hered to the no dome, flush top style of boiler; dry steam being supplied to the cylinders by means of a perforated pipe lying close up to the crown sheet of the boiler (see dotted lines), the perforations being made only in the upper side of the pipe; the perforated area decreasing in width from the center toward each end of the pipe so that the tipping of the engine on the grades shall not throw water into the pipe. The aggregate area of the perforations exceed by several fold the area of the cross section of the pipe, hence there can be no danger of water entering the pipe by suction. The throttle valve is placed in the smoke arch close to the cylinders. This is another commendable feature of the engine, as it permits but little waste of steam and time in starts and stops.

The springs and equalizing levers are arranged in a pair of stout plate iron girders (C) placed beneath the mud ring of the firebox, there being just room enough between them for the ash pan, their outer face being about flush with the face of the boiler. This arrangement allows of a much wider firebox than usual. The side bars (L), which carry the main boxes being only an inch or an inch and an eighth in thickness where they pass the firebox and but seven or eight inches wide, which gives them ample strength. The stand pipes (A) discharge the escaping steam from the safety valves above the outlook of the engineer.

Both passenger and freight engines are of this type; the only difference being that the passenger engines have a larger wheel and a shorter cylinder, everything being constructed upon the interchange system as much as possible.

ON WATER BALLAST.*

By MR. BENJAMIN MARTEL, Chief Surveyor to Lloyd's.

THE subject of this paper is one which has exercised the minds of many shipowners and builders, and has had considerable influence on the mercantile marine of this country; but I doubt whether, even among the shipping community—excepting, of course, those who have given the subject special attention—its history and commercial importance are fully understood. If I am right in this view, my paper may not be uninteresting to this meeting. The question of double bottoms is so mixed up and associated in the mercantile marine with that of water ballast, that it has, I think, a somewhat different significance from the idea which prevails as to double bottoms in the Royal Navy. In the latter, as I take it, double bottoms are fitted, as it was in the Great Eastern, chiefly as a source of additional strength and security in the event of accident occurring to the outer bottom; whereas in the mercantile marine they are fitted as sources of commercial profit and convenience, although, of course, the question of safety is not entirely ignored. It is, however, from the commercial point of view that I wish principally to treat the subject, and I think I cannot do better, in the first place, than glance briefly at the early adoption of water ballast in mercantile ships. This occurred about twenty-five years ago in some of the steam colliers trading from the north-eastern ports to London. In fact, the general adoption of water ballast in merchant steamers owes its existence entirely to our steam colliers. When the coal trade from the north to London was carried on by sailing colliers, the question of ballasting on every return voyage was not only one

which involved considerable extra cost to the consumers, but also occasioned a serious inconvenience, to which some of the north-eastern ports, even at the present day, by their unsightly mounds or ballast heaps bear witness. On the vessel entering the river, the ballast had to be disposed of; and this was done by discharging it on to the river side, thus rendering valuable land unsuitable for industrial purposes. The first attempts made to overcome these objections appear curious when viewed in the present day; but they answered a valuable purpose in preparing the way for more mature plans, and showing the practicability of making water ballast commercially successful. One of these was the adoption of strong canvas bags, which were filled with water for ballast, and on the termination of the voyage the water was discharged into the hold, and pumped out of the vessel. This plan, however, found but

FIG. 2.

little favor, as the bags soon became chafed by the rolling of the vessel, and they sometimes tended to endanger her safety by bursting while she was performing her voyage. The John Bowes, built at Newcastle in 1852, was the first screw collier in which temporary appliances for carrying water ballast were adopted, and the comparative success of these means led to the building of a vessel with tanks fitted in the ship for containing the water ballast. This vessel was the

steamship Samuel Laing, of 609 register tons, built in 1854, by Messrs. Palmer Brothers, at Jarrow, for Messrs. John Fenwick and Sons, of London. These tanks consisted of iron, made to the form, and fitted in the bottom of the vessel, as shown in Fig. 1. The Samuel Laing is still employed as a collier, and the tanks originally fitted remain serviceable in her at the present day. Immediately following this, the same builders built the steamship Rouen, and fitted an inner bottom, entering the structural arrangement of the vessel similar in principle to the double bottoms now fitted. The adaptation of water for ballasting steam colliers effected quick despatch, together with other attendant economy, and showed that steamers could successfully compete with the sailing colliers and railways. This naturally led to the employment of other similar vessels in this trade, and, with the increase of number, improvements were made in the construction of water ballast tanks, or double bottoms. Great economy having been effected in steam colliers by the introduction of water ballast, which could be quickly run into the vessel while she was discharging, or pumped out whilst proceeding with the loading, steps were taken to secure similar advantages in steam vessels employed in the Mediterranean, Baltic, and general home trades; and an impetus

FIG. 3.

was given to the building of steamers to compete with sailing vessels in the European trade. At the present time provision is made for water ballast in most of the large steamers trading to the East, and all parts of the world. And the coal carrying trade on our coasts now principally done by steamers owes its present large dimensions to the introduction of water ballast, which has contributed in no small degree to enable steamers to compete successfully, and prevent this trade from becoming a monopoly by the railways, with its attendant evils to the coal consumers of the South. The reason for this is easily seen. As we have said, one of the greatest elements in the successful competition maintained by

FIG. 4.

steam colliers is the quickness with which the passages are made, the saving of cost and time in ballasting, and the great facilities afforded at each end of the voyage for loading and discharging, as compared with sailing vessels. A sailing collier, carrying from 250 to 400 tons of coals, occupied, on an average, three weeks in making the voyage from the Tyne to the Thames, and when she arrived at the port of discharge the shipper or purchaser had, by an old trade custom of the port, the power of restricting the output to forty-nine tons per day. Thus, a vessel carrying 400 tons of coal might be detained nine or ten days in discharging. Then comes the comparatively costly process of ballasting. In the first place there was 1s. per ton to be paid to the Trinity lighters for the ballast, and an additional 6d. per ton for putting it on board. Again, on her return to the loading port, 1s. per ton had to be paid as cess to the river commissioners and an ad-

FIG. 5.

ditional 10d. per ton for depositing it on the river side. The steamers, on the other hand, with the means of carrying water ballast, were much more favorably situated. The voyages of these vessels from the Tyne to London occupy about thirty-six hours; and in the place of being restricted to the old rate of discharge of forty-nine tons per day, facilities are provided—the steam collier companies having become strong enough to break through the old custom limiting the output, and it is no uncommon thing to discharge 150 tons per hour. As the discharging proceeds, water

FIG. 6.

ballast is run into the double bottom, and it costs nothing for taking in, and but little for discharging, and the facilities thus afforded enable these vessels to make as many as sixty voyages from Newcastle to the Thames during the year. The number of voyages has risen, I believe, in the case of one vessel, to seventy-two per annum. The result of this is, that whereas nearly the whole of this trade would, in all probability, have been lost to shipowners, had water ballast steamers not been introduced and developed, we find that, during the year 1876, 3,273,442 tons of coals brought into London were sea-borne; and this cannot fail to produce a beneficial effect on the market. Whilst, however, the great advantages arising from the introduction of water ballast may thus be clearly seen in vessels engaged in the coasting coal trade, its economical use and advantages are not so readily admitted by some for vessels engaged in foreign trades. It is doubtless found unnecessary to carry water ballast in certain specific trades; but when we consider the great facilities afforded by it for trimming steamers in all situations, whilst avoiding heavy ballast charges, with the

consequent much heavier expenses attending detention, I think it can be pretty plainly shown that there are very few steam vessels indeed where some kind of arrangement for carrying water ballast would not be an advantage. In fact, for steam vessels engaged in general trades, and having often to seek cargoes at various ports, it has become a prime necessity, and may well be allowed to take its place by the side of compound engines, as an important economical intro-

FIG. 7.

duction into this description of vessel. To convey an idea of the approximate yearly saving to a steamer engaged in a few general trades, I will give a few examples; but it must be understood that in doing so I am merely glancing at the subject, and that many circumstances might arise, well known to the owners of this class of vessels, by which the savings shown might be easily doubled. I will take first a steamer built for the Mediterranean trade, and costing about £20,000. Such a vessel will make, say, four voyages in the year. As a rule she would load at a Mediterranean port, thence go in ballast to her grain-loading port in the Black Sea. This vessel would require about 200 tons of ballast, and assuming a moderate charge for dry ballast of 2s. per ton, this would amount to £20; supposing 65 tons per day could be obtained, the detention caused in shipment, at the moderate calculation of £25 per day, would be an additional £75—thus mak-

FIG. 8.

ing £95. But on arrival at the loading port, this ballast has to be discharged, and by using the steam winches of the vessels, a further expense, including craft hire, of about 1s. per ton, or £10, is incurred—thus making £105. By allowing two days' detention before the vessel is in position to take cargo on board, which—especially in a foreign port, where craft have to be sought, etc.—is not too much to allow, this would increase the expenses to £155. Suppose now the steamer to be ordered on arrival, off Falmouth, to some port to discharge cargo from which an outward freight could not be obtained; this same process of ballasting, with its attendant expenses and detention, must again occur—as such a vessel, not being a regular liner, would have to proceed in all probability to Wales or the north of England, or other coal port. This additional cost, allowing 3s. per ton

FIG. 9.

on 200 tons, for taking in and putting out ballast, would amount to £30—bringing up our expenses to £185; and with three days' detention, being another £75, the total cost of expenses at moderate calculation on one voyage would be £260. This taken on four similar voyages would amount to about £1,000 in the year, or, on a capital of £20,000, to 5 per cent. per annum—a rather startling fact. If we take the case of a steamer engaged in the Baltic trade, the expenses on a vessel of the same value, in view of the greater number of voyages she would make, would be at least £1,500, or 7½ per cent. per annum on the cost of the

FIG. 10.

vessel. Nor are the advantages of water ballast confined to steamers in the European trade. If we consider the coasting trade of China—a most important trade, particularly between Saigon and Hong Kong—it is questionable whether steamers could have driven the sailing vessels from this trade but for the economical advantages of water ballast. Notwithstanding the high price of coals in those waters—viz., 40s. to 60s. per ton—the facilities afforded by water ballast

* Institution of Naval Architects.

have enabled steamers so adapted to carry on the trade at freights at which it is found sailing vessels cannot exist. Some eminent builders, I know, have expressed doubts as to its desirability in steamers engaged in the China trade; but I know steamers engaged in bringing home tea and other valuable cargoes, which are provided with facilities for carrying nearly 300 tons of water ballast, in which it is carried with perfect safety, and found to be most convenient and economical. Recent circumstances have shown in a very striking manner the great benefits arising from large steamers, engaged in the India trade, being provided with facilities for the use of water ballast. During the recent

famine in India, the great demand for steam tonnage caused every available steamer there to be employed at exceptionally high freights—as much, in fact, as £2 15s. per ton was given for carrying rice to Madras, a run of four days only. The result of this great demand was to fill Madras Roads with a greater amount of tonnage than had ever anchored there before. This naturally led to exorbitant demands being made by the native boatmen, and it was with the utmost difficulty they could be induced to carry ballast to steamers which were not adapted for carrying water ballast at six rupees per ton—or about ten or twelve times the ordinary cost; and even at this exorbitant charge such steamers might have to wait two months for an amount of 200 tons. Many of the large steamers, under these circumstances, which were not fitted for water ballast, had to keep part of their former cargo on board, and go down to Pondicherry, where dry ballast was obtained at a reasonable rate, and, after getting ballasted, had to return to Madras to discharge the remainder of the cargo, and then start to a loading port for rice. The great loss thus incurred at such a time, when employment was so profitable, can be easily understood. In many cases, I believe it amounted to at least

£500 per voyage. This experience, I know, has induced the owners of some of these large steamers to have some kind of provision fitted to them for carrying water ballast, when so required. I need not dwell longer on this part of the subject, but I may perhaps add that I have a strong opinion that before long scarcely a steamer will be built without some kind of adaptation for carrying, in cases of emergency or occasional divergence of trade, sufficient water ballast to enable her to shift from port to port.

And here I think it may be useful to refer to the great prejudice which existed a short time ago, and does still to some extent exist, in the minds of underwriters and others, against vessels fitted with double bottoms. This arose from the lamentable fact that, during the years 1872-73, a large number of screw steamers were reported as missing, nearly the whole of which were fitted double bottoms. Another feature common to most of them was that they were grain laden, on the homeward voyage. I am not prepared to con-

tend that the existence of double bottoms in some of these vessels did not contribute in some measure to the disasters; because some of them were inordinately high, and were fitted in vessels whose dimensions and forms would necessarily have rendered them tender ships. There can be little doubt that those disasters were brought about by a combination of most unfortunate circumstances. A tendency to carry double bottoms up to excessive heights had been developing itself, without any compensating increase of beam. And vessels of this type were put into the Atlantic trade to load grain in bulk at time when the necessity for extreme caution in securing such cargoes from shifting was not sufficiently well attended to. The sad experience then gained, however, produced a very marked and salutary change, both in the precautions adopted in loading, and in the fitting of the double bottoms, and when the inner bottom is suitably arranged to the form of the vessel, it is a source of safety as well as profit. Obviously there is much greater strength obtained, and many vessels that have been ashore have owed their safety to their double bottoms. I need not enumerate instances, as they will readily occur to many, and argument

is not required to show, for experience has abundantly shown, that, if the double bottom be kept within proper limits as to height, no increased danger arises from this arrangement. When a double bottom is fitted throughout the length of both holds, and of a height greater than is absolutely necessary to secure sufficient water ballast to enable the vessel to shift from port to port, the cargo is obviously raised more than it need be, and especially with homogeneous cargoes like coal or grain; and with vessels of ordinary proportions this unduly reduces the stability. Considerations and experiences of this kind have induced builders and owners of this type of vessel to limit the height of the inner bottom, or to restrict it to the after hold and under the boilers, and thus to admit of the cargo in the main hold of the vessel being stowed lower to insure sufficient stability, whilst at the same time providing sufficient water ballast to admit of the vessel being shifted from port to port. A comparatively low double bottom, extending through both holds under the engines and boilers, doubtless combines best the properties of safety and strength with the facility for ballasting, and there is a tendency in large steamers to carry the double bottom through under the engines and boilers, as objections that were formerly raised to this are now deemed of less importance. A serious objection to double bottoms being too much reduced in height is the difficulty of examining the internal condition, as they must always admit of a man getting through, for unless they can be periodically examined deteriorations might be going on without detection, and serious results might ensue.

I will here glance briefly at different modes of construction that have been adopted for water ballast tanks or double bottoms. The Samuel Laing, before alluded to, was built like any ordinary vessel, and Fig. 1 shows how the tanks were arranged in the hold. The tanks are connected by pipes, and the water is let in and pumped out in the usual manner. Fig. 2 shows the arrangement of the double bottom fitted to the Rouen, being the first vessel in which a permanent double bottom entered into the structural arrangement of the vessel. The frames were separated at A, and the sides of the tank were formed by vertical plates B connected to the outside plating by the continuous angle iron C. Longitudinal girders D E F were connected to the top of the floors and on these the inner bottom G was fitted, the whole being made watertight. Fig. 3 illustrates an improvement on this, having the flange plate A arranged so as to be at right angles to the bilges. In these plans a gutter is thus formed at the sides of the vessel, thus admitting any drainage from the top of the tank to find its way into this, and thence into the engine room, or into the well at the end of the tank. This is called McIntyre's plan, from the name of Mr. John McIntyre, of the firm of Messrs. C. Palmer and

FIG. 15.

Co., who first introduced it. Fig. 4 is a plan introduced by Mr. Withy, and the builders at Hartlepool and the Tees. It is similar to McIntyre's plan with the exception of the angle irons connecting the flange plate to the outside plating being fitted on the outside, which, it is considered, offers greater facilities for caulking. Fig. 5 shows the plan first introduced by Mr. James Laing, of Sunderland. The reversed frames only are separated in this mode of constructing the double bottom, and knees or doubling pieces of angle iron about 3 ft. long are fitted to the main frames to compensate for this local weakness. The side plate A is flanged, and riveted to the outside plating, and around the frames are fitted collars, B, riveted to the frames, outside plating, and inner bottom. Mr. Laing has been very successful in fitting large number of vessels in this manner, but he is almost alone in a continuance of this plan. Fig. 6 is a plan adopted by Messrs. C. Mitchell & Co., of Newcastle. Instead of the flange plate A being horizontal, as in the previous case, it is arranged as in McIntyre's plan, but the main frames are not

separated. The flange plate is connected to the outside plating by the angle iron B, and the angle iron collars C are fitted around the main frames. Fig. 7 shows an arrangement of beams A for receiving the inner bottom, fitted to every frame, and supported by angle irons or plates B. The flange plate is fitted against the outside plating at C, and the main and reversed frames are not cut. A continuous iron D is connected to the reversed frames, and the spaces between have pieces of wood closely fitted between the frames, and caulked. This plan was originally adopted on Tyne, but it is not now continued. Fig. 8 is a plan adopted by some builders on the north-east coast. The main and reversed frames are preserved intact, and the inner bottom is con-

nected to the outside plating by the angle-iron A, forming collars round the main and reversed frames. The spaces between the reversed frames and plating are filled with wrought iron plugs made to the form for each separate frame. Fig. 9 illustrates a mode of constructing a deep tank extending to the height of the hold beams. This is preferred, in some instances, as it can be utilized for cargo when ballast is not required; and as the cargo can be placed lower down by this plan, the stability of the ship is increased. In some of the early ships where this plan was adopted it caused disappointment, as the importance was not sufficiently realized, when carrying a large body of water, of completely filling the compartment containing it. In early cases coamings were dispensed with, and, conse-

quently, that was sometimes a difficulty in completely filling it, and when the tank was not quite filled it admitted of a considerable momentum being generated when the vessel rolled or pitched. Sufficient care was likewise not always taken in making the transverse bulkheads forming the tanks sufficiently rigid by stiffeners, and it was not unusual to find these broad bulkheads stiffened with only small angle irons. These have either bulb plates, or plates and angle irons, to give sufficient rigidity. In cases where these tanks have been properly constructed—such as shown in Fig. 9 or other approved mode—the arrangement has given great satisfaction and been found most useful. The frames and reversed frames in Fig. 9 are not separated, and the spaces between are filled with blocks cast to the form, and made watertight by rust putty, and covered with cement. Great care should be observed where this form of tank is used to provide a sufficient number of manholes for ventilation, as, owing to the absence of these, the cargo in some instances has been damaged from sweating. Fig. 10 is a plan which was

adopted in building the steamship Carbon, at Liverpool, in 1854, which vessel is still running as a steam collier, and the plan has answered its purpose. Fig. 11 shows a double bottom in a steamer built in Italy, for an English firm, in 1874. A center through plate, A, is fitted with deep floors connected to the same. The inner bottom is fitted on the floors, and the space between is divided by intercostal plates B. This vessel is employed in general trade, and the arrangement has given satisfaction to the owners. Fig. 12 is somewhat similar. This vessel was built in 1876 by Messrs. Austin and Hunter, Sunderland, and is, it is considered, a very satisfactory as well as novel mode of construction. The longitudinal webs are about 4 ft. apart, and there are solid transverse intercostal floor plates 14 ft. 8 in., at eight frame spaces apart, and intermediate between these, at four spaces of frames, are bracket plates, as shown, B B B; intermediate between these again are angle iron stiffeners to the longitudinal girders and inner bottom C C C, and the frames extend across the ship at every 22 in. apart—the ordinary room and space for a vessel of her size. Such a mode of construction, whilst providing for the carrying of water ballast, enables a strong bottom to be formed with less weight of iron, and, it is said, less cost. Figs. 13, 14, 15,

16, 17, 18, and 19 show plans which have been adopted at various times, but most of which have not been repeated. Other plans have been adopted, but time or space will not admit of a description of all of them.

I cannot conclude without drawing to a novel adaptation of water ballast to sailing vessels. Several of these vessels, as illustrated in Fig. 20, have been designed and built by Mr. Bone, formerly surveyor to Lloyd's Register, late manager for Messrs. Cole Brothers, Newcastle, and now managing director of the Tyne Shipbuilding Company. These sailing vessels are designed to carry a cargo of coals which will just fill them. They take coals to Almeria or Valencia, or any of the Spanish ports, and whilst discharging take in water ballast, and proceed to Pomaron or Huelva for ore, which is brought to the Tyne, Hull, London, or Aberdeen. They have provision for 150 tons of water ballast, which, on arrival at the port of loading, is pumped out by the crew with

a 6 in. Downton pump. The voyage occupies about two months, on which, in addition to the saving from detention, there is a gain of £40 each voyage from not having to purchase or take in dry ballast. These vessels have answered well, and have been enabled to compete successfully with steamers. I have seen other attempts to introduce the advantages of water ballast to sailing ships, some of which scarcely deserve such high recognition. Whether provi-

sion and arrangement for water ballast will be extended to larger sailing ships I cannot venture to predict; but in view of the early attempts to introduce it in steamers, and the vast importance it now assumes in this description of property, it would not be surprising if we were to experience a further development to some extent in this direction. However this may be, my chief object has been in this paper to place before you some of the plans that have been adopted, and the expedients that have been resorted to, together with the circumstances that have given rise to them, in connection with this subject of water ballast.

THE SUTRO TUNNEL.

A CORRESPONDENT of the London *Mining Journal*, who calls himself "An Engineer," gives the following rather discouraging view of the value of the Suto Tunnel.

The tunnel will be 20,000 ft. long, and will cost £720,000. It will tap the Comstock lode at 1,800 ft. from the surface; but as the various workings on this lode occupy a length of more than three miles the tunnel will be of no use to them until they are connected with it. In new sinkings machinery must be erected in the first place, and the same machinery will haul the ore to the surface, and the water also.

The minerals and water from the workings below the level of the tunnel (and the principal mines are all below 1,800 ft.) will have to be raised up to that level, and as in all probability the engines for raising it will be erected on the surface the extra 1,800 ft. would not add much to the cost of raising the ore.

Coals can be drawn 300 fms. at 2d. a ton, and suppose fuel and wages to be ten times it would only be 20d. per ton or less than half-a-dollar; but as there will be machinery needed to draw the ore from the workings below the tunnel there will not be much saving on this head. As to ventilation any practical man knows that the shorter distance the air has to travel the less is the friction, and of course, the easier the ventilation; and if a pair of shafts of 15 or 20 ft. diameter, 1,800 ft. deep, were sunk from the surface, and a 30-ft. fan put on them, there would be vastly more air than would pass through the four miles of the Suto Tunnel.

The probable benefits of the tunnel are, therefore, narrowed down to the drainage of the lode to a depth of 1,000 ft., and if this be all we have the cost of draining early bought. Thus the interest of £720,000 at 10 per cent. per annum is £72,000.

I understand the feeding raised by all the engines upon the Comstock lode is about 1,500 gallons per minute. If, therefore the advantage of the tunnel be confined to the drainage only, we have the cost of raising 1,500 gallons per minute 1,800 ft. high, £72,000 per annum. I rather think some of our Cornish engineers would do it for less.

MACHINERY FOR BORING ROCK.

THIS improvement, by Shaw and Clark, of Ovenden, near Halifax, England, consists of a cylinder and piston rod with two pistons. Steam, air, or other elastic fluid is introduced into the middle of the cylinder, and acting on one or other of the pistons, closes the exhaust, and forces the steam or air from one piston to the other piston. This is effected by one or other of the pistons coming into contact with a slide valve, which at the proper time closes the required port or ports, leaving other port or ports open. The drill, being fixed or attached to one end of the piston rod, is automatically fed into the rock at every blow of the piston by means of a small cylinder fixed to the side of the above-named cylinder, and so arranged that steam or air will pass from the large or first-named cylinder to the small cylinder, and act upon suitably arranged catches and wheels.

LIVERPOOL ENGINEERING SOCIETY.

THIS Society held its usual meeting on Wednesday evening, Oct. 10, at the Royal Institution, the President in the chair. A paper was read by Mr. I. E. Clanchy, B. A., on "Civil Engineering in Brazil." The author gave a very interesting account of the construction of the San Paulo and Rio de Janeiro Railway, on which he was engaged as sub-resident engineer. Owing to the peculiar physical character of the country, great difficulties had to be overcome, both as regards surveying the line (no maps and very seldom roads being available), and afterwards in the construction. As is usual in Brazil, the work was let to a number of small contractors who gave endless trouble by their craftiness and ignorance. Young engineers were urged to make themselves acquainted with the properties and qualities of limes and clays, as in an undeveloped country they were called upon to decide what clay was suitable for brick and what worthless, and similarly in regard to the local stone used for making lime. In Brazil the contractors tried to use a stone called *saiba*, very much resembling limestone in appearance, but possessing none of its properties, and which was, of course, utterly useless for mortar. The railways in Brazil are laid to the 5 ft. 3 in. Irish gauge, and the meter gauge—the latter being most in favor at present. The San Paulo and Rio Railway was constructed to this gauge with rails of the Vignoles pattern weighing about 45 lbs. per yard. Steep gradients had to be adopted on some portions of the line, but nothing like the Santos and San Paulo Railway, which rises 2,600 feet in about 5 miles. This line is worked by stationary engines placed at intervals, and the traffic is so arranged

that descending trains assist those ascending. In case of accident a novel brake is provided which grips the rails and instantly arrests the motion of the trains. Mr. Clanchy referred to the absence of good roads in Brazil as checking the development of the railway system; for without arteries and ramifications in the shape of roads extending into the country around, a railway is merely an expensive luxury. In conclusion, details of the cost and mode of construction were given, together with much valuable information as to carrying out works of this class abroad.

After reading the paper, Mr. Clanchy received a hearty vote of thanks for the interesting manner in which he had brought the subject before the meeting.

W. WILKINSON, Hon. Sec.

Dockyard, Liverpool.

ON LAUNCHING THE IRONCLADS KAISER AND DEUTSCHLAND, AND OTHER LARGE SHIPS.*

By MR. D. A. SAMUDA, M.P., Vice-President.

THE launching of a large and costly vessel is a serious matter. There is scarcely any operation throughout the construction of a vessel likely to cause the builder more anxiety or to result in more serious consequences if from any cause a failure should attend his efforts to insure a successful launch. If reference is made to the cases of important failures that one man can recollect during the last twelve or fourteen years—omitting altogether the failure of launching the Great Eastern as a vessel both exceptional in itself, and also in the mode adopted of launching—we should have to record that of Her Majesty's frigate *Cesar*, at Pembroke, the iron-clad frigate *Northumberland*, and the Brazilian iron-clad *Independencia*, on the Thames. The cost of failure in these three cases could not have been very short of £300,000, and the matter therefore appears to be of sufficient importance to place on record, for the benefit of the present and future shipbuilders, the precautions that have been taken by my own firm, and which have been based on the result of many years' experience, and possess the advantage of having been uniformly successful. The most convenient course to adopt, I think, will be to describe accurately the course pursued in some special case, and to draw attention to any special conditions that should be carefully borne in mind in similar cases, and I have therefore selected the case of two of the largest vessels I have built, as in all cases reducing the proportions and precautions for smaller craft will be more easily and more safely accomplished than by working up to larger and heavier vessels. I propose therefore to describe arrangements employed in constructing the ships and carrying out the launch of the two German iron-clad frigates, *Kaiser* and *Deutschland*. The principal dimensions of each were: length, 285 ft.; beam, 63 ft.; gross displacement—when fully equipped and engine—7,400 tons.

Preparation of Slip.—The slip is formed of no less than 400 piles of Dantzic fir, each 16 in. square and about 30 ft. to 40 ft. long. These are arranged in traverses rows of seven piles in each row; spaced with intervals of 7 ft. for the entire length of the slip. These piles are arranged generally as shown in the engraving, page 170, as follows:—Two in the middle line to support the keel of vessel; two approximately under each launch, and one beyond alternately on each side. In addition, the number of piles is increased on the lower portion of the slip beyond that on which the vessel is built, and over which it has to travel before finally leaving the end of the sliding planks. Cross baulks of Dantzic fir, 16 in. square, are worked on the top of each row of (seven) piles and tenanted on the top of them. Additional piles are also driven under the fore-foot of the vessel to support the extra weight of the overhanging bow. The piles are in every case driven down to the gravel, generally about 30 ft. to 35 ft. below the surface of the ground, for which purpose a pile-engine and a 20 cwt. monkey is used, and when this weight falling through 26 ft. fails to drive the pile more than half an inch, the required solidity is considered to have been attained. Longitudinal baulks are worked on the fore end, where the piles project much above the ground; and aft where from the rise and fall of the tide, the ground is shifting 50 tons of chalk were also placed round about the ship to obviate the action of the tide. On the top of the cross baulks, shorter baulks are fastened, also of Dantzic fir, and these are surmounted with hard wood blocks on which the keel of the vessel rests.

Buttresses.—In addition to the solid foundation thus obtained, it is a usual practice to build up at least six buttresses, three on each side—in this case four on each side were adopted—under the bilges of the vessel. These buttresses are formed of baulks of timber about 16 in. square and 8 ft. long, and are laid alternately lengthwise and transversely, forming a solid pedestal 8 ft. square, and reaching from the ground to the underside of the bilge, and thus relieving a large portion of the weight of the ship from the blocks under the keel in the center line. As a further precaution, blocking is used between the ground and the transverse or cross blocks, so as to distribute the weight more effectually from the center to the side piles. Though the cross baulks were of Dantzic fir, as here described, I would remark that it would have been a great improvement to have used hard wood instead. While building the vessel the entire weight—except to the extent relieved by the buttresses and shores—clearly is taken by the logs over the center piles, and the effect on the cross baulks was to press them so seriously that they actually forced in the fibre of the wood where tenanted to the center piles, and caused a deflection of the cross baulks to the extent of $\frac{1}{2}$ in.—a result due to the softness of the fir, which probably hard wood might have resisted.

Inclination.—The inclination of the slip while building was $\frac{1}{8}$ in. per foot, and the blocks were kept a sufficient height to allow convenient room for working under the vessel, and for giving additional inclination for launching. If this is not attended to when the keel is laid, great difficulty and risk may occur when the launch has to be prepared. The launching ways are laid with a camber of 8 in. in their length, the line being carefully set off to form the arc of a circle; the inclination at the top is $\frac{1}{4}$ in. per foot, increasing lower down in accordance with the camber.

Launching Ways.—These are of rock elm, 4 in. thick, bolted together and to the cross baulks on the top of the piles and supported by blocking up between the piles, wherever they are sufficiently out of the ground to enable this to be done. The ways are 3 ft. 8 in. wide, with a ribbon of oak 8 in. by 4 in., increased at the fore-end to 11 in. by 11 in. to receive the heel of the dog-shores on the outer side of each.

Bilge Logs and Launch.—The bilge logs are of oak, each 260 ft. long by 3 ft. 1 in. wide, and are each composed of five lengths attached together by chains. The total area of the bilge logs on both sides was 1,600 ft.—the launching weight of the *Kaiser* was 3,500 tons—thus giving a weight of 2.15 tons on each superficial foot of bilge-log surface. The *Deutschland* weight as launched was something less, viz., 3,000 tons, giving a weight of 2 tons—nearly—on each foot of bilge-log surface. The greatest weight that I find by practice may safely be allowed is 3 tons of weight to each foot of greased bilge-log surface; anything within this may be considered safe. On the top of the bilge logs is worked the stopping up, which is composed of Dantzic fir timber, carefully fitted to the ship with poppets at fore-and-aft ends. The top of the poppets are lined with iron and fitted with iron forgings against the lands of the skin plating and secured by two iron bars, each $3\frac{1}{2}$ in. diameter, lashed together at both ends by chains passing under the fore-foot of the vessel—as shown in the drawing. The fore-ends of the launching logs are also securely lashed together by chains and ring bolts, having fore-locks for disengaging after the launch, which is done from the deck of the ship. By this arrangement the fore poppets and launch are maintained in their places, and prevented from spreading out when the extra strain comes on the fore-end of the launch at the time when the stern is lifting, and are easily and instantaneously disengaged and set free when the launch has been effected.

Sustaining Power of Slip.—The sustaining power of each pile driven under the conditions before named may be taken, approximately, to be thirty tons—it is really more. The slip, therefore, under the entire ship—280 ft. long—would support no less than 8,400 tons; but during the building of the ship and before the launch is laid, the weight would have to be carried on the center piles only, and then 2,400 tons only could be carried—showing that, with all these preparations, there would still be 1,000 tons weight to be carried by the buttresses, shores, and the distribution of weight—by the means previously noted—from the center to the side piles.

Shoring up inside the Ship.—A tier of shores between the inner and outer bottom is placed over each launch, with shores above the inner bottom up to each deck above; particular care is taken to shore up strongly over the foremost poppet to resist the extra strain that part receives when the vessel is partly in the water. The vessel received no damage or straining whatever in launching, not a rivet head fell off nor did the slightest sign of injury show itself, and the same may be said of the numerous vessels launched during the last twenty-five years from the same works, and in which similar care—according to the size of the vessel—had been bestowed on the arrangements and carrying out of the launch. The small change of form of vessel before and after launching was further most satisfactorily proved by ascertaining that no caulking of water-tight compartments of the double bottom was disturbed; the whole of the compartments—thirty-two in number—were tested by filling with water under pressure while the vessel was on the slip, and a repetition of the water testing was again made after launching, and every compartment found to be absolutely tight.

Launching.—After the whole of the launch, stopping up, poppets, &c., have been accurately fitted to the vessel, and about three weeks previous to the launch, the launch is turned out and the ways coated with hot tallow and soft soap, then replaced and fixed. On the day of launching oil is forced between the bilge logs and the launching ways through oil holes provided for the purpose, the quantities used being as follows, viz., for the entire operation of launching:—Tallow, 4 tons 6 cwt.; soft soap, 5 cwt.; oil, 55 gallons. On the morning of launching, the vessel was set up by driving in wood wedges between the bilge logs and stopping up; and when the weight is so far taken on the launch, the blocks under the keel, and the bilge blocks and shores are gradually removed, beginning from aft, but leaving from ten to twenty blocks, according to circumstances, under the fore foot of the vessel until the dog shores are down. Cleats at the after part of the launch are provided to assist the dog-shores till near the time of launching, when they are gradually and carefully removed. The dog-shores are removed by the fall of the weights—one on each side of 6 cwt., acting on its own dog-shore and suspended over them by a rope passing round the stem. This rope is cut by the lady who launches the vessel, thus releasing the two weights at the same instant and insuring the dog-shores being removed simultaneously.

Hydraulic Ram for Starting Vessels.—One 60-ton ram was fixed at the end of each bilge-log, and one 100-ton, one 60-ton, and one 40-ton ram under the fore-foot of vessel, besides a large tackle on each side led to a double-purchase crab. These were provided in case of need to start the vessel, but were not required, as she began to move as soon as the dog-shores were down, tripping most of the blocks left under the fore-foot.

Check Rope.—A hawser was fixed to the stern of the vessel and attached to a chain cable and anchor carried some distance up the stream, and so arranged in length and position as to cant the stern of the vessel up the river as soon as she became clear of the slip, and so prevent the danger of the vessel running on shore on the opposite side of the river. By this means the vessel is also brought into a suitable position to be laid hold of by a tug steamer that is kept in readiness for that purpose; and when so attached to the tow-rope of the steamer, other tugs are employed to draw out the launch and entirely sweep and clear away whatever fragments of it may still be left adhering to the hull. In conclusion, I would wish to be allowed to express a hope to any with less experience than myself that no inducement, however great, should be accepted as sufficient for foregoing what to many may seem the unnecessary precautions and the great expense that must result from following the plan of operations here described, after, of course, making suitable variations from it to meet the demands of each special case. I know in these times of competition how anxious all—and especially young firms—are to save every expense that can possibly be avoided; but it is only those who have seen the misery that failure in so important an effort in a man's life involves, and the financial ruin that results from trusting to luck instead of to well-cultivated arrangements and caution, that can properly estimate the advantages of insuring success at any cost and care—and this induces me to take the unusual course in a paper of this sort, of urging in the interest of all engaged in the important operation of building and launching vessels of the size and cost that they have now reached, to think no trouble or expense wasted that will insure the success of the important accomplishment of their work.

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