efficient system of mechanical draft. The writer has had experience with the successful working of four large induced draft plants, where their installation had resulted in a considerable saving in fuel, and also a perfect control of the steam supply. It might interest the members to know that the Colonial Sugar Refining Company were making and installing three plants this year, the largest of which was 12ft. diameter × 5ft. 6in. in width; engine for driving fan, 16in. diameter × 12in. stroke, high speed, of the enclosed forced lubrication type. The capacity of this fan was 130,000 cubic feet of hot gasses per minute, and was intended to handle the gasses from twenty large locomotive boilers in a sugar refinery in Fiji.

Mr. James Shirra, in opening the discussion, said that our ferry steamers had been more than once discussed at the Association's meetings, and a study of the paper by Mr. Reeks, given in 1894, on double-ended ferry steamers, and the discussion thereon, will be profitable; while Mr. Harry Selfe, in 1886 and 1888, read papers that did much to awaken interest and induce progress in the design of these boats. The contrast between the boats of a quarter of a century ago and those now on our harber was marked. We had gonc on increasing the beam and fining the ends until the hull of a ferry steamer resembled that of a miniature battleship. The "Kookooburra" showed this proportionate increase of beam more than some of our recent boats, her length being under five times her breadth, while her co-efficient of displacement was fairly high. Still she steered well for so short and broad a boat, a result due not only to her shape, but to the bow propeller neutralising to some extent the erratic tendency of the after one. At the same time the requirement of a bow propeller being fitted complicated the problem of attaining a high speed. The speeds attained in our modern battleships could not be reached if fitted with screws at both ends; however, their manœuvring qualities would be affected. This point, the mechanical disadvantage of a bow screw, as regarded speed producing, was, he thought, clearly demonstrated at the discussion on the paper of 13 years ago; but then an expression of opinion was made that a series of progressive trials of such double-screw boats might elucidate something interesting. We had had such a trial now, and the most remarkable feature, to his mind, disclosed was the great rise of power needed for a given increase of speed; the configuration of the Admiralty formula co-efficient curve showing this. At low speeds—eight knots or so—the co-efficient was fairly good, but it rapidly fell at higher speeds, doubtless due to the power wasted against the wash of the bow propeller. If we took the formula

$$\frac{\text{area of immersed midship section} \times \text{speed}}{\text{I.H.P.}} = c,$$

we found the constant c was similarly low and variable. While the co-efficients never really were constant, they were nearly enough so in ordinary vessels as to be useful; here, the disturbing influence was great enough to practically vitiate them. The co-efficient would be still further reduced if we took the total horse power at which the machinery was working, and not that of the main engines only. Besides the fan engines we had independent and circulating feed pumps using boiler steam direct, and doing work that in most engines was done by the main pistons, but which was not noted in our I.H.P. The effective horse power, which, could we determine it, was what we should work on, was, of course, more in this engine than if it had to work these pumps and fan also; which auxiliary horse power would amount to perhaps 25 at full speed, which, if added to the figures in table, would reduce the co-efficient still more. It was on the fuel economy that this auxiliary machinery influence was most marked. When the feed pump was worked off the main engine it was seldom run at its full capacity, and churned air up with the feed water; but if it did happen to run full it was being driven by a more economical engine than any donkey pump ever was. The auxiliary pump would take about three times the steam the main engine required to do the same work. Hence the figures for steam and coal consumption per I.H.P. would be higher if we neglected the H.P. of the auxiliaries, or even if we iucluded it, as they worked with so much less economy. He pointed this out as partly explaining the seemingly high coal consumption per I.H P. hour, 2·83lb. It was not possible in so short a trial to be very accurate, but allowing for the auxilaries would bring down the apparent consumption to about 2½lb., which was probably still in excess of the true figure. At the trials of H.M.S. "Argonaut" in 1899, the water, and therefore coal, consumption of the pumps, fans and such auxiliary engines, were nearly one-fifth of the whole at low power (22 per cent. of the main engine consumption), and one-eleventh of the whole, or 10·4 per cent. of main engines at full power. In the "Kookooburra" we might assume it one-eighth of the whole, so that consumption for main engines only was 1068lb., instead of 1220, which would make the nominal consumption 2½lb. per I.H.P. The auxiliaries included the steam steering gear, which engines were well known to be very wasteful steam users. They worked without expansion of steam, and without steam or exhaust lap in the slide valve, so that there was nearly always a leakage. In the "Kookooburra," however, there was no sound of a blow through here, and the engine worked quietly and promptly. The turning trials were made when going at speed, so a larger circle was described than if starting from rest, as was done in the "Lady Northcote" trials last year; but the trial at full speed was the most rational way to do it. He thought she turned more rapidly to starboard than to port, showed the predominating influence of the bow propeller. Ordinarily a right-hand screw tended to turn the stern to starboard, or head to port. With the double screw, the forward one more than neutralised this tendency. On the stopping trial the same influence was seen; the bow propeller made her head sheer off 11deg. to port when the engines were working astern.

Mr. Norman Selfe said that by the liberality of the author of the paper and the Company owning the boat, the data already given was so full that there were not many questions left to answer. He thought it right to mention, first, as one of the founders of this Association many years ago, that he looked upon such papers as those of Mr. Reeks and the one under discussion as among the most valuable that had been read. They might not have involved the burning of so much midnight oil by their authors as some of the abstract subjects which at times had been brought before us; but they were of more practical use as guides for future developments along that special branch of engineering, which he was pleased to say Sydney had already so far advanced as to have nothing to be ashamed of.

If he could not see much to criticise in the paper, he might be permitted to make one or two remarks suggested by the special case of such large boats as the "Kookooburra's" owners now run on the Milson's Point Ferry, although the special boat under notice was intended for river traffic.

As the distance from wharf to wharf was 55 chains (say, three-quarters of a mile) the time of a direct and economical run at the speed giving the best co-efficient (8·6 knots) was 5 23 minutes, and the horse power 140 I.H.P. At highest speed, or 12·1 knots, the time would be approximately two-thirds of the above, or 3·48 minutes, thus making a saving of 1¾ minutes; but to effect this the horse power was 645 I.H.P.! We were brought face to face with the startling fact that these ferry boats had now reached such proportions that in order to save 1¾ minutes in a single trip an additional 500 horse power was required. This position suggested that in a case presenting such a very short continuous run it would be worth while to inquire whether it would be more economical to keep the engines running continuously, and at the wharf driving a generator to charge a storage battery, and when under way throw in a motor as auxiliary to the engine in driving the screw. Possibly, if the company had the route to itself, it would be better to put the engines ashore and drive the boat by a motor and flexible conductor.

Looking at the A, B, C and D trials, it was noticeable what a small proportion of the work was done by the low-pressure cylinder, only about half that of the high-pressure cylinder, whereas at full power the low-pressure cylinder did about 15 per cent. more, and this was easily understood; but was not nearly so clear why the intermediate cylinder should jump 100 H.P. between D and E trials—in fact, 125 H.P. on the return trip—while the high-pressure cylinder only advanced 23 H.P. As nothing was said in the paper about expansion gear or separate adjustments to the stroke of the valves through the reversing shaft levers and links, it was possible that more more equable turning moments would secure quieter and smoother running.

With these large ferry boats and such short runs there seemed to be an opening for some inventor to find a way by which they could be wound up, so to speak—something like an alarm clock—at the wharf, and when started have sufficient power stored to go on till they got to the other side. The vessel in such a case, for a given number of passengers, might be half the present weight, be stopped and started in half the present time, and only take half the power now required. Would any member take the job in hand?

As a companion to this latest vessel of the Sydney Ferries, engined by our President, it might be interesting to give the approximate particulars of a Sydney ferry boat that was running 50 years ago:—

Name—"The Pet." Built in Waterview Bay.
Length—28 feet.
Beam—7 feet; over paddle-boxes, 11 feet.
Depth—4 feet to 4·6
Boiler—3·0 to 3·3 dia. 4 feet long,
Furnace—Egg-shaped, about 12 inches wide, with return flue.
Engine—Side-lever, about 5in. cylinder and 10in. stroke,

Paddle wheels—About 5ft. diameter; floats, about 18in. x 5in.; pressure, 30 lbs.; revolutions, about 35.

Time—Gasworks to site of Jubilee Dock (about 55 chains), 15 to 20 minutes; speed, about three miles per hour; fare per trip, 6d.

8ft. was decked in the middle, and the bow and stern sheets were open, with side seats; maximum number of passengers, 28 to 30.

A piece of kentledge was generally carried on deck, to shift as the coal was used from one side, and passengers were continually being asked to "trim the dish," because two or three walking to one side brought the weather wheel nearly out of the water. Two hands—both boys. He used to get up at 5 o'clock in those days, and leave the wharf at 5.30 to get to work at 6 a.m., yet he had managed to survive so far.

The two steering engines of the "Kookooburra" probably cost more than the whole "Pet" complete, hull and machinery.

Fan for Induced Draft.—He had not had time to quite understand the diagram (Plate IX); but there did not seem to be set forth any particulars of the ratio of the work done by the fan to the horse power of the fan engine—only in relation to horse power of the main engines. As the former was necessarily wasteful, and the latter economical, it was a question whether the fan could not be blown more economically off the main engines by friction, as was done in the torpedo boat "Acheron," designed by him for the New South Wales Government. The "Avernus" had a little compound engine on purpose, but it was at the expense of much more complication. There was, however, the advantage, of course, of blowing up while the main engines were standing, but that could be done by a steam jet.

As the air in the smoke box occupied practically double the volume it did in the stoke hold, although only the same weight, this question was interesting. Did the induced draft take practically the same power as a forced draft ? The only artificial draft system that he had had experience with was the closed stoke hold, and an injector under grate blower ; and the former seems to be much the cleaner, cooler, and safer ; but, of course, was not always practicable. Exact data on these points it was to be hoped would be forthcoming in future trials of a similar character.

Steering by the Feed Water.—He had seen boats steered by the feed water, and it was much simpler than a steam steering gear ; he hoped to be able to bring some illustrations of the same, but all he could now find were stereoscopic pictures of the " 'tween decks " of the boats. The fast, flat, spoon-bowed stern wheel steamers, which run on the western rivers of the United States, had from three to five rudders, and of course they took a lot of handling. As the passengers were all on the upper deck and the cargo below, the tiller cables were run under the upper deck to the wheel barrel. On each side of the boiler room they ran by a rod through the stuffing box of a long tube, which formed a cylinder open at the back end, the piston having about 5ft. stroke. The feed pump was of the beam type, and just in front of the boiler, almost under the steering wheel, and this worked a water valve by a spindle through the upper deck. The pipes from the hydraulic valve communicated with the rear ends of the two cylinders. The feed pipe, and return water pipe, were also connected up to the valve ; and the whole arrangement was of the extremist simplicity, the pressure in the boiler serving as the accumulator load. With a pilot house in each bow for a double-ended vessel, and with cabins on the lower deck (as in our ferry boats) the arrangement would have to be modified, and since last meeting he had designed a feed water steering gear for this purpose. It might have some interest to members, and if the committee thought fit, it could be explained at a future meeting. In conclusion he would say that the information given in Mr. Sinclair's paper, presented a great contrast to the custom in the days when engineers jealously guarded their secrets. The liberal way in which the author had, so to speak, "shown his whole hand," and the broad minded policy of the company in permitting the full designs of their vessel to be made known for the general information of engineers and the public deserves the warmest commendation of the members of this Association.

MR. WALTER REEKS said that he desired to add his thanks to those of the author of the paper, and those gentlemen who followed him, to the Directors of The Sydney Ferries, Ltd., Messrs. Morrison & Sinclair, the contractors, Messrs. Wildridge & Sinclair, the engineers, for their courtesy and open mindednes, in putting the "Kookaburra" at the disposal of this Association particularly so, as they must have known beforehand that the trials would be made by men who knew their business, and that whatever the performance of the vessel turned out to be, accurate record would be taken and reported without prejudice or favour.

He congratulated the Sydney Ferries, Ltd , on the acquisition of another comfortable ferry boat. The "Kookooburra" was well built, the joinery work above decks excellent, fully up to the builder's usual standard, and that was all that need be said about it. He had the highest authority for saying that the engines were first class in every way, therefore, it was only reasonable to suppose that the steamer had a long life of usefulness before her. He thought that Messrs. Wildridge & Sinclair were specially to be congratulated on the results, proving their calculations so accurate. They figured their engines to indicate 650 I.H.P., they developed 661 maximum and showed a mean of 644 which could only be regarded as highly satisfactory. Their calculations again as to the air to be supplied to the furnaces, the quantity of hot gas to be handled by the fan was out only to the tune of a hair's breadth on the fan engine throttle. The estimated coal consumption was also very close. The complete absence of friction in that long line of shaft bearings spoke volumes for the accuracy of judgment, and of the fitting on the part of Messrs. Begg & Greig, and, judging through his experience of their work, just what he would expect. The accuracy of the vessel's floatation reflected credit on the man who designed the hull. However, we had this highly satisfactory result:—The power was right; the induced draft was a success, by it the power was at command at all times and seasons; the coal consumption was rather under than over the calculations, thus leaving a margin on the right side; the draft of water was right; and the height above water complied with the contract conditions. Therefore, they looked forward with pleasure to seeing this commodious ferry boat "Kookooburra," soon running on the Parramatta River service, for which she was, as stated by the President in his opening remarks, specially designed.

Trial trips, such as those recently conducted and forming the subject of this discussion, were undoubtedly good things; they gave all of us opportunity to gather a great deal of useful information, information not only useful to us individually, but adding to the total sum of human knowledge.

Confining ourselves for the moment to ferry boats, ; was it not pleasant to to hear our friends from other parts of the world praise our ferry services; and were we not proud to know that people from all parts of the States send here to Sydney for designs of ferry steamers? Did it not then behove us to make the best use possible of these trials, and by thus freely imparting knowledge each to each, raise the general standard of our work and so keep this port of Sydney, of which we were all so proud, in the first rank of progress.

He had learned a great deal from the trials of the "Kookooburra," and those of the "Lady Northcote" last July. One of the lessons we had learned was that Nature did not alter her laws to please even the most powerful corporations, and that with all our modern improvements, we were still held hard fast to a strict obedience of those laws. Water moved through the same curves and with the same velocity to-day as it did when man first went afloat in a coracle, whose skin plating was the hide of a goat; the same resistance to progress that ancient mariners experienced, we experienced to-day, he did not know how to calculate it, we did, or should know. We might lay it down as an axiom, that vessels of similar form made similar surface disturbance at similar relative speeds, that was the principle on which tank experiments were conducted. By that surface disturbance, she told with unerring truth, the simple story of what was going on below. Mother Nature never lied. Now, if you observe the shape and character of the surface disturbance of the "Kookooburra," you would find that it was almost identical with that of the "Kangaroo" and "Lady Napier." He had occasion to make a careful analysis of the underwater bodies of these two steamers and found the error in the distribution of displacement in the "Lady Napier" to be 28 tons; in the "Kangaroo," 39 tons, and while he had had no opportunity of going into figures of the "Kookooburra," he should judge the error to be between 60 and 70 tons. Error there must be, the question was how much? The effort of suspending say 60 tons of water a mean of about 1ft 9ins above the normal level had, of course to be taken out of her total horse power during the term of natural life, which in, say, 30 years would represent in coal bill of many thousands of pounds. We had seen that the engines had proved themselves capable of all that was expected of them and that the draft of water calculations were correct. Now how did the "Kookooburra" come out in the very important matter of speed relative to the horse power developed. The tables made up by the Committee proved that 644 I.H.P. was absorbed in producing $12\frac{1}{4}$ knots, which in the absence of anything to compare it with, might pass as satisfactory, but in the light of the results obtained by over a dozen other boats running in this port and owned by the leading ferry companies, to wit, the Port Jackson Co-operative Company, the Balmain New Ferry Company, the Watson's Bay Ferry, and the Sydney Ferries, and about whose horse power there could be no secrets, it was not so good as would appear at first sight. Figuring on the same formula as the boats above referred to, and taking data from their actual results, a boat of the "Kookooburra's" dimensions and built to the same scantling, and consequently the same strength should attain $12\frac{1}{4}$ knots on 374 I.H.P., in point of fact she required 644, the question naturally arose then, what became of the balance of nearly 100%? Putting it the other way, and again using data based on actual results from the same vessels extending over a period of ten years at least, the formulæ showed $14\frac{3}{4}$ knots for 644 I.H.P. She did $12\frac{1}{4}$ knots. And why was this? It was because of all those tons of water which were being shifted, lifted and brought into violent collision with the vessel, and the surrounding water that ought to be allowed to remain peacefully at rest. It might be argued that the boats in question were of smaller displacement, that was true, but requiring as they did only about half the horse power, the weight of machinery was reduced about 50%, and just so much less displacement required accordingly.

We now turn to the business aspect of the case, and though this Institution was primarily a technical one, and the subject before us was rather the scientific than the commercial consideration of the case, still it could not be gainsaid that unless the financial side be kept closely in view, few of us would be here to constitute an Association. His experience was that this financial question was all important, those magic letters, £ s. d., were indelibly stamped on every sheet of drawing paper, and on every page of a specification, they hovered round one's pencil point like a restraining spirit; they stared one in the face on all occasions. It would be remembered that in July of last year, the Balmain New Ferry Company extended to us the courtesy of placing the ferry steamer "Lady Northcote" at our disposal, and a series of runs was made generally, similar to those which form the subject of this discussion, and the records of which we had as part of our proceedings, therefore it appeared to him a fitting opportunity to make a few comparisons directly from results.

"Kookooburra" is 138ft. over all, against "Lady Northcote" 116ft., beam 25ft. and 24ft. respectively, "Kookooburra" draws 7ft. 9in., "Lady Northcote" 9ft. "Kookooburra" will carry 794 passeagers, "Lady Northcote" being certified for 608. Admittedly the "Kookooburra" was the larger boat, and naturally should need more power to drive her, but being 22ft. longer should most certainly also be capable of higher maximum speed. We found, however, by actual trial that indicating 644 I.H.P. as the mean of three full speed trials, she attained 12·178 knots against the "Northcote" 12·19, indicating only 348·7 I.H.P., approximately double the H.P. for the same speed. Comparing the boats at ordinary normal speed. say 11 knots, the "Kookooburra" required 427 I.H.P., while the "Northcote" under the same conditions, and working both ways, propeller ahead and astern, averaged 265 I.H.P. At normal speed the "Kookooburra" was ascertained to consume 1220lbs. of coal per hour; the "Northcote" averaged on the ferry service at about the same speed, but including stops, 233lbs, per hour, and down harbour continuous running, 400lbs. Her average through the year was 25 cwt. per 12 hours, the "Kookooburra," therefore, consumed over three times the coal for the same speed, one's coal bill working out at £182 10s. a year, the other's £546. He would not, however, press this as an argument, because when high speed was aimed at, coal consumption was not the first consideration, and "Northcote" was admittadly the most economical boat in the Company's fleet (and their latest), so the comparison was between two extreme examples, and therefore, not the best data on which to base calculations for future work.

Nature had laid down rules for our guidance, and prescribed obedience thereunto, and applying these applicable to this instance, it was found that a given volume of water moving at a given velocity, moved always through the same path, unless caused by some outside force to do otherwise. Our lesson, therefore was to design our boats to comply with and not in opposition to the unalterable law of Nature and so find the path of least resistance for which economy was only another name. Practical considerations often necessitated a departure from the strict path of truth (he was speaking, of course, in a mechanical sense) but let that departure be as little as possible, for any such deviation had to be paid for at high cost.

The Directors of the Balmain New Ferry Company had permitted him to say, that when complete, their new boat would be placed at the disposal of this Institution, and he, as her designer, invited the strictest investigation, for, if we were in earnest in saying that Sydney was to hold her place as leading in this direction, conducting these trials seemed to him the way to ensure it. In concluding, he desired to assure members that any criticisms, however severe, while couched in courteous language, would be received in the same kindly spirit that always characterised the discussions of this Institution, for that spelt education.

Mr. W. Marr said that the question of forced combustion in the boilers of our ferry steamers had become a live one, was evidenced by three late productions for different owners having been fitted with modifications. Curiously enough, the three well-known types in marine practice, viz :—the closed stokehold or "plenum" in s. s. "Vaucluse," the closed ash-pit in s. s. "Lady Northcote" and the induced or "suction" draft in s. s. "Kookooburra."

The subject was one of great interest to engineers, and he had gained much information in reading the results of trials as set forth by the Committee, in the paper under discussion, though he might differ with its estimate of the results obtained.

No mention was made of a natural draft speed trial, although an arrangement had been fitted to provide for the use of either system—in his experience no such combination had been a success, and he thought better results would have been obtained if boilers had been designed for forced combustion only.

The length of boiler tubes was given as 8ft. 6ins., and of of retarders as 4ft. only. He believed that with retarders approaching the length of tubes, an appreciable gain in efficiency would be shewn, and the necessary flexible jointing would offer little difficulty.

Of induced draft installation in our coastal fleet, the only example he had knowledge of was Martin's system, as fitted in the s.s. "Birksgate." It had a chequered career and was finally thrown out owing to constant troubles through buckling of fan casing.

The A.U.S.N. Co.'s "Kuranda" offered an example of the complete "plenum" system, but the cost in upkeep of stokehold flooring plates was, he was informed, very heavy, and stokers were reported to suffer from rheumatic affections peculiar to this system.

His personal experience extended to two years at sea in charge of boilers working under Howden's system, and in his opinion the advantage of such a system outweighed any disadvantages urged against it. The tedious job of drawing retarders when sweeping tubes in port, was, perhaps, one of its greatest drawbacks, though, of course, not peculiar to Howden's system, and various modifications had been tried with but doubtful success, for the full length retarder still obtained in our latest coastal installation.

In the A.U.S.N. Co.'s "Suva" a mechanical arrangement was fitted for rotating the retarders with boilers under steam, but had not proved a success. The inventor, however, was not daunted, and on the last voyage a different apparatus had been supplied for trial.

The buckling of smoke box doors was a common occurrence in forced draft installations, and he had pleasure in bringing under our notice an arrangement by Mr. Houston, of Vancouver, B.C. (Plate X.), which he considered would commend itself as a practical remedy, the cold air circulating through the doors themselves, and effectually protecting them from injury; other features of this system were the horizontal arrangement of air heating tubes and the provision for sweeping tube spaces by steam jets.

He ventured to predict that the future steam generator of our ferry boats would lie between the present type of naval boiler under some well approved system of forced draft, and the water tube boiler, with, perhaps, assisted draft for special trips. The handicap imposed on designers, with regard to speed by limitation of draft of water, appealed in but a slight degree to the average laymen who wished to travel westwards at the same speed as eastwards of Sydney Cove.

Mr. W. F. Flashman said: With regard to the "Kookooburra" trials, the speed difficulty seemed to be due, partly, at any rate, to the uncertainty of our knowledge of the power distribution between the two propellers, and your President had thought this an opportune time for bringing before your notice some work which the University had been doing on this subject.

The "Lady Northcote" trials of last year showed that for the same speed (11·3 knots) a 15% increase in revolutions, a 32% increase in slip, a 38% increase in thrust and a 40% increase in power were required if the propeller was pulling instead of driving. Hence in a double-ended boat with two propellers, the object was to send as little power along the forward shaft as possible, for its efficiency was so low at the propeller.

Mr. Shirra mentioned at the last meeting, that the most remarkable feature of the trials was the rapid increase of power for a slight increase of speed, it might be possible to explain this, if it could be shown that more and more power went to the forward propeller as the speed increased, and such seemed possible, when we considered how quickly the ship was moving at top speed. It was only a matter of seven or eight seconds and the after propeller was right up in the very water the forward propeller threw off sternwards, so the after propeller was able to get hardly any grip on the water at