the ends of the vessel being supported by two crests, this condition tending to make her sag. In the hogging condition, the structure at the upper part, i.e., the deck, is called upon to take up a tensile stress, while the material at the bottom is in compression. The next minute, the sagging condition puts the bottom material in tension, and the top, i.e., the deck, in compression.

Consider a vessel of simple box form, having the same dimensions as those quoted by Mr. McEwin. In a sea-way, she would be subject to a bending moment—alternately hogging and sagging—of something over 30,000 ft. tons. For the box shape an average thickness of about ½in. of steel plating will be required. This plating, both on the top and the bottom at different periods, will be called upon to withstand tensile stresses of about 5 tons per sq. inch. As concrete will not withstand stresses in tension at all, then as much steel will be required for reinforcement as is fitted at present; therefore, why put in the concrete?

A previous speaker has stated that a reinforced concrete vessel would be two and a half times the weight of a steel vessel. The hull and machinery of a 10-knot tramp, carrying 3,000 tons deadweight, will weigh about 1,800 tons, i.e., the total displacement will be about 4,800 tons. 1,600 tons of the 1,800 tons given above will be hull; multiply 1,600 by 2½, giving 4,000 tons, and add 200 for machinery, and 600 tons are left for fuel and cargo. The dimensions, therefore, of a reinforced concrete would be considerably greater than those of a corresponding steel ship having the same carrying capacity.

It is not easy for one trained to steel shipbuilding to free himself from prejudice on such matters as these. I have tried to approach the subject with an open mind, however, and while wishing to avoid any dogmatic statement, I am not able to agree that reinforced ships for seagoing purposes can be successfully built.

Mr. Shirra said that he had not heard anything as to how boats made of concrete shape at sea. The pontoons made of concrete were very good, but they sweat a little, and when it comes to a ship we must not have sweating, and we must have something that will move through the water able to bear the most severe stresses. He could not understand a naval architect advocating the building of concrete ships. If such ships would weigh 2½ times as much as steel ships there would be no room for cargo; it would be all bulkheads and cross walls. A ship is wanted that will carry cargo, and what we want to know about its strength is not the elastic limit, but its capacity for standing alternating stresses. What is the use talking about a girder? A ship is not a girder. A ship must be ship shape, and I doubt if a concrete ship could be made rigid enough to give it the curved lined of a ship. The cement would have to be of the very highest quality, and an army of inspectors would be required, and water is sure to leak through. Then another question is: Could they be built so quickly as to be of any use just now? It would be of no use to build one in six months; a score would have to be turned out in that time to meet the present crisis.

Mr. Galbraith said he had not come prepared to take part in this discussion. The building of concrete ships was not a new proposition; it was proposed 15 years ago to apply this form of construction to battleships. Mr. Hart had pointed out the difficulties brought about by hair cracking of the cement, and he also considered that this was one of the most serious difficulties. It was an axiom in reinforced concrete that the reinforcement bears the tensile stress and the concrete the compression stress, and we know that for tensile stress concrete is very weak. Professor Talbot had made some experiments in this direction, and found that when the reinforcement was stressed to 5,000 lbs. per square inch, microscopic cracks developed, and it seems that very great care is essential that the reinforcement be so arranged that all the tensile stress will come on the reinforced concrete. Another point interesting to me was the use of high tensile steel bars; that also is not a new idea, and in ship construction it would have an enormous advantage economically

I may say that some seven years ago in East Africa we used steel bars, and some of them only lasted for five years. I made a suggestion to the Government to allow me to build some steel lighters in reinforced concrete. My proposition was rather laughed at, and nothing came of it. I had another problem a little later with wireless masts. I used reinforced concrete for these. They were some 50 feet high, and proved a great success.

We all know that in structures like piles and masts there are stresses that would be approximate to the stresses in a ship, namely, alternating and impact stress. That fact alone strengthens the practicability of reinforced concrete ships.

There are no other points on which I can speak without having read all the matter, which I should like to have done. I shall therefore give place to some other gentlemen. I should like to offer my congratulations to Mr. McEwin for his very able paper. I came here not in sympathy with the suggestion of making concrete ships. I had not realised what strides had been taken in this important form of ship construction until I heard Mr. McEwin's paper read to-night.

Mr. Oakden said he had been extremely interested in listening to Mr. McEwin's paper, and he had also been surprised at the points raised in this paper, as Mr. McEwin was neither a naval architect nor a ferro-cement expert.

Cement could not be used with galvanised steel, because cement will not combine with galvanised steel; that has been demonstrated by many tests.

Mr. Reeks mentioned that he treated the ship as a girder, and ignored the skin. I take it that the skin of the ship would become a member of the girder. With regard to the hair cracks, I think that the paper touched on a feasible way of overcoming that. I can see no insurmountable difficulty except in the initial venture. There is no doubt it will come, but the designs will be radically altered before a successful one is arrived at.

The President said he did not care to express an opinion as to the practicability of building satisfactory sea-going vessels here, but questioned the advisability even to meet the urgent need of the moment in view of the fact that our actual experience in the matter was practically nil. If the authorities in this State were in possession of absolutely complete details of a sea-going vessel of about the size it was proposed to construct, and these details were copied from similar vessels that had already been constructed, had run several sea voyages and had met with ordinary conditions without failure, then he would say that it would be a mistake if the Government did not seriously take the matter up. He was sorry, in the circumstances, to be amongst those who could not see the possibility of building concrete vessels here in a better light, but the steel ships as we saw them to-day were so obviously the result of gradual development and long experience that he doubted whether, in the absence of experience, they could safely proceed.

It was generally accepted that in no branch of applied science more than in ship construction were there problems of greater variation, and even now calculations of strength, were to a great extent based upon assumption, and built up empirically from observation of existing vessels. The idea of a seamless vessel was very attractive, and if the cost of welding could be considerably reduced, and the reliability absolutely assured, it would be a tremendous step to be able to dispense with the huge mass of joints and rivets in the modern vessel. It seemed to him that perhaps the greatest possibility for ship construction on a moderate scale here at the present time to meet urgent requirements lay in the direction of composite vessels, for we could obtain the necessary constructional steel members, and had ample timber of splendid quality for the hulls, besides a good many experienced shipwrights in timber and steel construction.

It was certainly interesting to know that they had actually launched a 3,000 ton concrete vessel in Scandinavia, and also many others of smaller size, and the experience with these would be closely watched all over the world. It may be that we may see in this form of construction another epoch in the history of shipbuilding, and those who believe in cycles will notice that it is approximately 80 years since iron sides displaced the "Wooden Walls of Old England," and about 40 years since steel replaced iron.

With regard to the machinery for vessels built locally, he would strongly favor adhering to the steam engine, which no one had any doubt could be satisfactorily built in our shops. To supply steam for these, the greatest possibility seemed to lay in the direction of water tube boilers, and perhaps in view of their simplicity the Howden boiler would most satisfactorily fulfil the necessary requirements. Diesel engines have not been without their serious troubles, even when manufactured by skilled men in workshops specialising this style, so that in this direction we should also make use of existing equipment and experience rather than develop urgently the local construction of an article comparatively new to us.

He thought everyone would admire Mr. McEwin for bringing the matter of concrete ship construction forward, and he had certainly produced ample confirmation to show that the matter was rapidly getting beyond the experimental stage, and was well worthy of serious consideration here. Whatever form of construction was adopted, it is to be hoped that everybody concerned would realise the very pressing nature of the business. He had much pleasure in conveying to Mr. McEwin the vote of thanks for his exceedingly interesting paper.

The vote was put to the meeting, and carried with acclamation.

Mr. McEwin, in reply, said that there was no need for him to reply at much length. There were a number of experts present from whom he could no doubt learn a great deal.

One important aspect of the question that had not been gone into was the labor question. This would be very much simplified if ferro-concrete ships were built.

Mr. McEwin said they were much indebted to Mr. Reeks for preparing diagrams, and he looked forward to seeing them in the next copy of the Proceedings.

The main objection which had been raised to the scheme of ferro-concrete shipbuilding has been with regard to the possible behaviour of the ship at sea, on account of salt water finding its way to the reinforcement, but I think some of the suggestions that I made in the paper would show a way out of that difficulty. Certainly it is not possible to reinforce against fine cracks, but it has not been proved that these cracks go any distance below the surface. The use of light reinforcement near the surface would prevent cracks. Oil mixed concrete need only be used where water might obtain ingress. Mr. Oakden's suggestion for building in the whale back form is a very good one. Mr. E. G. Stone had been very busy with a scheme for building submersible vessels. This scheme had been considered impracticable for the present, but such vessels would not be subject to the same stresses as ordinary surface ships. The nearest point at which we could approach the building of submersible vessels would be by building whale back vessels.

The original proposal to build iron ships in place of wooden vessels was in effect a proposal to substitute a constructional material with a specific gravity greater than that of water for one with a specific gravity less than that of water. The use of concrete in place of steel merely substitutes one constructional material of high specific gravity for another, and is therefore not so revolutionary as the other proposal.

In speaking of the expense of repairing concrete vessels, Mr. Hart took an extreme case when he stated that the reinforcement would have to be removed and renewed. This would only occur when a ship had been very badly damaged indeed. Mr. Galbraith told us of the mild effect upon concrete caused by the impact of a shell, and this is evidence of its resistance to shock. He could not say definitely that there was a cement gun in Australia. He had heard that there was one in Melbourne, and possibly arrangements could be made to use it as a pattern for the construction of others which could be used if required in building concrete vessels.

With regard to the penetration of sea water into concrete, he considered that concrete could be made water proof by mixing oil in it to the extent of from 5 per cent. to 20 per cent. With regard to the length of life of a concrete ship, at the present time it would not matter if they lasted only a few years—we want them so desperately. The difficulty of securing a truly monolithic structure without joints would probably be got over by organisation. If ships were constructed by the dozen, the trouble of the cement hardening and forming joints could be got over, as it would pay to make arrangements for continuous pouring.

On the whole, he had expected that there would be more adverse criticism. From what he had heard to-night, he felt even more convinced than before that concrete shipbuilding would be a success. He did not affect to be a second Galileo; indeed, he did not even claim that his notes were original. Galileo made the then daring statement that the earth moved round the sun. He was forced to recant, but murmured under his breath: "It does move!" Here, on the one hand, the speaker was confronted by several gentlemen who declared in effect that the concrete ship was impossible; on the other hand, when he looked at the evidence and saw that concrete was in extensive use for various purposes—that a concrete yacht had been constructed to tour the world, and that a three thousand ton concrete hull had already been launched in Norway—he felt compelled to turn to his critics and say: "But it does move!"

He was pleased to hear Mr. Adams speak favorably of this proposition. The figure he mentioned appears to provide for much greater strength than would be required.

He was also glad to hear Mr. Shirra's remarks; but it was not quite fair to compare pontoons with ships. The thickness of the shell would depend upon the size of the vessel and the system of reinforcement used. He thought a great many people did not realise how desperate the position was, and that it would very soon be much worse. We cannot expect those on the other side of the world to provide ships for our use if we do not try to make some for ourselves. If we can build wooden ships, let us do so, for we must build ships of some kind. In view of the condition of our shipbuilding, we should not hesitate to do anything that we can to bring the matter before the authorities, and try to have something begun at once in this matter, which will, at least, help in the work which is being so bravely carried on at the other side of the world.

Mr. Allen Hoare, C.E., attaches a design of a "Reinforced Concrete Freighter" (Figs. 4 and 5*) to an article contributed by him to "Marine Engineering" for July, 1917.

The dimensions and other particulars of this vessel are as follow:—Length between perpendiculars, 312 feet; overall, 330 feet; beam, 43 feet; depth, 26 feet; total displacement, 7000 tons; cargo capacity, 2500 tons; indicated horse power, 2000; speed, 12 knots. Specification: Hull of plaster concrete, 1:1:2 mix, using ¼in. stone; reinforcement, wire mesh and ½in. longitudinal bars; concrete to be plastered on inside and completed from outside by means of the cement gun; a second lighter mesh being used close to the outside surface, the latter being brought to a hard trowelled finish.

Frames, stringers, etc., to be cast in place by the pneumatic system of mixing and placing, using 1:2:4 stone concrete, and reinforcing with square and round bars.

Inner bottoms and bulkheads to be of 1:2:4 stone concrete, precast in slabs, transported to position, and grouted in place, special precautions being taken to secure perfect jointing of the concrete and its reinforcement. Decks to be cast monolithic of 1:2:4 stone concrete, reinforced both ways with ½in. square bars.

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* See Page 171, this Journal.