did not think this should be taken into consideration, as an argument in favour of giving up one propeller, as the difficulty of operating a through shaft should not occur if the vessel was built sufficiently strong. Personally, he had had to do with the fitting of the machinery on board of a number of double-ended boats with propellers at each end, and in none of them did he experience any difficulty such as the Author mentioned, up to the time we handed the machinery over, nor had he heard of any trouble with them afterwards.

As regarding equal handling power, the author stated that the "Lady Northcote," as a point of fact, steered better with the propeller ahead than when it was astern. It was, he thought, slightly misleading; it might be correct when the vessel had got up speed and steerage

way, but it did not appear to be the case when the vessel was starting from rest, leaving a wharf, or when manoeuvring, as could be noticed any time when the vessel was negotiating a wharf; he had observed then that with the propeller ahead it appeared to be a necessity to make the wharf with the bow well off and the vessel lying, when at the wharf, with the bow at an angle of 30 deg., and the engines kept going slowly astern gradually throwing the bow out; then, in spite of that, for fully two boat's lengths after going ahead the vessel would come back more than this 30 degrees before it could be said that the rudder had proper control of the vessel.

The observations taken during the steering trials of the "Lady Northcote" showed that when going full speed and the engines were stopped and reversed, which was a condition of service most likely to occur, the vessel's head swung round from 32 deg. to 35 deg. (in the latter the propeller being aft); if the rudder had been operated this tendency to swing might have been corrected to some extent by the drag, but when the propeller was ahead no such help was possible.

It will also be noticed that the turning circles with the propeller ahead on both starboard and port were very much greater than with the propeller astern, showing conclusively that the handling of the vessel was by no means equal.

Since the reading of the paper he had endeavoured to notice the behaviour of the ferry boats with two propellers, having, like many of us, to travel daily by them, and had not noticed this tendency to cut off when approaching or leaving a wharf. It was no unusual occurrence for six steamers to start simultaneously from Circular Quay separated only by a few feet, and he submitted that were many of these fitted only with

one propeller and they were to start with that propeller forward, that there would be a considerable amount of risk of them fouling each other, to the alarm of passengers. No doubt with a skilful captain, careful handling, and slowing down well off the wharf, the vessels could be satisfactorily handled, but a ferry boat was called upon very often to meet emergencies, and it was its capacity for meeting these emergencies that determined whether it had equal handling power as compared with the boat with a propeller at each end. It was in connection with the Author's claim of equal average speed that the speed trials of the "Lady Northcote" were especially useful, as they provided the first reliable data of performances of this class of vessel which had so far been obtainable. Without these trials it would not have been possible to compare the results with any other vessel. The trials, however, enabled us to form an idea of what advantages there were, if any, also what the efficiencies were. The figures and curves of I.H.P. and slip showed at once that there was a marked advantage of better speed with the propeller aft as compared with the propeller forward; or, rather, it should be put the other way, there was a very marked loss of efficiency with the propeller forward as compared with the propeller aft, an average on the speeds of 7.73 per cent.

The mean full speed, "stern going" and "bow going" was 11.748 knots, and there was a difference of .883, or just over 7/8th of a knot between them. At the lowest of the trials the mean speed was 9.552, and there was a difference of .831, or just under 7/8th of a knot difference. Comparing this with the results obtained during a test with the "Kangaroo," as given by Mr. Cruickshank, in the discussion on a previous paper read by the author and published in the transactions of the

Association in 1894, it would be found that in the "Kangaroo" the difference between the aft screw driving with bow screw disconnected and revolving freely, and the bow screw pulling, the after screw revolving freely, at a similar mean speed, viz., 9.16 knots, was 1.39 knots. That showed that in the "Lady Northcote," a vessel specially designed with fine lines, and a co-efficient of fineness of .334, the improvement as between driving and towing was only :56 or a little over half a knot. When it was considered that in the "Kangaroo" the vessel was much bluffer with a coefficient of fineness of :521, that the propellers were each only about one half of the surface they would have been had they been designed for absorbing the full power of the engines, it might be reasonably concluded that a better result would have been obtained had each propeller been of the correct surface, and probably not much greater difference between pulling and driving than in the "Lady Northcote." This tended to show that the efficiency of the propeller when pulling could not be much improved in comparison to driving, that was that the difference in efficiency between the two ways could not be done away with. Practically the loss was constant, and that this loss was due to the action of the column of water thrown back by the forward propeller impinging on the hull whether the ends of the vessel were cut away much or not, and that the author's suggestion that it depended on the excellence or otherwise of the bow design was not of so much importance as he gave to it, and that more advantage could be taken of the greater strength and rigidity to be obtained by carrying the keel straight to the ends without greatly impairing the speed efficiency. It was, however, in considering the co-efficients of performance at full power that an opinion could best be found as to the advantages or

disadvantages of the single screw, as compared with two screws.

In the "Lady Northcote" the co-efficients of performance of the full power trials had worked out at 183.5 for the propeller aft driving, and 146.2 for the propeller ahead towing, showing a very considerable loss of efficiency when towing. The Author had claimed that the greater efficiency when driving fully counterbalanced the loss when towing. This he (the speaker) thought could hardly be upheld, because the mean co-efficient was only 164.9.

It is only by comparison with results from other vessels of a similar type that it is possible to ascertain whether the performance of the single screw type is better or otherwise.

For a single-ended vessel with a bow and stern of ordinary type and of somewhat similar dimensions a co-efficient of 183.5 would not be said to be a very good result. We might reasonably expect over 200. While the mean co-efficient of 164.9 would be considered below what should be obtained. Comparing the results with a double-end steamer having a propeller at each end, I would instance the "Kurraba," whose dimensions were: Length pp. 134'4", beam of hull 25'6", draft 8'6", displacement 353, I.H.P. 528, mean speed 12 knots.

The co-efficient of performance at this speed worked out at 164, and at 11.748, the mean speed of the other, it would have been 168; that is rather better than the "Lady Northcote," but she is a much heavier built vessel, and therefore not such a fine underbody, having only a co-efficient of fineness of .463, so that had she been as fine as the "Lady Northcote," a better co-efficient would have been obtained, I think, at least equal to that due to her greater length.

Of course, in comparing the results of one vessel with another, the use of the performance co-efficient by the displacement formula cannot be taken as absolutely reliable, but he thought that it served to shew that practically the mean performance of the vessel with the one propeller is not any better than the performance of the boat with a propeller at each end, and that after all there is no real economy or benefit except in the one item of first cost, while on the other hand there appears to be a considerable loss of efficiency in handling and loss of time in making wharves, and as this latter condition enters very largely in the service of this class of vessel, the loss of a few seconds making or leaving a wharf being really far more important than the gain of a knot or more over the measured mile; I would be inclined to place efficiency to meet that condition as the principal one to be considered in designing a ferry steamer.

The President said that during the first stage of our discussion some misapprehension arose as to who was responsible for the design of the first double-ended screw boat in our Harbour. In consequence, this letter had been handed to him to read. It is dated May 9th, 1878, and addressed to Mr. Norman Selfe, from the North Shore Ferry Company:—"Dear Sir,—I have the pleasure, by instruction of my Directors, to inform you that your design of a double-screw passenger and horse boat, motto "North Shore," has been awarded the advertised ten guineas, and I enclose you a cheque for that amount. Kindly acknowledge receipt for same.—Alfred A. Burgess, Secretary." Mr. Selfe, will you offer any remarks on this subject?

Mr. Norman Selfe said he did not desire to say much, but as a Member he would like to bear testimony to the very great obligation this Association was under