THE INTEROCEANIC SHIP RAILWAY.

The transisthmian projects which for many years have attracted the attention of engineers may be divided, perhaps not improperly, into three classes: 1st. Those in which the construction will be at the mercy of floods. 2d. Those lacking good harbors. 3d. Those which empty into the Doldrums or Zone of Calms. Of these three fatal objections, the Panama tide water canal scheme is open to the first and third, and the Nicaragua lifting-lock plan to the second and third. The ship railway project of Mr. James B. Eads, illustrated in this number, is open neither to the one objection nor to the other, and besides being far less costly, it furnishes a quicker means of isthmian transit than either of them, and will shorten by considerably over a thousand miles the contemplated route *via* Panama between our Atlantic States and San Francisco or the East Indies.

Until the arrival in the field of Mr. Eads, it seemed to have occurred to no one that anything but a waterway would serve for ship transit between the two oceans. It did not appear impracticable to some of the transisthmian projectors to build a ship canal in a region annually inundated by mountain streams, or to expect sailing vessels to traverse hundreds of miles of wind-bereft seas. But to take ships across a narrow isthmus by rail was monstrous, and not to be thought of.

It is no part of the purpose of this article to cast discredit upon the rival projects of Panama and Nicaragua, but the promoters of both the one and the other, in very laudable efforts in support of their own theories, have led at least a portion of the unthinking public to look upon the ship railway scheme as impracticable and visionary, and a comparison is necessary to show the relative practicability of the ship railway and the two most prominent canal schemes, and its superior advantages when considered from a commercial standpoint. In making this comparison, however, we shall endeavor to give each its just due, setting down naught in malice.

A careful study of the engravings as presented in this number, and the explanation which accompanies each, will show that while the ship railway is novel and original when taken as a whole, it demands no other methods in the treatment of a ship than those usually employed in the dry dock and the marine railway, and which experience has shown to be safe. Indeed, the only remarkable thing about the scheme is that no one has ever thought of it before.

In the ship railway project a ship is lifted out of the water by means of a submerged pontoon, similar to those in use all over the world; but no such force as that used in hauling a ship up out of the water on a marine railway is required on the ship railway, although, as well known, ships are constantly taken on the marine railway without injury. In the Eads system, however, there is no necessity for using any force whatever on the ship itself.

It is lifted out of the water in a cradle which rests upon a series of rails; and these being brought even with the tracks on the dry land, the cradle in its capacity of a car is wheeled along an almost level railway across the Isthmus of Tehuantepec, and when it reaches the other side a similar means is employed to float it again. This is the whole project—a combination of the lifting dock in general use and an improvement upon the marine railway, because the ship is never, as in the latter, required to be off an even keel.

Looking upon the chart, we find that the Isthmus of Tehuantepec is in Mexico, and in the extreme northern end of the long, slim neck of land which separates North from South America, and that the Isthmus of Panama is on the extreme south end of Central America, and at the farther end of this strip of land. Having discovered this, we naturally turn to a consideration of ocean lanes from the Atlantic and Gulf States to California and the East Indies, and from California to the British Islands, because, in these days of expedition, the shortest route, all else being equal, is sure to prove the most popular. We have not proceeded far in this inquiry when the advantages of the Tehuantepec route in time and distance become plainly apparent.

From New York to San Francisco *via* the Panama Canal, a steamship would be compelled to pass the Isthmus of Tehuantepec, sail south about 1,200 miles, and after crossing sail north again the same distance before reaching the short route to San Francisco. In other words, she would have to traverse about 1,200 miles more than if she had crossed the isthmus at Tehuantepec. From Gulf ports to San Francisco and the East the difference in distance in favor of Tehuantepec is still more marked; the route between New Orleans and San Francisco *via* Tehuantepec being about nineteen hundred (1,900) miles shorter than *via* Panama. From Liverpool to San Francisco there is a saving of 600 miles *via* Tehuantepec. With sailing vessels—and sailing vessels, much as we hear of steamers, carry fully three-quarters of the world's freights to-day, and are likely to continue to carry slow freights—the contrast is still more marked.

A sailing vessel having crossed the Isthmus *via* Panama is left in a very ocean of waters, over which reigns a perennial calm, broken only by occasional squalls and baffling zephyrs. She must be towed hundreds of miles until the region of the trade winds is reached. This, of course, serves to add a large expense to the voyage and to lengthen it many days, so that when we say the voyage between the Atlantic States and California is shorter by 1,200 miles *via* Tehuantepec than it is *via* Panama, we greatly underestimate the advantages of the former route. It would be a generous estimate to allow for only ten days'—good authorities say from 20 to 30 days'—delay between the Pacific side of the Panama Canal and the point where a sailing ship strikes the northeast trades, by reason of calms and the slow progress made while in tow. Allowing that a sailing ship can average 170 statute miles in a day's run, this would add 1,700 miles to the 1,200 miles extra run required *via* Panama, and hence would serve, practically, to make the Tehuantepec route 2,900 miles shorter in the run from New York to San Francisco, and 3,500 miles shorter in the run from New Orleans to San Francisco.

In confirmation of this, indeed, as showing that in the above we have underestimated the time required by sailing vessels *via* Panama to cross the calm zone, we append herewith the testimony of a practical seaman, Captain Silas Bent, as given before the Merchants' Exchange in St. Louis, pending the unanimous adoption by that body of the resolution recommending a favorable consideration of the ship railway to the United States Government:

"Mere statements of the difference in miles is a very inadequate measure," he says, "of the difference in time that would be occupied by sailing vessels in making these several passages; and when we consider that three-fourths of the ocean commerce of the world is carried in sailing vessels, you can see what an important factor this question of *sailing time* becomes in the solution of the problem before us.

"The northeast trade winds which extend across the Atlantic are so broken and interrupted when they encounter the West India Islands that they never penetrate the Caribbean Sea; but the northwest portion of them, however, do extend into the Gulf of Mexico, and often so far down as to reach well toward Tehauntepec, so that while in the Gulf winds are always found, yet the Caribbean Sea remains a region of almost relentless calm.

"Nor is this all, for the mountain ranges, extending the length of the Isthmus of Panama and through Central America, offer a still more formidable barrier to the passage of these winds, thus throwing them still higher into the upper regions of the atmosphere, and extending these calms far out into the Pacific Ocean, on the parallel of Panama, with lessening width, for fifteen or eighteen hundred miles to the northwest, along the coast of Central America.

"This whole region of calms, both in the Caribbean Sea and in the Pacific Ocean, is so well known to navigators that sailing vessels always shun it, if possible, though they may have to run a thousand miles out of their way to do so.

"This absence of wind, of course, leaves this vast area exposed to the unmitigated heat of a torrid sun, except when relieved momentarily by harassing squalls in the dry season and by the deluging rainfalls of the wet season. With these meteorological facts in view, let us now suppose that the Lesseps canal at Panama and the Eads railway at Tehuantepec are both completed and in running order; then let us start two sailing ships, of equal tonnage and equal speed, from the mouth of the Mississippi, with cargo for China, one to go by the way of the Panama Canal, and the other by the way of the Tehuantepec Railway, and I venture to affirm that by the time the Panama vessel has cleared the canal and floats in the waters of the Pacific, the Tehauntepec vessel will have scaled the Isthmus and be well on to the meridian of the Sandwich Islands; and that before the former vessel can worry through the fifteen or more hundred miles of windless ocean before her, to reach the trade winds to the westward of Tehuantepec, the latter will have sped five thousand miles on her way across the Pacific, and be fully thirty days ahead of her adversary. For it is a fact worth mentioning here, that the strength of the northeast trade winds in the Pacific, as well as the maximum strength of the northern portion of the great equatorial current in that ocean, are both found on or near the parallel of latitude of Tehuantepec, the former blowing with an impelling force to the westward of ten or twelve miles an hour, and the latter with a following strength of three or four miles per hour."

It is not to be supposed that Mr. Eads hit upon the plan of his railway before carefully studying the various canal projects; such was not the case. It was, in fact, the result of these canal studies which led him to seek some other means of crossing the narrow strip of land that separates North from South America. For to his practical mind neither the one canal project nor the other of them gave evidence of feasibility, owing to their excessive cost. It was a great problem to solve! Here were a paltry forty or one hundred miles of earth and rock, which, if pierced, would serve to shorten by ten thousand miles the present voyage *via* Cape Horn from New York to San Francisco, which now is 15,687 miles, and to reduce the distance by water between New Orleans and San Francisco from 16,112 miles to something less than 4,000 miles.

It is not surprising that the mind that conceived the jetty system, as applied to the mouth of the Mississippi River, should not be thwarted by the obstacles which confront the transisthmian projector; nor is it surprising to find that the plan that he has hit upon is thoroughly original, or that it is decried by those who do not understand it. Indeed, it would be more surprising if this were not the case; for have not all original schemes been laughed at? The idea, when first proposed, of forcing carbureted hydrogen illuminating gas through the London streets furnished no little amusement to the illuminati; when the project of sending a vessel across the ocean to England propelled by steam was first made public, an eminent scientist was so sure of the impracticability of the scheme that he promised to swallow the vessel on its arrival; when Captain Ericsson proposed to substitute for the direct action of the paddle wheel the oblique action of the screw, he was looked upon as bereft of reason. Yet all succeeded.

"Whatever is attempted without previous certainty of success," says an eminent writer, "may be considered as a project, and among narrow minds may, therefore, expose its author to censure and contempt; and if the liberty of laughing be once indulged, every man will laugh at what he does not understand, every project will be considered as madness, and every great and original design will be regarded as impracticable. Men unaccustomed to reason and researches think every enterprise impracticable which is extended beyond common effects, or comprises many intermediate operations. Many who presume to laugh at projectors or designers would consider the navigation of the air in a flying machine as the dreams of mechanic lunacy, and would hear with equal negligence of the accomplishment of the Northwest Passage and the scheme of Albuquerque, the Viceroy of the Indies, who, in the rage of hostility, had contrived to make Egypt a barren desert by turning the Nile into the Red Sea."

Mr. Eads knew that ships had been going on and off lifting docks without injury from time immemorial, and that vessels that could safely withstand the terrible buffeting of ocean waves could be moved over a smooth roadbed without fear of injury. In order to be sure as to the roadbed, he took with him, to the Isthmus, Mr. E. L. Corthell, an experienced and able engineer, who had successfully carried out his plans at the mouths of the Mississippi, and is an expert in railroad construction, having been chief engineer of the West Shore Railroad. Being a practical man Eads, naturally sought to discover a route that would furnish a substantial roadbed, possess something in the shape of harbors at either end and above all a location outside of that, to the mariner, vexatious belt of perpetual calm. He found a cross section of the Isthmus of Tehuantepec which combined all these qualities; nay, more, for of all the routes across the narrow strip of land joining Mexico with South America, none shortens so much as this the voyage from the Atlantic and Gulf States to California.

Having selected the site for his ship railway, he now sought a concession from the Mexican Government. This was obtained in 1881, and extends over a period of ninety-nine years from its date. It authorizes the construction across the Isthmus of Tehuantepec of a ship railway, an ordinary railway, and a line of telegraph. Besides this it exempts all ships and merchandise *in transitu* from government duty, grants the concessionaire a million acres of public land, and guarantees protection during the construction and subsequent operation of the works. To crown all, the right is given the company to obtain the aid of any foreign government, and in consideration of this assistance the company is authorized by the terms of the concession to discriminate in favor of the commerce of such government against that of all other countries, save, of course, Mexico. The concession obtained, Mr. Eads set about having a careful survey made, topographical and physical, for the several previous surveys were with reference to a canal or an ordinary railway. One of the Eads surveys was made by Mr. Corthell, and another by a party of engineers under the direction of Don Francisco de Garay, an able Mexican engineer, with forty assistants and linemen; he being assigned by the Mexican government to assist Mr. Eads in making the survey. Two lines were run over the mountains, and a careful hydrographic survey was made of the approaches of the termini. A series of additional surveys were recently made from Minatitlan to Bocca Barra and to Salina Cruz.

The length of the whole line will be about 134 miles from Atlantic to Pacific. Beginning on the Atlantic side, the route will start from the Gulf of Mexico, the ships sailing up the Coatzacoalcos River to Minatitlan, a distance of about 25 miles. From Minatitlan there extends for about 35 miles an alluvial plain having an underlying stratum of heavy, tenacious clay. In the elevation and ridges clay loam and sand are found. Next comes an undulating table land, and then irregular mountain spurs of the main Cordilleras, that run through the entire continent, making at this point one of the most marked depressions to be found in its whole length. From this basin the line passes through a valley formed by a small stream to the plains of Tarifa, where is situated the summit of the line. This is 736 feet above low tide. After traversing these plains, the Pass of Tarifa is reached. This is the most accessible of the many passes in this depression in the mountain chain. From here the line gradually sinks to the Pacific, reaching the plains on this side 118 miles distant from Minatitlan.

The pontoon, or floating dock (see Figs. 1 to 4), is of the same general construction as those in use all over the world, save in some important modifications rendered necessary to fit it for its special work. For it is not enough that the vessel should be docked and lifted out of the water, but that it shall be caused to rest upon a cradle in such a manner that its weight shall be equalized fore and aft, and thus enable the carriage with its load to move easily and safely. This is effected by means of a system of hydraulic rams arranged along an intermediate deck about six feet below the upper deck of the pontoon (see Fig. 2). The arrangement of the rams is in both lateral and longitudinal lines, the former standing a little less than seven feet apart, the one from the other. The area of the combined rams in each lateral line is the same; the area of the one ram under the keel forward or aft is equal to the area of the five or seven rams amidships.

They may be connected and made to work in unison, so that the same pressure per square inch of surface of the rams will exist throughout the whole system, or they may be disconnected by valves, so that a greater pressure may be brought upon the rams in a certain section or on a certain line.

It is no part of the duty of these rams to lift the vessel. They are designed only to resist its weight as it gradually emerges from the basin. They get their power from a powerful hydraulic pump placed on a tower affixed to the side of the pontoon, and rising and sinking with it, but of such a height that, even when the pontoon rests upon the bottom of the dock, it is not entirely submerged. The pontoon itself is directed by powerful guides, which cause it to descend and emerge from the water always in the same position.

A ship having entered the mouth of the Coatzacoalcos River, on the Atlantic side, and come up to the basin, the carriage with its cradle is run on to the floating dock, then water is let into the compartments of the pontoon, and dock and cradle gradually sink to the bottom. Then the ship is brought in from the exterior basin, and so adjusted as to position that her keel will be immediately over the continuous keel block of the cradle, and her center of gravity over the center of the carriage. The water is then pumped out of the submerged pontoon in the manner employed in floating dock systems, and it rises gradually, bringing the cradle up under the ship's hull (see Fig. 2). As soon as the keel block of the cradle is close to the ship's keel, the hydraulic pump is called into action, and pushes up the pendent rods and posts of the supports gently against the vessel, closely following the lines of her hull and the run of the bilge. The pressure upon the rams increases as the vessel emerges from the water, but the water pressure under them being prevented from escaping by the closing of the valves, the ship's weight, when she stands clear of the water, is borne by the rams by means of the supports.

In the case of a ship weighing five thousand tons, each of the fifty lines of rams would, of course, be called to sustain a burden of exactly one hundred tons; and these lines being placed at equal distances the one from the other, it will readily be seen that each unit of the ship's weight is equally distributed. The weight and displacement of the vessel is learned from the pressure gauge on the hydraulic pump.

The vessel being clear of the water, hand wheels or adjusting nuts that move in threads cut in the columns of the supports are run down to the bearings in the girder plates, whereupon the valve is opened and the rams withdrawn, leaving the girders to support the weight of the ship. Now each girder has the same number of wheels, and as described above bears its just proportion of weight and no more, hence each of the multitude of wheels under the carriage is called upon to bear the same weight. This weight has been calculated to be only from eight to nine tons, though tested to twenty.

One of the many ingenious contrivances in the scheme is the "hydraulic governor," so called, and by which the unevenness of the plane of the pontoon when it comes to the surface with its load can be readily corrected. This apparatus is thus described:

"Two cylinders are attached to each corner of the dock, one being upright and the other inverted. Plungers attached to the pontoons move in them. These two cylinders are connected by pipes, and all spaces in the cylinders and pipes are filled solid with water. As the pontoon rises, the water forced out of one cylinder by the ascending plunger is forced into the inverted cylinder on the diagonal corner where the plunger is being withdrawn. Now, if there is say one hundred tons preponderance on one end of the pontoon, one-half this weight, or fifty tons pressure, will be exerted by each plunger on that end upon the water in its cylinder. This pressure is instantaneously transmitted through the pipes to the water in the top of the upright cylinder in the opposite diagonal corner, which acts with the same amount of pressure as a water plunger upon the metal plunger to hold it down; thus an equilibrium is maintained, and the pontoon compelled to rise and fall perfectly level. It is possible by aid of a pressure gauge attached to the pipes to ascertain the exact amount of the excess of weight, so that, should this gauge show too great a preponderance, the pontoon must be lowered and the ship placed in a new position."

The pontoon cannot elevate the rails on its deck above what would be a prolongation of the rails ashore, because of the heads of the anchor bolts or guiding rods, and these will also prevent any tipping of the pontoons when the ship-burdened cradle is moving off. The carriage with its cradle which comes up upon the submerged dock, is calculated to hold a ship even more firmly than the launching cradle used at the ship yards, with its shores and stays. This carriage moves upon six rails, three standard gauge tracks each of 4 feet 8½ inches. Ships themselves are girders, and must of a necessity be so, from stem to stern, because in the tempestuous seas in which they are designed to roam, the one part is constantly being called upon to support the other; now her bow projects over a great billow with nothing under to support it, and again she is poised upon a huge wave, leaving the midship section to support in great measure both the bow and the stern, and were she not constructed as a girder fore and aft, her back would be broken in the first big seas she encountered. Comprehending this, the designers of the ship carriage make its strength reach its maximum in the cross girders, which are spaced like the lateral lines of the rams already described; that is to say, seven feet apart, and having sufficient depth and material in their plates to insure an equal deposit of weight upon all the wheels. These latter are double flanged and are placed close together, each being hung independently on its own journals, and having its own axle. Under an ordinary railway car the four or six wheel trucks move together about a central pin. But in the ship carriage, which is not designed to move off from an almost straight line, this is not required, and greater strength is obtained by adhering to the rigid principle; elasticity being had by placing a powerful spring over each wheel. These springs will, as said before, bear a weight of twenty tons and have a vertical movement of about six inches, while the maximum weight they will be called upon to bear will not depress them more than three inches, and allow for crossing irregularities without bringing an undue weight upon the wheels.

There is also a system of supports for the vessel, each having adjustable surfaces hinged to the top of the supports by a toggle joint in such a way that they may be made to closely follow every depression and yield easily to every protuberance or bulging. They pierce the girders of the carriage, and are exactly pendent over the hydraulic rams when the carriage is on the pontoon and rests in its proper position. Thus, as will be seen, the ship when crossing the Isthmus (see frontispiece) rest upon what might be called a cushion, and indeed she will have experienced far rougher treatment, both in the Atlantic and Pacific under only ordinary conditions of weather, than that had while *in transitu* by rail across the Isthmus.

As said before, the road is designed to be almost exactly straight, since there will be no curves having a radius of less than twenty miles, for the carriage is four hundred feet long, and rests upon wheels which, as already explained, are not set on trucks swinging to a common center. There are only five places in the whole line where it is necessary to deviate from a straight line, and at each of these places a floating turntable (see Fig. 5 to 7) will be built. These turntables in design resemble pontoons, for they rest upon water, and will be strong enough to receive the carriage and its burden. The turntable pontoon will be firmly grounded, when the carriage is run upon it, by the weight of water upon the circular bearers of the basin. The water is pumped out by a powerful centrifugal pump, the water being emitted through an opening in the cylindrical pivot of the pontoon and discharged into the basin. Now, the pontoon has been made sufficiently buoyant to be turned easily upon its pivot by steam power, and the ship carriage is quickly pointed in its new direction. The valves then permit the water to enter once more, and the pontoon turntable again rests on its bearings. These turntables may be made to serve another purpose. By their means a ship can be run off on a siding, so to speak, where she can be scraped, painted, coppered, calked, or otherwise repaired without removal from her cradle, and thus be saved the heavy expense of going on a dry dock.

The locomotives for hauling the ship carriage over the Isthmian railway will not differ from those in ordinary use. The big freight engines of the day have no difficulty, as we know, in drawing freight trains of a total of two thousand tons; and as the ship carriage moves along three tracks it would be easy, if such a course were necessary, to place three locomotives in front of it and three behind. The time estimated for crossing from ocean to ocean is only sixteen hours.

Having now been over the ground of the ship railway and examined its several engineering features, let us turn to consider from the same practical standpoint the plans on which it is proposed to construct the rival projects at Panama and Nicaragua.

We have seen that, in the proposed Interoceanic Ship Railway, no really new or startling engineering problems present themselves. Is this the case with the canal projects? Let us see. At the International Canal Congress in Paris, in May, 1879, the Panama plan was rushed through despite the protests of the American and English delegates, who insisted that it was altogether impracticable. A simple reconnaissance had been made by Lieut. Lucien Wyse, and this was given precedence by the French over the many and careful surveys which have from time to time been made by skillful American engineers and by engineering expeditions from other countries.

It was evident from the start that the French had made several serious miscalculations. They had not given sufficient weight to the deadliness of the climate in that part of the Isthmus and the extent of the floods—two factors, as we shall see, which, if they do not finally prove an effective barrier to the progress of the work, are sure to greatly retard it and render its construction so costly as to make it, at the best, but a sorry venture from a financial standpoint. When nearly two-thirds of the whole appropriation for the canal was expended, and about one-thirtieth of the work performed, a startling discovery was made. The course of a great river, the Chagres, must be turned, and some means found of diverting the mountain streams, before active work on the canal proper could be resumed. Now, the Chagres River, so say expert engineers who have been on the ground, will require an immense expenditure of money—$20,000,000 at the least—to dam it at Gamboa, and a dam 150 feet high; also a lateral channel to divert these impounded waters *thirteen miles in length and as large as the main canal,* for there will be twenty million cubic meters in it.

Some idea of the destructive powers of this Chagres River may be had from the fact that, in 1879, during an unusual freshet, it flooded its entire valley for thirty miles; there being eighteen feet of water on the line of the Panama Railroad. The lateral canals for carrying off the water are likely to prove dangerous as well as expensive. As to these Colonel John G. Stevens, of New Jersey, one of the most eminent and experienced canal engineers in the country, and who visited Panama some two years since for New York capitalists, says: "Being situate in a depression of the Cordilleras, and flanked on each side by lofty mountain ranges, with steep sides, all water drains rapidly into the valley. Then again the rainfall of the tropics is excessive, and with us would be called phenomenal; at times being six inches in twenty-four hours for days in succession. The river consequently rises rapidly, and the greater part of the valley is submerged. . . . I think I can say that but one efficient plan can be formed, and that is to construct drainage canals on each side of the valley, so as to intercept the water that will drain from the mountain ranges on each side. Now, in severe floods the surface waters of these canals will be about seventy feet above that of the canal proper; consequently heavy guard banks will require to be constructed to restrain these intercepted floods. In other words, *the water will have to be hung up on the sides of the mountains.* Of course, with such a pressure, there will always be a great risk of the water breaking through the banks and the canal so filled by sediment as to stop navigation until it is removed. This would necessarily be a work of time, and destroy the prestige of the canal as an avenue of transport. . . . I do not remember ever to have seen money expended and such slight results effected; but I wish to add that this was evidently not due to the gentlemen in immediate charge, who were capable and zealous."

From evidence furnished by other expert engineers who have visited this region, it may be safely predicted that the wash from the slopes (clayey) in the profuse rainfall of this tropical region will tend to fill up the canal and entail a large expense in removing material.

The original estimate of the quantities of material to be removed has, of course, been greatly increased by the proposed Chagres River dam and the diverting channel back of it. Prices for labor, since the deadliness of the climate has come to be realized, have advanced to double and even thrice their original figures, and labor which at first was had for 30 cents advanced last year to 90 cents; 10,000,000 cubic yards, mostly soft dredging in the terminal marshes, has been done in four years. But even suppose they can do 6,000,000 cubic yards of dredging and rock excavation per year—and this is surely a generous estimate—then $\frac{200}{6}=33$ years to complete the canal. The original estimate was from $120,000,000 to $170,000,000, but with the obstacles now in view, and considering that the rock work has hardly been touched, $200,000,000 would seem to be a not unreasonable figure which the work will have cost when performed.

Let us now turn to the Nicaragua scheme. This project is for a lifting-lock canal—from 17 to 20 large locks being required. The time necessary to cross from ocean to ocean would probably be about three days. The location is 800 miles farther south than Tehuantepec, and consequently far south of the shortest route to California and the far East. It is situated also in the calm zone and in a country frequently visited by earthquakes, and hence liable at all times to serious injury.

The harbor of Greytown (north side) is irretrievably ruined, and Major McFarland estimates that it will cost $14,000,000 to make a good harbor of it. The harbor of Brito, as it is called, at the point where the Rio Grande enters the Pacific, is in fact only a small angular indentation of the land, partially protected by a low ledge of rocks, entirely inadequate for the terminus of a transisthmian canal and incapable of answering the commonest requirements of a port.

No reliable estimate of the expense of the Nicaragua canal has fallen short of $92,000,000; the Government Commission estimated $100,000,000, and Major McFarland $140,000,000. Capt. Bedford Pim, M.P., who is but recently returned from Nicaragua, estimates $200,000,000. The complication with England, too, makes the Nicaragua route to a great extent objectionable. By the Clayton-Bulwer treaty, made with England in 1850, we pledged ourselves to exercise with her only a joint control over any canal that should be built at this point, then looked upon as a favorable position for a canal because at that time there was a good harbor at Greytown. (The natural breakwater was destroyed by the sea in 1859, and the harbor filled up and ruined.) Only two years ago, as we know, England reasserted her claims, and insisted that the terms of the treaty should be complied with. In the recent concession made by Nicaragua, the government of the latter country makes the modest demand for *one-half the tolls collected,* should the canal be built.

The cost of the ship railway as computed by expert engineers will be about sixty million dollars ($60,000,000), or $75,000,000 at the outside.

A careful estimate has shown that it would not be unreasonable to look for a gross tonnage of 5,000,000 tons in 1888 for any passage across the Isthmus. Four dollars the ton would be but a moderate charge—the Panama Railroad demands $15 a ton. This would give $20,000,000 as gross receipts. Now, it has been estimated that 50 per cent of this would pay all working expenses, thus leaving $10,000,000 as net profit, or 10 per cent on a capitalization of $100,000,000

The Tehuantepec ship canal is a private enterprise that does not ask a dollar from the government, and there will

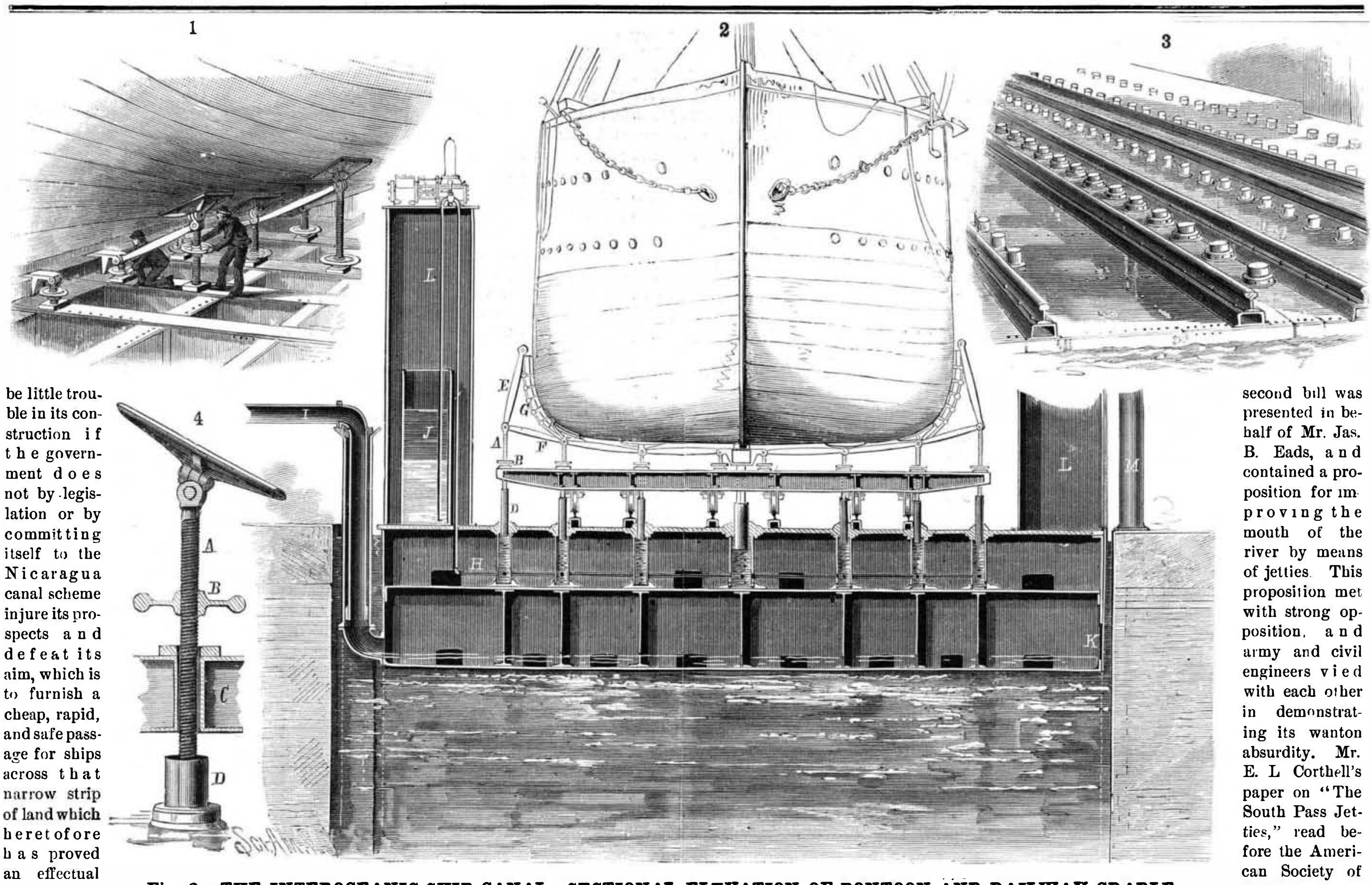


Fig. 2.—THE INTEROCEANIC SHIP CANAL.—SECTIONAL ELEVATION OF PONTOON AND RAILWAY CRADLE.

be little trouble in its construction if the government does not by legislation or by committing itself to the Nicaragua canal scheme injure its prospects and defeat its aim, which is to furnish a cheap, rapid, and safe passage for ships across that narrow strip of land which heretofore has proved an effectual barrier to aspiring canal builders. The promise of an original undertaking may be said to be directly as its author has succeeded or failed in previous enterprises, and hence it is but natural that the reader should like to know something about Mr. James B. Eads.

Ten years ago the bars at the mouths of the Mississippi below New Orleans had approached so near the surface that it looked as though the great city of New Orleans would be open in the near future to nothing larger than sloop navigation. A gradual shoaling had been going on for years, and various devices were suggested for deepening the channel, but none of them seemed to offer any hope of success. At last two bills were introduced into Congress relating to this subject.

One of these came from the headquarters of the Engineer Corps of the army, and advocated the construction of the Fort St. Philip Canal, leading from the river to the adjacent bay, about forty miles above the mouth of the river. The second bill was presented in behalf of Mr. Jas. B. Eads, and contained a proposition for improving the mouth of the river by means of jetties. This proposition met with strong opposition, and army and civil engineers vied with each other in demonstrating its wanton absurdity. Mr. E. L Corthell's paper on "The South Pass Jetties," read before the American Society of Civil Engineers, says:

"The propositions enunciated by the Board of Army Engineers and by the Chief of Engineers, on which they based their published prophecies of failure, were:

"*First.*—That the jetties would be undermined at the sea ends.

"*Second.*—That the foundation on which they would rest was unstable. And

"*Third.*—That there would be a greatly accelerated advance of the bar after the jetties were constructed.

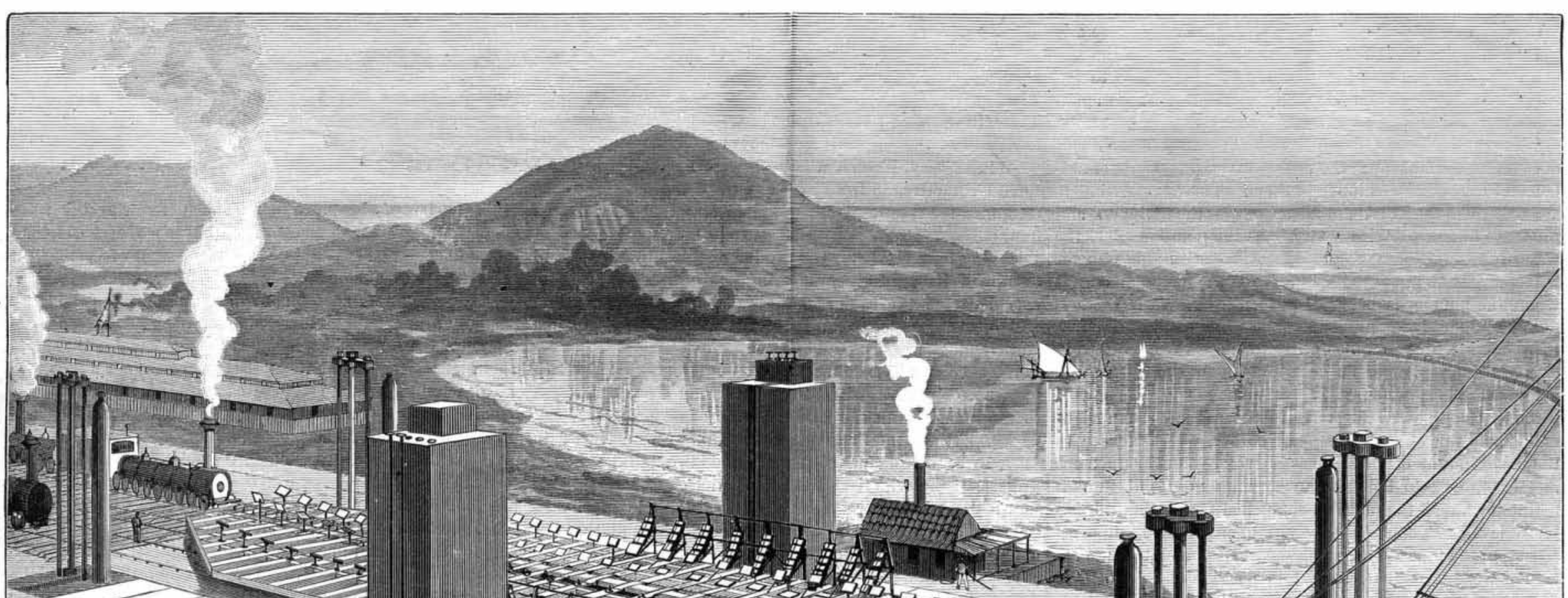


Fig. 3.—THE INTEROCEANIC SHIP RAILWAY.—THE LIFTING PONTOON AND RAILWAY CRADLE.

"Three positive opinions were given in official reports by three prominent United States engineers—one the then Chief of Engineers, another the present Chief of Engineers, and the third the officer in charge of the improvement of the Gulf ports—in reference to the rapid and accelerated growth seaward of the bar in consequence of jetties, which would produce a depth of from 25 to 27 feet, if such could be constructed. These gentlemen respectively gave as the annual rate of advance, after the construction of jetties at the mouth of the South Pass, 670 feet, 2,240 feet, and (in the language of the third) 'jetties will have to be built further and further out, not annually, but steadily every day of each year, to keep pace with the advance of the river deposit into the Gulf, provided they are attempted.'"

Of this ponderous opinion Mr. Corthell remarks, with something very like sarcasm:

"The necessary extension of the jetties into the Gulf with these rates of bar advance would have been up to this date respectively three-quarters of a mile (to where there is now actually 160 feet depth of water), two and one-half miles, and well out toward Cuba."

Mr. Eads finally succeeded in convincing Congress that there was at least something in his scheme, and he was given the contract, with the proviso that he should not be paid until he had secured the depths and widths of channel specified in the contract.

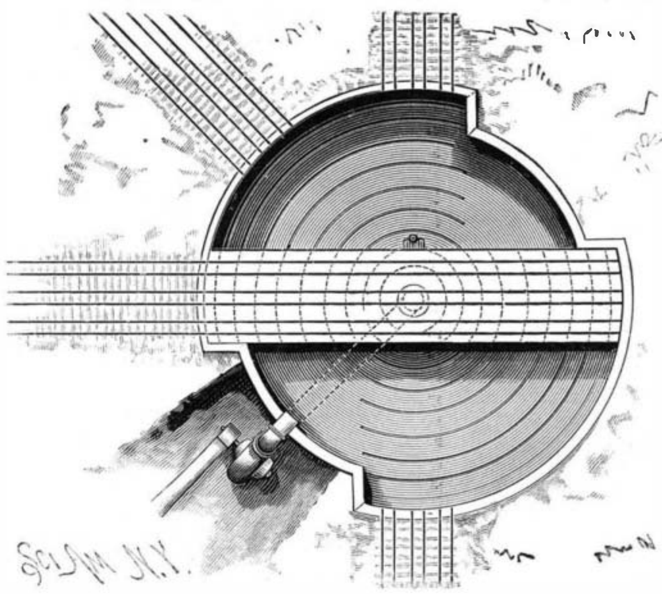
When he undertook the work, the depths in the crests of the bars in the Gulf, outside of the land, were 13 feet at the Southwest Pass, 11 feet at the Pass a Loutre, and 8 feet at the South Pass, all measured at mean low water. From the very inception of his jetty system it was a remarkable success; the South Pass deepened more and more by the scour of the river, until upon its shoalest spot he had 30 feet of water—a depth it maintains to this day, when the Great Eastern, the largest ship in the world, is able to cross the spot where, ten years ago, there was only 9 feet of water.

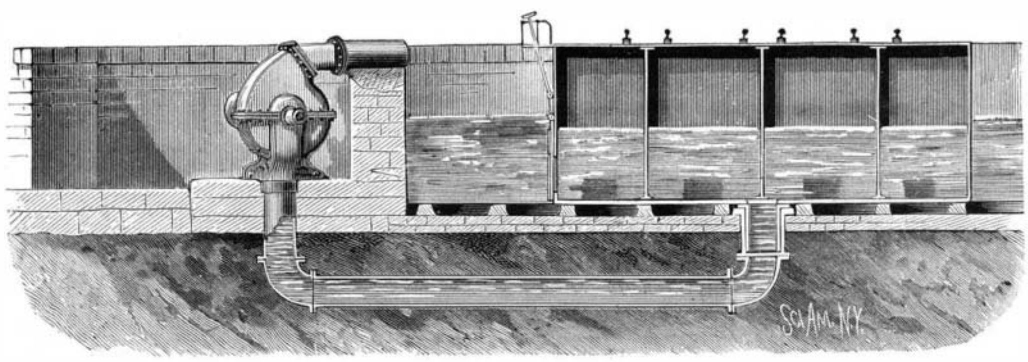
The fame of Mr. Eads, and his new interpretation of the Old World's jetty system, soon became an absorbing topic among hydrographers and engineers far and near. The Prince of Wales himself presented him with the Albert medal. This medal is inscribed:

"Captain James Buchanan Eads, the distinguished American engineer, whose works have been of such great service in improving the water communications of North America, and have thereby rendered valuable aid to the commerce of the Old World."

It is the same man who has projected the ship railway across the Isthmus of Tehuantepec, and if his plans are not thwarted by unwarranted government interference, there is reason to believe that ere yet the graceful masts and trailing yards of majestic ships will be seen to mingle with tropic palms in the mountain fastnesses of the Cordilleras.

In our illustrations, Fig. 1 shows an elevation of the adjusting of the screw standard for supporting the vessel on the pontoon, the detail of these standards being given in Fig. 4. A is the standard, having a head plate with universal joint, its top cushioned with rubber or canvas, to prevent damage to the ship; B is an adjusting nut, which, when the rams are down, stops the descent of the jack by contact with the top side of the main girder, C, on which they will rest, D being the top of the hydraulic jack of the pontoon, the number of these jacks used being better shown in Fig. 3, a section of the floating pontoon. E F G, in Fig. 2, show the sectional girders by which the weight of the vessel is distributed on the jacks. H shows one of the upper pontoon sections. J shows arrangement in connection with the pump on pumping tower, L, to distribute the load of the vessel equally on all the jacks. I and K show the arrangement by which the water is exhausted from the pontoon. On each side of the basin there are several rods on top of which are nuts capable of holding the pontoon, to prevent its rising above the level of the railway when the ship and cradle have been taken off. Figs. 5 and 6 show a plan and sectional view of the floating turntable, and Fig. 7 a perspective view, with a ship on the turntable.





Figs. 5 & 6.—ILLUSTRATIONS OF THE TURNTABLE.

THE castor bean plant, says the Los Angles (Cal.) *Herald*, has been found very efficacious in killing grasshoppers by the million, and is also useful for killing flies.

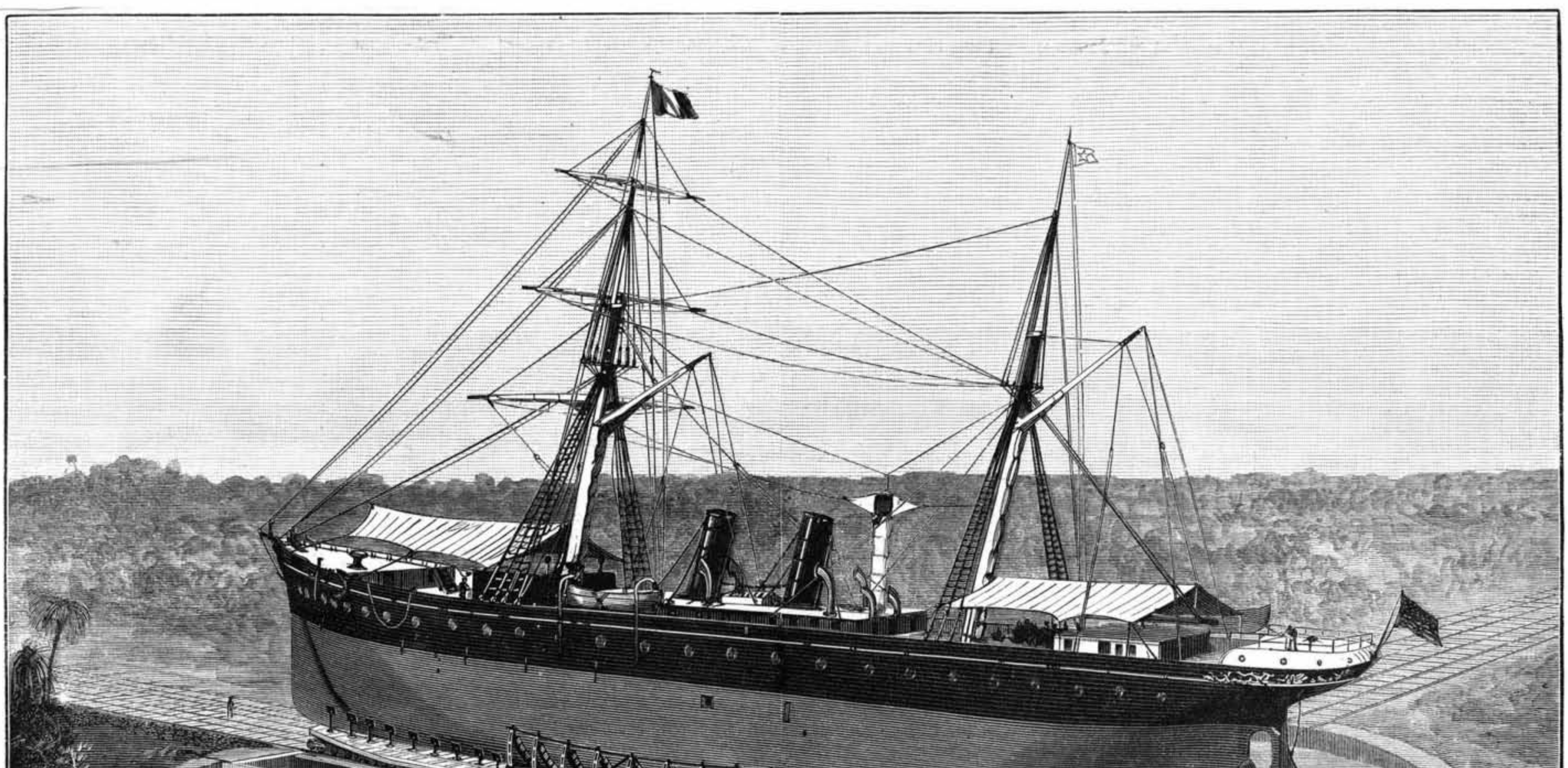


Fig. 7.—THE INTEROCEANIC SHIP RAILWAY.—THE FLOATING TURNTABLE.

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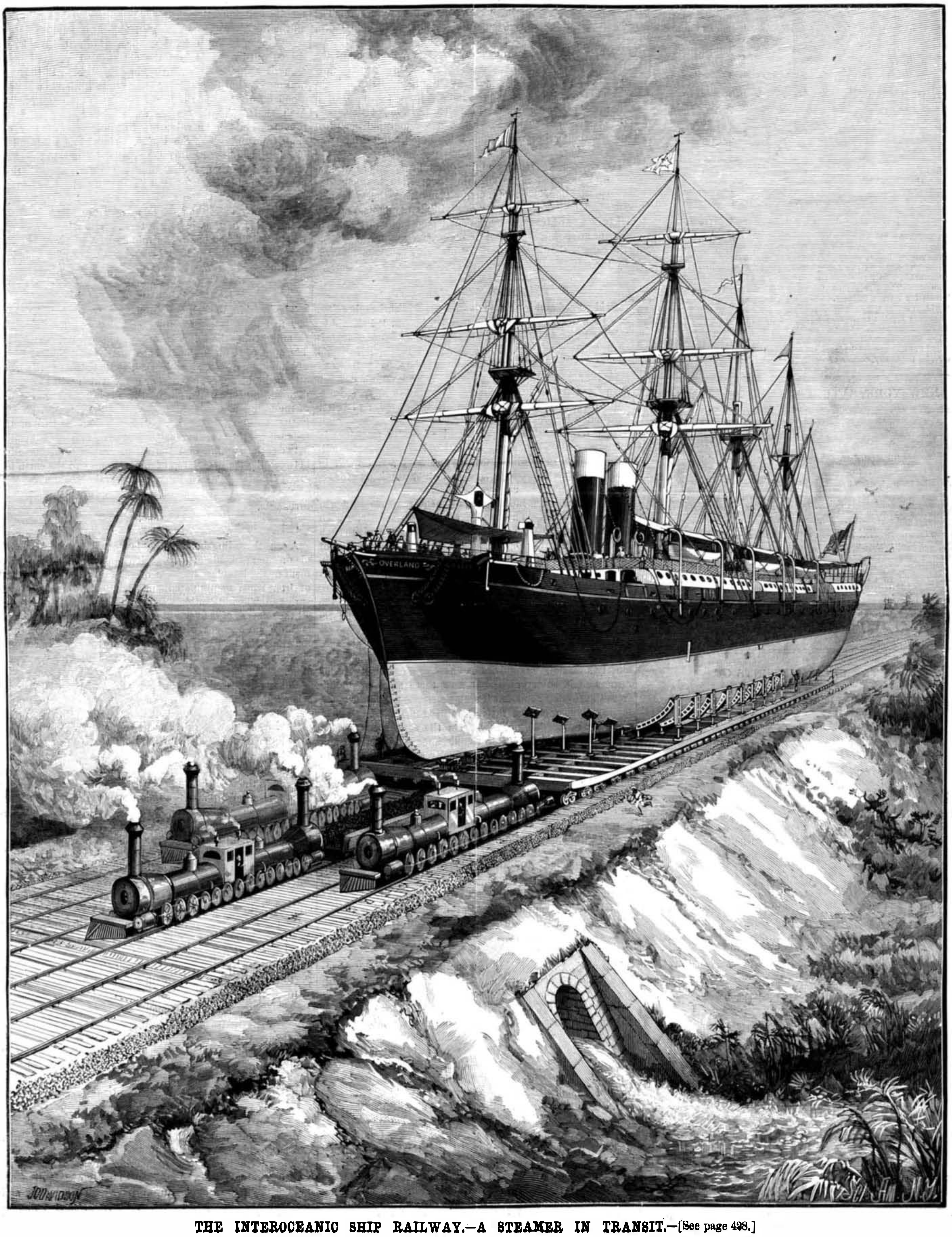

THE INTEROCEANIC SHIP RAILWAY.—A STEAMER IN TRANSIT.—[See page 428.]