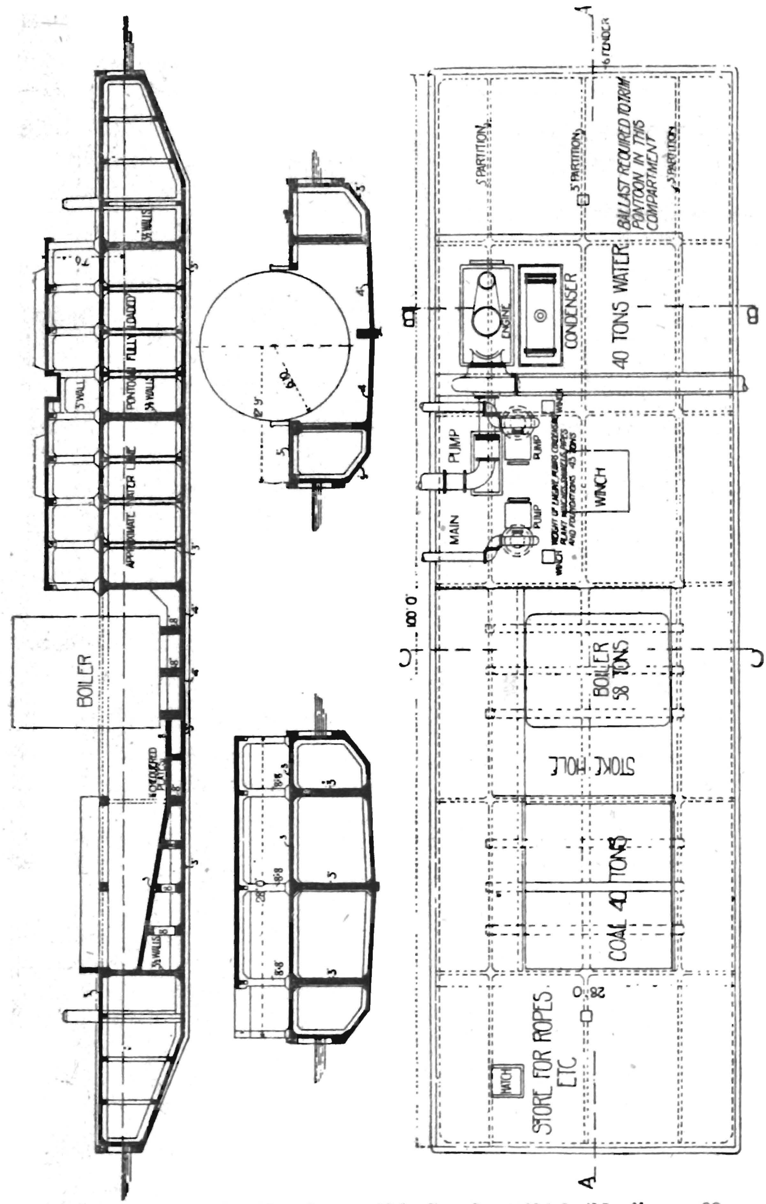

Fig. 1.—Pontoon for Manchester Ship Canal. *"Shipbuilder,"* page 69.

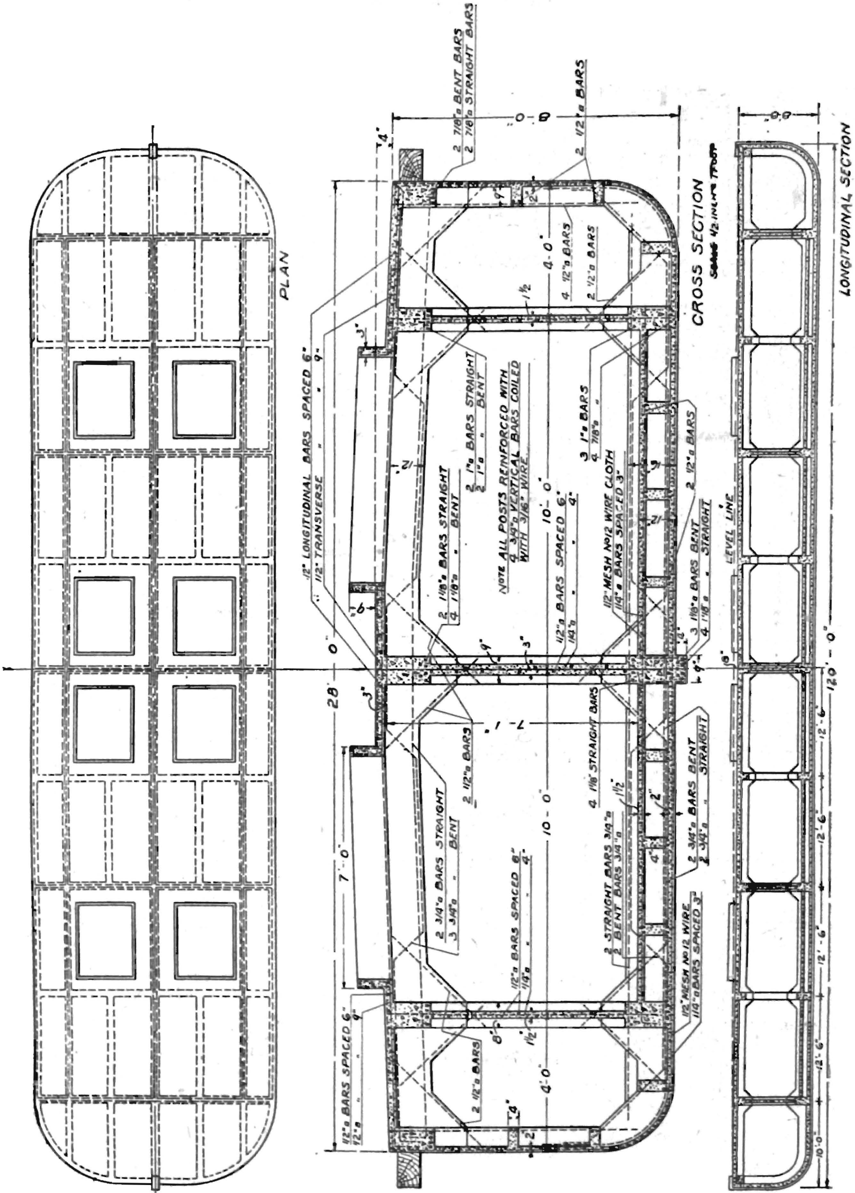

Fig. 2.—Reinforced Concrete Barge. "*Marine Engineering*," page 301.

Now as to design. Sea-going vessels must be so constructed as to safely withstand the rapidly alternating stresses that are induced by wave action. There seems little doubt that a reinforced concrete ship can be designed to withstand these stresses. Such a ship would be a good deal heavier than a steel ship, but would compare favourably with a wooden vessel of the same size and strength.

It will be absolutely essential to the life of the vessel that the salt water should not come into contact with the steel reinforcement. To guard against such a disaster the concrete must be proportioned for maximum density; and so placed that voids would be entirely eliminated, and the mass thoroughly compacted. As already suggested, the latter results could be attained by causing the concrete to set under pressure, by depositing it with considerable force, or failing either, by tamping it thoroughly.

Permeability decreases with the density of the concrete. A really dense concrete will resist the ingress of any liquid. Further, a cement coating preserves steel against the action of salt water. As a complete safeguard, the concrete may be oil-mixed, a process that will retard setting, but which has small effect on the ultimate values of the concrete. As regards the effect of salt water on the concrete itself, experiments made in America have shown that the addition of 5 per cent. of finely ground clay increased the resistance of the concrete to the action of the chemical agents in the water.

Temperature or setting cracks may occur in the skin of concrete ships, but will be of small moment owing to their extreme shallowness. More serious cracks, set up by overstressing of the outside skin of the ship, may provide a passage from the surface to the reinforcement. It is good practice to reinforce against any such cracks, and it is possible to do so by means of a very light reinforcement comparatively close to the surface. Should it be possible, however, for such cracks to be set up under extreme conditions, it will be wise to provide against them. It is only in the actual bottom of the ship that they could possibly occur. In plain concrete such a crack would act as a capillary tube, in which the water would rise on the very instant of its formation.

In oil-mixed concrete the capillarity would be resisted by the presence of the oil, and the mere saturation of the surface of the concrete with oil may be a sufficient safeguard against the ingress of the water.

Tests carried out at the Manchester Technical School, in 1911, shew that concrete will submit to considerable deflection before any appearance of the finest cracks may be observed. These tests were made on two beams reinforced against shear by two different methods, and were reported in "Concrete" for April, 1911. In Beam No. 1, shear was inadequately provided for with vertical stirrups unattached to the main reinforcement. In Beam No. 2 the stirrups were diagonally placed, and were keyed to the main bars. These beams were tested on a span of 15 feet, the loads being applied at two points, each 3ft. 9in. from the centre of the span.

The deflection diagram published shews that no cracks appeared in Beam No. 1 until a deflection of .366 inches, equal to .2 per cent. of the span, had been reached at the centre. This was very satisfactory for an imperfectly reinforced beam. In Beam No. 2 it was not until reaching a deflection of .455 inches, approximately equal to .25 per cent. of the span, that a faint hair crack appeared near the supports. This crack did not extend. The beam ultimately failed on account of cracks that developed near the centre. Taking the smaller deflection of .2 per cent., it will be found that proportionately there would be a deflection of 6.6in. in the length of a 3000 tons vessel before hair cracks would appear. If the vessel, unlike the beam, were reinforced against surface cracks, it is improbable that they would be set up at all, even under the maximum adverse conditions that might be encountered at sea.

An investigation of the properties of concrete in which a fibrous material had been mixed might lead to results which would be of value in providing against cracking of any kind. If a fibrous concrete has greater working values than ordinary concrete, it would be advantageous to employ it on the ships' bottoms, at least.

Mr. A. W. C. Shelf recently proposed to the Society of Engineers: ''That greater efficiency and economy are obtained by physically developing mild steel bars to take out the first yield in the steel, which is useless, and has a detrimental effect on the concrete. When this first yield is taken out a higher yield point is obtained without any injury to the steel, so that it was safer to employ a stress of 20,000 lbs. per square inch—which results in a saving of 20 per cent. in the weight of the steel required—than it was to employ a stress of 16,000 lbs. per square inch before the steel was physically developed.'' ''Engineer,'' 16/3/17.)

Mr. C. A. M. Smith, in his ''Handbook of Testing Materials,'' publishes an autographic diagram, here reproduced as Fig. 3, which illustrates the phenomenon of raising the yield point of a specimen of mild steel by a series of overloadings. To raise the yield point the loading was carried a little beyond the initial elastic limit, and kept so for a given time. The load was then removed, and presently was reapplied, with the result that the specimen did not yield at the original elastic limit, but at a higher point. Repeated overloadings gradually raised the yield point until it coincided with the breaking load of the test piece.

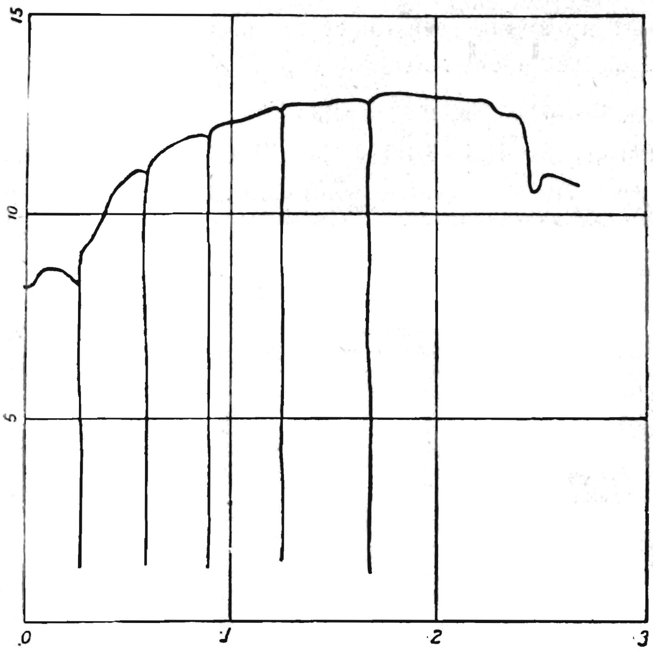

Fig. 3.—Autographic Diagram.

Apart from the saving in the steel reinforcement, Mr. Shelf's proposal is worth considering for the sake of the concrete in the structure. To secure the greatest benefit for concrete, it will be inadvisable to attempt to save the whole of the 20 per cent. represented by the increased value of the initial yield of the steel, as referred to by Mr. Shelf. The saving in steel, however, which may be secured by a process which increases its value in tension, is also an important item under present conditions, especially in concrete shipbuilding. The process of raising the yield point reduces the value of the steel in compression, but as the steel in a reinforced structure is assumed to have only the same strength in compression as the concrete, this reduction is unimportant.

Points of this character would hardly be worth considering in connection with the design of a land structure of reinforced concrete, wherein weight is a matter of comparatively small importance, and in which sudden flexure would rarely be experienced. When reinforced concrete is designed for marine work, the character of the structure is so much transformed, and the conditions are so novel, that consideration should be given to all or every means that may serve to secure a maximum of strength and safety with a minimum of weight. We cannot apply the principles of building construction to the building of ships; it is to the engineer rather than to the architect, that we must look for assistance in solving the various problems that may confront the designers of reinforced concrete ships.

The proposed vessels will find their most useful service in the carriage of wheat in bulk. The tank ship style of construction, therefore, may be followed with advantage. The longitudinal and transverse diaphragms will permit of a strong and light type of vessel. It will be very safe for the transport of wheat in bulk, as no shifting of the cargo would take place and the rupture of any one tank, from a torpedo or other cause, would not endanger the whole ship.

The writer suggests that these vessels should have a carrying capacity of 3,000 tons. Their dimensions would then be approximately: Length 275 feet, beam 41 feet, depth 21 feet, draught 18 feet, engines 1,000 horse power, speed 10½ knots.

It is interesting to note in passing that the Standard Shipbuilding Corporation of New York has been established for the purpose of building one single type and size of ship only. The standard adopted is as under:—

Length	392 feet
Beam	25 „
Deadweight capacity	7300 tons
I.H.P.	2500
Speed	10½ knots

The United States Shipping Board has tentatively approved of a plan of building 2,500 tons standardised wooden ships, to be propelled by means of oil engines. It is rightly claimed that a large number of small vessels will be safer at sea than a smaller number of large vessels; and that additional safety will be achieved by the use of oil engines as against the use of steam engines, as the smoke from the latter is visible at a long distance.

In the absence of plate for boilermaking purposes, it seems inevitable that the proposed vessels should be fitted with Diesel engines, preferably of the two stroke cycle type. With a little effort these could be made in this country. It should be possible to arrange for the construction here, under license, of a proved design of engine. As a Diesel engined vessel is lighter than a steam engined vessel of the same carrying capacity, the installing of Diesel engines will enable some compensation to be obtained for the increased weight of the ship due to the concrete construction.

The requirements of the Allied Cause, and the need of the Empire, call for our best efforts in this matter. Circumstances are such that our capacity for shipbuilding is strictly limited unless we can make use of such a material as reinforced concrete. Its claims, therefore, should be carefully examined, and neither the novelty of the proposal, nor the natural conservativeness of the cautious designer, should be a bar to a thorough investigation of the whole matter.

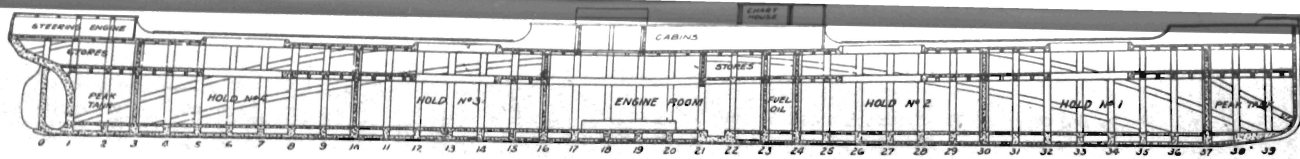

Fig. 4.—Reinforced Concrete Freighter. "*Marine Engineering*," page 302.

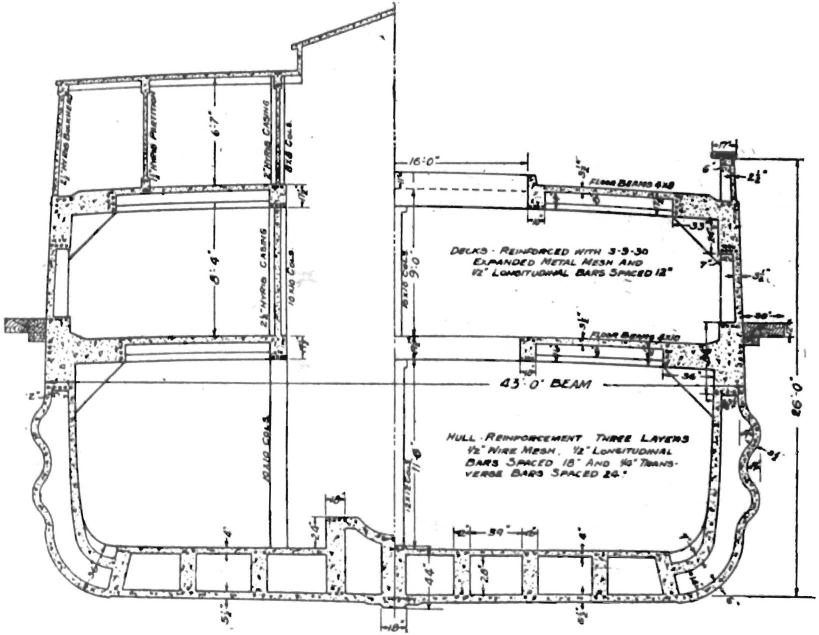

Fig. 5.—Reinforced Concrete Freighter. "*Marine Engineering*," page 302.