Whilst the pursuit of these investigations was in themselves a pleasure, yet the surroundings were such that a man must be callous, indeed, who was not impressed with the awful grandeur and power of the scene, and with its possibilities, and with an appreciation of the vivid description and keen sympathy with his fellows of the man who wrote:—

"They that go down to the sea in ships, &c."

Discussion.

Mr. H. Kidd said he had pleasure in proposing the vote of thanks to Mr. Chalmers for his valuable and interesting paper. The historical portion of it carried them a long way back into the early days of steam boat engineering in New South Wales. He thought the Engineering Association was much indebted to Mr. Chalmers for the attention he had given to this matter of the stability and behaviour of a steamer in a sea-way. Mr. Chalmers referred to the starting of the "Illalong Hunter River Company in 1885 with three vessels, the "Hunter," "Williams," and "Patterson." He remembered the three vessels, more especially the "Hunter," as he was second engineer in her in 1872. The chief engineer was the late Mr. W. D. Cruickshank. At that date the steam pressure carried on the "Hunter's" boilers was 10 lbs. per square inch, and even at that reduced pressure the vessel could steam 10 to 11 knots per hour.

Mr. Chalmers mentioned the steamer "Rose" as carrying 7 lbs. of steam per square inch on her boilers. To some of our young engineers this would seem a very low steam-pressure indeed; but he remembered, as an apprentice, working on two Parramatta River steamers, the "Emu" and the "Pelican," which only carried 3 lbs.

pressure per square inch on their boilers, and this fell sometimes to 1½ lbs. per square inch, so that the engines were working almost on vacuum. One of the vessels had an oscillating jet condensing engine; the steam cylinder was about 50in. diameter x 4ft. stroke. The other had a side lever jet condensing engine, with a steam cylinder about the same diameter and stroke.

There was a large difference between 3 lbs. per square inch and 225 lbs. per square inch, and much of the economy in steam consumption in the present day was due to the higher steam-pressure. The comparative figures for the piston speed of the paddle steamers and screw engines given by Mr. Chalmers showed a large increase in the modern engine, which made for fuel economy and reduced cost of construction for equal horse-power, and there were other improvements mentioned, such as carrying the exhaust of the auxiliaries into the L.P. valve casing; this also made for economy of fuel. In this connection he would like Mr. Chalmers to explain how leading the exhaust of the auxiliaries in the "Hunter's" low pressure casing contended to keep the boilers cleaned. He was not quite clear how this action was brought about.

The figures giving the life of the steam boilers in these early vessels were interesting, and if Mr. Chalmers could add to his paper some information about the working and care of water tube boilers, it would be valuable to both young and old engineers who had this type of boiler under their charge.

The tests made by Mr. Chalmers on the squatting effect of steamers when travelling at different rates of speed were interesting and valuable to engineer and captain alike.

The great improvement in the coal consumption of the s.s. "Hunter" when doing the same service was very marked, and showed the value of the triple expansion engine, combined with high initial steam pressure. If Mr. Chalmers would be good enough to supply some figures on the working of the water tube boilers, such as lbs. of coal per square foot of heating surface, lbs. of water evaporated per square foot of heating surface, and the temperature and percentage of CO_2 of the combustion gases as they leave the smoke tubes, it would add value to the paper. He understood that when the vessel was running under normal conditions, about 1800 I.H.P., the temperature of the combustion gas leaving the tubes was about 600 deg. F., which was a fair temperature, and indicated that the boilers were working at about 65 per cent efficiency, exclusive of losses by radiation.

Mr. Chalmers' observations on the pitching and rolling of the s.s. "Hunter" in a sea-way were interesting. The height of the meta-centre, 4ft. 8½in., is unusually high, and should make the "Hunter" very quick, jerky in her rolling motion, but very stiff to heel over. He had occasion a few years ago to investigate the question of the least meta-centre height that should be given to a vessel about the same size as the "Hunter,' and found that a mita-centra height of 10ins. to 12ins., while perfectly safe, gave an easy rolling motion.

He wished to compliment Mr. Chalmers on the design of the simple automatic recorder which he had fitted in his cabin for taking the diagrams indicating the variation in the angle of rolling and pitchng as affected by the quantity of water carried in the trimming tank. The diagrams showed very clearly the benefit of such an arrangement, and, if only for the comfort of the passengers, should receive the attention of naval architects.

On the diagram showing the pitching movement there were about 8 down strokes of the indicator pencil, which showed that the vessel must have been on the down slope of a wave when her stern lifted pretty high, which no doubt caused the engines to race heavily.

The question of the depth and length and velocity of sea waves is one that has been dealt with by Lord Kelvin, Froude, and Dr. Fleming. Kelvin said it was very rare for waves to exceed 45 feet in height from crest to bottom of hollow. Personally, he had been on board some of the small coastal steamers in a severe southerly gale when he felt something like Mr. Chalmers' ship-mate as regards the height of the waves. The feeling that one experienced under these circumstances was that the waves were mountains high, and that the small vessel was about to be engulfed.

Mr. Chalmers said he estimated the length of the waves to be about 300 to 350 feet. If the time be taken for each wave to pass a given point on the shaft, making due allowance for the speed of the ship, the length and speed of the waves can be determined by calculation. He thought the rule was that the speed in miles per hour was equal to the square root of $2\frac{1}{4}$ times the length of the wave in feet. Taking the estimated length of the wave observed by Mr. Chalmers at 300 feet, then $\sqrt{300 \times 2.25} = 26$ miles per hour nearly as the speed of the waves.

In conclusion, he would like to express his appreciation of the value of the paper. He had only been able to read it briefly, and hoped to study it more carefully. The facts collected and recorded by Mr. Chalmers were exceedingly valuable, and would be referred to by engineers when they were considering similar problems to those dealt with and recorded in the paper.

Mr. Sinclair said: In seconding the motion of thanks to Mr. Chalmers for his paper, he would shortly remark that the paper was one of very great use to those members of the Association who were interested in naval architecture and marine engineering, because of the very careful observations which have been recorded, and a paper which gave records and actual data of original observations, and something performed and executed, was often of far more value than a purely theoretical one, though the latter was also of supreme importance. He commended him for the exercise of very great patience, and for a great devotion to the subject about which he had written. We were, therefore, the more indebted to him for having placed the record of these extended, and what must have been tedious observations, taken at trying times, before us.

The first portion of the paper, being almost entirely historical, permitted of little criticism; but one point struck him in that the Newcastle and Hunter River Steamship Navigation Co. seem to have suffered greatly from the blighting influence of cheap fuel, as Mr. Chalmers says there was no inducement for economy, and the directors of the company would appear to have let that influence them in not progressing with engineering development. It would be a sorry day for our profession as engineers when any development of Nature's resources made fuel too cheap to be worth considering; then all ambition and competition to do better than our neighbour would have largely vanished, and engineers would go back to the old days of the empirical mechanic.

That this influence told against the development of the company was shown by Mr. Chalmers' statement that the "Namoi," with compound engines, did not eventuate until 1884, and the "Hunter," with triple engines, until 1907; or 30 years and 26 years after others had adopted them—practically a whole generation of progress lost.

The author was not quite correct in stating the advent of triple engines as 1887. He could remember as a draughtsman designing and superintending the triple engines of the "Shamrock," the first three-crank triple to come out of the Tyne, in 1884, and "Isle of Duiseg" and "Kirks," Aberdeen, 1886.

The notes re the deep ballast tank were very interesting, but it was hardly correct to claim this tank as virtually an anti-rolling tank.

To Sir Phillip Watts belonged the honour of first introducing the anti-rolling water tanks on the "Inflexible" in 1885, but though 25 per cent. reduction of rolling was obtained, nothing further was done till Herr Frauluns introduced it again with a "U" shaped tank, cone leg on each side of the vessel, with a connecting passage underneath, and obtained as much as 60 per cent. reduction. All the same, credit was due to Mr. Chalmers for adopting the deep tank in the "Hunter" to this additional purpose, and obtaining a reduction in the rolling amplitude. What enabled this benefit to be derived, the tank had evidently been the fore and aft bulkhead, perforated with comparatively small openings at the bottom (3in. the author gave as this opening). This gave a partial resemblance to the Fraulun tank, provided the tank was not filled full, but maintained about two-thirds full only. And if the owners of the "Hunter" found that less than the full capacity of the tank would serve them for the purposes of trim, then an interesting experiment would be to convert the tank into an anti-rolling tank by introducing two bulkheads to join to two side tanks, with the contact passage below and air pasages and water above; while a greater result in reduction of rolling would be obtained; this could be obtained easily, because a two Fraulun tank only required about 1 per cent. total weight of water to the total displacement of the vessel. The "Aquitania" had only 410 tons against 53,000 tons displacement; while the "Hunter" would probably be about 2600 tons displacement, and had a tank capacity of 200 tons. On the ratio of 1.3 per cent., only 38 tons would be required for the anti-rolling tanks, while the usefulness of tanks for trimming could be maintained by the centre portion being still used as a deep ballast tank. If this were applied to the ship, the owners would have the satisfaction of having the first passenger ship with anti-rolling tanks on the Australian coast, which would do something to remove what he had previously hinted at—their backwardness in progress.

MR. WALTER REEKS said he had listened to Mr. Chalmers' paper with interest. The paper presented many points worthy of careful thought and earnest discussion, but he must confine himself to a few remarks only.

First then, the question of draft of water, the author pointed out that paddle steamers were retained on the Sydney-Hunter River service for many years on the assumption that they would give better speed, and he enlarged on that by saying that five feet immersion of float practically equalled ten or eleven feet required for twin screws, both systems absorbing 2000 I.H.P., and that the paddle was superior as disturbing only the top half of the water, while the propeller operated on the whole, and drew the water from under the hull, causing more squat than would be the case with paddles. He thought this was quite a misconception.

He thought that was entirely a hull question, and not affected by the method of propulsion, or, in other words, if the same hull could be driven at the same speed over